VOLUME II

RADIOLOGICAL PROTECTION MANUAL

AND

ASSOCIATED RADIOLOGICAL

CONTROL PROCEDURES

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TABLE OF CONTENTS

NUCLEAR ENERGY SERVICES

RADIOLOGICAL PROTECTION MANUAL

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NUCLEAR ENERGY SERVICES

RADIOLOGICAL PROTECTION MANUAL

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

APPENDICES

CHAPTER 1
INTRODUCTION

1.1 SCOPE AND PURPOSE

This manual presents the radiation protection standards and controls to be in effect for Nuclear Energy Services (NES). Adherence to these controls is the responsibility of each individual as well as members of line management. All management personnel responsible for operations in a radiation environment involving handling or processing of radioactive materials must be knowledgeable of the contents of this manual, and must ensure that each employee has a good understanding of the sections which apply to their job assignment. Any deviation from this manual requires the written approval of the Radiological Safety Committee (RSC).

These radiological safety requirements have been developed based on the recommendations and requirements of the National Council on Radiation Protection and Measurements, the U.S. Department of Energy, and the International Commission on Radiological Protection, and on standards which have been reviewed and accepted by the Public Health Service, the Nuclear Regulatory Commission, the Department of Labor and the Environmental Protection Agency.

It is necessary that all personnel associated with the handling of radioactive material or who are in radiation areas understand that a knowledge of standard radiation protection rules and practices is a part of their job. It is not independent of, or in addition to their routine duties, but an integral part of their duties and responsibilities.

Each person should understand that it is their responsibility to minimize their own exposure to radiation. Also, each person associated with the handling of radioactive material shall receive periodic instruction in the general and specific radiological aspects which they may encounter, and shall also be made aware of their responsibility to the company, the public, and their co-workers for safe handling of radioactive materials.

The major purpose of this manual is to establish the basic practices to be implemented throughout the company to ensure satisfactory control of radioactive materials and radiation exposures to personnel. The basic philosophy is to maintain radiation exposures as low as reasonably achievable (ALARA) and to keep radioactive material contained at all times in the smallest practical volume.

The implementation of this operating philosophy will be the responsibility of facility operations and line management. The RSC shall provide support to NES management in implementing the NES Radiological Safety Program.

1.2 PERSONNEL TRAINING

Personnel authorized to work with radioactive material and who requires routine or emergency access to controlled areas shall be qualified as "Radiation Workers". The need for an employee's qualification will be determined by his manager. Annually, radiation workers shall be retrained and demonstrate by written and practical examination the required knowledge, understanding, and practical abilities necessary to retain their qualification.

Any individual who requires access to controlled area for any purpose and who is not qualified as a radiation worker shall be escorted by a qualified radiation worker while in the controlled area. The non-qualified individual shall not be permitted to handle, process, or work with radioactive materials.

Qualification as a radiation worker requires that the worker meet the following criteria:

A. Bioassay and/or whole body count baseline completed
B. Inclusion on periodic bioassay roster, if required
C. Medical baseline examination
D. Inclusion on periodic medical examination roster
E. Completion of radiation worker training program
F. No precluding physical limitations or radiological restrictions

G. Inclusion on personnel dosimetry program

H. NRC Form 4 or equivalent on file with the Radiation Records Control Officer (RRCO).

Individuals who may be required to use respiratory protective equipment in the performance of assigned tasks must complete a medical questionnaire and be determined to be medically fit by a physician for respirator use. The individuals must complete the respiratory protection training program and be successfully fitted with an approved respirator prior to any respirator use.

The Radiation Worker Training Program will use as a text the Radiation Worker Handbook and Training Manual (82A8006). This program consists of a minimum of eight (8) hours of classroom training and eight (8) hours of practical factors training. In order to qualify, individuals must satisfactorily complete all phases of the program and demonstrate by written examination that they retain the required knowledge, understanding and practical abilities listed below:

A. Theoretical

Each individual shall receive instruction from authorized health physics personnel in the following areas:

* 1. Radiation Exposure Control

a. Have knowledge of the limits for whole body penetrating radiation exposure.

b. Understand the significance of "Stay Time".

c. Be aware of the seriousness of violating instructions on radiation warning signs and unauthorized passage through barriers; be aware of the penalties for violating these requirements.

