MKM

MKM ENGINEERS

Radiation Safety Procedures

Book 1

"SAFETY IS THE FIRST & MOST IMPORTANT ASPECT OF ANY JOB"

MKM ENGINEERS - 1999

A/2

Radiation Safety Procedures

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SAFETY

MKM

Radiation Safety Manual

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GLOSSARY

Glossary of terms used in the text of this safety manual.

Airborne Radioactivity Area - A room, enclosure or area in which radioactive material is dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases and the concentration of the dispersed radioactive materials is in excess of:

a) The derived air concentrations (DAC's) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations (Also noted in Appendix B of this manual).
b) Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Annual Limit on Intake (ALI) - The annual limit on intake (ALI) of radioactive materials is the smaller amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year (40 hours per week for 50 weeks) that would result in a committed effective dose equivalent of 5 rem to the whole body or a committed dose equivalent of 50 rems to any individual organ or tissue.

Byproduct Material - Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Committed Dose Equivalent ($H_{T,50}$) - Committed dose equivalent is the dose equivalent to an organ or tissue that will be received from an intake of radioactive material by an individual during the 50 year period following the intake, i.e. fifty year organ dose (total dose for fifty years from internal contamination).

Committed Effective Dose Equivalent ($H_{E,50}$) - Committed effective dose equivalent is the sum of the products of the weighing factors applicable to each of the body organs of tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Controlled Area - Controlled area is an area outside of a restricted area but inside the site boundary, access to which can be limited by the activity for any reason.

Curie (Ci) - The unit of activity, one Curie equals 3.7×10^{10} nuclear disintegrations per second.

Declared Pregnant Woman - A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Deep Dose Equivalent (H_d) - Deep dose equivalent, which applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2). Deep dose equivalent establishes a standard depth for specifying the dose from whole body external exposure.

Derived Air Concentration (DAC) - Derived air concentration is the concentration of a given radionuclide in air which, if breathed by the "reference man" for a working year (40 hours per week for 50 weeks) under the conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one ALI.

Effective Dose Equivalent (H_E) - The probability of a stochastic effect, e.g., cancer induction or hereditary effect, in any tissue is proportional to the dose equivalent to that tissue. The value for the proportionality factors differs among the various tissues because of the differences in tissue sensitivity. If radiation dose is uniform throughout the body then the total risk factor is one. For nonuniform radiation, such as partial body exposure where the isotope concentrates to different degrees in the various tissues, weighing factors which are based on the relative susceptibility of the tissues to stochastic effects may be used to calculate an effective dose equivalent. The effective dose equivalent is the sum of the products of the weighing factors applicable to each of the body organs of tissues that are irradiated and the dose equivalent to these organs or tissues.

External Dose - Portion of the dose equivalent received from radiation sources outside the body.

Extremities - Extremities means hand, elbow, arm below elbow, foot, knee, or leg below the knee.

Eye Dose Equivalent - Eye Dose Equivalent applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeters.

High Radiation Area(HRA) - Any radiation area accessible to personnel in which there exists ionizing radiation at such levels that an individual could receive in excess of 100 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Internal Dose - That portion of the dose equivalent received from radioactive materials taken into the body.

Ionizing Radiation - Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter. Ionizing radiation includes the following: Gamma rays, x-rays, alpha particles, beta particles, neutrons, protons, and other particles and electromagnetic waves capable of producing ions.

Licensed Material - Licensed material means source material, special nuclear material, or byproduct material received, possessed, used, transferred, or disposed of under a general or specific license.

Members of the Public - Individuals who are not occupationally exposed to ionizing radiation.

RAD. - The unit of absorbed dose which is equal to the absorption of 100 ergs per gram in any substance.

Radiation Area (RA) - Any area accessible to personnel in which there exists ionizing radiation at dose-rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrems in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radioactive Contamination - A radioactive substance dispersed in or on materials or in places where it's presence is undesirable

.Radiological Control Program (RCP) - A company responsibility comprising all procedures and techniques which are used to control radiation sources and radioactive materials to minimize exposure to personnel and the environment. It includes control of all ionizing radiation sources during storage, handling, use, shipping and disposal.

<u>Radiation Safety Committee (RSC)</u> - A committee that consists of the RSO, at least one representative of management; and at least one user from each of the activities that will use radioactive materials under the license. The RSC is responsible for establishing appropriate policies and procedures to ensure control, overall development, and implementation of the Radiation Safety Program.

<u>Radiation Safety Officer (RSO)</u> - This individual is responsible for oversight of the day-to-day radiation protection program established by the RSC, communication with senior management and the RSC regarding program implementation and compliance status, and is available to provide advice and assistance on radiological safety matters.

<u>Radiation Safety Staff</u> - The staff of health physics professionals that support the RSO in the maintenance and control of the licensed program.

<u>Rem</u> - The unit of dose equivalent for any type of ionizing radiation absorbed by body tissue in terms of its estimated biological effect relative to an absorbed dose from exposure to one roentgen of high energy x or gamma rays.

<u>Restricted Area</u> - Restricted Area means any area, access to which is limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

<u>Roentgen</u> - A unit of exposure to electromagnetic ionizing radiation. It is that amount of x-ray or gamma radiation which will produce in air 2.58×10^{-4} coulombs of charge per kilogram of dry air at standard temperature and pressure.

<u>Shallow Dose Equivalent (H_S)</u> - Shallow dose equivalent, which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeters (7 mg/cm^2) averaged over an area of at least 1 square centimeter.

<u>Source Material</u> - Uranium or thorium, or any combination thereof, in any physical or chemical form.

Stochastic Effects - Stochastic effects are health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Total Effective Dose Equivalent (TEDE) - Total effective dose equivalent is the sum of the deep dose equivalent (external dose) and the committed effective dose equivalent (internal dose) .

Unrestricted Area - Any areas to which access is neither limited or controlled by the customer or by MKM for the purpose of radiation protection.

Very High Radiation Area - Any area accessible to personnel in which there exists ionizing radiation at such levels that an individual could receive in excess of 500 Rad in 1 hour at 1 meter from the radiation source or from any surface that the radiation penetrates.

Whole Body - Whole body means, for purposes of external exposure, head, trunk, arms above the elbow, and legs above the knee.

SECTION I - MANAGEMENT POLICY AND ORGANIZATION

1.0 PURPOSE AND PHILOSOPHY

1.1 Statement of Purpose

The purpose of this manual is to define program requirements and radiation protection standards for MKM Engineers, Incorporated (MKM) operations with respect to the health and safety of employees and workers, their protection from ionizing radiation, and the prevention of any release of radioactive contaminants that could adversely affect the environment. These requirements and standards will be implemented during MKM's performance of site surveys, remediation activities, decontamination activities, waste characterization, waste packaging, and waste shipment.

1.2 Statement of Philosophy

MKM's philosophy is to control the receipt, possession, use, transfer, and disposal of radioactive materials at a customers facility in such a manner that the total dose to any individual does not exceed standards for protection against radiation prescribed in regulations set forth by the Nuclear Regulatory Commission (NRC), Department of Energy (DOE), Environmental Protection Agency (EPA), state regulatory agencies and licenses or permits issued to MKM or our customers by NRC, EPA or state regulatory agencies. In addition to maintaining radiation exposure within regulatory standards, MKM is committed to maintaining radiation exposures As Low As Reasonably Achievable (ALARA) through the use of engineering controls, employee training, and administrative procedures. These exposure controls must be maintained for the sum of doses received by all exposed individuals as well as each individual. All personnel are responsible for making recommendations that would further reduce exposures.

Risk versus Benefit: Benefits from the use of ionizing radiation may require some risk of exposure to radiation. In these instances, it is necessary to determine a balance between risk and benefit. Though objective criteria cannot be identified to apply in all circumstances, objective guidelines and established regulations will be followed whenever possible. We will be able to demonstrate, if necessary, that improvements have been sought, modifications have been considered, and implemented when reasonable. If modifications have been recommended but not implemented, the reasons for not implementing them will be described.

1.3 Implementation of Policy

This policy will be implemented by a Radiation Safety Committee (RSC) and a Radiation Safety Officer (RSO). The RSC will be composed of members drawn from various company areas that would use, manage the use of, or train personnel in the use of sources ionizing radiation. The implementation of recommendations or decisions of the RSC is the responsibility of the Radiation Safety Officer, who will ensure implementation by the Radiation Safety Staff members.

2.0 RESPONSIBILITIES

2.1 Radiation Safety Committee

The Radiation Safety Committee reports directly to the president of MKM as shown in Figures 1 and 2. The Radiation Safety Committee has the following duties and responsibilities:

1) Meet as often as necessary to conduct business but not less than quarterly,

2) Conduct periodic reviews and audits of the Radiation Safety Program, and along with the RSO and Staff, review records, reports from the RSO, results of NRC inspections, and written safety procedures. Observe audits performed by the RSO and Staff to ensure adequacy of the management control systems. These reviews may be conducted by an independent auditor, but this does not relieve the RSC of the responsibility to ensure that the reviews are conducted in accordance with regulations. Examples of review include, but are not limited to, the following:

- Review of letters of agreement or Basic Ordering Agreements (BOAs) with contract agencies, pertaining to activities that affect the radioactive materials license,
- Review of audit findings,
- Review of projects documents, such as the Specific Work Plan, Health and Safety Plan and QA Plan,
- Review of operating procedures to ensure compliance with this manual, pertinent federal regulations, license, and customer requirements,

3) Ensure that operations comply with the provisions of this manual and other pertinent federal and state regulations,

4) Establish a radiation control program for those projects involving radioactive materials and implement development of procedural guidance for the program and the projects. In accordance with guidance given in Regulatory Guidance 10.5, *Applications for Licenses of Broad Scope,* the RSC may authorize the following program changes without notifying the NRC:

- Changes dictated by NRC rule changes,
- Changes in internal management forms or specific dates,

- Changes in contractors for bioassay or waste disposal or for servicing and calibrating personnel dosimeters (providing the new contractor is NVLAP approved),

- Changes in contractors for other outsourcing services (labs, project personnel, equipment rental, etc.) Providing the new contractor presents equivalent or better credentials,

- Changes in a piece of referenced equipment providing the replacement is equivalent or better or the need has not been altered.

5) Ensure that employees working with radioactive materials have received the required training in operating procedures, rules, and special precautions prior to being occupationally exposed to ionizing radiation,

6) Evaluate MKM's overall efforts for maintaining doses ALARA on an annual basis, which will include the efforts of the RSO, authorized users, and workers as well as those of management,

7) Provide final approval of authorized users of radioactive materials on the license,

8) Inform the president of MKM on program status and radiation safety objectives, the quality of the radiation safety program in meeting customer needs, maintaining dose to personnel and members of the public ALARA, and assuring protection of the environment.

2.1.1. RSC Membership and Qualifications

The Committees is composed of members from the following activities or areas of responsibility:

1) Radiation Safety

2) Projects

3) Brokering

4) Training

The membership of the RSC may be changed as necessary to meet programmatic needs. The designated representative of each of these areas is valid as of the date shown on Attachment 1.

All members of the Radiation Safety Committee must have a college level degree and two (2) years of experience at a senior or management level in the area that they represent, or five (5) years of experience at a senior or management level in the area that they represent. All members must be familiar with MKM Radiation Safety procedures, applicable Federal and State regulations, and our license requirements.

A quorum of the Radiation Safety Committee is authorized to act on behalf of the committee for approval of necessary actions between regular meetings of the Committee. A quorum shall consist of the Chairman, the RSO, and at least one (1) other committee member or a minimum of 50% of the RSC.

The RSC is required to keep minutes of all quarterly meetings, any quorum meetings, and any ancillary actions of the Committee that affect or are affected by the Radiation Safety Program.

2.1.2 Minimum Qualifications of the Corporate Health Physicist, Program Manager, and the Radiation Safety Officer:

The Corporate Health Physicist must have a B.S. or higher degree in Health Physics or a related field and at least five (5) years of practical health physics experience. Unless certified by the American Board of Health Physics, eight (8) or more years of practical experience is required.

The Program Manager must have a college degree in Health Physics or a related science or engineering, and at least five (5) years of practical experience, of which at least one (1) year must be in field operations experience. In addition to the field experience, at least two (2) years of the practical experience must be in a similar position and/or in equivalent training

The Radiation Safety Officer must have a college degree in Health Physics, or a related science, or engineering, and at least five (5) years of practical experience, of which at least two (2) years must be in a similar position and/or in equivalent training.

In the absence of the Radiation Safety Officer, the Corporate Health Physicist serves in that capacity. As designated by procedure and for a specified purpose; i.e.,required for two (2) or more projects at the same time, other qualified persons may act as or represent the office of the RSO for that function. These personnel may assume the duties of the RSO, however the responsibility for decisions of the RSO remain with license designated Radiation Safety Officer.

Minimum qualifications for a RSO designee (or a Program Manager designee) shall be similar to the qualifications required to hold the office. The designee should have the required degree and at least five (5) years of practical experience, of which at least two (2) years must be in a similar position and/or in equivalent training, or at least eight (8) years of practical radiation safety experience, of which at least three (3) years must be in a similar position and/or in equivalent training.

2.2 Radiation Safety Officer

The RSO is qualified in the field of health physics and radiation protection and heads the Radiation Safety Program. The RSO performs or supervises others to ensure that the duties required are performed in a timely manner. The person designated as the Corporate Health Physicist is available to the RSO for technical support and auditing purposes. The RSO reports to the Vice President of the Las Vegas Division and has unrestricted access to the President of MKM on all matters pertaining to Radiation health and safety of MKM. The RSO is assisted by a Radiation Safety Staff to administer the MKM Radiation Program as set forth in this manual. The Radiation Safety Officer has the following minimum duties and responsibilities:

1) Responsible for oversight of the day-to-day radiation protection program established by the Radiation Safety Committee,

2) Communication with senior management and the RSC regarding program implementation and compliance status,

3) Be available to provide advice and assistance to the RSC and management on radiological safety matters,

4) Review and make recommendations to the RSC regarding the list of qualified users of radioactive materials in support of the license,

5) Report to the Radiation Safety Committee, at periods not exceeding one (1) year, on all findings and recommendations to reduce exposure to personnel,

6) Serve as the MKM liaison to the U.S. Nuclear Regulatory Commission on license and inspection matters.

2.3 Radiation Safety Staff

The RSO and the Radiation Safety Staff have the following duties and responsibilities:

1) Implement and maintain an effective Radiological Controls Program that complies with the provisions and conditions of this manual, operating procedures, the radioactive materials license, and pertinent federal and state regulations,
2) Provide necessary information on all aspects of radiation protection to personnel at all levels of responsibility, pursuant to 10 CFR 19.12, and 10 CFR 20,

3) Maintain surveillance of overall activities involving radioactive material, including monitoring and surveys of all areas in which radioactive material is used or stored,

4) Maintain a current ionizing radiation source inventory under MKM control and a record of their location to ensure that sources are secure against loss or unauthorized use,

5) Perform or arrange for leak tests on all sealed sources and calibration of radiation survey instruments,

6) Develop, coordinate, and participate in training and orientation programs for occupationally exposed individuals at periodic intervals (refresher training), and other personnel as required by changes in procedures, equipment, regulations, etc.,

7) Maintain current all applicable required license amendments, and apply for amendments and renewals in a timely manner as approved by the RSC,

8) Distribute and process personnel radiation monitoring equipment, determine the need for and evaluate bioassays, monitor records for trends and unexpected exposures, notify individuals and their supervisors of radiation exposures approaching maximum permissible amounts, and recommend appropriate remedial action.

9) Formulate procedures for and in support of, revise, and maintain the Radiation Safety Manual,

10) Both the Corporate Health Physicist and the Radiation Safety Officer have individual authority to stop any job or activity which in their opinion could pose a hazard to the health and safety of the employees or the general public,

11) Investigate the cause of any incident, determine the appropriate actions to prevent recurrence, and complete documentation as required. (Use of an approved evaluation tool, such as the Institute of Nuclear Power Operations's, Human Performance Evaluation System (HPES), is advised.)

The Radiation Protection Staff has the responsibility of maintaining records associated with activities specifically designated above. For example, records on receipts, transfers, and surveys as required by 10 CFR 30.51, "Records", and subpart L, "Records", of 10 CFR Part 20. Other records include, but are not limited to;

- License amendments and applications,
- License inspection reports and responses,
- Radiation history, past and present, on all MKM personnel,
- All requests for sources of ionizing radiation,
- Surveys and recommendations,
- Calibration results,
- Surveys of all sealed sources.

All records will be maintained a minimum of five (5) years after the NRC terminates each pertinent license requiring the record.

2.4 Project Manager(s)

Project Managers report to the Program Manager of the Las Vegas Division on all matters other than those specific to Radiation Protection. The Project Manager should have at least three (3) years of experience in managing the various aspects of projects. At least one (1) year must be field experience in the area(s) specific to the planned evolution, i.e., remediation, soil movement, characterization, underground storage tanks (UST) or UXO handling. Less qualified Project Managers may be assigned simpler tasks (in training) as long as they report directly to an experienced Project Manager or the Program Manager. The Project Manager has the following duties and responsibilities:

1) Ensure that all radioactive materials are handled in accordance with the provisions of this manual, the radioactive materials license, and pertinent state and federal regulations,

2) Provide technical advice and assistance to MKM management and personnel on all matters pertaining to project operations, specific work plan execution, project field personnel as those matters related to needs, qualifications, and abilities.

3) Assist the Waste Broker in packaging, marking, labeling, shipping and transportation of radioactive materials,

4) Assist the RSO and Training Coordinator in training and orientation programs, for occupationally exposed individuals, for handling and processing of radioactive materials, and other personnel as required,

5) Stop any job or activity which in their opinion could pose a hazard to the health and safety of employees or the general public. Conduct a complete review of the noncompliance and obtain RSC approval prior to allowing the job or activity to continue.

2.5 Waste Broker

The Waste Broker reports to the Program Manager of the Las Vegas Division on all matters other than those specific to Radiation Protection. The Waste Broker has the following duties and responsibilities:

1) Package and ship radioactive materials in accordance with the provisions of this manual, the radioactive materials license, and pertinent state and federal regulations,

2) Provide technical advice and assistance to MKM management and personnel on all matters pertaining to packaging, marking, labeling, shipping and transportation of radioactive materials,

3) Assist the RSO and Training Coordinator in training and orientation programs, for occupationally exposed individuals, for handling and transportation of radioactive materials, and other personnel as required,

4) Stop any job or activity which in their opinion could pose a hazard to the health and safety of employees or the general public. Conduct a complete review of the noncompliance and obtain RSC approval prior to allowing the job or activity to continue.

2.6 Radiation Safety Training

The training program provides a commitment to initial training, retraining, and continuing education. The type and amount of instruction will be based on regulatory requirements, past documented experience, and will be commensurate with potential radiological health protection problems in the areas in which employees are expected to work. Performance-based training and continuing education, are considered important aspects of this training program.

In accordance with 10 CFR 19.12, all radiation workers will receive instruction prior to beginning work with licensed materials. The elements of this orientation will include, but are not limited to;

- Applicable regulations and license conditions,
- Areas where radioactive material is used and/or stored,
- Potential hazards associated with radioactive material,
- Appropriate radiation safety procedures,
- Individual's obligation to report unsafe conditions to the RSO or applicable authorities,
- Appropriate response to emergencies or unsafe conditions,
- Locations of pertinent procedures, regulations, licenses, and other material required by regulations,
- Radiation Work Permit (RWP).

In addition to basic classroom instruction, performance-based (on-the-job) training specific to the individual's duties may be conducted. This helps to ensures safe handling of radioactive materials in accordance with ALARA principles.

Since different radiation hazards will be encountered with different types of projects, site specific programs and/or job specific programs will be developed to instruct each different group with appropriate information in accordance with 10 CFR 19. This information may be incorporated into other training programs or may be presented separately. Specialized training such as; emergency procedures, OSHA, etc. are examples of training programs that would be presented as a separate training subject.

Records of training will be maintained for a minimum of three (3) years. Training records will include, but are not limited to;

- A list of topics presented,
- An approximation of the time spent on each topic,
- Names of instructors and students, including a manner of positive identification,
- Date(s) of training,
- A written assessment or test for each student that documents satisfactory completion of the training,

- The location of the training and a copy of materials involved in the training.

2.7 Radiation Workers

Employees of MKM who are assigned to work activities involving radioactive material have the following responsibilities, in accordance with 10 CFR 19 and this manual:

1) Obey posted, verbal and written radiological control procedures,

2) Wear dosimetry devices as instructed by procedure and when required by other specific instruction, of this manual, project health physics, etc. Promptly report any lost or damaged devices to their supervisor and/or the project health physicist,

3) Promptly report to their supervisor or RSO any incident, personnel injury, suspected overexposure, contamination, internal deposition, and any suspicious or questionable occurrence involving radioactive material,

4) Be thoroughly familiar with equipment, procedures and requirements for the use of any special devices, prior to using or working with any source or device which produces ionizing radiation,

5) Avoid any unnecessary exposure and use of the concept of time, distance and shielding when working in the presence of radiation sources to maintain their exposure As Low As Reasonably Achievable (ALARA).

SECTION II - PROGRAM IMPLEMENTATION

3.0 RADIATION PROTECTION STANDARDS

3.1 Introduction

Every effort will be made to maintain personnel radiation exposures below the indicated radiation protection standards as set forth in this section and consistent with the ALARA principle. The occupational exposure standards prescribed in this section are exposures received by an individual assigned duties involving exposure to radiation and to radioactive materials. Radiation exposures received from background radiation and medical exposures are not included in the radiation exposure limits specified in this section.

3.2 Occupational Exposures

Radioactive materials and sources of radiation will be controlled in such a manner that radiation exposures to workers do not exceed limits specified in 10 CFR 20, Subpart C.

Occupationally exposed workers who have received radiation exposure prior to employment with MKM are required to provide MKM with their radiation exposure history records or names and addresses of employers where they have received exposures. These previous exposures along with any exposure they may receive during employment with MKM will be recorded in the employee's file.

3.3 Embryo/Fetus

All reasonable efforts will be made to keep ionizing radiation exposure to the unborn child to the lowest practical level, as prescribed in 10 CFR 20.1208. Once a female employee determines she is pregnant, she is encouraged to notify MKM in writing of her pregnancy. MKM will then institute radiation control measures which will limit radiation exposure to the unborn fetus to less than 500 mrem for the term of the pregnancy and below 50 mrem per month in any month after the declaration.

3.4 Minors

No individual under 18 years of age will be assigned radiation worker duties.

3.5 Members of the Public

Members of the general public are not allowed in MKM work areas where radioactive materials are being handled. If an individual requires entry into a MKM work area for inspection or audit purposes, they will be required to provide information on their radiation worker training status. Appropriate supplemental training and dosimetry will be provided commensurate with the hazards involved in the work area. Radiation exposures to the general public will be maintained below the following limits as prescribed in 10 CFR 20.1301:

1) The dose in any unrestricted area will be maintained below 2.0 mrem in any one hour period,

2) The maximum exposed individual's total effective dose equivalent (TEDE) from occupancy in all unrestricted areas will not exceed 100 mrem per calendar year.

3.6 Contamination Standards

Radioactive material will be controlled in such a manner that the surface contamination does not exceed the levels specified in Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors,* and in the USNRC, Division of Industrial and Medical Nuclear Safety, August 1987 guideline document, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,* and as set forth in Table 1. Each of these sources cite the same levels.

The contamination levels in Table 1 represent the maximum allowable levels and every effort should be made to maintain contamination levels below these levels by implementing contamination control levels lower than the levels indicated. Contamination control levels for customer facilities where MKM works may, in fact, be lower than the levels indicated in the table. In those cases and in all cases of lower contamination levels, the more stringent contamination control levels will be used to maintain compliance with customer requirements.

Table 1. Contamination Limits.

RADIONUCLIDE	ALLOWABLE SURFACE CONTAMINATION (DPM/100 CM^2)	
	REMOVABLE	FIXED + REMOVABLE
Transuranics, Ra-226,Ra-228 Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	100
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1000
U-natural, U-235, U-238, and associated decay products	1000	5000
Beta-Gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	1000	5000

3.7 Airborne Radioactivity Standards

The amount of radioactive materials taken into a workers body will be limited to less than 10% of the ALI as specified in Table 1, Columns 1 and 2, of Appendix B of 10 CFR Part 20, providing the total effective dose to the individual is maintained ALARA.

4.0 CONTROL OF EXPOSURES

Exposure to radiation will be controlled by administrative procedures, employee training, and engineering controls. Only through the mutual cooperation and commitment of all employees can MKM meet its goal of maintaining personnel exposures As Low As Reasonably Achievable (ALARA).

4.1 Training

Effective training will be implemented to:

- Develop worker awareness of radiation safety procedures to encourage performance of tasks with greater efficiency and confidence.
- Make individuals aware that there is some risk associated with exposure to ionizing radiation. This promotes participants to become active in the decision to accept and, where possible, to reduce the risk as part of their job.
- Reduce or eliminate the number and seriousness of accidents and incidents.

Each radiation worker shall, prior to performing any radiation work, successfully complete radiation safety training including the following topics as a minimum. Successful completion of this training will be demonstrated by the individual attaining a minimum score of 75% on a written exam.

1) Types and sources of ionizing radiation contributing to personnel exposure.

2) Biological effects and risks associated with exposure to ionizing radiation.

3) Radiation exposure limits and control levels.

4) Specific procedures for using time, distance and shielding to maintain individual exposures ALARA.

5) Specific personnel dosimetry requirements.

6) Operating, maintenance, handling and accountability procedures for radioactive sources.

7) Facility or site survey requirements and procedures.

8) Responsibilities of individuals.

9) Emergency procedures.

10) Specific survey instrument requirements and operating procedures.

Initial training will be a minimum of eight hours and conducted by the RSO or a designated representative. Completion of the training course includes successfully completing a minimum 20 question exam with a minimum passing grade of 75%. An alternative to attending the eight hour class is passing a 50 question challenge exam with a minimum grade of 80%. This alternative is designed for an individual with prior experience, similar qualification at another facility, or formal training in radiological controls or health physics.

Once an individual has successfully completed the course (through either process), they are classified as a Radiological Worker 1 (RW-1) for a period of two (2) years. This requalification periodicity will be tracked through personnel and training matrix documentation, which will be maintained by either or both the Radiation Safety office and the Training office. The worker will be retrained or may challenge not later than the end of the month in which their two-year RW-1 classification expires.

4.2 Visitors

Casual visitors will always be escorted in any restricted area. Casual visitors may not work nor supervise personnel performing work.

Routine visitors who will receive occupational dose will be escorted during their entry into any controlled area. Training information commensurate with the hazard or risk involved will be provided and documented for retention in the visitors file. An attachment documenting the entry will be provided to the visitor upon completion of the entry/visit.

Escorted visitors will not be allowed to enter any high radiation, contaminated, or airborne areas. Permission to deviate from this must be obtained on a case-by-case basis, in writing, from the MKM RSO. The visitor may be requested or required to become an MKM radiation worker. Some level of formal documented training will be required in all cases.

4.3 Administrative Procedures

Administrative procedures define precise methods used to control radiation exposures, contamination, and airborne radioactivity.