*Abilities identified by an asterisk (*) require verification by separate signature and date.

d. Understand the procedures and methods for minimizing exposure, such as working at a distance from a source, reducing time in a radiation area, and shielding.

e. Have knowledge of potential sources of radiation associated with work performed by the individual's trade.

f. State where dosimetry badges and self-reading dosimeters should be placed on an individual's body.

g. Understand the importance of the individual keeping track of his own radiaton exposure.

* 2. <u>Contamination Control</u>

a. Understand how contamination is controlled during radioactive work.

b. Have knowledge of procedures for preventing contamination of personnel and how personnel contamination is detected.

c. Have knowledge of potential sources of contamination associated with the individual's job.

d. Understand what radioactive contamination is, and how it is removed from items and personnel.

e. State the removable contamination limits for clean areas in the facility.

*Abilities identified by an asterisk (*) require verification by separate signature and date.

* 3. Transfer of Radioactive Materials

Discuss and demonstrate knowledge of procedures for transferring contaminated materials from contaminated areas.

* 4. Waste Disposal

Have the ability to discuss how individual workers can reduce the amount of radioactive liquid and solid waste.

* 5. Radiological Incidents

a. Understand the need to consult with health physics personnel when questions or incidents occur.

b. Have knowledge of the procedures to be followed after a spill of material (liquid or solid) which is or may be radioactive.

c. Discuss the procedure to be followed when notified that airborne radioactivity is above prescribed limits.

d. Have knowledge of the actions to be taken when an individual discovers his dosimeter is off scale.

* 6. Responsibilities of Individuals

a. Discuss individual employee responsibilities.

b. Discuss actions required to obtain authorization to work in a controlled area.

*Abilities identified by an asterisk (*) require verification by separate signature and date.

B. PRACTICAL

Each individual shall demonstrate the following practical factors to the satisfaction of a qualified instructor.

* 1. Demonstrate the ability to read the commonly used self-reading dosimeters.

* 2. Demonstrate the proper procedure for putting on and removing protective clothing and respiratory protective devices.

* 3. Demonstrate the proper procedures for entering and leaving a contaminated area, including proper self-survey technique.

* 4. Demonstrate the action to be taken by an individual in the event of a spill of radioactive material.

* 5. For personnel required to work in containment areas, such as glove bags and walk-in enclosures, demonstrate the proper procedures for working in these areas.

C. Instructions Concerning Prenatal Exposure

All female employees and members of management shall receive instruction in the possible health risks to children of women who are exposed to radiation during pregnancy. This instruction shall be both oral and written and shall be given by a health physics or medically trained individual. Female employees who receive this instruction shall acknowledge in writing that the instruction has been received. These acknowledgements shall be maintained indefinitely by the RRCO.

*Abilities identified by an asterisk (*) require verification by separate signature and date.

The instruction to and acknowledgement by female employees shall normally be completed at the time of new employee orientation.

It is the responsibility of the female employee who is a qualified radiation worker to notify her supervisor/manager that she suspects or knows that she is pregnant.

All personnel receiving instruction in accordance with this paragraph shall sign the following statement prior to being issued dosimetry:

> "The recommendation of the National Council on Radiation Protection and Measurements to limit radiation exposure to the unborn child to the very lowest practical level, not to exceed 0.5 rem during the entire priod of pregnancy, have been explained to me."
>
> Signature ______________________________
>
> Typed or printed name ______________________________
>
> Date ______________________________

The signed statements shall be kept with the training records. Statements signed by visitors shall be retained until the end of the job and turned over to NES.