4.3.1 Contamination Control

Contamination control is a method of keeping radioactive material within a confined or predetermined area or space. The contamination control also applies to the prevention of individuals from ingesting or inhaling radioactive materials. The general requirements for contamination control are outlined below:

1) Areas which contain contamination above the limits specified in Table 1 will be isolated using a system of barrier ropes or entry doors which will be marked with "CONTAMINATED AREA" signs. Entry into these areas will be controlled through a buffer area which will provide an area for monitoring of personnel and equipment exiting the area.

2) Eating, drinking, chewing or smoking shall not be allowed in any radiologically controlled area or in areas where unsealed sources are used or stored.

3) Storage of food in contaminated areas shall not be allowed.

4) Eating, drinking, chewing or smoking while wearing potentially contaminated clothing shall not be allowed.

5) Radioactive liquids and powders shall be carried in containers with sealed closure devices.

6) A caution label shall be affixed to all containers actually containing or contaminated with radioactive material.

7) Protective clothing shall be removed or monitored for release before an individual leaves a contaminated area.

8) Tools and equipment used in a contaminated area shall be routinely monitored and decontaminated as necessary before release to unrestricted areas.

9) Any injury sustained in a contaminated area shall be reported to the RSO.

10) Contamination control shall not take priority over medical treatment of injuries sustained in a contaminated area.

4.3.2 Exposure Control

Exposure control is a concept of minimizing the amount of radiation exposure workers receive during the normal performance of their assigned duties. Exposure control guidelines used in the MKM radiation safety program include the following:

1) Radiation workers will receive training to make them aware of radiation exposure sources and to utilize the concepts of time, distance and shielding to reduce radiation exposures.

2) Areas where an individual could receive a radiation exposure greater than 5 mrem in any one hour period will be posted with a "CAUTION, RADIATION AREA" sign to alert personnel of the elevated radiation levels in the area.

3) Areas where radiation sources are present will be routinely surveyed prior to work activities.

4.3.3 Airborne Activity Control

Airborne activity control is a concept of minimizing the amount of radioactive contamination that is present in the air which workers could inhale during their work activities. The control philosophy used in the MKM radiation safety program includes the following concepts:

1) Engineering controls and work procedures will be utilized to prevent the entrainment of contamination into the workers breathing zone. Engineering controls include ventilation systems and tent barriers to control airborne activity.

2) Procedural controls include misting surfaces to reduce entrainment of radioactive materials, minimizing the contamination levels in work areas, and enhancing the containment of contamination.

3) Airborne activity levels will routinely be maintained at less than 10% of the DAC listed in Appendix B of 10 CFR Part 20. Work performed in Airborne Radioactivity Areas or with potential airborne concentrations shall be evaluated so as to keep TEDE ALARA for all affected individuals.

4) Periodic air samples will be taken to verify that the airborne radioactivity concentration levels are maintained ALARA.

5). Limiting the concentration of activity in air also minimizes the possibility of releases of radioactivity to the work area and to the environment and subsequent deposition of activity on surfaces thus requiring decontamination.

5.0 SURVEYS AND MONITORING

5.1 Personnel Monitoring

Personnel likely to receive in one year from radiation sources external to the body, a dose in excess of 10% of the applicable limits will be monitored by personnel dosimetry. The personnel dosimetry devices will indicate the approximate amount of ionizing radiation to which the wearer was exposed. The personnel dosimeter will normally be worn on the upper torso. Personnel are responsible to wear dosimetry as directed by the RSO. If a personnel dosimeter is lost, misplaced, or indicates an offscale reading, the employee is required to notify their supervisor, Radiation Protection personnel and/or the RSO immediately.

5.2 Radiation Surveys

Radiation surveys are performed to determine radiation conditions in the work area and provide personnel awareness to implement the MKM ALARA commitment. Radiation surveys also identify radiation conditions which require special posting as required by regulations to alert personnel of elevated radiation levels in a particular work area. Worker exposures can be estimated and controlled by knowing exposure levels and working time.

Radiation surveys are also used to determine the levels of radioactive material on surfaces when characterizing sites and facilities. These surveys determine if residual activity is below "unrestricted" release criteria or identifies specific areas which must be decontaminated to meet the release criteria.

Radiation surveys are performed using MKM procedures listed in Attachment 2.

5.3 Contamination Surveys

Contamination surveys are used to determine the levels of fixed and removable radioactive materials on surfaces and equipment. The survey technique uses filter paper swipes on surfaces to determine the amount of activity which can be removed from the surface. The swipes are then counted in a sample counter to determine alpha and beta activities which were removed in the test. The fixed plus removable contamination is determined by direct measurement on surfaces. If the fixed and removable contamination is below the limits specified in Table 1, the area or equipment can be further evaluated for release or disposal as "uncontaminated".

Contamination surveys also identify areas or items which must be placed under control to prevent the dispersion or release of radioactive materials. Once identified, the area or materials are confined using roped off areas and entry controlled to isolate the contamination until the levels are reduced by decontamination techniques below the "*unrestricted*" release criteria.

Contamination surveys are performed using MKM procedures listed in Attachment 2.

5.4 Air sampling

Periodic air samples are taken as required to verify air concentration routinely remains below 10% of the DAC, to maintain the TEDE ALARA. Air samples are taken using lapel air samplers or grab samplers which provide measurement of concentrations in the worker breathing zone. If the air concentration exceeds 10% of DAC values the RSO should be notified so appropriate corrective actions can be taken and exposures received by the workers evaluated and included in their exposure file.

Air sampling is performed using MKM procedures listed in Attachment 2.

5.5 Bioassay

Bioassay is used to assess inhaled, ingested, or absorbed radioactive materials in order to determine internal and/or total dose to workers. The detection level for bioassay samples shall be 10% of the Annual Limit of Intake (ALI) or lower, if practical.

Bioassay sampling is performed using MKM procedures listed in Attachment 2 and all current regulatory guidance.

5.6 Calibration and Use of Instruments

Radiation detection instruments will be used only by personnel trained in their use and in accordance with MKM procedures. Instrumentation is calibrated on a 6 month schedule by the manufacturer or a certified calibration laboratory and a calibration sticker attached to the instrument to allow the operator to verify the instrument is within current calibration before use. If an instrument is found to have a past due calibration, the instrument shall not be used and shall be tagged with an "OUT OF CALIBRATION" sticker.

All radiation protection instruments shall be source checked before use.

6.0 STORAGE AND CONTROL OF RADIOACTIVE MATERIAL

6.1 Licensed Material

MKM's work with licensed materials will be performed within the requirements specified in a Radioactive Materials license issued by the NRC or an agreement state.

6.2 Exempt Materials

MKM can and does possess exempt quantities of radioactive materials in the form of check sources which are used to check instrument operation. Radioactive sources (which are exempt from licensing) are kept in a source storage locker located within the MKM Radiation Safety office in Las Vegas, NV. When these sources are used in field assignments, they are transferred by the RSO out of the storage locker by the individual user who is responsible for their control. Upon completion of the field assignment, the sources are returned to the storage locker and logged in by the RSO.

These sources may be inventoried in their field locations, if necessary.

6.3 Contaminated Areas and Materials

All licensed materials at customer facilities shall be stored in secured areas when not in use or under surveillance by personnel to prevent unauthorized removal or access. Contaminated Areas which exceed the contamination limits in Table 1 shall be secured to prevent unauthorized entry or removal of contamination.

7.0 PRECAUTIONARY PROCEDURES

7.1 Posting Requirements

7.1.1 Radiation Areas

Any area accessible to personnel in which there exists ionizing radiation at dose-rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates shall be posted with a sign "CAUTION, RADIATION AREA". Sufficient indicators (such as radiation barrier tape or ribbon) shall be used to identify the boundary of the radiation area.

An exemption to this posting requirement is allowed in areas or rooms containing radioactive materials for periods of less than 8 hours, if each of the following conditions are met:

1) The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure to radiation or radioactive materials in excess of the limits specified in section 3.0 of this manual; and

2) The area or room are subject to the licensee's control.

For example, the area around a truck loading radioactive waste does not require posting if the above conditions are met

7.1.2 High Radiation Areas

Any radiation area accessible to personnel in which there exists ionizing radiation at such levels that an individual could receive in excess of 100 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates shall be locked or continuously guarded and posted with a sign "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA".

7.1.3 Very High Radiation Areas

Any area accessible to personnel in which there exists ionizing radiation at such levels that and individual could receive in excess of 500 Rad in 1 hour at 1 meter from the radiation source or from any surface that the radiation penetrates shall be locked or continuously guarded when open and posted with a sign "GRAVE DANGER, VERY HIGH RADIATION AREA".

7.1.4 Airborne Radioactivity Area

Any room, enclosure, or area in which airborne radioactive materials exist in concentrations in excess of the derived air concentrations (DAC's) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations, or concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI), i.e., 12 DAC-H for 40 Hour work week, shall be posted with a sign "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA".

7.1.5 Radioactive Materials Area

Any area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C, Title 10 Part 20 of the Code of Federal Regulations shall be posted with sign or signs "CAUTION, RADIOACTIVE MATERIALS AREA" OR "DANGER, RADIOACTIVE MATERIALS AREA".

7.2 Labeling Containers

A container which contains licensed material shall have a durable clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". The label shall also contain the following information which, will allow individuals working with or around the containers to take precautions to avoid or minimize exposures:

1) Radionuclide present,

2) Quantity of radioactivity and date of estimate,

3) Radiation levels,

4) Kinds of material and if appropriate, mass enrichment.

Containers are exempt from the above labeling requirements if the following conditions are met:

1) Containers holding licensed material in quantities less than the quantities listed in Appendix C Title 10 Part 20 of the Code of Federal Regulations.

2) Containers holding licensed material in concentrations less than those specified in Table 3 of Appendix B to Title 10 Part 20 of the Code of Federal Regulations.

3) Containers when they are in transport and packaged and labeled in accordance with the regulations of the Department of Transportation.

7.3 Receiving and Opening Packages

In accordance with 10 CFR 20.1906, packages containing radioactive materials will be surveyed for radioactive contamination and radiation levels within three (3) hours after receiving the transported package during normal working hours, or not longer than three (3) working hours from the beginning of the next scheduled working day after receipt, if delivered after work hours.

Procedures for the receipt, surveying and opening of packages are listed in Attachment 2.

8.0 WASTE DISPOSAL

8.1 Disposal of Waste at Licensed Landfill

A licensee can dispose of licensed (radioactive) material by transferring the material to an authorized recipient, i.e., another licensee with a valid license to receive and store or receive and bury (provide final disposition) the material. In order to provide a disposal service in a land disposal facility licensed under 10 CFR Part 61, the authorized recipient must be specifically licensed to receive waste containing the specified or identified licensed material. The transfer of material between a licensee and an authorized receiver must be accompanied with a system of manifesting, a certification or characterization process and control/tracking system.

8.2 Disposal of Liquids in Sanitary Sewer

MKM employees shall not dispose of liquids containing radioactive or hazardous materials in a sanitary sewer.

8.3 Incineration of Waste

MKM employees shall not incinerate waste materials containing radioactive materials.

8.4 Disposal of Wastes From Contaminated Areas Following Surveys

Materials, items, and waste which have been decontaminated and a though survey indicates contamination levels are below those specified in Table 1 can be evaluated for disposal in a sanitary land fill. Note that more restrictive limits may apply at certain customer facilities where MKM works and the most restrictive contamination limits will prevail. Items from contaminated areas that are known not to have been contaminated and exhibit 'no detectable activity above background, as measured with an instrument appropriate for the material' may be released. If the waste consists of containers which have held contained radioactive materials, any radioactive materials signs shall be removed or defaced clearly indicating that the container no longer contains radioactive material.

8.5 Operation of a Waste Compactor or Compaction Equipment

MKM employees shall not operate a waste compactor or compaction equipment unless performed under the provisions of a subcontractor's or client's license at a client site.

SECTION II - PROGRAM IMPLEMENTATION

All personnel must comply with all conditions of the subcontractor's or client's license in performing any equipment operations. Personnel shall be trained in the proper operation and testing of such equipment prior to commencing any operations.

SECTION III - DOCUMENTATION

9.0 RECORDS, REPORTS, AND NOTIFICATIONS

9.1 Personnel Records

A personnel file is maintained for each employee assigned work duties involving radioactive materials. The content of these files include:

1) A record of radiation exposure received by the individual during previous employment is maintained by requesting exposure information from previous employers where the individual worked with radioactive materials.

2) A record of personnel dosimeter measurements is recorded in the personnel file to provide a permanent record of radiation exposure received during MKM work assignments.

3) If a personnel dosimeter is lost or damaged an exposure investigation will be performed and an exposure will be assigned for the monitoring period. A report detailing the exposure estimate will be included in the personnel record.

4) If the air concentration in the work area exceeds 10% of DAC values, air samples and bioassay samples will be used to estimate internal exposures received by the worker and included in their exposure file.

5) If a worker finds contamination on their person above the limits specified in Table 1, a report of the incident will be placed in the personnel file to determine exposure from the incident.

The personnel records will be maintained indefinitely and personnel may review their file or request copies of information in their files. The licensee for which work is performed will be provided individual exposure information as required by their license or regulations.

9.2 Radiation and Contamination Records

Radiation and contamination survey records collected during site surveys, remediation/decontamination activities, and radiological characterization activities are stored in site specific files at the Las Vegas office. Duplicate copies of the records are also supplied to the licensee where the work was performed.

9.3 Records of Waste Disposal

Radiation survey records, contamination survey records, shipping manifests, and certifications generated for a licensee's shipment of radioactive materials to a licensed disposal site shall be stored in specific shipment files in the Las Vegas office. Duplicate copies of the records are supplied to the licensee for which the work was performed.

9.4 Notifications

MKM will immediately notify the NRC and the licensee for which work is being performed if any of the following conditions listed in 10 CFR 20, Subpart M exist.

MEMBERS OF THE RADIATION SAFETY COMMITTEE

as of 9/1/99

Khodi G. Irani President	Management Liaison
Thomas J. O'Dou, CHP, Corporate Health Physicist	Chairman
Dixie J. Wells, RRPT Corporate Health & Safety	Radiation Safety Officer
James E. Maffessanti RP Supervisor	Projects
To Be Named	Training/Hazardous Materials
Robin E. Beasley Certified Materials Broker	Brokering & Transportation Projects

NOTE: This table is subject to change in accordance with procedures without notification to Regulatory authorities.

LIST OF PROCEDURES

MKMP-001	Operation of Contamination Survey Meters
MKMP-002	Alpha-Beta Sample Counting Instrumentation
MKMP-003	Operation of Micro-R Survey Meters
MKMP-004	Operation of Ionization Chambers
MKMP-005	Direct Reading Dosimeters (DRD)
MKMP-006	Radiation Work Permits
MKMP-007	Air Sampling and Sample Analysis
MKMP-008	Radiation and Contamination Surveys
MKMP-009	Routine Radiological Surveys
MKMP-010	ALARA - As Low As Reasonably Achievable
MKMP-011	*Containment Devices*
MKMP-012	Portable HEPA Systems and Vacuum Cleaners
MKMP-013	Step-Off Pads
MKMP-014	Radiologically Restricted Areas
MKMP-015	Personal Protective Equipment (PPE)
MKMP-016	Radioactive Materials Brokering
MKMP-017	Empty Transport Vehicle Radiological Surveys
MKMP-018	Classifying Radioactive Waste
MKMP-019	Radioactive Material Tracking
MKMP-020	Use and Control of Radioactive Check Sources
MKMP-021	Solidification of Radioactive Liquids/Sludges
MKMP-022	Packaging Radioactive Material
MKMP-023	Opening Radioactive Material Containers
MKMP-024	Decontamination of Equipment and Tools
MKMP-025	Unconditional Release of Materials from Radiological Controls
MKMP-026	Soil and Sediment Sampling
MKMP-027	Water Sampling
MKMP-028	Material Sampling
MKMP-029	Sample Chain of Custody
MKMP-030	Document Control
MKMP-031	*Project Control*
MKMP-032	Respiratory Protection
MKMP-033	Bioassay
MKMP-034	Dosimetry
MKMP-035	Emergency Response
MKMP-036	Training
MKMP-037	Radiological Compliance Audits
MKMP-038	Procurement, Receipt, and Opening of Radioactive Material
MKMP-039	Radiological Conditions Awareness Report
MKMP-040	Leak Tests for Non-Exempt Sources of Radioactive Material
MKMP-041	*Confined Space Entry*
MKMP-042	Lockout - Tagout

TRAINING

MKM

MKM ENGINEERS

Radiation Worker Training

Study Guide

"EDUCATION IS THE KEY THAT UNLOCKS THE BOOK OF KNOWLEDGE"

FORWARD

This manual has been designed to allow the user to learn "on their own". It is written in simply terms with room to write. Of course, it can then be taken to class and used as an instruction manual.

Since I (we) have be required to take (and give) many Rad Worker courses over a significant number of years, you will find the back of each page blank...for the taking of many notes - in a classroom setting.

Enjoy! Ask many questions! That's what we're here for!

(THE) AUTHORS

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INTRODUCTION

MKM Engineers, Inc. (MKM), is firmly committed to having a radiological control program of the highest quality. This program, as outlined in the MKM Radiation Safety Manual, requires managers and supervisors at all levels to be involved in the planning, scheduling and conduct of radiological work. **This directive also requires that adequate radiological safety shall not be compromised to achieve production or project objectives.**

Radiological Worker 1 Training (RW-1), is required for the worker whose annual whole body dose is likely to exceed 500 mrem or who needs unescorted entry into:

1. *Restricted Areas*
2. *Radiation Areas*
3. *Radioactive Materials Areas* (RMAs) containing sealed sources, activated material or properly packaged and labeled radioactive material.
4. *Contaminated Areas* containing dispersible radioactive material, or if work is in progress that could create dispersible radioactive material.
5. *Airborne Radioactivity Areas* containing radioactive materials dispersed in the air above the concentrations specified in the Radiation Safety Manual.

The RW-1 course is divided into ten units which provide workers with the information needed to work safely around radiological hazards. These units are:

1. Radiological Fundamentals
2. Biological Effects
3. Radiation Limits
4. ALARA Program
5. Personnel Monitoring Programs
6. Radioactive Material Control
7. Radiological Postings and Controls
8. Radiological Emergencies
9. Responsibilities of Individuals
10. Procedures for entry into contaminated areas

Completion of the course includes successfully completing a 20 question exam with a minimum passing grade of 75%. An alternative to attending the eight hour class, is passing a 50 question, multiple choice challenge exam with a minimum grade of 80%. This alternative is designed for an individual with prior experience, similar qualification at another facility or formal training in radiological controls or health physics. Once an individual has successfully completed the course (through either process), they are classified as a Radiological Worker 1 (RW-1) for a period of two years. A training certificate is issued to the individual and maintained in his/her personnel file to indicate successful completion of the course.

RADIOLOGICAL FUNDAMENTALS

The learning objectives in this lesson include:

1. Identify the three basic parts of an atom.
2. Define radioactive material, radioactivity and radioactive half life.
3. Identify the units used to measure radioactivity.
4. Define radiation.
5. Define ionization and ionizing radiation.
6. State the four basic types of ionizing radiation.
7. Distinguish between ionizing and non-ionizing radiation.
8. Identify the following for each of the four types of ionizing radiation:
   a. Physical characteristics
   b. Range/shielding
   c. Biological hazard(s)
9. Identify the units used to measure radiation dose.
10. Convert rem to millirem and millirem to rem.

History of Radiation

The discovery of radiation occurred in the late 1800's. Wilhelm Roentgen observed in 1895 that undeveloped photographic plates became exposed while he was working with high voltage arcs in gas tubes, similar to a fluorescent light. Unable to identify this energy, he called them "X" rays. Within a short time of the discovery of x-rays, physicians were using them to examine a buck-shot wound to the hand.

The following year, Henri Becquerel observed that while working with uranium salts and photographic plates, the uranium seemed to emit a penetrating radiation similar to Roentgen's x-rays. Madam Curie called this phenomenon "radioactivity". Further investigation by her and others showed that this property of emitting radiation is specific to a given element. It was also identified that atoms producing these radiations are unstable and emit radiation at characteristic rates to form new atoms.

Early researchers investigating the properties and uses of these energetic radiations, had yet to discover the harmful effects in living tissue. As research increased, effects were observed in individuals and controls were put into place to limit exposures. The first limit was based on preventing the skin from turning red. The long term effects of exposure to radiation were still not understood. As knowledge of the biological effects of radiation exposure increased, additional controls were established. During this same time, the ability of radiation to damage tissue was being put to beneficial uses in the medical treatment for cancers and other diseases.

Until the late 1930's, radioactive sources were limited in size and strength. They were made stronger by concentrating more radioactive material from natural ores. This was a difficult process, so large (high activity) sources were not readily available. As technology advanced, x-ray machines improved and better high voltage generators were developed. Accelerators were also invented and used in high energy physics research which led to the ability to make stronger sources.

There were other major developments in atomic energy research during World War II. The discovery of atomic fission led to the development of the first "atomic pile" or nuclear reactor in Chicago. Within a few years, under the name Manhattan Project, the U.S. built and detonated three atomic bombs and ushered the world into the atomic age.

One of the more significant contributions from the Manhattan Project was radiation protection controls. These controls continued to develop and evolve under a new agency called the Atomic Energy Commission, where they were transferred to commercial, military and non-military uses. Today, even more rigorous controls are in place as we learn more about the risks and benefits of radiation.

The peaceful uses of atomic energy after the war led to research and development of power reactor technology, the production and use of many new forms of radioactive materials and advances in medicine and biology using radioactive materials developed at national lab facilities. With each new advancement in research at these laboratories, improved programs for radiation protection followed. The challenge remains to keep industry at the forefront of uses of radiation, and maintain high standards of radiation protection.

Atomic Structure

All of the materials we work with, whether they are gas, liquid, solid, plant, animal or mineral, are composed of atoms. Atoms are the smallest unit of matter that retain the properties of an element (such as carbon, lead, and helium). The atom is composed of three major parts: the neutron, proton, and electron. Neutrons and protons form the central core or nucleus of an atom. These particles are approximately the same size. The particles differ in that protons have a positive electrical charge and neutrons have no electrical charge. The number of protons determines what the element is, for example, oxygen or iron. Surrounding the nucleus is an electron cloud composed of negatively charged electrons in orbit. The number of electrons depends on the element and generally equals the number of protons, so the atom is neutrally charged.

An element is a substance made up of atoms bearing an identical number of protons in each nucleus. Most of the atoms of an element also have the same number of neutrons in each nucleus, but not always. If atoms have the same number of protons, but a different number of neutrons, they are called isotopes of the element. They retain the same ***chemical properties*** of the element, but may exhibit different ***nuclear properties***, such as radioactivity.

Radioactivity

Radioactivity is the property of certain atoms to spontaneously emit particles or energy. The nuclei of some atoms are unstable, and eventually adjust to a more stable form by the emission of radiation. These unstable atoms are called radioactive atoms or radioactive isotopes. When radioactive (or unstable) atoms change by emission of radiation, it is called radioactive decay or disintegration. Material containing a large number of radioactive atoms is called either radioactive material or a radioactive source. Radioactivity is measured in units that are equivalent to the number of disintegrations per second (dps) or disintegrations per minute (dpm). The unit of measure is the curie (Ci) where one curie equals thirty seven billion disintegrations per second.

1 Ci = 37,000,000,000 dps or 3.7×10^{10} dps. 1 Ci = 2.22×10^{12} dpm.

A measurement program called System International (SI) uses the unit Becquerel (Bq) to measure radioactivity. The Becquerel is equal to one disintegration per second.

1 Bq = 1 dps 1 Ci = 3.7×10^{10} Bq

This system is not currently used at MKM, but will be phased in over the next few years.

Each radioactive element decays or disintegrates at a characteristic rate that is measured as a radioactive half life. This is the time it takes for a radioactive substance to lose 50% of its activity by decay and is different for each element and each isotope of an element. After seven half lives of a radioactive element, less than 1% of the original radioactivity remains.

NUMBER OF HALF-LIVES	*FRACTION REMAINING*	*PERCENT OF ACTIVITY REMAINING*
0	1	100%
1	$1 \times \frac{1}{2} = \frac{1}{2}$	50%
2	$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$	25%
3	$\frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$	12.5%
4	$\frac{1}{8} \times \frac{1}{2} = \frac{1}{16}$	6.25%
5	$\frac{1}{16} \times \frac{1}{2} = \frac{1}{32}$	3.125%
6	$\frac{1}{32} \times \frac{1}{2} = \frac{1}{64}$	1.5625%
7	$\frac{1}{64} \times \frac{1}{2} = \frac{1}{128}$	0.78125%

Radiation

Radiation is energy emitted in the form of electromagnetic waves or sub atomic particles. Radiation is emitted from radioactive (unstable) atoms or from a radiation producing machine (such as an x-ray machine or accelerator). Radiation sometimes has enough energy to separate electrons from their atoms when the energy is absorbed in matter. The resultant, positively charged atom is called an ion and the process is ionization. When radiation has sufficient energy to create ions, it is called ionizing radiation. For the purposes of this course on radiation protection, ionizing radiation includes alpha particles, beta particles, gamma (and x rays) and neutrons. These will be discussed in further detail later.

Non-ionizing radiation has insufficient energy to form ions. Examples of non-ionizing radiation includes most visible light, infrared light, microwaves and radio waves. For the purposes of this course, the term "radiation" refers only to ionizing radiation.

Alpha particles

Alpha particles are charged particles containing two protons and two neutrons that are emitted from the nucleus of certain heavy atoms, such as uranium when they decay. Because of its size and charge, an alpha particle only travels a few centimeters in air. It can also be stopped or shielded using a sheet of paper. The alpha particle cannot penetrate the dead layer of human skin, but can be damaging if the source of alpha radiation is inside the body. There are only a few sources of alpha radiation normally encountered during work at MKM. These are primarily from uranium, thorium and plutonium wastes.

Beta particles

Beta particles are electrons emitted with high energy from many different radioactive atoms. The range of a 1 Mev beta particle is about 10 feet in air. Beta particles can easily be shielded by using ¼" of plastic or thin lightweight metals such as ⅛" of aluminum. High doses of beta particles can penetrate the surface of the skin or eyes and cause serious damage. Some sources of beta radiation include tritium (^{3}H), phosphorous (^{32}P), strontium (^{90}Sr) and carbon (^{14}C).

Gamma and X-rays

Gamma and x-rays are electromagnetic radiation with no mass or charge. Gamma rays are emitted from the nucleus during radioactive decay, while x-rays are emitted from orbital electrons. Electromagnetic radiation may also be given off by a charged particle accelerating or decelerating in an electric field. Because they have no mass and no charge, gamma and x-rays are very penetrating forms of radiation. In air, high energy gamma or x-rays may travel several hundred feet. Dense materials such as lead are used for shielding. From a biological perspective, x-rays and gammas are considered external hazards, meaning that even with the source of radiation outside your body, the radiation can penetrate and affect internal organs.