1.3 RECORDS AND REPORTS

A permanent record of the individual's qualification shall be maintained by the RRCO. The results of the individual's written examination shall be maintained in the permanent training file. A field copy of the individual's qualification shall be maintained by his department manager.

Specifically, the RRCO shall maintain those records shown in Appendix D for the retention periods indicated.

The RRCO shall, in addition, maintain those records specified in accordance with any and all NES radioactive material licenses and NRC requirements.

All records held by the RRCO shall be compiled in accordance with Appendix D, "NES Central Radiological Records Program", personal qualifications for specific health physics positions are specified in Appendix A, "Radiological Personnel Qualification Standards".

CHAPTER 2
CONTROL OF PERSONNEL EXPOSURE

2.1 RADIATION EXPOSURE LIMITS

A. Occupational Radiation Exposure Limits

Radiation exposure limits are used for controlling personnel exposure to radiation (excluding medical and dental exposures) to levels which are believed to cause no ill-effects even if the employee was exposed to these levels throughout his/her entire working life. These limits are based on those promulgated by Title 10, Code of Federal Regulation, Part 20, "Standards for Protection Against Radiation". Personnel should endeavor to maintain their own exposures as low as reasonably achievable and below these limits. The occupational exposure limits are contained in Table 2-1.

Normal operations shall be controlled such that no employee exceeds any 10 CFR 20 occupational exposure limit and the total of all employees' exposures is limited to the lowest levels reasonably achievable. A method of achieving this shall be the setting of exposure goals on individual projects.

In addition, Table 2-1 also lists NES corporate limits for occupational radiation exposure. These limits are less that or equal to those specified in 10 CFR 20. The NES limits shall be the operating limitations for exposure to all NES personnel. No NES employee shall exceed these limits without receipt of a formal written extension of allowable exposure by a Radiation Safety Officer (RSO). This extension shall be limited to one calendar quarter in duration, after which another formal written extension may be issued. In no event shall these extensions exceed the limitations imposed by 10 CFR 20 for individual exposure.

Also, no NES employee shall be exposed to further radiation of any kind whatsoever which may produce a lifetime exposure to the individual greater than the following limiting calculation, as specified in 10 CFR 20:

5 times (N-18) where "N" = worker age in calendar years

TABLE 2-1

RADIATION WORKER OCCUPATIONAL
EXPOSURE LIMITS AND CONTROLS

	10 CFR 20 LIMITS, REM		NES ADMINISTRATIVE CONTROLS, REM		
TYPE OF EXPOSURE	ANNUAL	QUARTER	ANNUAL	QUARTER	DAILY
Whole Body, Head and Trunk, Gonads, Lens of Eye, Red Bone Marrows, Active Blood Forming Organs	5.	3.	3.	1.25	0.10
Unlimited Areas of the Skin, (except hands, feet, ankles, and forearms)	30.	7.5	15.	3.75	0.10
Hands and Forearms, Feet and Ankles	75.	18.75	15.	3.75	0.10
Minors (less than 18 year of age)	10% of above levels		No Exposure Allowed		

(1) As measured by the "open window' portion of the Film Badge.

(2) Estimated by in-vivo counting or bioassay measurements.

(3) As measured by an appropriate dosimeter worn with the TLD chip oriented toward the source.

B. Exposure to Minors

Individuals under the age of 18 are not permitted to enter controlled or any radiation area of NES facilities or to receive whole body exposures during any calendar year at NES supervised worksites.

C. Exposure to Unborn Child

Female employees shall be advised of the Nuclear Regulatory Commission's and the National Council on Radiation Protection and Measurements recommendations to keep radiation exposure to an embryo or fetus to the very lowest practicable level during the entire gestation period. Therefore, NES shall not permit an embryo or fetus to enter a controlled area at an NES work site.

Personnel shall be informed of the biological risks to the embryo and fetus from radiation in accordance with Section 1.2 and RCP-2.0, "Radiation Worker Training Handbook".

D. Emergency Exposures

In an emergency situation, it may be necessary for emergency personnel to exceed the exposure limits in order to save lives or valuable property. In such situations, the probable effect of high exposure to the rescuer must be weighed against the expected benefits. All emergency exposure or rescue action that may involve substantial personal risk shall be performed by volunteers, and each volunteer shall be advised of the known or estimated extent of such risk by the RSO or his delegate prior to participation.

1. In emergency situations which require search and recovery for injured personnel, or in operations undertaken to prevent conditions that would injure numbers of people, the planned dose to the whole body shall not exceed 100 rem per individual.

2. In situations where it is desirable to enter a hazardous area to protect facilities, eliminate further escape of effluents, or to control

fires, the planned whole body dose shall not exceed 25 rem per individual.

3. The allowed exposure from an emergency situation shall be determined by the RSO. Each individual's planned exposure shall not exceed the above limits and the total exposure allowed should be consistent with the potential risk from the situation.

4. Volunteers or other personnel in an emergency situation who may have received exposures exceed the limits will, on an individual basis, have their exposure evaluated and appropriate action taken to limit future occupational exposure.

5. Emergency procedures are listed in Appendix F.

E. Exposure to NES Personnel While Off-Site

If during work at other than NES worksites, an employee anticipates entering a radiation area, the employee shall be assigned a temporary dosimeter to be worn in addition to the dosimeter provided by the off-site organization and a copy of his radiation exposure history. Upon return to NES, the temporary dosimeter result will be used as a preliminary estimate of the exposure received. The official record is made upon receipt of the exposure from the organization being visited.

F. Exposure to Visitors at NES Facilities

NES shall control the exposure of visitors to its worksites to levels as low as is reasonably achievable. For exposure control purposes a "visitor" is defined as any non-NES employee or any NES employee not qualified as a radiation worker and who requires access to NES controlled areas.

If the visitor will not enter any controlled areas, he will be instructed such that he can recognize how these areas are marked and further

instructed to not enter any area so marked. Visitors will normally require an escort and will be issued temporary dosimetry.

Entry by a visitor to a controlled area shall require the following:

1. Assignment of a temporary film badge;

2. Escort by a qualified radiation worker at all times while in the controlled area;

3. Application of the following exposure controls:

   a. Less than an estimated dose of 50 mrem per week or visit, whichever is longer, if the visitor signs a statement that an additional 50 mrem will not cause his exposure to exceed 300 mrem in the current calendar quarter year or 500 mrem in the current calendar year; or

   b. An estimated dose exceeding 50 mrem if prior authorization is obtained from his employer. This authorization must be from an RSO or equivalent and must include:

      1) Name
      2) Social Security Number
      3) Exposure limit to be applied
      4) Dated copy of the individual's radiation exposure history

   c. No access to any area where there is a significant risk of internal deposition of radioactive material.

If repeated entries to controlled areas are required by a visitor, over periods exceeding two weeks, a temporary film badge can be issued if the visitor meets appropriate requirements as a radiation worker.

2.2 PERSONNEL MONITORING AND DOSIMETRY

A. Personal Dosimeters

1. Film Badge

The film badge dosimeter is a device used for measuring personnel radiation exposure for permanent record purposes. This dosimeter measures beta and gamma exposure and distinguishes between penetrating and non-penetrating radiation. The results of the film badge measurements are the basis of the legal record of an employee's exposure; therefore, any deliberate action by an employee which invalidates the dosimetry measurements is cause for disciplinary action.

Those personnel who have qualified as radiation workers and who have a need to enter a controlled area shall be issued a permanent dosimeter.

An individual's permanent dosimeter shall be worn on the front of the body between the waist and neck, facing away from the body.

In some specific work situations where the source of radiation is oriented relative to the individual in an unusual manner, (for example, some part of the head or trunk will receive a substantially higher dose than other parts of the body), assignment of additional dosimeters may be required (Section 3). These dosimeters shall be worn at the point(s) of highest dose rate or as directed by Health Physics personnel.