Gamma radiation will probably be the major contributor to the total dose encountered by MKM employees during their work activities. Some of the major sources of gamma radiation anticipated include gamma emissions from radioactive sources and waste materials.

Neutrons

Neutrons are neutral particles emitted from the nucleus during radioactive decay or fission (splitting of an atom). Because they have no charge, neutrons can be a very penetrating form of radiation and can travel several hundred feet in air. At high energies, they transfer energy by collision with light atoms, especially hydrogen. At lower energies, neutrons can be absorbed and the absorbing material can become radioactive. Neutrons, like the x-rays and gammas, are considered an external hazard. Shielding that is most effective for neutrons includes water, paraffin, boron, cadmium and concrete.

Sources of neutrons are not anticipated in the normal MKM work activities. Neutron exposure could be encountered when handling, packaging or shipping neutron sources. If neutron exposure is likely, ensure proper precautions including assignment of neutron dosimetry have been taken.

TYPE	*PROPERTIES*	*RANGE*	*SHIELDING*	*HAZARDS*	*SOURCES*
Alpha	2 protons 2 neutrons +2 charge	1 - 2 inches in air	Paper, outer layer of skin	Internal only	Uranium, Thorium, Plutonium in radioactive waste and sources
Beta	1 electron -1 charge (+1 for a positron)	Up to 10 feet in air/Mev	Thin metal or plastic	External to the skin, eyes and internal	Tritium, Carbon and mixed fission products in radioactive wastes and sources
Gamma and X-rays	No mass, no charge	Several hundred feet in air	Lead, steel or concrete	External (whole body) and internal	Radioactive waste and radioactive sources
Neutron	Neutral particle	Several hundred feet in air	Water, paraffin or concrete	External (whole body)	Neutron sources and nuclear reactors during operation

Units of Dose and Dose Rate Measurement

Dose is a general term which will be used in this manual to quantify radiation risk in the unit **rem**. Since the measurements of dose are frequently small fractions of a rem, **millirem** or **mrem**, (the prefix, milli, meaning 1/1000), is the more commonly used term.

To convert rem to mrem, multiply the number of rem by 1,000 or move the decimal point three places to the right. For example, 1.3 rem would be 1,300 mrem.

The amount of radiation dose you receive from both external and internal sources is called the **Total Effective Dose Equivalent (TEDE).** TEDE is usually expressed in mrem.

Dose rate is the amount of dose received in a specified period of time. Dose rate is usually expressed in units of mrem per hour (mrem/hr).Dose can be estimated by multiplying the dose rate and the time of exposure to the radiation. For example, if you spend 4 hours in an area with 12 mrem/hr dose rate, your dose would be approximately 48 mrem.

BIOLOGICAL EFFECTS

The learning objectives in this lesson include:

1. Identify the major sources of natural background and man-made radiation
2. Identify the average annual dose to the general population from natural background and man-made sources.
3. State the methods by which radiation causes damage to cells.
4. Identify the possible effects of radiation on cells.
5. Define the terms "acute dose" and "chronic dose."
6. State examples of chronic radiation dose.
7. Define the terms "somatic effect" and "genetic effect."
8. State the potential effects associated with prenatal radiation doses.
9. Compare the biological risks from chronic radiation doses to health risks workers are subjected to in industry and daily life.

Introduction

Of the many environmental factors that cause cancer in man, we know more about the biological effects of ionizing radiation than most others. Our information is based on animal studies as well as a large body of information involving exposures to people. There are four groups of people that have been exposed to high doses of radiation, and studied to determine the effects of radiation on man.

The first group includes radiation workers from the early 1900's, early medical radiologists and radium workers who received large doses of radiation before the biological effects of radiation exposure were recognized. Since that time, standards have been developed to protect workers.

The second group is the 77,000 survivors of the bombing of Hiroshima and Nagasaki using atomic weapons during World War II. Some survivors received estimated doses in excess of 100,000 mrad.

The third group includes individuals who have been involved in radiation accidents. New studies of the Chernobyl accident continue to expand this knowledge.

The fourth group of individuals are patients who have undergone radiation therapy for a variety of diseases. Patients who receive radiation treatment for cancer are being studied, but generally only short term effects can be observed.

Sources of Radiation

Exposure to radiation is generally discussed in two broad categories, radiation doses to the general public and occupational doses. Within the category of radiation doses to the general public, it is further divided into natural background and man-made sources.

Man has been exposed to natural background sources of radiation throughout his history. The major natural background sources include:

1. Radon gas; comes from the radioactive decay of uranium which is naturally present in the soil. The radon gas can migrate through the soil and into the air. The decay products of radon attach to dust particles and may be inhaled. The decay products of radon will then deliver a dose to the tissue of the lungs. On Long Island, the dose from radon is much lower than the national average because there is very little uranium in the soil. The average effective dose equivalent from radon in the United States is **200 mrem/year.**
2. Cosmic radiation; comes from outer space and our own sun. The atmosphere shields us from most of the cosmic radiation, so your dose from cosmic radiation is determined by where you live. The dose is greater at higher altitudes than at sea level because there is less atmosphere to shield against cosmic radiation. For a comparison, the dose rate at sea level is about 24 mrem/year, the dose rate in Denver, Colorado (approximately 5,000 ft. above sea level) is 50 mrem/year, and in Leadville, Colorado (approximately 10,000 ft. above sea level) the annual dose rate is 125 mrem/year. The average dose from cosmic radiation in the U.S. is **28 mrem/year.**
3. Terrestrial sources; exist because a number of materials have remained radioactive since the formation of the earth. These natural radioactive materials are found in the ground, rocks and building materials. Some of the contributors to terrestrial sources are the natural radioactive elements radium, uranium and thorium. In fact, there are some areas in Brazil where the natural background radiation levels reach 3,000 mrem/year. The average dose from terrestrial sources in the United States is **28 mrem/year.**
4. Internal source; our bodies contain various, naturally occurring radioactive elements, and potassium (^{40}K) is one of the major contributors to your internal dose. The average dose from internal sources in the United States is about **40 mrem/year.**

The major man-made sources that contribute to the radiation dose to the general public include:

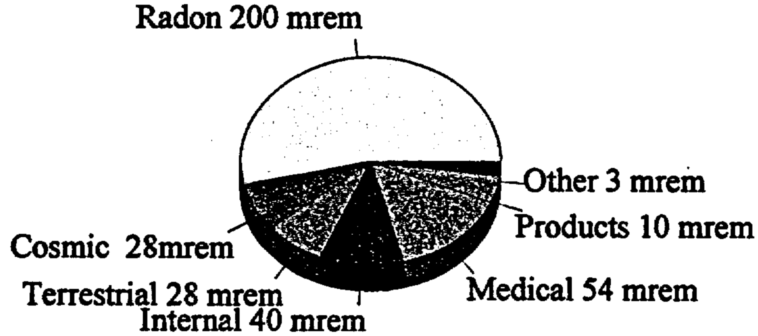
1. Medical/dental sources; this includes diagnostic (such as chest or dental x-ray) and therapeutic uses of radiation (such as radiation therapy for tumors). Because medical and dental doses are so individualized, your dose may vary from zero to several thousand mrem. The average dose from medical and dental sources in the United States is about 54 mrem/year.

2. Consumer products; some consumer products contain small amounts of radioactive material. Examples include certain ceramic dishes (usually with an orange glaze), some luminous dial watches, and some smoke detectors. These consumer products account for a very minor contribution to the background dose. The average dose from consumer products in the United States is about **10 mrem/year.**

3. Other; this category includes radiation doses from fallout caused by bomb testing and accidents such as Chernobyl.

Overall, the average radiation dose to a member of the general population in the United States, from background and man-made sources is about 360 mrem/year, or about 25,000 mrem over the average lifetime.

ANNUAL DOSE



Natural and man-made radiation sources

The other broad category of radiation sources is occupational. Occupational sources for MKM employees will depend on the type of work undertaken. Always talk with the Radiation Safety Officer or health physics personnel to identify the actual sources and types of radiation you will encounter.

The dose you receive while working at MKM as a Radiological Worker, is called an occupational dose. This is in addition to any dose received from natural background and man-made sources identified above.

Biological Effects of Exposure to Radiation

A biological "effect" is a change in the body caused by cellular damage from radiation. This damage may be the result of the radiation directly interacting with a vital part of the cell or indirectly by the formation of toxic substances within the cell. Whenever a cell is exposed to radiation, one of the following will occur:

1. The cell may be undamaged by the radiation.
2. The cell may be injured, repair the damage and continue to function normally.
3. The cell may be injured, be unable to repair the damage and function abnormally.
4. The cell may sustain an injury so severe that it will die.

The extent of the damage done by the radiation is dependent on many factors. Some of these include how fast the dose was received, the magnitude of the dose and which part of the body was actually exposed. How soon these effects appear after the radiation dose, determines if they are classified as short term or long term effects. A short term effect usually appears a few days or weeks after the dose. A long term effect usually appears years after the dose.

Acute Doses

For the purposes of this course, an acute dose is defined as a large dose received over a short time period. An example of an acute dose is 100,000 mrads received in less than one week. The short term effects from this acute dose may include changes in the blood, nausea, diarrhea, fatigue, hair loss, sterility, easy bruising or other effects. Short term effects are detectable only when the acute dose exceeds about 10,000 mrad. Below this level, the effect or damage from the radiation is too small to detect with today's technology.

In addition to the short term effects, an individual may also experience a long term effect from an acute dose. This primarily develops as a form of radiation induced cancer several years after the acute dose. The probability of a long term effect occurring, increases with increased dose, but the severity of the cancer does not change as the dose increases.

It is important to note that acute exposures of radiation workers occur only in accident situations. Improper uses of, or violations of interlock protection for hot operations or radiation producing machines have the ***potential*** to cause acute doses.

Chronic Doses

In this course, a chronic dose is one received over a long period of time, usually in small increments. Examples of chronic doses include the dose received as a Radiological Worker (occupational dose) and the dose from background sources. Chronic doses may present an increased risk of a radiation induced cancer developing later in life. This is the possible long term effect associated with a chronic dose. ***There are no short term effects associated with a chronic low level radiation dose.*** Within the allowed dose limits, this increased risk of a radiation induced cancer is considered small, especially when compared to risks people accept in their everyday lives

Prediction of long term effects occurring are based on studies of people exposed to large doses, and include the survivors of Hiroshima/Nagasaki, radium dial painters, Ankylosing Spondylitis (arthritis of the spine) patients, and uranium miners. The effects observed from these high doses are extrapolated to lower doses by assuming a direct, linear correlation. There has been some discussion about the appropriateness of these extrapolations from high dose to low dose, but scientific opinion generally concurs that these estimates are conservative.

Somatic Effects

Biological effects of radiation doses that appear in the individual exposed, are called somatic effects. These include the short term effects associated with an acute dose and the long term effects associated with either an acute or chronic dose.

Genetic Effects

Biological effects that appear in an offspring would be a somatic effect, if the mother was exposed **after** conception. If a biological effect appears in an offspring, or in a future generation, as the result of one of the parents being exposed **prior** to conception, it is called a genetic effect. These effects are the result of radiation injury to parent germ cells (egg and sperm cells). The prediction of genetic effects is based on plant and animal studies. **Genetic effects have not been observed in people, only calculated.**.

Prenatal Exposure

Any harmful effect to the embryo/fetus (in utero) is called a teratogenic effect. As with many other physical factors that are known to cause a teratogenic effect, radiation at relatively high doses to the fetus may cause low birth weight or retarded growth. Some of these other factors include the mother smoking, consuming alcohol during pregnancy and the use of caffeine. The rapidly developing and immature cells of the fetus are more sensitive to damage. The actual effects on the embryo/fetus are a function of the time during gestation that the dose is received, and the amount of dose received.

The prediction of these effects occurring are based on studies from Hiroshima/ Nagasaki and pregnant women receiving radiotherapy. When compared to the normal risks associated with a pregnancy, risk of teratogenic effects from exposure to radiation up to the DOE limits (500 mrem/gestation period) is considered negligible. Current knowledge indicates that only when radiation doses exceed 15,000 mrem is there a significant increase in the risk.

Because the embryo/fetus is more susceptible to injury from radiation (compared to mature, non-dividing cells) DOE, NRC and MKM have a policy restricting the dose allowed to a "declared" pregnant Radiological Worker. This policy is explained in detail in the section on Radiation Dose Limits.

Risks Associated With Exposure To Ionizing Radiation

Based primarily on human studies, the National Academy of Science, National Council on Radiation Protection and Measurement, and the International Commission on Radiation Protection estimate the average risk (to an adult) of fatal cancer from radiation in his/her lifetime is 4 in 10,000 per rem, using linear extrapolation.

To illustrate this, in a population of 10,000 people, current statistics indicate that approximately 3,000 will contract cancer in their lifetime. Of the 3,000 that develop cancer, approximately 2,000 will die from their cancer. If all 10,000 people were to receive 1,000 mrem (in addition to the radiation dose from natural background and man-made sources), an additional 4 deaths may occur due to radiation induced cancers. This increases the total fatality from approximately 2,000 to 2,004. This small effect cannot be "seen" in the normal variation of the death rates, and therefore must be calculated.

Another way of stating this is that each member of the general population in the United States has roughly a 20% chance of dying from cancer (this is the natural cancer mortality rate). If this person were to receive an occupational dose of 1 rem (cumulative during his/her life), their risk of developing a fatal cancer would increase from 20 % to 20.04%.

Still, it is assumed, as a conservative approach to radiation protection, that there is some probability for effects occurring even at very low doses. This "no threshold" concept is the basis for our ALARA (As Low As Reasonably Achievable) policy. This requires us to justify the need to receive radiation dose in order to provide some value to life and ensure the benefit outweighs the risk.

The following chart may be used to gain perspective of the risk associated with exposure to radiation:

COMPARISON OF MORTALITY RATES

CAUSE	*ANNUAL DEATHS MILLION PERSONS*
Cardiovascular disease	4780
Cancer	1700
Motor accidents	220
Home accidents	150
Homicides	100
Fire	30
Drowning	30
Poisoning	13
Radiation effects (per rem)	9
Aircraft crashes	8
Electrocution	6
Lightning	1
Animal and insect bites	1

The following charts provides a break down of occupational and work place hazards based on death rates:

RELATIVE OCCUPATIONAL DEATH RATES

OCCUPATION	RELATIVE VALUE	OCCUPATION	RELATIVE VALUE
Taxi cab/Chauffeur	15.1	Stocker/Bagger	3.1
Police Officer	9.3	Store Owner/Manager	2.8
Hotel Clerk	5.1	Bartender	2.1
Gas Station Worker	4.5	Radiation Worker (est.)	0.02
Security Guard	3.6		

RELATIVE WORKPLACE DEATH RATES

WORKPLACE	RELATIVE VALUE	WORK PLACE	RELATIVE VALUE
Taxi cab/Dispatch Office	26.9	Grocery Stores	3.2
Liquor Stores	8	Jewelry Store	3.2
Gas Stations	5.6	Hotels/Motels	1.5
Detective/Protective Agencies	5	Restaurants/Bars	1.5
Court/Prison/Police/Fire Dept	3.4		

As can be seen from these tables, the estimated or calculated risk of death from radiation exposure is quite low compared to many other actual or observed causes of death in our society.

Benefits of Radiation

Although the risks are low, some individuals are concerned about exposure to radiation, even at very low levels. These are personal value judgements that every individual must make for themselves. Everyone should keep in mind that many uses of radiation are very important in health care or in other applications by society. The potential benefits of such use should be carefully weighed in consideration of the small risks produced by them. Some beneficial uses of radiation include:

1. Medical/Dental x-rays
2. Cancer therapy
3. Radiography for structural integrity
4. Nuclear medicine scans (heart stress test, thyroid, liver, bone, kidney, brain, etc.)
5. Food preservation
6. Airport security
7. Biomedical research, such as DNA, cancer and immune system diseases
8. Electric power production from nuclear facilities

RADIATION DOSE LIMITS

The learning objectives in this lesson include:

1. State the purpose for radiation dose limits.
2. State the occupational dose limits.
3. State MKM's administrative radiation dose level.
4. State the radiation dose limits for members of the general public.
5. Recognize the definition of PSE.
6. State the MKM policy concerning prenatal radiation dose.

Basis and Purpose for Radiation Dose Limits

Radiation dose limits have been established to minimize the potential risk of biological effects associated with radiation exposure. The dose limits established by DOE/NRC for occupational workers are based on guidance from the Environmental Protection Agency (EPA), National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). These limits are also consistent with those of other state agencies and other countries. Limits are set by regulatory agencies (such as Department of Energy) and cannot be exceeded intentionally, except for planned special exposures discussed later in this section.

Occupational Dose Limits

The occupational dose standards are limits for doses received by workers assigned duties involving exposure to radiation and/or radioactive materials. Every effort will be made to maintain personnel radiation doses as far below the indicated radiation protection standards set forth in this section and consistent with the ALARA principle. Radiation doses received from natural background and medical exposures are not included in the radiation dose limits specified in this section.

The regulatory (NRC and DOE) occupational dose limits for radiation workers are:

Location	*mrem Per Year*
Whole Body: Head, Trunk (Including Male Gonads), Arms above the Elbow, and Legs above the Knee (TEDE)	5,000
Extremities: Hands, Forearms, Feet, Ankles	50,000
Internal Organs	50,000
Lens of the Eye	15,000
Skin: of Whole Body Region	50,000
Embryo - Fetus (per entire gestation)	500

The whole body dose limit combines both internal and external dose for an individual and is reported as *TEDE*.

Administrative Dose Level

At MKM, extensive controls are in place to keep dose well below regulatory limits. An administrative occupational dose control level of 1250 mrem TEDE per quarter is part of these controls. Keeping doses low requires a cooperative effort between radiation protection staff and individual radiation workers.

Public Dose Limits

Radiation doses to the general public will be maintained below the following limits:

1) The dose in any unrestricted area will be maintained below 2.0 mrem in any one hour period.
2) The maximum exposed individual's total effective dose equivalent from occupancy in all unrestricted areas will not exceed 100 mrem per calendar year.

In addition, members of the general public are not allowed in MKM work areas where radioactive materials are being handled. If an individual requires entry in a MKM restricted work area for inspection or audit purposes, they will be required to provide information on their radiation worker training status. Appropriate supplemental training and dosimetry will be provided to these radiation workers commensurate with the hazard involved in the work.

Also, minors (anyone under 18 years old), will be considered as members of the public for radiation protection purposes and will not be assigned radiation worker duties.

Planned Special Exposure (PSE)

A planned special exposure is an authorized exposure that is separate from and in addition to annual dose received under the Federal limits previously specified. MKM does not anticipate that a PSE will be used in any of the work performed by the company or its workers. A PSE would only be considered: in the unlikely event that it was the ALARA solution to the serious conditions of an unusual situation, and all Federal requirements to perform the PSE had been met, and MKM senior management had provided prior written approval.

Prenatal Policy

Any Radiological Worker who becomes pregnant, is encouraged to voluntarily notify her supervisor in writing. Upon receipt of the written notification, she is classified as a "declared pregnant worker". Because of the woman's right to privacy, no action can be taken until the formal notification is received. The policy of MKM is to offer the option of a mutually agreeable assignment without loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely.

If the declared pregnant worker decides to continue working as a Radiological Worker, her dose limit for the gestation period is 500 mrem. MKM's goal is to control her dose to less than 50 mrem/month. To qualify as a Radiological Worker, you are required to sign a statement that this policy has been explained to you. All female Radiological Workers must sign this statement.

AS LOW AS REASONABLY ACHIEVABLE

The learning objectives in this lesson include:

1. State the purpose of the ALARA concept.
2. State the MKM management policy for the ALARA program.
3. Identify both individual and management responsibilities regarding the ALARA program.
4. Identify the basic protective measures of time, distance and shielding.
5. Identify the worker's responsibilities concerning dose limits.
6. Describe the actions a worker should take if he or she suspects that dose limits are being approached or exceeded.
7. Identify the purpose of interlocks and alarm systems.

ALARA Concept

Every person working at MKM has a responsibility to themselves and their co-workers to work safely and maintain a safe working environment. Because there is a possibility, however small, of an effect occurring from any exposure to radiation, all doses are maintained As Low As Reasonably Achievable (ALARA).

Under the ALARA concept, MKM management policy includes:

1. Controlling radiation doses to workers and the public well below the regulatory limits.
2. Ensuring that no radiation exposure occurs without a corresponding benefit, and the benefit outweighs the risks associated with that dose.
3. Preventing unnecessary exposures to workers and the public.
4. Protecting the environment.

Individual Responsibilities

Some of the individual's responsibilities as a Radiological Worker at MKM include:

1. Assuming the ***primary responsibility*** for maintaining your radiation dose ALARA and below the dose limits.
2. Use time, distance, and shielding to maintain your radiation doses low.
3. Maintain radiation interlock systems in a fully operational condition.
4. Read and comply with all radiation barriers, signs, labels and postings.
5. Do not climb over barrier fences, or defeat any radiological protection systems.
6. If you suspect you are approaching or have exceeded a dose limit, stop work, leave the area and report your concern to your supervisor.
7. Comply with all regulations and orders establishing radiation dose limits.

As a Radiological Worker, and part of the MKM team, you have many resources at your disposal to aid in carrying out these responsibilities. Among these resources are the MKM Management, Radiation Safety Officer, Supervisors and Health Physics Technicians.

MKM Management Responsibilities

Under the ALARA program, MKM management is responsible for the following:

1. Management must be involved in the planning, scheduling and approving the conduct of radiological work.
2. Must ensure that radiological safety is not compromised to achieve production or schedule objectives.
3. Must ensure the staff has completed the required training.
4. Must develop procedures to keep doses ALARA.
5. Providing overall health physics coverage for work activities.
6. Performing radiation and radioactive contamination surveys.
7. Providing coverage for Industrial Hygiene and Industrial Safety concerns.

Minimize Time of Exposure to Radiation

The main goal of the ALARA program is to reduce the radiation doses to a level that is As Low As Reasonably Achievable. Reducing the amount of time in a radiation area or field lowers the dose you receive. One of the keys in minimizing your time in a radiation area is to pre-plan the job or experiment. This may include:

1. Use of mock-ups to prove equipment or procedures, or to gain proficiency at the task to be done.
2. Taking the best route to the job site; the shortest route may not be the best - know where the higher and lower radiation level areas are.
3. Preparing the necessary tools and equipment prior to entering the area; verify any special calibration or tool preparation is done before entering the radiation area.
4. Never loiter in an area controlled for radiological purposes.
5. Working efficiently and quickly.
6. Eliminating rework by doing the job right the first time.
7. Performing preparatory work and parts assembly outside the area.

Maximize Distance from the Radiation Source

Use the protection offered by distance from the source of radiation whenever possible. For many sources, radiation levels decrease exponentially with increased distance. If the distance from a small (point) source is doubled, the radiation level decreases by a factor of 4.

Some methods to increase your distance from the radiation source include:

1. During work delays, move to lower dose rate areas.
2. Use long handled tools, mechanical arms, robotics, or remotely operated tools to avoid higher dose rate areas.
3. Know the radiological conditions of the area you are entering. If possible, move the item being worked on away from the source of radiation, or move the source of radiation away from the work area.
4. Use mirrors or closed circuit TV to monitor the job site.

Use Shielding to Lower the Dose Rate

Shielding reduces the amount of radiation dose to the worker.

1. Select the proper materials to shield a worker from the different types of radiation.
2. Take advantage of permanent shielding such as equipment or existing structures.
3. Position yourself so that shielding is between you and the source.
4. Wear safety glasses/goggles to protect the eyes from beta radiation, when applicable.
5. Install temporary shielding when required by procedure or the Radiological Work Permit (RWP).

Interlocks and Shielding Design

Interlocks and alarm systems are examples of engineering solutions that support the ALARA concept. Their purpose is to prevent unnecessary radiation exposure. Some of the basic interlock systems include:

1. Interlocks that prevent access.
2. Interlocks that turn off the source of radiation.
3. Interlocks that shield the source of radiation.

Alarms systems are also used in various ways to warn people of a hazardous condition or situation. Because there are so many different interlock and alarm systems in use, specific operating instructions and concerns will be discussed when you receive site specific training.

PERSONNEL MONITORING PROGRAMS

The learning objectives in this lesson include:

1. State the purpose of each of the personnel dosimeter devices used at MKM.
2. Identify the correct use of each of the personnel dosimeter devices used.
3. State the method for obtaining dose records.
4. Identify worker responsibilities for reporting radiation dose received from other sites and from medical applications.

Dosimeters

There are several devices used to monitor occupational dose. They include the thermoluminescent dosimeter (TLD), film badge, self reading dosimeter and finger ring TLDs.

Thermoluminescent Dosimeters

The TLD is issued to monitor your occupational dose while working for MKM. This dosimeter offers no protection from radiation, but monitors your exposure to beta, gamma and (if needed) neutron radiation. The TLDs are exchanged on a monthly basis and processed by an outside contractor. This processing usually takes a few weeks, unless there is a need for a quicker turn around in an individual case. There are many rules and requirements regarding the use of a TLD because the ***TLD is the basis for the legal record of your occupational dose.*** These requirements include:

1. TLDs are worn when required by MKM or work site-specific procedures.
2. TLDs must be worn on the front of the torso, between the waist and the neck. The best location is the center of the chest with the label side of the dosimeter facing away from the body.
3. When other type of dosimeters are required, they shall be worn adjacent to the TLD unless otherwise directed by the Radiation Safety Officer or a Health Physics Technician.
4. The TLD user should place his/her TLD on the dosimeter board at the job site (if provided) at the close of business. If the work assignment requires the dosimeter be taken away from the job site, keep it in a cool, dry place and return it to the job site the next working day.
5. TLDs at MKM are usually exchanged the first Saturday of each month.
   a. If you leave MKM (employment is terminated or your contract has expired), turn your TLD in to the supervisor before you leave the site. The supervisor will notify the Radiation Safety Officer who will in turn cancel the TLD service.
   b. If you will not be here for the monthly exchange (e.g., business trip or vacation), leave your TLD on the dosimeter board or leave the TLD with your supervisor.
   c. Personnel that fail to return a TLD may be restricted from continued radiological work.

6. Radiological Workers should never wear another worker's TLD, and never allow another to wear theirs. Because the TLD is issued to monitor an individual's monthly dose, either of these practices would invalidate the dose recorded on the TLD.

7. TLD wearers should notify their supervisor if the TLD has been misused or damaged in any way, (such as a trip through the laundry cycle or worn during a medical x-ray). A complete dose estimate will be documented and the dose assigned based on your work activities and radiological conditions of your work sites. A new TLD will be issued to accurately monitor your occupational dose for the remainder of the month. **Wearers should never open or tamper with the dosimeter.**

8. Individuals working in areas controlled for radiological purposes should take specific actions if their TLD is lost, damaged, or contaminated. These actions include placing your work activities in a safe condition, immediately exiting the area and notifying your supervisor or Health Physics Technician of the situation.

9. **TLD results are your legal records of dose.** Report any lost badge immediately, and if you find a dosimeter, turn it in to your supervisor. If you lose your dosimeter or fail to return it, an estimated dose is assigned to you based on your work activities and radiological conditions of your work sites.

Direct Reading Dosimeters

Direct Reading Dosimeters (DRDs) can be used to monitor an individuals exposure to gamma or x-ray radiation. The main benefit of the DRD is that it provides an immediate read out, and should be checked periodically by a worker during performance of a task. At MKM, the DRD is usually used only in High Radiation Areas, or when an individual is expected to receive a relatively high monthly dose to track their dose on a more frequent basis.

Finger Ring TLD

The Finger Ring TLD (Thermoluminescent Dosimeter) is used to monitor the dose to your hands under certain circumstances. If you are working with sources that will give your hands a much greater dose than that recorded by your film badge, notify the supervisor or Health Physics Technician. He or she will evaluate the situation and determine if the use of the Finger Ring TLD is warranted. Proper use of this TLD is explained prior to issue.

Dose Records

Every employee has a right to know their current dose levels. The records maintained by MKM are available to you and may be obtained from your supervisor. Additionally, a copy of your dose record is provided to you on an annual basis, and at the request of the individual (within 30 days after the request or receipt of results, whichever is longer). If you are a visitor or guest and receive a detectable exposure, copies of your records are mailed to your parent organization when you leave MKM.

Reporting Doses From Other Facilities.

Occupational doses received from another facility (such as a DOE Laboratory or civilian nuclear power plant) or from previous employment (such as a part time job as an x-ray technician at a local hospital) shall be reported to your supervisor or Radiation Safety Officer. This is to ensure your dose records reflect your total occupational dose and reduce the possibility that you might receive excessive dose.

The dose from nuclear medicine studies and tests is not included in occupational doses, but may affect the dose registered by your TLD badge, or may inhibit your ability to detect radioactive material on your person when exiting certain areas. Because of this problem, MKM must be notified when you have been treated with radionuclides. You also have a right to privacy concerning any medical treatment you may be receiving. In order to preserve your right to privacy, this notification can be made to MKM through the Radiation Safety Officer. Otherwise you may notify your supervisor. Our concern is that we monitor your occupational dose only. This reporting requirement does not include the routine use of medical or dental x-rays. Do not wear your TLD or dosimeter during any dental or medical exam that uses radiation.

RADIOACTIVE MATERIAL CONTROLS

The learning objectives in this lesson include:

1. Define activated material, sealed sources, unsealed (dispersible) sources and radioactive contamination.
2. Define fixed, removable and airborne contamination.
3. State the pathways radioactive material can enter the body.
4. Identify the methods used to minimize internal radiation dose.
5. State the purpose of internal monitoring.
6. Identify worker responsibilities concerning internal monitoring programs.
7. Describe the purpose and use of personnel contamination monitors.
8. State the appropriate response to personnel contamination monitor alarms.

Until now, discussions have primarily focused on external exposure to radiation. Because an individual qualified as RW-1 may enter and work in Radiation Areas, Radiological Contaminated Areas, Radioactive Material Areas and Airborne Radioactivity Areas, certain radioactive material controls must be discussed.

Activated Material

Activation is the process of making a material radioactive by bombardment with neutrons, protons or other high energy particles or radiations. Activated material is found at accelerators, reactors, neutron generators, neutron sources and around other sources of high energy particles or radiations. Controls for activated materials include:

1. Surveillance by a trained individual. If an item is determined to be radioactive, it must be labeled to ensure proper handling before being removed from the area.
2. Activated solid objects are normally considered non-dispersible radioactive material and should present only an external radiation hazard.
3. Activated materials must be controlled to prevent inadvertent release to uncontrolled areas.
4. Additional controls are required if solid activated material is machined, sanded, welded or processed in any manner that could create dispersible radioactive material.

Sealed Sources

Sealed sources are radioactive materials that have been encapsulated to prevent easy dispersion. They are manufactured to allow use as a source of radiation for instrument calibration sources, instrument check sources, irradiation of other materials and use in radiography. Controls for sealed sources include:

1. Labeling and conducting inventories for all sealed sources above a threshold quantity.
2. Leak testing to ensure integrity of the source capsule.
3. Proper shielding during storage and use.
4. Training in source control techniques, posting, area control, and emergency recovery. Never taste or touch a sealed source. These sources are usually of high activity and will cause high dose with only short exposure times.

Unsealed (Dispersible) Sources

Unsealed sources are radioactive materials intended for use in a dispersible manner, such as radioactive tracers, loose chemical compounds, gaseous materials, radiopharmaceuticals and certain alpha and beta check sources. Controls for unsealed (dispersible) sources include:

1. Labeling and conducting inventories.
2. Containment design to prevent unwanted dispersion.
3. The use of appropriate personal protective clothing.
4. Required training required for handling dispersibles.

Contamination

Contamination is defined as a dispersible radioactive material in a location where it is not wanted. Contamination is found in three forms: removable (sometimes called loose), fixed and airborne. Some examples include dispersible radioactive material that is spilled, mixed with "clean" waste, found on a person's skin or spread by way of welding, machining, sanding, grinding, or similar process. Some of the controls for contamination include:

1. Using boundaries, containments and surveys to minimize the potential to spread contamination.
2. Procedures and techniques for working with dispersible radioactive material that are designed to prevent the spread of contamination.
3. The use of appropriate personal protective clothing.
4. Training for individuals whose work has the potential for creating or spreading contamination.

Methods to Reduce Internal Radiation Dose

An internal dose is the result of radioactive material being taken into the body through inhalation, ingestion, absorption through the skin or entry through a wound. Methods used to reduce the potential for contamination to enter the body include:

1. The use of appropriate personal protective clothing.
2. Proper containment of dispersible radioactive materials.
3. Careful handling when transferring dispersible radioactive materials.
4. Controlling access to certain areas for individuals with skin cuts or abrasions. As a general rule, you should notify the Health Physics Technician of an open skin wound before working with dispersibles.
5. Complying with all the requirements of the Radiological Work Permit or other work documents.
6. Restricting certain processes to designated areas.
7. Meticulous self monitoring (frisking) practices.

The routine bioassay methods for internal monitoring are urinalysis and whole body counts. The purpose of internal monitoring is to support MKM's program for airborne activity control. The results of this monitoring are used to determine the amount of radioactive material taken into the body. If you are suspected of getting contamination inside your body, you may be asked to provide a bioassay sample and/or have a whole body count. The results of the internal monitoring (calculated dose) will be documented in your dose records.

Self Monitoring (Frisking) Procedure

Self monitoring or frisking refers to the process of carefully checking your person or work area for contamination. Frisking techniques or methods used to monitor for contamination on the body must be performed in a methodical manner. Actual frisking requirements and procedures are posted at the exit of the Radiological Buffer Area. Monitoring is generally performed in the following order:

1. Pre-operational checks.
   a. Perform a visual check of the instrument for physical damage.
   b. Verify the calibration of the instrument is current.
   c. Perform a battery check.
   d. Perform a source check. Meter response must be within ± 20% of expected response listed on the side of the meter.
2. Determine background levels.
3. Survey hands before handling the probe or meter.
4. Hold the probe ¼" to ½" from the surface of the part of the body being surveyed.
5. Move the probe over the surface no faster than 2 inches per second.
6. ALWAYS listen for the audio response.
7. If you hear increases in the audio response, stop moving the probe and wait for the meter to respond, (up to 22 seconds in the slow mode). Note the meter reading.
8. Finally, survey the designated portions of your body, (hands and feet are minimum required to exit a Contaminated Area); a whole body frisk takes 2 - 3 minutes.

If contamination is found, either while frisking or by an alarming personnel contamination monitor, remain in the area, notify the Health Physics Technician or your supervisor and try to prevent further spread of contamination. **The Health Physics Technician or your supervisor will provide instructions and procedures used to decontaminate the affected area.**

RADIOLOGICAL POSTINGS AND CONTROLS

The learning objectives in this lesson include:

1. Identify the colors and symbols used on radiological postings, signs and labels.
2. Define Restricted, Radioactive Material, Very High Radiation, High Radiation, Radiation, Airborne Radioactivity, and Radiological Contaminated Areas.
3. State the entry, working in and exiting requirements for Restricted Areas, Radiological Contaminated Areas, Radioactive Material Areas, and Very High Radiation, High Radiation, and Radiation Areas.
4. Identify the radiological areas that a Radiological Worker may enter, and the postings for each area.
5. State the purpose of and information found on Radiological Work Permits (RWPs).
6. Identify the individual's responsibility in using Radiological Work Permits.
7. State the radiological and administrative consequences of disregarding or of unauthorized removal of radiological postings, signs and labels.

Radiological Postings

Radiological postings are used to alert personnel to the presence of radiation and radioactive materials. All areas controlled for radiological purposes are posted with a sign containing a magenta (or black) three-bladed radiological warning symbol (trefoil) on a yellow background. Additionally, yellow and magenta ropes, tapes, chains, or other barriers may be used to denote the radiological boundaries. These barriers must be clearly visible to anyone approaching the area, and entrance points to those areas shall be posted with signs (or equivalent) listing the entry requirements.

Before entering an area controlled for radiological purposes, read and comply with all requirements on the signs. As radiological conditions change, the signs are updated to reflect the new conditions and requirements for entry.

Disregarding or unauthorized removal of radiological postings, signs, or labels may cause unnecessary dose, violates federal regulations, and MKM policy and may lead to disciplinary action.

Restricted Area

A Restricted Area is any area to which access is controlled to protect personnel from exposure to radiation or radioactive materials. A Restricted Area may exist any place where radiation levels are above background and where an individual may receive an occupational dose. A restricted area is posted with a sign bearing the words, CAUTION - Restricted Area. After successful completion of this course, you will be allowed unescorted access to Restricted Areas.

Radioactive Material Area

A Radioactive Material Area (RMA) is an area or structure where radioactive material is being used, handled or stored. Any area or room in which an amount of licensed material exceeding 10 times the quantity of such material specified in appendix C, Title 10 Part 20, Code of Federal Regulations is used or stored, must be posted with a sign or signs "CAUTION, RADIOACTIVE MATERIALS AREA" OR "DANGER, RADIOACTIVE MATERIALS AREA".

Requirements to enter an RMA include:

1. Radiological Worker (RW-1) training as a minimum.
2. Applicable dosimetry.

The only general requirement to work in an RMA is to follow ALARA practices to keep your dose low and be conscious of the radiological conditions. Specific requirements to enter or exit the area will be posted.

Radiation Area

A Radiation Area is an area accessible to personnel, in which radiation levels could result in a person receiving a dose equivalent greater than 5 mrem, but less than 100 mrem in one hour. Any area accessible to personnel in which there exists ionizing radiation at dose-rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrems in 1 hour at 30 centimeters from the radiation source, or from any surface that the radiation penetrates must be posted with a sign "CAUTION, RADIATION AREA". Sufficient indicators (such as radiation ribbon) shall be used to identify the boundary of the radiation area.

An exemption to this posting requirement is allowed in areas or rooms containing radioactive materials for periods of less than 8 hours, if each of the following conditions are met:

1. The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure to radiation or radioactive materials in excess of the limits specified in section 3.0 of the Radiation Safety Manual; and
2. The area or room is subject to the licensee's control.

   For example, the area around a truck loading radioactive waste does not require posting if the above conditions are met.

After successful completion of this course, you will be allowed unescorted access to Radiation Areas.

Requirements to Enter a Radiation Area include:

1. Radiological Worker (RW-1) training.
2. Worker's signature on the RWP (if applicable).
3. TLD and other appropriate dosimetry.
4. Site specific training (as appropriate).

Requirements for working in the area include:

1. Practice ALARA methods.
2. If unanticipated elevated radiation levels are indicated by an off-scale dosimeter, radiological alarms or other indicators; stop work, alert others, immediately exit the area and notify the Health Physics Technicians or your supervisor.

High Radiation Area

Any radiation area accessible to personnel in which there exists ionizing radiation at such levels that an individual could receive in excess of 100 mrems in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates must be posted with a sign "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA".

Radiation workers will only work in these areas under the control of a specific work permit and only under the direct observation of radiation protection personnel.

Very High Radiation Area

Any area accessible to personnel in which there exists ionizing radiation at such levels that and individual could receive in excess of 500 Rad in 1 hour at 1 meter from the radiation source or from any surface that the radiation penetrates must be posted with a sign "GRAVE DANGER, VERY HIGH RADIATION AREA".

Radiation workers will not enter a Very High Radiation Area without specific prior written approval of MKM management.

Radiologically Contaminated Area

A Radiologically Contaminated Area (RCA) is a restricted area established to prevent the spread of radioactive contamination. A restricted area that has fixed and removable radioactive materials in the form of dusts, particulates, and sorbed contaminates which are above the limits specified in the following table is identified and posted with a "CONTAMINATED AREA" sign. Contamination control procedures and step off pads are used for entry and exiting the contaminated area to retain contamination within the designated area. Personal protective clothing are required for entry into a contaminated area to prevent contamination of workers and their personal clothing.

Requirements to enter a Radiologically Contaminated Area:

1. Radiological Worker training.
2. TLD and other appropriate dosimetry.
3. Site specific training (if appropriate).
4. Protective clothing as required by an RWP.

Requirements for working in an RCA.

1. Always practice ALARA.
2. Follow the no eating, drinking, smoking or chewing policy for the area.
3. Obey all posted, written or oral requirements including **"Evacuate"** or **"Stop work"** orders from the Health Physics Technician or supervisor.
4. Use labels or tags to identify specific radiological hazards.
5. When storing radioactive material in drums, vials, flasks, boxes, etc., ensure containers are marked appropriately.
6. Report to a Health Physics Technician if you identify that radiological controls are not adequate or are not being followed.
7. Report to the Health Physics Technician if you see any unusual conditions such as leaks or spills, dust, hazy air or alarming radiological control instrumentation.
8. If a spill of radioactive material should occur, notify the Health Physics Technician or supervisor.
9. Be aware of changing radiological conditions.
10. Make certain that your activities do not create radiological problems for others and be alert that their activities may change the radiological conditions where you are.

Requirements for Exiting an RCA:

1. Workers must monitor for contamination in accordance with procedures or posted instructions at the RCA exit. The minimum requirement for exiting an RCA includes a survey of the hands and feet.
2. All items being removed from the area must be monitored for contamination.
3. Personnel frisking must be completed before exiting.

Airborne Radioactivity Area

A room, enclosure or area must be posted with a "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA" if radioactive material is dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases and the concentration of the dispersed radioactive materials is in excess of:

a) The derived air concentrations (DAC's) specified in Table 1, column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations.

b) Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

Radiation workers may only work in these areas under the direction of a radiation work permit and the site supervisor or designee.

Escorts

Visitors with a demonstrated need to enter the following areas, may be allowed access if that access is controlled with a combination of training, dosimetry, and the use of escorts trained for the specific area:

1. Radiological Contaminated Areas
2. Radiation and High Radiation Areas
3. Radioactive Material Areas

If you have any questions concerning the use of escorts, contact your Supervisor.

Radiological Work Permits (RWPs)

A Radiological Work Permit is an administrative mechanism used to establish radiological controls for intended work activities. As a RW-1 trained individual, you may be required to use an RWP. RWPs serve to:

1. Inform workers of area radiological conditions.
2. Inform workers of entry requirements into the areas.
3. Relate radiation doses received by workers to specific jobs or tasks.

Typical information found on Radiological Work Permits includes:

1. A description/location of work.
2. Radiological conditions of the work area. This information may be determined from radiological survey maps/diagrams or the radiological posting for that area.
3. Dosimeter requirements.
4. Required level of training for entry.
5. Radiological control support requirements.
6. Limiting radiological conditions that may void the permit.
7. Special dose reduction considerations.
8. Technical work documents and other unique identifying numbers.
9. Date of issue/expiration.
10. Authorizing signatures.

Responsibilities of the worker when using a RWP

When using a Radiological Work Permit, workers are responsible for reading the RWP, understanding the permit before entering the area and complying with all instructions on the RWP. Never make substitutions for specific requirements. Sign in on the RWP (if applicable), or associated sign-in log, indicating:

1. You have read, understand, and will comply with the permit prior to entering the area.
2. If you think that the RWP is incorrect or you do not understand any of the information, do not start the job until your concerns are resolved. Contact your supervisor or Health Physics Technician.

Supervisor Responsibilities

1. Has front line responsibility for worker safety.
2. Ensures staff has completed required training.
3. Develops procedures to maintain dose ALARA.
4. Informs staff of Radiation Safety Manual, MKM Procedure, and RWP requirements.
5. Ensures all areas are properly posted.
6. Keeps Health Physics Technician informed of work scope and radiological condition changes.

Health Physics Technician Responsibilities

1. Reports to Radiation Safety Officer or designee.
2. Has front line responsibilities for adherence to radiation protection policies and procedures.
3. Performs radiation surveys and safety inspections.
4. Implements Radiation Safety Manual requirements.

Employee Responsibilities

1. ***Primary responsibility for your own radiation safety protection.***
2. Obligation to work safely.
3. Ensure you are trained before attempting new tasks.
4. When in doubt, consult with your supervisor or Health Physics Technician.
5. Comply with dose limits and administrative control levels.
6. Comply with monitoring requirements.

RADIOLOGICAL EMERGENCIES

The learning objectives in this lesson include:

1. State the purpose of emergency alarms.
2. Identify the correct responses to emergencies and/or alarms.
3. State the possible consequences for disregarding radiological alarms.

Emergency Alarms and Response

The purpose of emergency equipment that monitors radiation and alarms to warn personnel of unusual radiation or airborne contamination is to avoid unnecessary and unplanned dose to workers.

Equipment that monitors for unusual radiation levels and airborne contamination is placed in strategic locations. Your response to radiation alarms is as follows:

1. Immediately, place your equipment in a safe condition.
2. Warn others in the area of the alarm and the need to leave the area.
3. Promptly leave the area and go to a safe location.
4. Prevent other workers from going into the area.
5. Notify radiation protection personnel of the alarming equipment.

It is essential that each worker be able to identify the equipment and respond appropriately to the alarms. Because of the variety of systems at various facilities, more detailed information will be provided during the initial job briefing at the work site.

Disregarding or deactivating emergency alarms without proper authorization can cause unnecessary dose to workers, violate federal regulations and MKM policy and may lead to disciplinary action.

If you witness any unusual situations, take appropriate actions for the situation, contact your Health Physics Technician or Supervisor for radiological concerns.

Spills

In general immediate actions taken to control radioactive materials can be very important to minimize exposure during recovery operations. Should a spill of radioactive or hazardous materials occur, and there is no immediate danger to you or others in the area, then:

1. <u>S</u>top the spill (upright the container, cover drums, etc.).
2. <u>W</u>arn others in the area of the spill.
3. <u>I</u>solate the area to prevent entry of others.
4. <u>M</u>inimize your exposure and that of others.
5. Notify health physics personnel and your supervisor.

The emergency action required can be remembered by the acronym **<u>SWIM</u>**.

RESPONSIBILITIES OF INDIVIDUALS

The MKM radiation safety program is administered by the Radiation Safety Officer who reports directly to the president of MKM. Responsibilities for the key functions of the radiation safety program are listed below.

Remediation Program Manager

The Program Manager has the following responsibilities on projects involving radioactive materials.

1. Ensure that operations comply with the provisions of the Radiation Safety Manual and other pertinent federal regulations.
2. Establish a radiation control program for projects involving radioactive materials.
3. Manages the preparation of operating procedures which ensure compliance with the Radiation Safety Manual, pertinent federal regulations, and customer requirements.
4. Ensure that employees working with radioactive materials have received the required training in operating procedures, rules, and special precautions prior to being occupationally exposed to ionizing radiation.
5. Keeps the president of MKM informed on the status of program and radiation safety objectives.

Radiation Safety Officer

The Radiation Safety Officer (RSO) has the following responsibilities.

1. Implement and maintain an effective Radiological Controls Program that complies with the provisions of the Radiation Safety Manual and pertinent federal regulations.
2. Provide advice and assistance to MKM management on all matters pertaining to radiation safety requirements, procedures, and policies.
3. Perform surveys and inspections as required to ensure compliance with the provisions of the Radiation Safety Manual and other pertinent MKM directives, federal regulations, and customer requirements.
4. Develop, coordinate and participate in training and orientation programs for occupationally exposed individuals, and other personnel as required by the Radiation Safety Manual.
5. Maintain current all applicable required licenses and amendments.
6. Maintain a current ionizing radiation source inventory under MKM control to ensure that sources are secure against loss or unauthorized use.
7. Stop any job or activity which in their opinion may lead to an out of compliance situation. Conduct a complete review and obtain approval prior to allowing job continuation.

Waste (Materials) Broker

The Waste Broker has the following responsibilities.

1. Package and ship radioactive materials in accordance with the provisions of the Radiation Safety Manual and pertinent federal regulations.
2. Provide advice and assistance to MKM management on all matters pertaining to packaging, shipping and transportation of radioactive materials.
3. Assist the RSO in training and orientation programs for occupationally exposed individuals, and other personnel as required by the Radiation Safety Manual.
4. Stop any job or activity which in their opinion may lead to an out of compliance situation. Conduct a complete review and obtain CHP or RSO approval prior to allowing job continuation.

Radiation Workers

Employees of MKM who are assigned to work activities involving radioactive materials have the following responsibilities:

1. Obey posted, verbal and written radiological control procedures.
2. Wear dosimetry devices when required by the Radiation Safety Manual and promptly report any lost or damaged devices to their supervisor.
3. Promptly report to their supervisor or RSO any incident, personnel injury, suspected overexposure, contamination, internal deposition, and any suspicious or questionable occurrence involving radioactive material. It is recommended that this type of report be written on a Radiological Awareness Report.
4. Be thoroughly familiar with equipment, procedures and the requirement for and use of, any special devices prior to using or working with any source or device which produces radiation.
5. Avoid any unnecessary exposure and use the concept of time, distance and shielding when working in the presence of radiation sources to maintain your exposure As Low As Reasonably Achievable (ALARA).

CONVERSIONS

SI Prefixes

Factor	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

SI Units

Radioactivity units, curie (Ci) and Becquerel (Bq)

$1\ Ci = 3.7 \times 10^{10}\ dps = 3.7 \times 10^{10}\ Bq$

$1\ mCi = 3.7 \times 10^{7}\ Bq$

1 nCi = 37 Bq

1 Bq = 27 pCi

1 kBq = 27 nCi

1 MBq = 27 µCi

100 MBq = 2.7 mCi

Absorbed dose units, rad and gray (Gy)

1 mrad = 0.00001 Gy = 10 µGy

1 rad = 0.01 Gy = 10 mGy

10 rad = 0.1 Gy = 100 mGy

100 rad = 1 Gy

1,000 rad = 10 Gy

10,000 rad = 100 Gy

Dose Equivalent units, rem and sievert (Sv)

1 mrem = 0.00001 Sv = 10 µSv

1 rem = 0.01 Sv = 10 mSv

10 rem = 0.1 Sv = 100 mSv

100 rem = 1 Sv

1,000 rem = 10 Sv

10,000 rem = 100 Sv

Airborne Activity units, DAC and ALI

2000 DAC Hours = 1 ALI

Radiation Safety Procedure

for

Operation of Contamination Survey Meters

MKMP-001

Revision 0

Reviewed By: ______________________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer Date

Approved By: ______________________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist Date

MKM Engineers, Inc.

Procedure MKMP 001
Operation of Contamination Survey Meters

LIST OF EFFECTIVE PAGES
(Revision Level 0 = Original Document)

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This table provides the most recent changes to pages in this document. A '0' means the original page is valid, a date in the revision level box indicates the date of the most recent change to the page indicated.

1.0 Purpose and Scope

1.1 This procedure provides the methods for operating alpha/beta survey meters when performing contamination surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

1.2 These procedures will be used by MKM Engineers Inc. (MKM) personnel and sub-contractors on projects to measure fixed and removable alpha and/or beta emitting radioactive material on facility surfaces, equipment, waste packages, personnel and personnel protective clothing.

2.0 General

2.1 Definitions

2.1.1 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Alpha/Beta Contamination Survey - A survey technique to determine fixed plus removable alpha/beta contamination.

2.1.3 Acceptance Range - A range of values that describe an acceptable daily instrument source check result.

2.2 Precautions

2.2.1 Technicians will ensure that the thin Mylar or mica window on the probe face is protected from punctures during survey operations.

2.2.2 Check sources will be controlled in accordance with MKMP-020 at all times, to prevent accidental loss or release of radioactive materials.

2.2.3 If any instrument inconsistencies are observed (e.g., unusually high or low background counts, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the site supervisor.

2.2.4 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily, following work activities, as a final verification.

2.2.5 Survey instrument calibrations shall be performed by a NRC or Agreement State approved calibration facility with NIST traceable sources.

2.3 Quality Control

2.3.1 Contamination survey meters will be checked prior to each shift or daily with an alpha or beta check source as applicable to ensure the instrument is operating within the calibrated specifications.

2.3.2 Contamination survey meters will have current/valid calibration documentation attached to the meter or in the storage case.

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-008	Radiation and Contamination Surveys
MKMP-020	Use and Control of Radioactive Check Sources
ANSI N323-1978	*Radiation Protection Instrumentation Test and Calibration*
NUREG/CR-5849	*Manual for Conducting Radiological Surveys in Support of License Termination*

3.2 Records

MKMP Form 1-1	Survey Meter Source Check
MKMP Form 8-1	Radiation/Contamination Survey

3.3 Equipment

For Alpha Surveys Ludlum Model 43-5 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

For Beta Surveys Ludlum Model 44-9 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of operating contamination survey meters are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the contamination survey meters. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians using contamination survey meters are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Initial Preparations

5.1.1 Select the contamination survey meter and probe to be used in the survey and verify that the instrument is complete, has a valid calibration and that it has no visible damage or defects.

5.1.2 Turn the instrument selector switch to BATTERY TEST position and verify meter indication falls within the shaded region of the dial indicating the batteries have proper voltage to operate the instrument. Replace the "D" cell batteries if the indication is below the shaded region.

5.1.3 Turn the instrument selector switch to the X 0.1 position and let the instrument warm up for one minute.

5.1.4 Switch the audio toggle switch to "ON" and the response toggle switch to "FAST".

5.1.5 Check alpha detectors for light leaks by pointing the sensitive area on the detector toward a light source and observe the meter indication and listen for an increase of audible clicks on the speaker. If the meter indication or the audible clicks are above 10 counts per minute (CPM) contact the supervisor or RSO.

5.1.6 Check instrument response by placing probe over the check source and observing the meter indication. Record the meter indication on MKMP Form 1-1 and determine if indication is within stated values. If indication is not within stated values contact supervisor for instructions.

5.1.7 If the acceptable range for source checks hasn't already been calculated on MKMP Form 1-1, then follow the instructions below:

- Ensure the source and detector are in documented reproducible positions, which will be used each time this check is performed.
- Use the check source in a low background area to obtain a measurement (allow the meter to stabilize approximately 90 seconds) in net CPM.
- Multiply the measured net CPM value by 0.8 and 1.2 and record the values as the acceptable range on MKMP Form 1-1.

5.2 Contamination Survey Techniques

> **CAUTION:** The window area of alpha detectors are covered with a very thin (1 mg/cm^2) aluminized Mylar window and beta detector windows are 1.7 mg/cm^2 mica. Either window can be easily punctured; avoid surveying areas which have protruding fragments that might puncture the detector face. Remove these fragments before performing surveys. Be sensitive to the fact that any area you cannot see can contain something that will break the detector.

NOTE: Although beta particles travel several feet in air, the detection efficiency is calibrated with the detector probe held ½ inch from the calibration source. Therefore, the detector must be held at ½ inch from the survey surface to maintain calibrated detection efficiency. Alpha particles travel only a few centimeters in air. The detector must be held within ¼ inch of the survey surface to detect alpha particles.

NOTE: Touching the surface with the detector may contaminate the detector - avoid contact with the surface to be surveyed.

5.2.1 Verify the instrument selector switch is in the X 0.1 position.

5.2.2 For a stationary reading, place the detector over the area to be measured and allow meter to stabilize. Record the average meter indication in either CPM α/PA (probe area) or CPM β/PA (probe area) as applicable on the forms provided in procedure MKMP-008.

5.2.3 For a scan survey move the detector slowly over the surface (less than one detector width per second). Observe meter indication and listen for increases in audible clicks from the speaker. If increased readings are observed, return to the area and obtain a stationary reading. Record maximum area meter indication in either CPM α/PA or CPM β/PA as applicable on the forms provided in procedure MKMP-008.

5.3 Interpretation of Results

The meter reading on the alpha and beta survey meters must be corrected for detector efficiency and detector surface area before comparing results with the contamination limits in Section 3.6 of the Radiation Safety Manual. The conversion from CPM α or β/PA (Probe Area) to DPM α or β/100 cm^2 is performed using the following equation.

$$(DPM/100cm^2) = \frac{(A \times B)}{C}$$

Where: A = Alpha or Beta survey meter indication in net CPM α or β/PA (i.e. Gross Alpha or Beta Survey Counts minus background counts = Net CPM/PA)

B = 100 cm^2 divided by the effective detector surface area in cm^2. With an effective surface area of 50 cm^2 for the Ludlum 43-5 alpha detector, the value of *B* is ~2 or for the 15 cm2 for the Ludlum 44-9 beta detector, the value of *B* is~ 6.7.

C = Detector efficiency (expressed as decimal).

NOTE: This is an important concept which demonstrates why 2" diameter GM detectors are typically not adequate for release surveys. If required to detect 5000 dpm/100 cm2 for fixed activity, then you must be able to detect (assuming a 10% detector efficiency and 44-9-type detector):

$$\frac{(5000\times0.1)}{6.7}=74.6cpm(net)$$

In order to do this, background must be very low and the normal fluctuations with a GM can make detection of such an activity concentration, very difficult.

6.0 Attachments

MKMP Form 1-1 Survey Meter Source Check

MKM Engineers, Inc.

Survey Meter Source Check

Instrument ______________________ Serial No. ______________

Source ______________ Acceptable Range __________ to __________

Date	Cal Due	Reading	Tech Initials	Date	Cal Due	Reading	Tech Initials	Date	Cal Due	Reading	Tech Initials

Radiation Safety Procedure

for

Alpha - Beta Sample Counting Instrumentation

MKMP-002

Revision 0

Reviewed By: ______________________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer — Date

Approved By: ______________________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist — Date

MKM Engineers, Inc.

Procedure MKMP 002
Alpha-Beta Sample Counting Instrumentation

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7	0	8/28/99						

This table provides the most recent changes to pages in this document. A '0' means the original page is valid, a date in the revision level box indicates the date of the most recent change to the page indicated.

1.0 Purpose and Scope

1.1 This procedure provides the methods utilized in operation of the alpha/beta sample counter to determine alpha and beta activity on smear samples and air samples. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

1.2 This procedure will be used by MKM personnel to operate the alpha/beta sample counter during surveys at customer facilities. Types of surveys that may use the alpha/beta sample counter are as follows:

1.2.1 Smear surveys performed to determine the removable alpha and beta contamination on facility surfaces, equipment, waste and source packages containing alpha and beta emitting radioactive materials.

1.2.2 Air sample surveys performed in the workers breathing zone to determine alpha and beta air concentrations.

2.0 General

2.1 Definitions

2.1.1 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Smear sample survey - A survey technique using two inch diameter filter papers to determine the activity of alpha and beta emitting radioactive material which can be removed from facility surfaces and waste packages.

2.1.3 Air sample survey - A survey technique in which particulates are collected from a known volume of air drawn through a filter paper and the concentrations of airborne alpha and beta activity associated with the particulates is determined by counting.

2.1.4 Plateau - The level portion of the counting rate-voltage curve where changes in operating voltage introduce minimum changes in the counting rate.

2.1.5 Chi-Square test - A statistical test to evaluate the operation of a sample counter by determining the goodness of fit of a series of counts to a Poisson distribution.

2.1.6 Daily calibration - A determination of the alpha and beta sample counting efficiency by counting certified activity standards.

2.2 Precautions

2.2.1 If any instrument inconsistencies are observed (e.g., unusually high or low background counts, source checks outside the tolerance range, etc.), remove the instrument from use and report the condition to the site supervisor.

2.2.2 A battery check (if needed), general observation of instrument condition and source check shall be performed each day before instrument use.

2.2.3 Survey instrument calibrations shall be performed by a NRC or Agreement State approved calibration facility with NIST traceable sources.

2.2.4 This instrument should be set up for use in a low background area as determined by the site supervisor.

2.3 Quality Control

2.3.1 The alpha/beta sample counter will be checked for proper calibration daily with a NIST traceable source.

2.3.2 Chi-Square and plateau tests are verified and noted as currently valid.

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-008	Radiation and Contamination Surveys
MKMP-022	Packaging Radioactive Material

3.2 Records

MKMP Form 2-1	Plateau Data Sheet
MKMP Form 2-2	Chi-Square Data Sheet
MKMP Form 2-3	Daily Calibration Log
MKMP Form 2-4	Sample Calculation Worksheet
MKMP Form 8-1	Radiation/Contamination Survey

3.3 Equipment

Ludlum model 2929 or equivalent

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for ensuring that all personnel assigned the task of operating alpha-beta sample counters are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the alpha-beta sample counters. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians using beta survey meters are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Initial Startup

5.1.1 Turn high voltage potentiometer to its lowest position or reading (fully counterclockwise).

5.1.2 Turn main instrument switch on.

5.1.3 The operator can select one of four operational procedures depending on the function to be performed.

a) Plateau Curve - The proper operating voltage for the instrument must initially be selected and verified every six months. This procedure is performed only if the plateau curve date posted on the instrument has expired, or if eratic instrument response indicates possible calibration problems.

b) Chi-Square Test - The sample counter is statistically evaluated against a Poisson distribution every month that the instrument is used for counting samples. This procedure is performed only if the Chi-Square test date posted on the instrument has expired.

c) Daily Calibration - This procedure is performed before samples are counted on any day the instrument is in use.

d) Routine Operation - This procedure describes the method for counting samples.

5.2 Plateau Curve

NOTE: Before beginning, record the calibration high voltage values from the manufacturer.

5.2.1 Set up the instrument in a low background area.

5.2.2 Rotate the high voltage potentiometer clockwise until the meter indicates 500 volts.

5.2.3 Set time multiplier switch to X1.

5.2.4 Set the instrument preset timer to one (1) minute.

5.2.5 Insert alpha calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a one minute count.

5.2.6 Upon completion of the count, record high voltage reading and digital counts appearing in the instrument alpha display in the indicated columns on MKMP 2-1 (Plateau Data Sheet).

5.2.7 Continue increasing high voltage by 50 volt increments, completing counts and recording data until the end of the plateau is reached. If a rapid increase in count rate is observed, immediately reduce the high voltage.

5.2.8 Remove the alpha source and replace with a beta source.

5.2.9 Reduce high voltage reading to 500 by turning potentiometer counterclockwise.

5.2.10 Perform one minute counts at each 50 volt increment and record the data on MKMP Form 2-1 until the end of the plateau is reached. If a rapid increase in count rate is observed, immediately reduce the high voltage.

5.2.11 Using linear graph paper, plot alpha and beta counts on the "Y" axis and the voltage for the indicated count on the "X" axis.

5.2.12 Select an operating voltage 1/3 the distance beyond the knee of the plateau curve by marking the voltage on the graph and on the Plateau Data Sheet. Record the operating voltage and date of test on an adhesive label and attach to alpha/beta sample counter.

5.2.13 The preparer shall sign and date MKMP Form 2-1 and forward the entire results to MKM Health Physics Management for review.

5.3 Chi-Square Test

5.3.1 Set up the instrument in a low background area.

5.3.2 Rotate the high voltage potentiometer clockwise until meter indicates voltage posted on instrument label.

5.3.3 Set time multiplier switch to X1.

5.3.4 Set the instrument preset timer to one (1) minutes.

5.3.5 Insert alpha calibration standard into center of the sample tray, slide sample tray under the detector and depress the "COUNT" button to obtain a one minute count.

5.3.6 Upon completion of the count, record digital counts appearing in the alpha or beta display in the "X" column on MKMP Form 2-2 (Chi-Square Data Sheet).

5.3.7 Repeat counting sequence without changing settings until a total of 20 counts have been taken and recorded in the "X" column of the Chi-Square Data Sheet.

5.3.8 Add the 20 counts entered in the "X" column and divide by 20 to obtain the mean number of counts (X_m).

5.3.9 Calculate the individual count "(X)" difference from the mean (X_m)value and record in the "($X-X_m$)" column of the Chi-Square Data Sheet.

5.3.10 Calculate "$(X-X_m)^2$" as indicated on the data sheet and sum the "$(X-X_m)^2$" column.

5.3.11 Calculate the value of Chi-Square using the following formula.

$$X^2 = \frac{\Sigma(X - X_m)^2}{X_m}$$

5.3.12 The value of Chi-Square should be between 7.63 and 36.2 which represent a probability between 0.1 and 0.9. If the Chi-Square value falls outside the indicated range, contact the RSO for further instructions.

5.3.13 Write the date of the Chi-Square test and preparer initials on an adhesive label and attach it to the alpha/beta sample counter.

5.3.14 The preparer shall sign and date MKMP Form 2-2 and forward the results to MKM Health Physics Management for review.

5.4 Daily Calibration

5.4.1 Verify that the plateau curve and Chi-Square test have not expired by observing the due date for these tests posted on the instrument label.

5.4.2 Rotate high voltage potentiometer clockwise until meter indicates voltage posted on the instrument label.

5.4.3 Set time multiplier switch to X1.

5.4.4 Set the instrument preset timer to five (5) minutes.

5.4.5 Record the source efficiency type to be calculated as alpha or beta in the column indicated on MKMP Form 2-3. Use separate lines of the form for each source efficiency to be calculated.

5.4.6 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a five minute background count.

5.4.7 Calculate as below and record the "BKG CPM" results for alpha or beta (or both on separate lines of the form) in the field indicated on MKMP Form 2-3 (Daily Calibration Log).

CPM=Counts per minute or count time/minutes

5.4.8 Remove the blank sample and insert the alpha or beta calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a five minute count.

5.4.8 Upon completion of the measurement, calculate CPM as in Section 5.4.7 and record the "Gross Source CPM" on MKMP Form 2-3 (Daily Calibration Log).

5.4.9 Calculate "Net Source CPM" as below and record on MKMP Form 2-3.

Net Source CPM (CCPM) = Gross source CPM - BKG CPM

NOTE: Obtain activity (DPM) value for source efficiency calculation from the source certification paperwork. Decay correct activity, if needed.

5.4.10 Use the source disintegrations per minute (DPM) to calculate the efficiency as shown below and record as a percentage (%) or in decimal form on MKMP Form 2-3.

Efficiency (%) = Net Source CPM ÷ DPM

5.4.11 To calculate the next source efficiency, remove the current source standard, insert a new source standard and repeat Sections 5.4.4 through 5.4.10 as necessary.

5.4.15 The preparer shall record their initials in the proper field on MKMP Form 2-3.

5.4.16 Remove calibration standards and place in source holders. Place sources in secure area to prevent loss and unauthorized use.

5.4.17 The counting efficiencies determined in the above procedure will be used in Section 5.5 of this procedure to determine activity of unknown samples.

5.5 Routine Operation

5.5.1 Set up the instrument in a low background area.

5.5.2 Verify that the plateau curve and Chi-Square test have not expired by observing the due date for these tests posted on the instrument label.

5.5.3 Fill out the date, time, instrument model #, serial #, and alpha and beta efficiencies, at the top of MKMP 2-4 (Sample Calculation Worksheet).

5.5.4 Rotate high voltage potentiometer clockwise until the meter indicates the voltage posted on sticker.

5.5.5 Set time multiplier switch to X1.

5.5.6 Set the instrument preset timer to ten (10) minutes.

5.5.7 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a 10 minute background count.

5.5.8 Calculate Background CPM (as performed in Section 5.4) from the alpha and beta background count results appearing in the instrument alpha and beta digital displays and record on MKMP Form 2-4 (Sample Calculation Worksheet).

5.5.9 Set the correct instrument sample count time:

- Smear samples-1 minute or as directed by the work plan,
- Air samples-5 minutes or as directed by the work plan

5.5.10 Insert the smear sample or air sample into the center of sample tray, slide the sample tray under the detector and depress "COUNT" button to begin the counting sequence.

5.5.11 Calculate CPM as in Section 5.4 and record the sample counts appearing in the instrument alpha and beta displays as "Gross Alpha CPM" and "Gross Beta CPM", respectively, on MKMP Form 2-4 (Sample Calculation Worksheet).

5.5.12 Calculate (and record on MKMP Form 2-4) net counts per minute for the "Net Alpha CPM" and "Net Beta CPM" using the following formula:

$$\text{Net } (\alpha \text{ or } \beta) \text{ CPM} = (\text{Gross Sample } (\alpha \text{ or } \beta) - \text{Background } (\alpha \text{ or } \beta) \text{ CPM})$$

5.5.13 Calculate sample disintegrations per minute (DPM) for the net alpha and net beta count rates using the respective alpha and beta efficiencies as calculated on MKMP Form 2-3 (Daily Calibration Worksheet) and the following formula:

$$DPM = \frac{NetCPM}{Efficiency}$$

5.5.13 Enter the alpha and beta DPM values and your initials in the indicated columns on MKMP Form 2-4.

6.0 Attachments

MKMP Form 2-1 Plateau Data Sheet
MKMP Form 2-2 Chi-Square Data Sheet
MKMP Form 2-3 Daily Calibration Log
MKMP Form 2-4 Sample Calculation Worksheet

MKM Engineers, Inc.

Plateau Data Sheet

Date ______________ Recommended Operating Voltage ______________

Instrument ______________ Serial No. ______________

Alpha Source Serial No. ______________ Source Strength ______________

Beta Source Serial No. ______________ Source Strength ______________

Voltage Setting	Alpha Counts	Voltage Setting	Alpha Counts	Voltage Setting	Beta Counts	Voltage Setting	Beta Counts

Prepared By: ______________ / ______________ Date: ______________
Print/Sign

Reviewed By: ______________ / ______________ Date: ______________
Print/Sign

MKM Engineers, Inc.

Chi-Square Data Sheet

Date ________ Instrument ____________ Serial No. ____________ X^2= ____________

Alpha Serial No./Strength ____________/________ Beta Serial No./Strength ________/________

Count No.	X	$(X - X_m)$	$(X - X_m)^2$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Totals			

Prepared By: ______________/______________ Date: ____________
Print/Sign

Reviewed By: ______________/______________ Date: ____________
Print/Sign

MKM Engineers, Inc.

Daily Calibration Log

Instrument ______________________ Serial No. ______________

Alpha Serial No./Strength ______/______ Beta Serial No./Strength ______/______

	Background Information			Source Information				
Date/Time	Total Time	Total Cts	CPM	Total Time	Total Cts	CPM	Net CPM	% Eff

Prepared By: ______________/______________ Date: ______________
Print/Sign

Reviewed By: ______________/______________ Date: ______________
Print/Sign

MKM Engineers, Inc.

Sample Calculation Worksheet

Date/Time ______________ Instrument ______________ Serial No. ______________

Alpha Efficiency ______________ Beta Efficiency ______________

Alpha Background (CPM) ______________ Beta Background (CPM) ______________

Sample No.	Gross Alpha CPM	Gross Beta CPM	Net Alpha CPM	Net Beta CPM	Alpha DPM	Beta DPM	Technician Initials

Prepared By: ______________ / ______________ Date: ______________
Print/Sign

Reviewed By: ______________ / ______________ Date: ______________
Print/Sign

Page ___ of ___

Radiation Safety Procedure

for

Operation of Micro-R Meters

MKMP-003

Revision 0

Reviewed By: _______________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer   Date

Approved By: _______________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist   Date

MKM Engineers, Inc.

Procedure MKMP 003
Operation of Micro-R Survey Meters

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1.0 Purpose and Scope

1.1 This procedure provides the methods MKM utilizes in operation of the micro-R-meter for gamma radiation surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

1.2 This procedure will be used by MKM personnel to operate the micro-R-meter during gamma radiation surveys. Surveys performed to determine the gamma radiation levels from facility surfaces, equipment, waste and source packages containing gamma emitting radioactive materials. Surveys performed in facilities and on land masses to determine levels of gamma radiation.

2.0 General

2.1 Definitions

2.1.1 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Gamma radiation survey - A survey technique to determine gamma radiation levels from radioactive materials in facilities, materials, or land masses.

2.1.3 Acceptance Range - A range of values that describe an acceptable daily instrument source check result.

2.2 Precautions

2.2.1 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the site supervisor.

2.2.2 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily, following work activities, as a final verification.

2.2.3 Survey instrument calibrations shall be performed by a NRC or Agreement State approved calibration facility with NIST traceable sources.

2.3 Quality Control

2.3.1 The micro-R-meter will be source checked with an appropriate source each day before the instrument is used to perform surveys and daily, after work activities, for verification of proper operation.

2.3.2 Contamination survey meters will have current/valid calibration documentation attached to the meter or in the storage case.

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-008	Radiation and Contamination Surveys
MKMP-020	Use and Control of Radioactive Check Sources
ANSI N323-1978	Radiation Protection Instrumentation Test and Calibration
NUREG/CR-5849	Manual for Conducting Radiological Surveys in Support of License Termination

3.2 Records

MKMP Form 1-1	Survey Meter Source Check
MKMP Form 8-1	Radiation/Contamination Survey

3.3 Equipment

Ludlum Model 19 or equivalent detector

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of operating micro-R survey meters are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the micro-R survey meters. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians using Micro-R meters are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Initial Preparations

5.1.1 Select the Micro-R meter to be used in the survey, observe the physical appearance (i.e., no broken parts and instrument is complete) and verify that the instrument has a currently valid calibration.

5.1.2 Depress the BATTERY TEST button and verify the meter indication falls within the shaded region of the dial indicating the batteries have proper voltage to operate the instrument. Replace the "D" cell batteries if the indication is below the shaded region.

5.1.3 Turn the instrument selector switch to the lowest scale position (usually 25 μR/hour) and let the instrument warm up for one minute. With the selector switch in this position, use the 0 to 25 μR/hr scale on the dial for obtaining instrument readings.

5.1.4 Switch the audio toggle switch to "ON" and the response toggle switch to "SLOW".

5.1.5 If acceptable range values for source checks haven't already been calculated on MKMP Form 1-1, then follow the instructions below:

- Use the check source in a low background area to obtain a measurement (the meter reaches 90% of its final reading in 22 seconds) in net CPM.

- Multiply the measured net CPM value by 0.8 and 1.2 and record the values as the acceptable range on MKMP 1-1.

NOTE: Do not use malfunctioning or out of tolerance instruments to perform surveys.

5.1.6 Check the instrument response (in a low dose area) by placing the probe window over the check source or predetermined position in the facility and observing the meter reading (the meter reaches 90% of its final reading in 22 seconds). Record the meter reading in net CPM on MKMP Form 1-1 and determine if the measurement is within the acceptable range listed in MKMP 1-1. If the measurement is not within the acceptable range for the source used, contact the site supervisor.

5.2 <u>Survey Technique</u>

5.2.1 Grid surveys

a) Verify the instrument selector switch is on the lowest scale (usually the 25μR position). Turn the instrument selector switch to the next higher scale only if meter indication is off scale.

b) For a stationary grid reading in a facility or land mass, position the instrument one meter above the surface to be surveyed and allow meter to stabilize. With the instrument toggle switch set in the "SLOW" position, the meter reaches 90% of its final reading in 22 seconds. Record the average meter indication in μR/hr on the forms provided in procedure MKMP-008.

NOTE: Two survey methods (step c or d) can be used to obtain contact readings in the survey grids. The survey method used will be specified in the site specific work plan.

c) For a scan survey, make sure the meter response is set to fast and suspend the instrument from a strap which locates the detector is located at surface or ground level. Move the instrument slowly over the surface while walking in an "S" pattern or as described in the characterization work plan. Observe meter indication and listen for increases in audible clicks from the speaker. Areas which could concentrate radioactive materials such as drainage ditches, floor cracks and wall/floor joints should always be surveyed. If elevated readings above background are observed, a stationary survey shall be performed (at 1 meter height and also at the surface)at the point of elevated activity . Record area meter indications above background in mR/hr on the forms provided in procedure MKMP-008.

d) As an alternate to the "S" pattern survey used in step c), the survey grid can be divided into subgrids and readings taken as directed by the site work plan. Determine readings elevated above background the same manner as above (i.e., measurements at one meter and at the surface). The readings from each measurement are recorded on the forms provided in procedure MKMP-008.

5.2.2 Waste container surveys

a) Set the instrument scale to accommodate the highest expected radiation level. If radiation levels may approach 5000 µR/hr (5 mR/hr) obtain an instrument with appropriate range prior to performing any radiation surveillance.

b) Slowly scan the total surface of the package and record the maximum contact reading obtained on the forms provided in procedure MKMP-008.

c) Obtain instrument readings at 1 meter from all sides of the package and record the maximum reading obtained on the forms provided in MKMP-008.

5.3 <u>Interpretation of Results</u>

5.3.1 In a uniform background radiation field (without interfering sources of radiation), methods such as; selectively shielding the detector, soil sample analysis, etc., can be used to differentiate between extraneous radioactive sources(e.g., skyshine or radioactive waste shipment containers), naturally occurring radioactive material and/or radioactive contamination.

5.3.2 Note the location of installed devices which contain radioactive material and could cause elevated radiation survey levels in localized areas.

5.3.3 Land mass surveys might contain areas with naturally occurring radioactive materials which will elevate background radiation levels.

6.0 <u>Attachments</u>

None

Radiation Safety Procedure

for

Operation of Ionization Chambers

MKMP-004

Revision 0

Reviewed By: _______________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer   Date

Approved By: _______________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist   Date

MKM Engineers, Inc.

Procedure MKMP 004
Operation of Ionization Chambers

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1.0 Purpose and Scope

1.1 This procedure provides the methods MKM utilizes in operation of the ion chamber for dose rate surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

1.2 This procedure will be used by MKM to operate Ionization chambers during dose rate surveys, these surveys may encompass the following activities;

1.2.1 Surveys performed to determine the exposure rates in personnel work areas.

1.2.2 Surveys performed in restricted areas to define boundaries of radiation areas.

1.2.3 Surveys performed on shipping containers containing radioactive materials.

2.0 General

2.1 Definitions

2.1.1 DDE - Deep Dose Equivalent applies to external whole body exposure, and is the dose equivalent at a tissue depth of 1.0 cm (1000 mg/cm_2).

2.1.2 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.3 Radiation Area. - Any area accessible to personnel in which there exists ionizing radiation at dose-rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrems in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

2.1.4 SDE EX - Shallow Dose Equivalent/Extremities. The shallow dose equivalent for the skin of the extremity receiving the maximum dose.

2.1.5 SDE WB - Shallow Dose Equivalent/Whole Body. The shallow dose equivalent to the skin of the whole body.

2.2 Precautions

Technicians will exercise care not to puncture the thin Mylar window during survey operations.

2.3 Quality Control

The ion chamber will be checked with a gamma standard twice daily and verified to have a current valid calibration.

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-008	Radiation and Contamination Surveys
MKMP-020	Radioactive Check Source Use and Control

3.2 Records

MKMP Form 8-1	Radiation/Contamination Survey
MKMP Form 1-1	Instrument Source Check

3.3 Equipment

Ludlum Model 9 Ionization Chamber or equivalent.

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of operating ionization chambers are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the ionization chambers. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians using ionization surveys are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Initial Preparations

5.1.1 Select the ion chamber to be used in the survey and verify that the instrument has a currently valid calibration.

5.1.2 Turn the instrument selector switch to BATTERY TEST position and verify meter indication falls within the shaded region of the dial indicating the batteries have proper voltage to operate the instrument. Replace the "D" cell batteries if the indication is below the shaded region.

5.1.3 Turn the instrument selector switch to the X1 position and let the instrument warm up for five minute.

5.1.4 Move the instrument to a low background area and adjust "Zero Adjust" knob until meter indicates zero.

5.1.5 Switch the audio toggle switch to the "ON" position.

5.1.6 Check instrument response by placing probe over the check source and observing the meter indication. Record meter indication on MKMP Form 1-1 and determine if indication is within stated values. If indication is not within stated values contact supervisor for instructions.

5.2 Gamma Survey Technique

5.2.1 Ensure the beta shield is covering the Mylar window.

5.2.2 When entering a radiation area of unknown radiation levels turn the range selector switch to the highest scale or the highest scale for the dose rate expected. Rotate the range selector switch downscale until an upscale meter needle deflection is observed.

5.2.3 When obtaining a gamma exposure rate place the entire detector volume in and perpendicular to the radiation field.

5.2.4 Gamma exposure rates are obtained in the area where a workers will be located during work activities. If only a portion of the workers body will be exposed to the field, the highest exposure rate will be used to determine working time.

5.2.5 Gamma exposure rates on waste packages are obtained by placing the center line of the detector at the indicated distance from the package and perpendicular to the radiation field.

5.2.6 Record the highest meter indication in mR/hr and its' location on the forms provided in procedure MKMP-008.

5.3 Beta Survey Technique

CAUTION: The window area of the detector is covered with a 7 mg/cm^2 aluminized Mylar covering and can be easily punctured. Avoid protruding fragments that might puncture the detector face.

5.3.1 When a higher reading is obtained with the beta shield open compared with the beta shield closed, this indicates the presence of beta radiation.

5.3.2 To obtain the beta exposure first obtain a reading with the beta shield closed (CW) as described in Section 5.2. Open the beta shield and obtain a reading (OW) at the same location holding the meter in the same configuration.

5.3.3 Determine the beta exposure using the following formula:

$$\textit{True } \beta \textit{ Exposure} = (OW - CW) \times BCF$$

Where: OW = Open Window reading (beta shield open)
CW = Closed Window reading (beta shield closed)
BCF = Beta Correction Factor
BCF = 2 for reading taken at 30 centimeters
BCF = 5 for reading taken at 4 centimeters

5.3.4 Beta dose rates to the skin of whole body or lens of the eye are obtained in the area where a workers will be located during work activities. If only a portion of the workers body will be exposed to the field, the highest exposure rate will be used to determine working time.

5.3.5 Beta exposure rates to the extremities are obtained by obtaining measurements at 4 centimeters from the surface contacted by the worker.

5.3.6 Record the beta dose rates in mR/hr (β) and location on the forms provided in procedure MKMP-008.

6.0 Attachments

None

Radiation Safety Procedure

for

Direct Reading Dosimeters (DRD)

MKMP-005

Revision 0

Reviewed By: _______________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer Date

Approved By: _______________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist Date

MKM Engineers, Inc.

Procedure MKMP 005
Direct Reading Dosimeters (DRD)

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MKMP-005
Direct Reading Dosimeters (DRD)

1.0 Purpose and Scope

1.1 This procedure will be used by MKM personnel when using direct reading dosimeters (DRD) on radiological projects. These dosimeters can be used to provide an immediate readout of personnel gamma radiation exposure.

1.2 This procedure will apply to all projects where DRDs are used. The requirement for use will be described in the job-specific work plan. This procedure applies to all operations that may require the use of pocket ionization chambers. The requirements for use will be described in job-specific radiation work permits (RWPs)

The following activities are described in Section 5 of this procedure:

a) Zeroing the DRD
b) Wearing the DRD
c) Reading the DRD
d) Off-Scale Direct DRD

2.0 General

2.1 Definitions

2.1.1 Off-Scale DRD - A DRD that either displays the hairline past the maximum numerical value shown on the scale or is completely outside the viewing area.

2.1.2 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.2 Precautions

2.2.1 Technicians issued DRD should take care not to jar, drop, or otherwise cause the instrument to show false readings.

2.2.2 DRDs will be periodically checked during restricted area operations, if the hairline scale is at or past action levels immediately evacuate to the control point and notify the Radiation Safety Officer.

2.3 Quality Control

DRDs will be zeroed each day prior to use or if the DRD exceeds 75% of full scale response during work operations, following the directions in this procedure.

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-006	Radiation Work Permits
MKMP-034	Dosimetry

3.2 Records

Various records may be generated during the performance of this procedure. Dosimeter readings should be logged on the RWP sign-in sheet when departing the restricted area where the dosimeter is used. The original of all records generated as a result of this procedure will be retained in the project files.

MKMP Form 6-1 RWP Sign-in Sheet

3.3 Equipment

Pocket ion chambers calibrated to traceable gamma standards.

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for ensuring that all personnel assigned a task using DRDs are familiar with this procedure and are adequately trained with the specific instrument used to perform radiation surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of DRDs.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians using DRDs are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Zeroing the DRD

5.1.1 Remove the protective cap from the dosimeter and place the contact point on the dosimeter charger.

5.1.2 Place the dosimeter on the charging contact and press down firmly. Look through the dosimeter eyepiece and adjust the charging control until the dosimeter hairline is on zero. Remove the dosimeter from the charger.

5.1.3 Look through the eyepiece of the dosimeter, ensuring that the scale is horizontal and check that the dosimeter hairline is still on zero.

5.1.4 If the hairline has moved significantly away from the zero mark, as necessary, recharge the dosimeter and adjust the hairline above or below zero to compensate for the shift. Recheck after each adjustment.

5.2 Wearing the DRD

5.2.1 The DRDs should be worn, secured to the chest area near the TLD badge. The dosimeter shall be positioned so that it is not in front of the TLD.

5.3 Reading the DRD

5.3.1 Dosimeters should be checked periodically (such as every hour in a radiation area, every quarter hour in a high radiation area) by the user or a Radiation Protection Technician (RPT).

5.3.2 Hold the dosimeter horizontally toward a light source or as directed on a dosimeter reader. Look through the eyepiece, rotate the dosimeter until the scale is also horizontal. If the hairline is off-scale (It cannot be seen when looking through the eyepiece), leave the area immediately and contact a RPT for instructions. If there is more than one person working in the same area, they should all check their dosimeters. Note position of the hairline on the scale, the corresponding reading is the exposure.

5.4 Off-Scale DRD

5.4.1 Attempt to determine why the dosimeter went off-scale and other pertinent information such as:

- Did the individual drop or hit the dosimeter?
- Has the dosimeter been responding as anticipated?
- Where was the individual working and for how long?
- What were the exposure rates in the area?
- How long has it been since the user read the dosimeter?
- What was the last dosimeter reading that the individual remembers?
- Were there any other workers in the same area wearing DRDs? If so, what were their DRD readings?

5.4.2 If the individual recalls hitting or dropping the dosimeter, and in leaving the area immediately remembers the reading prior to the occurrence, this reading may be recorded on the RWP Sign-in Sheet. Replace the dosimeter, initiate an investigation, and have the questionable unit drift-tested and response checked.

5.4.3 If the individual does not remember dropping or hitting the dosimeter or if there is any doubt about the circumstances concerning the occurrence, initiate an investigation and have the TLD badge processed, if there is an estimated exposure greater than 100 millirem.

5.4.4 If the sum of the exposure estimate from Step 5.4.3 exceeds project administrative exposure limits, do not permit the individual to enter the Controlled Area until the TLD results are known and all exposure records have been updated; otherwise, an individual may be permitted entry into controlled areas after issue of a new dosimeter. If an exposure in excess of limits is suspected or verified, notify the RSO.

6.0 Attachments

None

Radiation Safety Procedure

for

Radiation Work Permits

MKMP-006

Revision 0

Reviewed By: [signature] 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer Date

Approved By: [signature] 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist Date

MKM Engineers, Inc.

Procedure MKMP 006
Radiation Work Permits

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MKMP - 006
Radiation Work Permits

1.0 Purpose and Scope

1.1 This procedure describes the circumstances when a Radiation Work Permit (RWP) is required on MKM Projects and addresses the requirements for planning, developing, issuing, using, modifying, and terminating RWP's. The RWP provides a complete document addressing existing radiological conditions, work scope, radiological limitations, specific protective requirements, ALARA considerations, and instructions to radiation workers. Adherence to this procedure will provide reasonable assurance that personnel exposures will be below specified limits, personnel will remain free of contamination and contamination will not be spread beyond the designated contaminated area.

?

1.2 This procedure will be used to initiate a RWP prior to jobs where GPI personnel enter areas where contamination is present above the limits specified in the Radiation Safety Manual, when radiation exposure rates classify the work area as a Radiation Area, when Air concentrations could exceed 10% of the Derived Air Concentration, and at the discretion of the Health Physics Technician or Project Manager. This procedure describes the radiological surveys required to generate a RWP and provides guidelines to specific protective measures required based upon the radiological conditions in the work area.

2.0 General

2.1 Definitions

2.1.1 Airborne Radioactivity Area. - A room, enclosure or area in which radioactive material is dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases and the concentration of the dispersed radioactive materials is in excess of:

a) The derived air concentrations (DAC's) specified in Table 1, column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations.

b) Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

2.1.2 Contaminated Area - A restricted area that has radioactive materials above the limits specified in the Radiation Safety Manual in the form of dusts, particulates, and sorbed contaminants that could adhere to personnel clothing and skin while working in the area.

2.1.3 Radiation Area. - Any area accessible to personnel in which there exists ionizing radiation at dose-rates such that an individual could receive a deep dose equivalent in excess of 5 mrems in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

2.1.4 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.5 Personnel Survey - A survey with radiation detection instruments that measures the amount of radioactive materials on personnel clothing or skin surfaces.

2.1.6 LDE - Lens Dose Equivalent. Exposure to the lens of the eye taken as the dose equivalent at a tissue depth of 0.3 cm.

2.1.7 SDE EX - Shallow Dose Equivalent/Extremities. The shallow dose equivalent for the skin of the extremity receiving the maximum dose.

2.1.8 SDE WB - Shallow Dose Equivalent/Extremities. The shallow dose equivalent to the skin of the whole body.

2.1.9 TEDE - Total Effective Dose Equivalent. Total effective dose equivalent is the sum of the deep dose equivalent (external dose) and the committed effective dose equivalent (internal dose).

2.1.10 TODE - Total Organ Dose Equivalent. Total organ dose equivalent is the sum of the external component (deep dose equivalent) and the internal component (committed dose equivalent to an organ or tissue).

2.2 Quality Control

Instrumentation used in the surveys will be checked with standards daily and verified to have current valid calibration

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-001	Operation of Contamination Survey Meters
MKMP-002	Alpha-Beta Sample Counting Instrumentation
MKMP-003	Operation of Miro-R Survey Meters
MKMP-004	Operation of Ionization Chambers
MKMP-005	Direct Reading Dosimeters
MKMP-007	Air Sampling and Sample Analysis
MKMP-008	Radiation and Contamination Surveys
MKMP-010	ALARA - As Low As Reasonably Achievable
MKMP-014	Radiologically Restricted Areas
MKMP-015	Personnel Protective Equipment

3.2 Records

MKMP Form 2-4	Sample Calculation Worksheet
MKMP Form 6-1	Radiation Work Permits
MKMP Form 6-2	RWP Access Sheets
MKMP Form 7-1	Air Sample Data Sheet
MKMP Form 8-1	Radiation and Contamination Survey

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the tasks of working in Contaminated Areas, Radiation Areas, and Airborne Radioactivity Areas are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

4.2 Radiation Safety Officer-The Radiation Safety Officer (RSO) is responsible for monitoring compliance with this procedure and training of personnel working in Contaminated Areas, Radiation Areas, and Airborne Radioactivity Areas. The RSO ensures the Health Physics Technician are qualified by training and experience to perform the requirements of this procedure. The RSO is responsible for issue, control, and termination of RWPs.

4.3 Project Manager - The Project Manager is responsible for initiating the RWP. The Project Manager periodically reviews RWP practices to ensure procedural compliance.

4.4 Health Physics Technicians - Health Physics Technician is responsible for performing the necessary surveys in support of the RWP's, and job coverage of RWP's. The Health Physics Technician has the responsibility to stop work if any unsafe condition exists in the work area, non-compliance with procedural requirements occurs, or significant changes in radiological conditions occur.

4.5 Radiation Workers - Radiation workers are responsible to read, understand, sign, and comply with the provisions of the RWP.

5.0 Procedure

5.1 Planning the RWP.

5.1.1 The Project Manager initiates the RWP process by filling in the description of work section of the RWP. A detailed work plan is encouraged but not required and can be attached to the RWP with appropriate reference in the description of work section.

5.1.2 The Health Physics Technician enters the date the RWP was initiated and assigns a consecutive RWP number to the document. Enter the end date which will correspond to the estimated completion date for the project.

5.1.3 The Project Manager meets with the RSO or designee to describe as much as possible about the nature of the work to be performed, the specific components or equipment to be worked on, the positions the workers may take to perform the work, the possibility of releasing radioactive contamination during the work activities, and the potential for changing radiation dose rates as work progresses.

5.1.4 The Health Physics Technician and Project Manager shall:

- Obtain and review any previous surveys performed in the work area.
- They obtain all information available on the identity, form and quantities of radionuclides present in the work area.

- Review facility drawings, if available to determine ventilation flows, component and equipment layouts, and building structures which can be used for contamination barriers.

5.1.5 The Radiation Safety Officer selects the necessary instrumentation, equipment and protective clothing to perform surveys in the work area. If contamination is expected in the work area, wrap equipment taken into work area to prevent contamination of equipment.

5.1.6 If anticipated contamination levels are above the limits specified in the Radiation Safety manual, establish a contaminated area as described in procedure MKMP-014 before entry into the area.

5.2 The RWP Pre-Job Survey

5.2.1 After entering the specified work area, The Health Physics Technician obtains radiation exposure rates in the area where the workers will be positioned during work activities. Also survey the adjacent area and path route to the work area to identify any "hot spots" where elevated readings are observed. Record readings on survey forms as specified in procedure MKMP-008.

5.2.2 Obtain smear samples from the work area, adjacent areas and along the path route to the work area. The number of smear samples in the work area should be 2 to 3 per 3 meter by 3 meter grid. If there is a specific piece of equipment which will be worked on, obtain an additional number of smear samples on the equipment to adequately characterize the activity distribution on the item. The number of smear samples in adjacent areas and along the path route to the work area should be one per 3 meter by 3 meter area. (see procedure MKMP-008).

5.2.3 Determine what additional safety hazards may be encountered during the work. (Confined space entry, electric equipment or mechanical equipment requiring lock out tags, falling objects, bumping hazards, slippery surfaces, fire hazards, etc.) An analysis of each hazard and precautions to be taken is included in the Site Health and Safety Plan.

5.2.4 Exit the area using procedures established in MKMP-015.

5.2.5 Count smear samples and any air samples collected in the area.

5.2.6 Authorize the RWP Survey section by signature.

5.3 Issuing the RWP.

NOTE: When the RWP request is received from the PM, the RSO will assign an RWP number.

5.3.1 A Health Physicist, the RSO or a Health physics Technician who surveyed the work area or obtained information from records, enters exposure rates measured during survey of work area in the radiation conditions section of the RWP. Also note any "hot spots" found during the survey in this section. Calculate working time in the specified locations and enter the time in the area provided on the RWP. Attach survey forms if necessary.

5.3.2 Enter the smearable contamination conditions found in the work area and other areas with elevated contamination in the contamination conditions section of the RWP.

5.3.3 Enter results of air sample (s), if taken, in the Area Air Concentration section of the RWP.

5.3.4 Based on current and anticipated contamination conditions in the area, the Health Physics Technician determines the required protective clothing to protect workers during work activities.

5.3.5 Based on contamination conditions and anticipated resuspension, determine respiratory protection requirements on the RWP.

5.3.6 Select air sampling requirements if air concentrations are likely to exceed 10% of the Derived Air Concentration (DAC).

5.3.7 Determine and mark the dosimetry requirements on the RWP form.

5.3.8 Determine Monitoring Requirements for HP coverage and job observation by marking appropriate boxes on the RWP.

5.3.9 Select or enter training requirements for workers on the project.

5.3.10 Indicate if pre-job or ALARA briefings are required for workers.

5.3.11 Authorize the ALARA/Radiological Protection requirements section by signature.

5.4 <u>Hold Points/Special Instructions</u>

5.4.1 Note any safety hazards in the Hold Points/Special Instructions section of the RWP and check any permits of lock out tags required.

5.4.2 Indicate any special precautions associated with PPE, dosimetry, monitoring, respiratory protection, training or ALARA.

5.4.3 Authorize this section by signature.

5.5 <u>Approvals</u>

The RWP shall be approved by the project manager and the RSO as a minimum, prior to work. MKM Health Physics Management approval shall be required for high exposure work.

5.6 Using the RWP

5.6.1 A pre-job briefing is held with the individuals performing the work described in the RWP. The following topics will be discussed in the pre-job briefing:

a) Complete description of the work tasks to be performed and method to minimize exposures to radiation and contamination while performing these work tasks.

b) Discussions of the radiation, contamination, and airborne radioactive materials in the work area and situations which could result in increased levels of these components.

c) Safety concerns which could be encountered during work activities.

d) Emergency procedures.

e) Discussions of the protective equipment requirements and the monitoring requirements of the RWP.

5.6.2 The Health Physics Technician will compile the current year dose for the individuals performing RWP work to verify the radiation exposure received during the work activities will not result in the individuals dose exceeding the limits specified in the Radiation Safety Manual. The current radiation exposures are listed on the RWP sign in sheet.

5.6.3 Each individual entering the RWP work area is required to read the RWP and sign the RWP sign in sheet indicating the individual understands the provisions of the RWP and will comply with the RWP requirements.

5.6.4 The Health Physics Technician (or individual) logs the time the individual entered the work area along with the reading on the individuals Pocket Ion Chamber (PIC) or Direct Reading Dosimeter (DRD), if worn. The health physics Technician (or individual) also indicates if the individual wore a respirator during the work activities.

5.6.5 When the individual exits the work area, the Health Physics Technician (or individual) will log the time the individual leaves the area and the individuals DRD reading. If the individual returns to the work area, another signature entry (and corresponding line entries) must be made on the sign in sheet.

5.7 Modifying the RWP.

5.7.1 In the event that conditions or scope of the work changes that do not justify the generation of a new RWP, modifications of the RWP may be made by the Health Physics Technician and the Project Manager.

5.7.2 To modify the RWP, each change will be made with a single line cross out of the text or item. The RSO representative and the Project Manager shall both initial and date adjacent to each change.

5.7.3 The RSO representative shall communicate all changes to the individuals working under the RWP.

5.8 Terminating the RWP.

5.8.1 The RWP is terminated when the end date of the RWP is reached or can be terminated by one of the following reason

a) The job has been completed,
b) There is a significant change in the scope of work,
c) There is a significant change in the radiological conditions,
d) There has been violations of the RWP requirements,
e) The RWP is revised.

5.8.2 When the RWP is terminated before the end date, a single line is drawn through the end date and a new end date recorded in its place. The person terminating the RWP initials adjacent to the change. The RWP can be terminated by the Health Physics Technician, RSO representative, or the Project Manager.

6.0 Attachments

MKMP Form 6-1 Radiation Work Permit
MKMP Form 6-2 RWP Access Log

MKM Engineers, Inc.

RWP Access Log

RWP No. ______________________ Revision No. ______________________ Date ______________________

Work Location ______________________________ Start Date ______________ End Date ______________

Date	Name	SSN/IDN	Badge/TLD	PIC/DRD #	Time In	Time Out	Dose In	Dose Out	Total Dose	Resp (✓)

Form MKMP 6-2 - RWP Access Log - 8/99

Radiation Safety Procedure

for

Air Sampling and Sample Analysis

MKMP-007

Revision 0

Reviewed By: ______________________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer Date

Approved By: ______________________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist Date

MKM Engineers, Inc.

Procedure MKMP 007

Air Sampling and Air Sample Analysis

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MKMP - 007
Air Sampling and Sample Analysis

1.0 Purpose and Scope

1.1 This procedure provides the methods MKM utilizes in operation of air samplers and calculation of radioactive particulate activity in air samples. This procedure describes the method used to calculate DAC hour exposures to workers. Adherence to this procedure will provide reasonable assurance that the surveys performed have accurate and reproducible results.

1.2 This procedure will be used by MKM to operate air samplers during surveys and work activities at customer facilities and calculate and record DAC-Hour exposures to workers. Air samples are performed when the average removable alpha and beta contamination on facility surfaces, equipment and waste packages exceed the contamination limits specified in table 1 of the radiation safety manual. Air monitoring shall be performed in areas with the potential to exceed 10 percent of any derived air concentration (DAC

2.0 General

2.1 Definitions

2.1.1 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Smear sample survey - A survey technique using filter papers (smears) to determine quantities of alpha and beta emitting radioactive material which can be removed from facility surfaces and waste packages.

2.1.3 Air sample survey - A survey technique which collects particulates from a known volume of air and determines the concentrations of radioactive materials associated with the airborne particulates.

2.1.4 Annual Limit on Intake (ALI). - The annual limit on intake (ALI) of radioactive materials is the smaller amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year (40 hours per week for 50 weeks) that would result in a committed effective dose equivalent (CEDE) of 5 rem or a committed dose equivalent (CDE) of 50 rems to any individual organ or tissue.

2.1.5 Derived Air Concentration (DAC). - Derived air concentration is the concentration of a given radionuclide in air which, if breathed by the "reference man" for a working year (40 hours per week for 50 weeks) under the conditions of light work (inhalation rate of 1.2 cubic meters of air per hour), results in an intake of one ALI.

2.1.6 DAC-Hour - The product of the concentration of radioactive material in air (expressed as a multiple of the derived air concentration for each nuclide) and the time of exposure to that nuclide, in hours. 2000 DAC-Hours represents one ALI.

2.1.7 Airborne Radioactivity Area. - A room, enclosure or area in which radioactive material is dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases and the concentration of the dispersed radioactive materials is in excess of:

a) The derived air concentrations (DAC's) specified in Table 1, column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations (Also noted in Appendix B of this manual), or

b) Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI).

2.2 Quality Control

The alpha/beta sample counter used to count air samples will be calibrated daily with a radioactive source with activity traceable to the National Institute of Standards and Technology (NIST).

3.0 References, Records and Equipment

3.1 References

RSM	Radiation Safety Manual
MKMP-002	Alpha-Beta Sample Counting Instrumentation
RG 8.25	*Air sampling in the Workplace*

3.2 Records

MKMP Form 1-1 Daily Calibration Log.
MKMP Form 2-4 Sample Calculation Worksheet.
MKMP Form 7-1 Air Sample Data Sheet
MKMP Form 7-2 Daily Air Sample Record
MKMP Form 7-3 Daily Air Sample Record Continuation Sheet
MKMP Form 7-4 Airborne Particulate Radiological Survey Form

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of air sampling and air sampling analysis are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the air sampling and air sampling analysis. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians performing air sampling and air sampling analysis are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Initial Preparations

5.1.1 Select the air sampler to be used for the type of sample and verify that the instrument has a currently valid calibration. If the work area contains radioiodine or radioactive gases of tritium, contact the radiation safety officer for special sampling procedures before proceeding.

a) Area air samples are normally collected with a low volume sampler having a nominal air flow of 1 CFM to 5 CFM.

b) Breathing zone air samples are normally collected using lapel air samplers which have a nominal air flow of 1 to 3 liters per minute.

c) All air sampling devices shall be calibrated to ensure accurate sample volumes are collected. The frequency of calibration shall not exceed one (1) year.

5.1.2 Attach the air sampling head to the air intake of the low volume sample pump or to the tygon tubing of the lapel sampler.

5.1.3 Obtain the filter paper to be used in the sample and mark the back side of the filter with a unique number which will represent the sample. During collection and handling of air sample filter papers, caution must be used to prevent the samples from being contaminated by other radioactive materials.

5.1.4 Place the filter paper in the holder and position the sampler as indicated below:

a) Area air samples are collected by placing the sample head at a distance of 3 to 6 feet above the floor and as close to the work location as practical. If there is an air flow in the work area the sampler should be placed "down wind" of the area where workers will be resuspending radioactive particulates into the workers atmosphere.

b) Lapel air samples are collected from the workers breathing zone. The sample head is attached to the shoulder of the worker with the sample head facing forward. The tygon tubing connecting the sample head to the pump is run down the back of the worker with the sample pump attached to the workers belt.

5.2 Collecting the sample

5.2.1 When the sample head is in position, start the sample pump and adjust the flow rate to the highest flow rate which can be maintained without flow rate fluctuations.

5.2.2 Record the time the sample was started and the initial flow rate of the sample pump on MKMP Form 7-1, the Air Sample Data Sheet.

5.2.3 If possible, identify the radionuclides which will be encountered in the work area and record the radionuclides along with the DAC for each radionuclide in the space provided on the Air Sample Data sheet. If a mixture of radionuclides are present, the DAC used in calculations of DAC-Hours will be the most restrictive concentration.

5.2.4 Collect the sample for the maximum time possible which represents the exposure encountered by the worker.

5.2.5 At the end of the collection period, note flow rate of the sample pump and record this flow rate and the time which sampling stopped on the Air Sample Data sheet.

> **Caution:** Be sure not to remove activity from the sample surface. Handle the filter carefully.

5.2.6 Remove the sample filter and place the filter in an individual envelope or poly bag to ensure no possibility of contamination by other sources of radioactivity.

5.2.7 Record the names of workers who were in the area and the time spent in the work area on the Air Sample Data sheet.

5.2.8 Determine the average sample flow rate by adding the starting sample flow rate and the ending sample flow rate and dividing by 2. Record the average sample flow rate in the space provided on the Air Sample Data sheet.

5.2.9 Calculate the total air volume sampled by multiplying the average sample flow rate in cubic centimeters per minute by the total minutes the sampler operated using the indicated spaces on the Air Sample Data sheet.

5.3 Determining minimum detectable activities (MDA). - During calculations of air concentrations in the following sections, the MDA for each analysis is calculated to determine the statistical significance of the calculated air concentrations.

5.3.1 For each air concentration calculation (alpha and beta) in the following sections, calculate the MDA using the following formula:

$$MDA\ in\ uCi/cm^3 = \frac{2.71+3.29\sqrt{\frac{R_B}{T_B}+\frac{R_B}{T_{S+B}}}}{(2.22X10^6)(E)(V)}$$

Where:

E = Counter efficiency in CPM/DPM
R_B = Background Count Rate in CPM
T_B = Background Counting Time in minutes
T_{S+B} = Sample Counting Time in minutes
V = Sample Volume in cm^3
2.22×10^6 = Disintegrations per minute per microCurie (DPM/μC)

5.3.2 If the MDA is larger than 10% of the Derived Air Concentration, recount the background to lower the MDA. (The maximum counting time should not exceed 1 hour for background and 30 minutes for the sample.) Enter the MDA for each air concentration calculated in the space provided on the Air Sample Data sheet.

5.4 Initial air sample analysis - The initial analysis of the air sample provides the air concentrations for short lived radionuclides and a first estimate of the long lived air concentrations. In situations in which there is a potential for worker intakes to exceed 40 DAC-hours in a week or if the radionuclides of interest are short lived, air samples should be analyzed promptly (within 15 minutes)on a daily basis. Sample results should be available before work resumes the following day.

5.4.1 Air particulate samples are to be analyzed as a minimum for gross alpha and gross beta activity using a Ludlum Model 2929 Dual Channel Scaler or equivalent.

5.4.2 Place the air sample in the sample counter with the collection side toward the detector. Count the air sample and calculate sample activity as described in MKMP-002 and record results on MKMP Form 2-4.

5.4.3 Record the Alpha and Beta sample DPM results from MKM form 2-4 to the Air Sample Data sheet.

5.4.4 Calculate the alpha and beta air concentrations using the following formula.

$$AIR\ CONCENTRATION\ IN\ uCi/CM^3 = \frac{ALPHA\ or\ BETA\ DPM}{(2.22X10^6\ DPM/uCi)(\ SAMPLE\ VOLUME\ IN\ CM^3)}$$

5.4.5 Enter the alpha and beta air concentrations on the Air Sample Data sheet in the space provided for initial air concentrations.

NOTE: If the air sample concentration is greater than 10% of the DAC value, notify the RSO and control the exposure to workers to minimize intake of radioactive materials.

5.4.6 If the air concentration is less than 10 percent of the most restrictive DAC, no further analysis of the air sample is required. If the air concentration exceeds 10% of the DAC concentration, proceed with the analysis in section 5.5.

5.5 Air sample analysis for long lived radionuclides - This analysis allows for the decay of naturally occurring radionuclides and provides equations for correcting air concentrations for naturally occurring radionuclides.

5.5.1 Air particulate samples are analyzed following 4 hours, 24 hours and one week of decay for gross alpha and gross beta using a Ludlum Model 2929 Dual Channel Scaler or equivalent.

5.5.2 Place the air sample in the sample counter with the collection side toward the detector. Count air sample and calculate sample activity as described in MKMP-002 and record results on MKM Form 2-4. In the Sample No. Column also record the time when the air sample was counted.

5.5.3 Record the Alpha and Beta sample DPM results from MKMP Form 2-4 to the Air Sample Data sheet.

5.5.4 Calculate the alpha and beta air concentrations using the following formula.

$$AIR\ CONCENTRATION\ IN\ uCi/CM^3 = \frac{ALPHA\ or\ BETA\ DPM}{(2.22X10^6\ DPM/uCi)(SAMPLE\ VOLUME\ IN\ CM^3)}$$

5.5.5 Enter the alpha and beta air concentrations on the Air Sample Data sheet in the space provided for 4 hour decay air concentrations. If the 4 hour decay air concentration is below 10% of the DAC no further analysis is required.

5.5.6 If the 4 hour air concentration is above 10% of the DAC value, recount the air sample following 24 hours of decay from the time the sample was stopped. Calculate the air concentration using the formula in step 4. and record the air concentrations in the space provided for the 24 hour decay concentration on the Air Sample Data sheet. If the 24 hour decay air concentration is below 10% of the DAC value no further analysis is required.

5.5.7 If the air concentration is above 10% of the DAC the sample concentrations are corrected for radon using the following formula:

$$A_{LL} = \frac{A_{24} - A_4\,(e^{-0.0655(\Delta T)})}{(1 - e^{-0.0655(\Delta T)})}$$

Where:

A_{LL} = Long lived air concentration
A_4 = Air concentration following 4 hour of decay
A_{24} = Air concentration following 24 hour of decay
0.0655 = Pb-212 decay constant
ΔT = Elapsed time (in hours) between 4 hour decay count and 24 hour decay count

5.5.8 Record the long lived air concentration obtained using the above formula in the calculated air concentration space on the Air Sample Data sheet. If the calculated long lived air concentration is below 10% of the DAC value no further analysis is required.

5.5.9 If the calculated long lived air concentration (A_{LL}) is above 10% of the DAC, save air sample and recount following one week of decay.

5.5.10 Calculate the air concentration using the following formula and record the results in the one week decay space on the Air Sample Data sheet.

$$AIR\ CONCENTRATION\ IN\ uCi/CM^3 = \frac{ALPHA\ or\ BETA\ DPM}{(2.22X10^6\ DPM/uCi)(SAMPLE\ VOLUME\ IN\ CM^3)}$$

5.5.11 If air concentrations exceed 10% of the DAC values notify the RSO for further instructions. Save the air sample for possible further analysis. For air samples which exceed 10% of the DAC values, an exposure is assigned to the workers residing in the area where the sample was taken.

5.6 *Assignment of DAC-Hour exposures to workers*

5.6.1 For air samples which exceed 10% of the DAC values, calculate the workers DAC-Hour exposure using the following formula:

$$Exposure\ in\ DAC\text{-}Hours = \frac{A\ X\ B}{C}$$

Where:

A = Area or Lapel air sample concentration in uCi/cm^3
B = Hours worker was in the calculated air concentration
C = DAC air concentration in uCi/cm^3 from regulatory reference

5.6.2 Enter DAC-Hour exposure in the column provided on the Air Sample Data sheet. If respiratory protection was used during the exposure period, contact the RSO for the protection factor used to adjust DAC-Hour exposure.

6.0 Attachments

MKMP Form 7-1 Air Sample Data Sheet
MKMP Form 7-2 Daily Air Sample Record
MKMP Form 7-3 Daily Air Sample Record Continuation Sheet
MKMP Form 7-4 Airborne Particulate Radiological Survey Form

MKM Engineers, Inc.

Air Sample Data Sheet

Sample # ____________________ Date ____________________

Description: ____

____

Radionuclides: ____________________ DAC value: ____________________

____________________ DAC value: ____________________

____________________ DAC value: ____________________

____________________ DAC value: ____________________

____________________ DAC value: ____________________

Initial sample flow rate: ______________ Time sampler on: ______________

Final sample flow rate: ______________ Time sampler off: ______________

Average sample flow rate: ______________ Total sample time: ____________ hours

Total sample volume: ______________ cm^3

SAMPLE

Initial Air Concentration:

Alpha = ____________ $\mu Ci\ \alpha/cm^3$ Beta = ____________ $\mu Ci\ \beta/cm^3$

MDA = ____________ $\mu Ci\ \alpha/cm^3$ MDA = ____________ $\mu Ci\ \beta/cm^3$

4 Hour Decay Air Concentration:

Alpha = ____________ $\mu Ci\ \alpha/cm^3$ Beta = ____________ $\mu Ci\ \beta/cm^3$

MDA = ____________ $\mu Ci\ \alpha/cm^3$ MDA = ____________ $\mu Ci\ \beta/cm^3$

24 Hour Decay Air Concentration:

Alpha = ____________ $\mu Ci\ \alpha/cm^3$ Beta = ____________ $\mu Ci\ \beta/cm^3$

MDA = ____________ $\mu Ci\ \alpha/cm^3$ MDA = ____________ $\mu Ci\ \beta/cm^3$

Calculated Long Lived Air Concentration:

Alpha = ____________ $\mu Ci\ \alpha/cm^3$ Beta = ____________ $\mu Ci\ \beta/cm^3$

MDA = ____________ $\mu Ci\ \alpha/cm^3$ MDA = ____________ $\mu Ci\ \beta/cm^3$

One Week Decay Air Concentration:

Alpha = ____________ $\mu Ci\ \alpha/cm^3$ Beta = ____________ $\mu Ci\ \beta/cm^3$

MDA = ____________ $\mu Ci\ \alpha/cm^3$ MDA = ____________ $\mu Ci\ \beta/cm^3$

Worker Name	Time In	Time Out	Total Time (Hrs)	DAC-Hour Exposure

Page ___ of ___

MKM Engineers, Inc.

Daily Air Sample Record

DATE:______________ PAGE ___ OF ___

COUNTING and AIR SAMPLING INSTRUMENTATION

METER MODEL/SERIAL NO		CAL DUE DATE	PROBE MODEL NO	SERIAL NO
A/ SAMPLER MODEL #		SERIAL NO	AIR FLOW RATE	CAL DUE DATE

COUNTER BACKGROUND AND EFFICIENCY DATA

COUNT TIME (minutes)		SOURCE S/N	ACTIVITY (dpm)	RADIONUCLIDE
BKGD COUNTS	BKGD CPM	EFF. COUNTS	CORRECTED CPM	% EFFICIENCY

TECHNICIAN (Print/*Sign*): ______________________________

AIR SAMPLE DATA

SAMPLE I.D.			
A/S FLOW (cfm)	A/S TIME ON	A/S TIME OFF	NET TIME (min)
TIME COUNTED	COUNT TIME	TOTAL COUNTS	ACTIVITY uCi/cc

TECHNICIAN (Print/*Sign*): ______________________________

AIR SAMPLE DATA

SAMPLE I.D.			
A/S FLOW (cfm)	A/S TIME ON	A/S TIME OFF	NET TIME (min)
TIME COUNTED	COUNT TIME	TOTAL COUNTS	ACTIVITY uCi/cc

TECHNICIAN (Print/*Sign*): ______________________________

REVIEWED BY (Print/*Sign*): ______________________________

ACTIVITY FORMULA FOR 2" FILTER PAPER:

$$\frac{\text{CORRECTED COUNTS PER MINUTE}}{\text{6.2E10*NET SAMPLE TIME*FLOW RATE*EFFICIENCY}}$$

MKM Engineers, Inc.

Daily Air Sample Record
Continuation Sheet

DATE:__________ PAGE ___ OF ___

AIR SAMPLE DATA

SAMPLE I.D.			
A/S FLOW (cfm)	A/S TIME ON	A/S TIME OFF	NET TIME (min)
TIME COUNTED	COUNT TIME	TOTAL COUNTS	ACTIVITY uCi/cc

TECHNICIAN (Print/*Sign*): __________

AIR SAMPLE DATA

SAMPLE I.D.			
A/S FLOW (cfm)	A/S TIME ON	A/S TIME OFF	NET TIME (min)
TIME COUNTED	COUNT TIME	TOTAL COUNTS	ACTIVITY uCi/cc

TECHNICIAN (Print/*Sign*): __________

AIR SAMPLE DATA

SAMPLE I.D.			
A/S FLOW (cfm)	A/S TIME ON	A/S TIME OFF	NET TIME (min)
TIME COUNTED	COUNT TIME	TOTAL COUNTS	ACTIVITY uCi/cc

TECHNICIAN (Print/*Sign*): __________

AIR SAMPLE DATA

SAMPLE I.D.			
A/S FLOW (cfm)	A/S TIME ON	A/S TIME OFF	NET TIME (min)
TIME COUNTED	COUNT TIME	TOTAL COUNTS	ACTIVITY uCi/cc

TECHNICIAN (Print/*Sign*): __________

REVIEWED BY (Print/*Sign*): __________

MKM Engineers, Inc.

Airborne Particulate Radiological Survey Form

Location/Area	Purpose	RWP#	Date	Time

Type ☐ Lapel/Breathing Zone ☐ General Area ☐ Alpha ☐ Beta ☐ Media	Requestor

Instrument and Probe Type and Serial Number		Surveyor(s) Printed Name	Surveyor(s) Signature

SAMPLING INFORMATION

#	Name (BZ) or Specific Location (GA)	Sampler Type	Sampler S/N	Cal Date	Start Time	Stop Time	Rotometer Start	Rotometer Stop	Start Flow Rate (L)	Stop Flow Rate (L)	Average Flow Rate (L)	Total Volume (ml) *V*

COUNTING INFORMATION

Beta-Gamma Airborne Radioactivity

Efficiency (*E*) _________ *cpm* / *dpm* Isotope _______________

Counting Data Attached ☐ Yes ☐ No

Alpha Airborne Radioactivity

Efficiency (*E*) _________ *cpm* / *dpm* Isotope _______________

Counting Data Attached ☐ Yes ☐ No

#	Count Date/Time	Gross cpm (*S*)	Bkgd cpm (*B*)	µCi/ml (*1*)	MDA (µCi/ml)	DAC	DAC Fraction (*2*)	DAC Hours (*3*)	Count Date/Time	Gross cpm (*S*)	Bkgd cpm (*B*)	µCi/ml (*1*)	MDA (µCi/ml)	DAC	DAC Fraction (*2*)	DAC Hours (*3*)

Conversions: $ft^3 \times 2.8E4 = ml$ $m^3 \times 1E6 = ml$ liter x 1E3 = ml FA = 1.05 (Glass Fiber Filter)

NOTE: If DAC fraction using gross alpha and/or beta activity is greater than 0.1 for most limiting radionuclide, may prform nuclide identification (w.g., gamma spectroscopy) to determine actual limit.

Remarks:	
Completed By: Date	Reviewed/Approved By: Date

Page ___ of ___

Radiation Safety Procedure

for

Radiation and Contamination Surveys

MKMP-008

Revision 0

Reviewed By: ________________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer — Date

Approved By: ________________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist — Date

MKM Engineers, Inc.

Procedure MKMP 008
Radiation and Contamination Surveys

LIST OF EFFECTIVE PAGES
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1.0 Purpose and Scope

1.1 This procedure provides the methods MKM uses to perform and document radiation and contamination surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results. Adherence to this procedure also provides adequate control of radiation exposures which meets MKM's goal of maintaining radiation exposures As Low As Reasonably Achievable (ALARA).

1.2 This procedure will be used by MKM personnel to perform radiation and contamination surveys at customer facilities. The following types of surveys may be performed using this procedure;

1.2.1 Surveys performed for shipping radioactive materials.

1.2.2 Surveys performed to characterize facilities, sites, and items contaminated with radioactive materials.

1.2.3 Surveys performed to provide direction in decontamination and decommissioning facilities and sites.

2.0 General

2.1 Definitions

2.1.1 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Contamination Survey - A survey technique to determine fixed and removable radioactive contamination on components and facilities.

2.1.3 Radiation Survey - A survey technique to determine radiation exposure rates to individuals working in areas containing radioactive materials.

2.1.4 ALARA - An approach to radiation exposure control to maintain personnel exposures as far below the federal limits as technical, economical and practical considerations permit.

2.2 Quality Control

2.3.1 Instrumentation used in the surveys will be checked with standards daily and verified to have current valid calibration.

2.3.1 All radiation and contamination surveys will be reviewed by the Radiation Protection Supervisor and the RSO for accuracy and completeness.

3.0 References, Records and Equipment

3.1 References

10 CFR 20, Subpart F	*Surveys and Monitoring*
10 CFR 20.2103	*Records of Surveys*
RSM	Radiation Safety Manual
MKMP-001	Operation of Contamination Survey Meters
MKMP-002	Alpha-Beta Sample Counting Instrumentation
MKMP-003	Operation of Micro-R Survey Meters
MKMP-004	Operation of Ionization Chambers
MKMP-015	Personnel Protective Clothing
MKMP-016	Radioactive Materials Brokering

3.2 Records

MKMP Form 8-1	Radiological Survey Report
MKMP Form 8-2	Radiation and Contamination Survey
MKMP Form 8-3	Radiation and Contamination Survey Results

3.3 Equipment

Radiation and Contamination Survey Meters will be selected based on job-specific requirements and will be identified in the Site Specific Work Plan. — RWP ?

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of performing radiation and contamination surveys are familiar with this procedure and are adequately trained with the specific instrument being used to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in performing radiation and contamination surveys. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Waste Broker - The Waste Broker is responsible to interpret and utilize the results of surveys in the shipment and characterization of waste to comply with applicable federal regulations.

4.4 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.5 Technicians - Technicians performing radiation and contamination surveys are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Initial Preparations

5.1.1 Obtain and review any previous surveys performed in the area to determine radiation conditions which will be encountered.

5.1.2 Obtain appropriate survey instruments and prepare the instruments for use.

5.1.3 Obtain the necessary forms, smears, and protective clothing which will be used during the survey.

5.1.4 Plan the strategy for performing the survey before entering the area to reduce exposure time in the area.

5.1.5 If smearable contamination is expected to be above allowable limits, set up an anticipated contamination entry into the area which will prevent the spread of contamination from the area.

5.2 Radiation Surveys

5.2.1 If radiation levels are unknown or previous surveys are in question, first measure general radiation levels in the area with the Micro-R-Meter or the Dose Rate Meter to determine if elevated radiation levels exist in the survey area. Alert personnel who will be working in the area of any elevated levels.

5.2.2 Small Areas/Items/Waste Containers - This survey technique is used to establish exposure rates from small areas, items or containers which contain radioactive materials.

a) Scan the entire surface area of the area, item, or container with a Micro-R-Meter or Dose Rate Meter and record the location and readings found on MKMP Form 8-1.

b) Measure the exposure rate at 1 meter from all surfaces or sides of the area, item or container and record the location and readings on MKMP Form 8-1.

5.2.3 Facility Surveys - This survey technique is used to release facilities (buildings, etc) to "unrestricted" status or determine status of facilities requiring decontamination and decommissioning.

a) Establish a 1 meter by 1 meter grid system of the facility surfaces using marking system which assigns a unique number/letter system to the center of each grid. Graphically illustrate the location of the grid system on MKMP Form 8-2.

b) Using a Micro-R-Meter obtain radiation levels at 1 meter from the grid center point and at contact with the grid center point. Record reading on MKMP Form 8-3. If elevated readings are noted, scan the surface of the grid and note location of any elevated areas with marker and on MKMP Form 8-3.

c) Obtain four Micro-R-Meter readings from locations surrounding the facility or within the facility which do not contain activity. This establishes a background level for comparison to the reading taken in step b above.

5.2.4 Area Surveys - This survey technique is used to release land masses to "unrestricted" status or determine status of areas requiring decontamination before release.

a) Establish a 10 meter by 10 meter grid system of the area to be surveyed using surveyor stakes which are numbered with a unique number/letter system to identify the center of each grid. Graphically illustrate the location of the grid system on MKMP Form 8-2.

b) Using a Micro-R-Meter obtain radiation levels at 1 meter from a grid corner point and at contact with the surface of the ground. Record readings on MKMP Form 8-3.

c) Survey the remainder of the grid at the surface using a "S" walking pattern. If elevated readings are noted above or below the grid center point reading, subdivide the grid into 9 subgrids (3 subgrids X 3 subgrids) and obtain readings at 1 meter above the ground surface, and obtain contact readings in the center of each subgrid. Record readings on MKMP Form 8-3.

5.3 <u>Contamination Surveys</u>

5.3.1 If removable contamination is suspected or previous surveys are in question, first scan likely contaminated surfaces with an α and/or β probe to determine if elevated areas of contamination exist. Obtain smear samples from any elevated areas and count smears in sample counter. If smearable contamination is found use appropriate protective clothing and entry control techniques to prevent the spread of contamination.

5.3.2 Small Areas/Items/Waste Containers - This survey technique is used to establish contamination levels on small areas, items and containers which contain radioactive materials.

a) If the area, item or waste container contains alpha activity, scan the area with an alpha probe at ¼ inch above the surface. Note readings on survey MKMP Form 8-1.

b) Hold the ß probe at approximately ½ inch above the surface to be surveyed and obtain reading following meter stabilization. Record meter reading on MKMP Form 8-1. The surface of a waste container can be surveyed for beta activity only if the radiation level from the container does not elevate the beta probe background. If the background level is below 200 CPM, scan the surface of the container and note readings on survey MKMP Form 8-1.

c) To determine the removable surface contamination on areas or items first take a large area smear (LAS) using a paper hand towel or masslinn cloth and count the smear in a low background area using the alpha and beta probes. If no contamination is found on the LAS, take 100 cm^2 swipe for every 2 square foot of surface area and count swipes for α and β activity in sample counter. Record the results of smear activity on MKMP Form 8-1.

d) For waste containers, a LAS should be taken from the bottom, top, and sides of the container. If no contamination is found on the LAS, take 300 cm^2 swipe for every 2 square foot of surface area and count swipes for α and β activity in sample counter. Take one smear each from the container sealing area, lid, and container contact points with ground or floor. Record results of smear activity on MKMP Form 8-1. If contamination levels are above limits, decontaminate surface of container and repeat survey.

5.3.3 Facility Surveys - This survey technique is used to release facilities (buildings, etc) to "unrestricted" status or determine status of facilities requiring decontamination and decommissioning.

a) The grid system established in section 5.2.3, step a) will also be utilized for contamination surveys.

b) Hold the ß probe at approximately ½ inch above the grid center point and obtain reading following meter stabilization. Record meter reading on MKMP Form 8-3.

c) If readings are at background levels, randomly scan the remainder of grid concentrating on cracks, floor/wall joints, top of horizontal surfaces, ventilation ducts/grills, and other areas that might collect radioactive materials. Mark any locations above the release criteria on survey MKMP Form 8-2.

d) If readings are at or near the release levels scan grid surface and identify portion of the grid that is above release criteria. Note these areas on the survey form and mark the area of the grid with spray marker and on MKMP Form 8-2.

e) Repeat steps b) through d) with an α probe.

If sufficient documentation of previous history is known about the facility, the α survey may not be required if;

- the α contamination is known <u>not</u> to be present, or
- the α measurements can be randomly taken of every 10th grid.

f) One smear sample from an 100 cm^2 area will be taken in each grid. If the above survey found no elevated readings in the grid, the smear sample will be taken in the center of the grid. If elevated readings are found, the smear sample will be taken from the area where the highest reading was obtained.

g) Each smear sample will be labeled with the grid location and counted for α and β activity in the sample counter. The smear sample results will be recorded on MKMP Form 8-3.

5.3.4 Area Surveys - This survey technique is used to release land masses to "unrestricted" status or determine status of areas requiring decontamination before release.

a) The grid system established in section 5.2.4, step a) will also be utilized for contamination surveys.

b) Hold the β probe at ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on MKMP Form 8-3.

c) If readings are at background levels, randomly scan the remainder of grid. Mark any locations above release criteria on survey MKMP Form 8-2.

d) If readings are at or near the release levels scan grid surface and identify portion of the grid that is above release criteria. Note these areas on the survey MKMP Form 8-2.

e) Areas contaminated with radioactive materials will require soil samples to determine the activity concentration. The quantity and location of samples will be determined on a case by case basis.

6.0 Attachments

MKMP Form 8-1	Radiological Survey Report
MKMP Form 8-2	Radiation and Contamination Survey
MKMP Form 8-3	Radiation and Contamination Survey Results

MKM Engineers, Inc.

Radiological Survey Report

	INSTRUMENTATION USED				
DATE: TIME:					
SURVEY NUMBER:	MODEL	S/N	% EFF.	CAL DUE	BKG
LOCATION:					
SURVEYOR:					
REVIEWED BY:					
RSO/HP:					

Smear locations circled; Dose Rates = μR/hr, mR/hr, R/hr (Circle appropriate)

Survey Drawing:

LOCATIONS AND FIXED/SMEARABLE RESULTS

RESULTS = DPM/100 CM² SMEARABLE or CPM/Probe Area FIXED

INDICATE FIXED (F) or SMEARABLE (S) on each

#	Alpha	Beta/Gamma

Description of Drawing: ______

Routine☐ (Daily/Weekly/Monthly) Nonroutine☐

Comments: ______

Radiation and Contamination Survey

DATE: TIME:	INSTRUMENTATION USED				
SURVEY NUMBER:	MODEL	S/N	% EFF.	CAL DUE	BKG
LOCATION:					
SURVEYOR:					
REVIEWED BY:					
RSO/HP:					
Number and Circle Survey Locations.					

Survey Drawing of Grid Layout:

'escription of Drawing: ____

Routine☐ (Daily/Weekly/Monthly) Nonroutine☐

omments: ____

Radiation and Contamination Survey Results

Date:	Time:	Survey Number:
Location:		Reviewed By:
Surveyor:		RSO/HP:

Location	Exposure Rate		Fixed + Removable		Removable		Comment
	Contact mR/hr	1 Meter mR/hr	Alpha cpm/probe	Beta/Gamma cpm/probe	Alpha $dpm/100cm^2$	Beta/Gamma $dpm/100cm^2$	

Description of Drawing: ______

Routine☐ (Daily/Weekly/Monthly) Nonroutine☐

Comments: ______

______

______

______

Radiation Safety Procedure

for

Routine Radiological Surveys

MKMP-009

Revision 0

Reviewed By: ______________________ 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer Date

Approved By: ______________________ 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist Date

MKM Engineers, Inc.

Procedure MKMP 009
Routine Radiological Surveys

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MKMP - 009
Routine Radiological Surveys

1.0 Purpose and Scope

1.1 The purpose of this procedure is to establish the framework and define the requirements for MKM personnel performing routine radiological surveys. This procedure is primarily meant to be used at sites where radiological remediation or removal work is taking place.

1.2 This procedure provides the requirements for identifying, scheduling, and performing routine, clean area, radiation, contamination, and airborne surveys by radiation safety personnel. All remediation and facility areas that are radiologically controlled as well as non-radiologically controlled areas containing fixed contamination and areas adjacent to contaminated areas are within consideration for routine survey performance. This procedure does not include survey requirements for radiation generating devices and survey requirements specified in radiation work permits (RWPs).

The following activities are described in Section 5.0 of this procedure:

- Frequency Requirements for Routine Surveys
- Identifying and Scheduling Routine Surveys
- Using As Low As Reasonably Achievable (ALARA) Principles For Scheduling and Performing Surveys
- Performance of Routine Surveys
- Periodic Evaluation of Routine Surveys
- Management Notification

2.0 General

2.1 Definitions

2.1.1 Restricted Area - An area containing radioactive materials to which access is controlled to protect individuals from exposure to ionizing radiation.

2.1.2 Contamination Survey - A survey technique to determine fixed and removable radioactive contamination on components and facilities.

2.1.3 Radiation Survey - A survey technique to determine radiation exposure rates to individuals working in areas containing radioactive materials.

2.1.4 ALARA - An approach to radiation exposure control to maintain personnel exposures as far below the federal limits as technically, economically and practical considerations permit.

2.2 Safety Considerations

The safety requirements specified in the job specific HASP and Work Plans, along with the Radiation Safety Program Manual, and other safety documentation must be adhered to when performing routine surveys.

2.3 Quality Control

Instruments used to perform routine radiological surveys will be inspected for serviceability each day and checked against check sources to verify they are in proper working condition per the applicable RWP and the appropriate procedure.

3.0 References, Records and Equipment

3.1 References

10 CFR 20, Subpart F	*Surveys and Monitoring*
10 CFR 20.2103	*Records of Surveys*
RSM	Radiation Safety Manual
MKMP-001	Operation of Contamination Survey Meters
MKMP-002	Alpha-Beta Sample Counting Instrumentation
MKMP-003	Operation of Micro-R Survey Meters
MKMP-004	Operation of Ionization Chambers
MKMP-015	Personnel Protective Clothing
MKMP-016	Radioactive Materials Brokering

3.2 Records

Radiological survey records, routine survey schedules, and tracking forms are generated during the performance of this procedure. The original of the records is the record copy for the Project files. The records are stored, arranged, indexed, retrieved, scheduled, retained, and disposed of in accordance with the project filing system.

3.3 Equipment

All instruments used to perform routine surveys shall be used in accordance with the applicable RWP and the appropriate procedure. All instruments will be supplied by the authorized suppliers of properly calibrated and maintained equipment.

4.0 Responsibilities

4.1 Program Manager - The Program Manager is responsible for insuring that all personnel assigned the task of performing routine radiological surveys are familiar with this procedure and are adequately trained to use the required instruments to perform surveys.

4.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in the performance of routine radiological surveys. The RSO can also assist in the interpretation of results obtained during surveys.

4.3 Project Manager (PM)- The PM is responsible for ensuring a copy of this procedure is available at the job site and that field technicians follow this procedure.

4.4 Technicians - Technicians performing routine radiological surveys are responsible for knowing and complying with this procedure.

5.0 Procedure

5.1 Frequency Requirements for Routine Surveys

Appropriate routine radiological surveys shall be performed at the following frequencies as a minimum:

5.1.1 Radiation surveys:

- Daily, in the office spaces located in Radiological Buffer Areas where the potential exists for personnel to be exposed to external radiation.
- Weekly, in the routinely occupied Radiological Buffer Areas adjacent to the areas posted for the control of personnel having exposure to any external radiation and to the Radiation Areas.
- Upon initial entry after extended periods of closure.
- Daily, during continuous operation, and when levels are expected to change in High Radiation Areas.
- Weekly, for operating HEPA-filtered ventilation units.
- Weekly, for any temporary Radiation Area boundaries to ensure that the Radiation Areas do not extend beyond posted boundaries.
- Monthly, or upon entry if entries are less frequent than monthly, for Radioactive Material Storage Areas.
- Monthly, for potentially contaminated ducts, piping, and hoses in use outside the radiological facilities.

5.1.2 Contamination surveys:

- Daily, at contamination control points, radiological change areas, or step-off pads, when in use; or once per shift in high-use situations.
- Daily, in office spaces located in the Radiological Buffer Areas used with the Radiological Areas posted for the control of contamination or airborne radioactivity.
- Daily, in lunch rooms or eating areas adjacent to the Radiological Buffer Areas used with Radiological Areas posted for the control of contamination or airborne radioactivity.
- Weekly, for all designated lunchrooms for the project.
- Weekly, in routinely occupied Radiological Buffer Areas and in locker rooms or the shower areas adjacent to Radiological Buffer Areas used with the Radiological Areas posted for the control of contamination or airborne radioactivity.
- Weekly, or upon entry if entries are less frequent, in the areas where radioactive materials are handled or stored.
- Weekly, or upon entry if entries are less frequent, in the Radiological Buffer Areas used with radiological areas posted for the control of contamination or airborne radioactivity.
- Weekly, or upon entry if entries are less frequent, in the Controlled Areas adjacent to contamination boundaries or postings (i.e., Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, Radioactive Material Areas where material is used in the unsealed form in quantities exceeding the surface activity guidelines).

- Monthly, in areas with fixed contamination located outside of the controlled area boundaries.
- All project offices will be surveyed weekly.

5.1.3 Airborne Surveys:

Airborne survey frequency, locations, and methods are determined by the radiation work permits (RWPs) and by the RSO.

5.2 Identifying and Scheduling Routine Radiological Surveys

5.2.1 The RSO or designee shall identify and schedule routine surveys as required by the radiological conditions and work activities.

Who, qualifications?

5.2.2 Routine survey schedules shall be developed using a standard system for designating surveys as follows:

Frequency of survey.

• Daily	D
• Weekly	W
• Monthly	M
• Quarterly	Q
• Semi-Annually	S
• Annually	A
• Upon Entry	U

Type of survey.

• Radiation	R
• Contamination	C
• Area TLD	T
• Air Sample	A/S
•	

Example: DRC-1

Where:

D: is the survey frequency (Daily in this example),
R: is a type of survey (Radiation in this example), and
C: is a type of survey (Contamination),
1 corresponds to the numerical sequence of the survey.

5.2.3 Routine survey schedules shall be submitted to and approved by the RSO.

5.2.4 Prepare routine survey tracking forms using the approved routine survey schedules.

5.2.5 Changes to any routine survey schedule shall be submitted to and approved by the RSO.

5.2.6 Typical forms are included in this procedure. Task Leaders may elect alternate forms containing, as a minimum, the information included on the typical forms.

5.3 Using As Low As Reasonably Achievable (ALARA) Principles for Scheduling and Performing Surveys

5.3.1 Routine surveys should not be performed in High Radiation Areas unless other work necessitates entry. Boundary verification surveys would be appropriate if an entry is not required.

5.3.2 Routine surveys should be performed in conjunction with other work surveys as much as practicable.

5.4 Performance of Routine Surveys

5.4.1 HPTs shall perform routine surveys in accordance with the RWP and the appropriate procedure.

5.4.2 Upon completion of a routine survey, the HPT shall initial the appropriate Routine Survey Tracking Form.

5.5 Periodic Evaluation of Routine Surveys

5.5.1 Routine survey schedules shall be reviewed and updated periodically to ensure that all areas within the project boundaries are receiving appropriate routine survey coverage.

5.5.2 Changes of conditions within the project area will be reported to the RSO and may require a modification of the routine radiological survey schedule.

5.6 Management Notification

5.6.1 The RSO shall be notified, in writing by the project manager, of any failure to complete a routine survey as scheduled. The missed survey will be completed within 24 hours of discovery that it was missed.

6.0 Attachments

MKMP Form 9-1	Routine Survey Schedule
MKMP Form 9-2	Daily/Weekly Routine Survey Tracking Form
MKMP Form 9-3	Monthly Routine Survey Tracking Form

MKM Engineers, Inc.

Routine Survey Schedule

Project: ____________________

Survey Designation	Location of Survey

Prepared/Submitted By: ____________________
Technician Date

Reviewed/Approved By: ____________________
RSO/Manager Date

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Daily/Weekly Routine Survey Tracking Form

Month ____________ Survey Location ______________ Survey Designation ____________

Day	RWP # (If Applicable)	Survey Form Number	Comments	HPT
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				

Reviewed/Approved: ______________________________________

RSO/Manager Date

Page ___ of ___

MKM Engineers, Inc.

Monthly Routine Survey Tracking Form

Month ______________________

Date	Survey Designation	Survey Location	RWP # (If Applicable)	Comments	HPT

Reviewed/Approved: ____

RSO/Manager

Date

Page ___ of ___

MKM

Radiation Safety Procedure

for

ALARA - As Low As Reasonably Achievable

MKMP-010

Revision 0

Reviewed By: [signature] 8/28/99
D.J. Wells, RRPT, Radiation Safety Officer — Date

Approved By: [signature] 8/30/99
T.J. O'Dou, CHP, MKM Health Physicist — Date

MKM Engineers, Inc.

Procedure MKMP 010

ALARA - As Low As Reasonably Achievable

LIST OF EFFECTIVE PAGES

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5	0	8/28/99						
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MKMP - 010
ALARA - As Low As Reasonably Achievable

1.0 Purpose and Scope

1.1 This procedure defines the requirements and methods for conducting As Low As Reasonably Achievable (ALARA) reviews and briefings.

1.2 This procedure applies to ALARA reviews and briefings conducted by radiation safety personnel, including the Radiation Safety Officer (RSO), and includes pre-job, job-in-progress, and post-job reviews.

The following activities are described in Section 5.0 of this procedure:

- General
- Trigger Levels for Performance of Formal, Documented ALARA Reviews and Briefings
- Conducting ALARA Pre-Job Reviews
- Conducting ALARA Pre-Job Briefings
- Conducting ALARA Job-In-Progress Reviews
- Conducting ALARA Post-Job Reviews

2.0 General

All work activities performed under this procedure shall be in accordance with the Specific Project Health and Safety Plan (HASP) and the Radiation Safety Program Manual.

3.0 References, Records and Equipment

3.1 References

10 CFR 20	*Standards for Protection Against Radiation*
RSM	Radiation Safety Manual
MKMP-030	Document Control

3.2 Records

ALARA review and briefing records are generated during the course of implementing this procedure. The original copy is the record copy and is forwarded to the RSO for processing, including arrangement and filing. Working copies of the records may be made as required and should be disposed of when no longer needed.

These records are used by project safety personnel to document evaluation of working conditions and radiological protection requirements associated with work activities.

The records are stored, arranged, indexed, retrieved, scheduled, retained, and disposed of in accordance with the Document Control Procedures in MKMP-030.

3.3 Equipment

3.3.1 Most current radiological data.

3.3.2 Work control documents to include radiation work permits (RWPs), standard operating procedures (SOPs), etc

3.3.3 ALARA Checklist

3.3.4 ALARA Briefing Attendance Record

3.3.5 Dose histories for site workers, as appropriate

4.0 Responsibilities

4.1 The RSO is responsible for:

- Reviewing and approving the ALARA documents generated in performance of this procedure.
- Implementing this procedure.
- Providing oversight and assistance for technicians and Project Managers performing actions governed by this procedure.
- Reviewing, approving, and transmitting documentation generated during the performance of this procedure.
- Conducting, reviewing, and/or approving ALARA reviews and briefings as described in this procedure.
- Ensuring that HPTs are trained on this procedure and that the training is documented.

4.2 HPTs are responsible for:

- Performing the requirements established in this procedure.
- If an HPT is unable to perform this procedure due to errors, extenuating circumstances, or for any other reason, the HPT shall immediately stop and notify the RSO.

4.3 Task managers are responsible for:

- Performing the requirements established in this procedure.

4.4 The Project Manager is responsible for:

- Reviewing and approving the ALARA documents generated in the performance of this procedure.

5.0 Procedure

5.1 General

5.1.1 This procedure sets the minimum standards for performance of ALARA reviews and briefings and does not prohibit the performance of any reviews by the Client Radiation Protection Department that are in addition to those established in this procedure. In all cases, project radiation safety personnel:

a.. Are expected to consider and discuss with the Project Manager and site workers the dose reduction techniques pertinent to the work to be performed for those jobs not meeting the criteria for the performance of formal reviews.
b. Are expected to participate in and support the efforts of the project in performance of ALARA related activities.

5.2 Trigger Levels for Performance of Formal, Documented ALARA Reviews and Briefings

5.2.1 Formal, documented ALARA Pre-Job Reviews shall be conducted and documented, using the attached Pre-Job Review Form, if work is expected to result in:

a. An individual dose exceeding 100 millirem (mrem).
b. The collective dose for the job exceeding 0.5 person rem.
c. Airborne exposures exceeding 40 DAC-hrs per person.
d. General area dose rates exceeding 1 rem/hr.
e. Contamination levels exceeding 100 times the values in Attachment 10-1, Surface Activity Guidelines.
f. Use of supplemental engineering controls (portable high efficiency particulate air (HEPA) systems, gloves bags, tents, or other similar devices) or respiratory protection to reduce potential internal exposures.
g. Installation, removal, or modification of temporary shielding.

5.2.2 Formal, documented pre-job briefings shall be conducted for work involving conditions in 5.2.1 above.

a. Pre-job briefings shall be attended by all project personnel expected to work the job, the Task Manager, HPTs, and project radiation safety personnel supporting job performance, and the individual performing the pre-job review.
b. Pre-job briefings shall be performed and documented using the attached ALARA Briefing Record and the ALARA Briefing Attendance Record.

5.2.3 Pre-job reviews and briefings shall be conducted as indicated below. Briefings shall be conducted jointly by designated radiation safety personnel and the Project Manager.

Table 10-1
Pre-job Review Matrix

Conditions	Review Conducted By	Review Approved By	Briefing Conducted By
Conditions listed in 5.2.1	Lead HPT	RSO/PM	Lead HPT
5X Conditions in 5.2.1 a-e	RSO	RSO	RSO
10X Conditions in 4.2.1 a-e	RSO/Corporate CHP (CCHP)	Radiation Safety Committee	RSO/CCHP

5.2.4 ALARA job-in-progress reviews should be performed for any long duration work (>1 week) for which formal pre-job reviews and briefings are required.

a. Job-in-progress reviews should be tentatively scheduled during the ALARA pre-job briefings.
b. Job-in-progress reviews should be conducted jointly by the radiation safety personnel conducting pre-job briefing, and the Project Manager responsible for the job.
c. Job-in-progress reviews shall be conducted and documented using the attached ALARA Job-In-Progress Review Form

5.2.5 Post-job reviews shall be conducted for any jobs exceeding the criteria in 5.2.1.

a. The post-job review should be, if possible, tentatively scheduled during the pre-job review.
b. Attendance at post-job reviews should include, as a minimum, radiation safety personnel knowledgeable of work performance and the Project Manager responsible for the job. The individual conducting the post-job review shall be, if practicable, the radiation safety individual conducting the pre-job review.
c. Document information obtained during the performance of the job that could reduce collective or individual dose rates for future work performance. This information may be recorded on the post-job review form or on pages attached to the form.
d. Post-job reviews shall be documented on the Post-Job Review Form.

5.3 Conducting Pre-Job Review

5.3.1 Obtain all the documentation needed for the pre-job review. This should include the following documents as appropriate.

a. RWP Request and Review Form.
b. Survey records.
c. Records of previous job performance.
d. Technical work control documents.

5.3.2 Review the work to be performed using criteria on ALARA Pre-Job Review Form as a guide.

5.3.3 Coordinate with the Project Manager, as required, to obtain pertinent job information.

5.3.4 Identify and record dose rate reduction methods to be employed before and during job performance.

5.3.5 Revise initial dose rate estimates and record the revised estimates in Section D.

5.3.6 Annotate the basis for any change on the form or on extra sheets attached to the review form.

5.3.7 Forward the completed review form for approval.

a. The designee indicated in Section 5.2.3 should conduct the review.

b. The person with approval authority shall return the review form to the individual designated to perform the pre-job briefing.

5.4 Conducting ALARA Pre-Job Briefings

5.4.1 Pre-job briefings shall be conducted jointly by the designated project radiation safety personnel and the Project Manager. The Project Manager shall address the job-specific aspects, and the radiation safety personnel shall address radiological concerns.

5.4.2 Record attendance at the briefing on the ALARA Briefing Attendance Record Form, attachment 5.

5.4.3 Conduct the briefing using Attachment 4 as a guide.

5.4.4 If additional ALARA requirements are identified during the briefing add the requirements to the Special Instructions Section of the RWP.

5.4.5 Forward briefing records, RWPs, attendance records, and any other documentation to the RSO and the Project Manager for review and approval.

5.5 Conducting ALARA Job-In-Progress Reviews

5.5.1 Obtain the ALARA Job-In-Progress Review Form (Attachment 2).

5.5.2 Obtain and record the collective dose and man-hour data.

5.5.3 Observe the work in-progress, using the review form as a guide

5.5.4 Record observations.

5.5.5 Discuss, as appropriate, the ALARA concerns and the work-in-progress with the Project Manager and radiation safety personnel involved with the job-in-progress review.

5.5.6 Revise the RWP, as appropriate, to correct any deficiencies noted.

5.5.7 Forward the completed review form, indicating any corrective actions taken, for review and approval in accordance with paragraph 5.2.3.

5.6 Conducting ALARA Post-Job Reviews

5.6.1 Obtain the ALARA Post-Job Review Form (Attachment 3).

5.6.2 Obtain and record the job-dose and man-hour data.
5.6.3 Complete the Post-Job Review Form.

5.6.4 Annotate any additional information obtained from the ask workers or radiation safety personnel involved with the job performance in the Corrective Action Section of the form.

5.6.5 Forward completed review form to the RSO and the Task Manager for review and approval.

6.0 <u>Attachments</u>

Attachment 10-1	Surface Activity Guidelines
MKMP Form 10-2	ALARA Pre-Job Review
MKMP Form 10-3	ALARA Job-In-Progress Review
MKMP Form 10-4	ALARA Post-Job Review
MKMP Form 10-5	ALARA Briefing Record
MKMP Form 10-6	ALARA Briefing Attendance Record

Attachment 10-1
Surface Activity Guidelines

Allowable Total Residual Surface Activity (dpm/100cm²)(1)

Radionuclides(2)	Average(3)(4)	Maximum(5)(6)	Removable
Group 1 - Transuranics, I-125, I-129, Ac-227, Ra-226, Ra-228, Th-228, Th-230, Pa-231	100	300	20
Group 1 - Th-natural, Sr-90, I-126, I-131, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
Group 3 - U-natural, U-235, U-238, and associated decay products, alpha emitters	5,000	15,000	1,000
Group 4 - Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous[7] fission) except Sr-90 and others noted above	5,000	15,000	1,000
Tritium (applicable to surface and subsurface)[8]	N/A	N/A	10,000

Notes:

(1) As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

(2) Where surface contamination by both alpha and beta-gamma emitting radionuclides exits, the limits established for alpha and beta-gamma emitting radionuclides should apply independently.

(3) Measurements of average contamination should not be averaged over an area of more than one m^2. For objects of less surface area, the average should be derived for each such object.

(4) The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h, respectively, at 1 cm.

(5) The maximum contamination level applies to an area of not more than 100 cm^2.

(6) The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area of less than 100 cm^2 is determined, the activity per unit area should be based on the actual area, and the entire surface should be wiped. It is not necessary to sue wiping techniques to measure removable contamination levels if detect scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

(7) This category of radionuclides includes mixed fission products, including Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

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ALARA Pre-Job Review Form

RWP# ______________ Project Manager ______________ Task Location ______________

REVIEW CRITERIA	OBSERVATION	COMMENTS
1. Are technical work documents that accurately define the work available?	☐YES ☐NO ☐N/A	
2. Has the procedure been verified through walk-downs or prior performance?	☐YES ☐NO ☐N/A	
3. Do procedures contain radiological hold-points?	☐YES ☐NO ☐N/A	
4. Are there specific points in the work evolution at which radiological conditions are subject to change? If yes, are these addressed as told points in work documents?	☐YES ☐NO ☐N/A	
5. Has the work force performed this job previously?	☐YES ☐NO ☐N/A	
6. Is specific training needed prior to job performance?	☐YES ☐NO ☐N/A	
7. Are photographs, videos, and/or drawings of actual equipment and work areas available.?	☐YES ☐NO ☐N/A	
8. Can mock-up or other training be used?	☐YES ☐NO ☐N/A	
9. Has the size of the work crew been evaluated?	☐YES ☐NO ☐N/A	
10. Have all identified support groups been notified of scheduled work and briefing requirements?	☐YES ☐NO ☐N/A	
11. Can work be delayed until short-lived isotopes decay off?	☐YES ☐NO ☐N/A	
12. Have primary sources of exposure been identified.?	☐YES ☐NO ☐N/A	
13. Is the release of airborne radioactive materials likely to occur as a result of the work?	☐YES ☐NO ☐N/A	
14. Can engineering controls (i.e., ventilation, HEPA filtration, containment devices, tool selection, etc.) reduce the potential for the release of airborne radioactive materials?	☐YES ☐NO ☐N/A	
15. If the release of airborne radioactive materials cannot be eliminated through engineering and process controls, has the use of respirators been evaluated in accordance with procedure and the HASP?	☐YES ☐NO ☐N/A	
16. Can temporary shielding reduce worker dose?	☐YES ☐NO ☐N/A	

ALARA Pre-Job Review Form

RWP# __________ Project Manager __________ Task Location __________

REVIEW CRITERIA	OBSERVATION	COMMENTS
17. Can work be moved to lower the work area's dose rate?	☐YES ☐NO ☐N/A	
18. Have waiting areas with lower dose rates been identified and located; and has their use been explained to the workers?	☐YES ☐NO ☐N/A	
19. Can flushing of lines, components, etc. result in lower dose rates?	☐YES ☐NO ☐N/A	
20. Can components be drained/filled to reduce dose rates?	☐YES ☐NO ☐N/A	
21. Can decontamination result in areas with lower dose rates?	☐YES ☐NO ☐N/A	
22. Can radioactive components be placed in shielded containers to reduce dose rates?	☐YES ☐NO ☐N/A	
23. Are stay-time limits appropriate for reduction of individual exposure?	☐YES ☐NO ☐N/A	
24. Have routes to and from work areas been identified?	☐YES ☐NO ☐N/A	
25. Will staging areas be used for tools and equipment? Where?	☐YES ☐NO ☐N/A	
26. Are required services (electrical, air, lighting, ventilation) available?	☐YES ☐NO ☐N/A	
27. Are special communication devices required due to ambient noise levels? Are special communication devices required to reduce collective exposures?	☐YES ☐NO ☐N/A	
28. Can remote tools or robotics be used?	☐YES ☐NO ☐N/A	
29. Is any special equipment or procedural restriction required to ensure worker safety during work performance? (Include lock-out/tag-out requirements.)	☐YES ☐NO ☐N/A	
30. Is heat stress a concern? Have stay-times been evaluated for heat stress considerations?	☐YES ☐NO ☐N/A	
31. Does work involve the use of hazardous materials?	☐YES ☐NO ☐N/A	
32. Will work result in waste generation?	☐YES ☐NO ☐N/A	
33. Has the handling and disposal of waste products been determined? How?	☐YES ☐NO ☐N/A	
34. Will liquids be generated, collected, and/or routed to drains? How? Have approvals been obtained? Include NPDES, if necessary.	☐YES ☐NO ☐N/A	
35. Is the whole-body thermoluminescent dosimeter (TLD) sufficient to monitor potential exposures?	☐YES ☐NO ☐N/A	

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ALARA Pre-Job Review Form

RWP# ______________ Project Manager ______________ Task Location ______________

REVIEW CRITERIA	OBSERVATION	COMMENTS
36. Should whole body TLD be moved to another body part? Is multiple badging required?	☐YES ☐NO ☐N/A	
37. Is extremity badging required?	☐YES ☐NO ☐N/A	
38. Is neutron dosimetry required?	☐YES ☐NO ☐N/A	
39. Does this work involve any criticality concerns? Have controls been identified?	☐YES ☐NO ☐N/A	
40. Are RAMs or CAMs going to be used for this work?	☐YES ☐NO ☐N/A	
41. Is operational bioassay required during or following the completion of work?	☐YES ☐NO ☐N/A	
42. Are any non-routine items of protective clothing required? (Face shields, heavy rubber gloves, etc.).	☐YES ☐NO ☐N/A	
43. Will photographs or videos be made to record the job or conditions?	☐YES ☐NO ☐N/A	
44. Are administrative control limits (ACLs) in place for workers, as required?	☐YES ☐NO ☐N/A	

Additional comments may be annotated on additional pages, attached to this form, and referenced to criteria in the ALARA review.

ALARA Estimates	DDE	CEDE	TEDE
Original Person-Rem Estimate	______	______	______
Revised Person-Rem Estimate	______	______	______

Review Performed By: ______________________ Date: ______________
Print/Sign

Review Approved By: ______________________ Date: ______________
RSO Print/Sign

Review Approved By: ______________________ Date: ______________
PM Print/Sign

MKM Engineers, Inc.

ALARA Job-in-Progress Review Form

RWP# __________ Revision ______ Start Date ____________ Review Date ____________ Conducted By ______________________________

Task Location ____ Task Manager(s) ______________________________

ALARA Estimates/Actual (To Date): Person Rem ____________ / ____________ Person Hrs ____________ / ____________

Review Criteria	Observation	Comments
1. Is work being performed as required by technical work documents and RWP?	☐YES ☐NO ☐N/A	
2. Are all workers at job site actively participating in work?	☐YES ☐NO ☐N/A	
3. Are workers knowledgeable of radiological conditions in work area?	☐YES ☐NO ☐N/A	
4. Are workers aware of their exposure data?	☐YES ☐NO ☐N/A	
5. Are tools and equipment available at job site adequate for tasks to be performed?	☐YES ☐NO ☐N/A	
6. Are tag-out/lockout procedures being followed?	☐YES ☐NO ☐N/A	
7. Were any unanticipated radiological conditions encountered?	☐YES ☐NO ☐N/A	
8. Can additional dose reduction measures be applied to further reduce worker dose?	☐YES ☐NO ☐N/A	
9. Is work area maintained orderly and clean?	☐YES ☐NO ☐N/A	
10. Have workers experienced any difficulties with heat?	☐YES ☐NO ☐N/A	
11. Are any observable safety hazards present?	☐YES ☐NO ☐N/A	
12. Have workers identified any potential difficulties affecting completion of job?	☐YES ☐NO ☐N/A	

Comments may be annotated on attached pages, with references to criteria number.

Corrective Actions Recommended/Taken ____

____

____

Prepared By ____ Date ____________________
Print/Sign

Reviewed/Approved By ______________________________________ Date ____________________
(RSO) Print/Sign

Reviewed/Approved By ______________________________________ Date ____________________
(PM) Print/Sign

MKM Engineers, Inc.

ALARA Post-Job Review Form

RWP# __________ Revision ______ Start Date ______________ Review Date ______________ Conducted By ______________________________

Task Location ____ Task Manager(s) ______________________________

Exposure Data For Job [Estimate/Actual (To Date)]: Person Rem ______________/______________ Person Hrs______________/______________

ALARA Goal ______________ person-rem DDE CEDE TEDE

REVIEW CRITERIA	OBSERVATION	COMMENTS
1. Were technical work documents accurate, sequenced correctly, and usable?	☐YES ☐NO ☐N/A	
2. Were equipment needs and the materials needed for the job identified in the procedure?	☐YES ☐NO ☐N/A	
3. Were prerequisite activities completed prior to the start of the job?	☐YES ☐NO ☐N/A	
4. Were support groups present, when required for job evolution?	☐YES ☐NO ☐N/A	
5. Were estimated manpower requirements exceeded? If yes, explain why.	☐YES ☐NO ☐N/A	
6. Was job-specific training completed for this job? If yes, was it adequate for the job?	☐YES ☐NO ☐N/A	
7. Were any unplanned or unanticipated conditions encountered? If yes, explain	☐YES ☐NO ☐N/A	
8. Were low-dose areas and staging areas used? If yes, were they effective?	☐YES ☐NO ☐N/A	
9. Were required services available? (Electrical outlets, ventilation, lights, etc.)	☐YES ☐NO ☐N/A	
10. Was temporary shielding used? If yes, was it adequate?	☐YES ☐NO ☐N/A	
11. Were engineering controls used to reduce potential for airborne radioactive materials? If yes, were they effective?	☐YES ☐NO ☐N/A	
12. Were contamination control practices followed? If yes, were they effective?	☐YES ☐NO ☐N/A	
13. Were respirators used? If yes, identify their impact on job performance.	☐YES ☐NO ☐N/A	
14. Are procedure changes needed to accommodate lessons learned during this job performance?	☐YES ☐NO ☐N/A	
15. Are additional radiological hold points needed in the procedure? If yes, explain.	☐YES ☐NO ☐N/A	

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ALARA Post-Job Review Form

RWP# __________ Revision ______ Start Date ______________ Review Date ______________ Conducted By ________________________________

Task Location ____ Task Manager(s) ______________________________________

REVIEW CRITERIA	OBSERVATION	COMMENTS
16. Are equipment or process changes needed to help reduce exposures for the next job performance? If yes, explain.	☐YES ☐NO ☐N/A	
17. Could actions be taken to prevent future performance of this job? If yes, explain.	☐YES ☐NO ☐N/A	
18. Were person-rem estimates exceeded? If yes, why?	☐YES ☐NO ☐N/A	
19. Were man-hour estimates exceeded? If yes, why?	☐YES ☐NO ☐N/A	
20. Could activities be done differently to reduce exposure the next time this job is performed? If yes, explain.	☐YES ☐NO ☐N/A	

Comments may be annotated on attached pages, with references to criteria number.

Corrective Actions Recommended for: (Specify actions required by Radiation Safety or Operations)/Taken By:

____

____

____

____

____

Prepared By ____ Date ______________________
Print/Sign

Reviewed/Approved By ____ Date ______________________
(RSO) Print/Sign

Reviewed/Approved By ____ Date ______________________
(PM) Print/Sign

ALARA Briefing Record

RWP#________ Rev ______ Task Description __________________________ Start Date ________

Radiation Safety: ____
Print/Sign

Project Manager: ____
Print/Sign

Task Manager: ____
Print/Sign

1. The Task Manager opens the briefing with descriptions of the work that is to be performed.

Job Description:

- Major steps in the job evolution
- Use of the procedure
- Required tools and equipment
- Staging areas
- Routes to and from work area

2. A radiation safety representative presents the radiological protection concerns and the protective measures that are to be employed.

Radiological Protection Concerns:

- Initial conditions
- Exposure estimates and goals
- Protective clothing and equipment requirements
- Monitoring requirements
- Coverage that is to be provided
- Radiation work permit requirements and implementation
- Location and use of low-dose waiting areas
- Response to unexpected or abnormal conditions

3. Group review, led by Task Manager, using technical work documents as a guide,

- Sequential step-by-step review of job to be performed
- Review of procedure for adequacy, sequence, and accuracy
- Identification of tool and equipment needs
- Radiological hold points and actions that are required
- Anticipated changes in radiological conditions and actions that are required of workers and coverage technicians
- Potential problem areas in procedure (i.e., where things are likely to go wrong)
- Safety or radiological concern points in procedure
- Housekeeping and final cleanup provisions

4. Requirements for performance of job-in-progress and/or post-job reviews. Tentative scheduling of these reviews.

5. Exception for communication of dose-reduction methods during and after the job performance.

ALARA Briefing Attendance Log

DATE	NAME: PRINT/SIGN		SSN/IDN	BRIEFING SUBJECT

Comments ______________________________

____

____

____

____

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