Film Badge processing frequency shall be monthly for radiation workers. Non-routine processing may be required by the Radiological Safety Committee (RSC).

2. Direct Reading Dosimeters

Direct or self-reading dosimeters may be issued to individuals who enter controlled areas. These dosimeters shall be utilized as required and shall be returned to the Health Physics Technician (HPT) for processing. The dosimeters shall be worn next to the permanent film badge.

Direct reading dosimeters shall be charged (zeroed), read out, and recorded daily or as specified by a HPT.

3. Thermoluminescent Device (TLD)

A TLD measures ionizing radiation by emitting a measurable amount of visible light which is directly proportional to the amount of incident radiation. These devices are sometimes used in the industry instead of or as supplements to a film badge.

4. Extremity Badges

In situations where dose rates to the hands routinely exceed dose rates to the skin of the whole body, or the anticipated monthly hand dose could exceed 1 rem, extremity dosimeters (finger rings) shall be worn.

Extremity dosimeters shall be made available by NES and shall be processed as used by the individual for the specific situation. Extremity dosimeters shall be worn using a TLD or a film badge oriented toward the source of radiation.

B. Loss, Damage, or Contamination of Dosimeters

Each instance of a lost, damaged, or contaminated personnel dosimeter shall be reported promptly to health physics personnel.

Individuals who lose, damage, or contaminate their dosimetry equipment while in a controlled area shall immediately exit the area and report the condition to the HPT. The individual shall be restricted from entering controlled areas until an exposure estimate has been completed and a new dosimeter issued.

Where possible, dosimeters which become contaminated shall be decontaminated by the HPT. In such an event, a personnel dose estimate shall be prepared by an RSO.

C. Estimation of Dose

Off scale or higher than expected readings on a direct reading dosimeter shall be promptly reported to the HPT for investigation of the circumstances resulting in the exposure. Processing of the wearer's film badge may be required as part of the investigation. The individual involved will be restricted from controlled area entry (Section 3) until his dose has been evaluated.

All exposures indicated by the film badge shall be considered to have been received by the individual unless it can be clearly demonstrated to be erroneous.

If an exposure measurement result from a dosimeter is lost or proven erroneous, an estimate of the dose received by the individual during the period in question shall be established by an RSO and documented as a part of the employee's Exposure Record.

Estimates of dose received shall consider at least the following:

1. Dose rates in the individual's work area

2. Actions taken by the individual during the time for which dose information is desired. This review should include consideration of work position, time in controlled areas, etc.

3. Doses received by other personnel doing similar work.

2.3 INTERNAL RADIOLOGICAL MONITORING

A. Bioassay

The program for internal dose evaluation shall include the analysis of samples of urine and possibly feces. The Radiological Safety Committee (RSC) is responsible for administering the program and ensuring that employees receive evaluations at a frequency appropriate to their level of risk.

The RSC through the Radiation Safety Officer (RSO) shall require periodic and baseline bioassay sampling of radiation workers. The analysis shall consist of urine and fecal analysis for isotopic content, both quantative and qualitative. In areas where uranium intake is possible, gamma spectroscopy and radiometric uranium analysis shall be performed on each sample.

Prior to termination of employment from NES, all personnel who at any time during their employment were designated as radiation workers shall be required to submit urine and fecal samples for assay as directed by the RSO.

In addition, all radiation workers shall be required to undergo bioassy once per calendar year if at any time during that year they worked in a controlled area or with radioactive materials if requested by the RSO.

B. In-Vivo Counting

The RSC shall ensure that an adequate in-vivo counting program is in place and that employees are evaluated by in-vivo examination as dictated by their level of risk of internal exposure.

In-vivo counting shall be performed on all new employees whose job classifications requires them to be qualified as a radiation worker.

Additionally, all employees whose job classification requires them to be qualified as radiation workers shall be evaluated by in-vivo counting at least annually and upon termination of employment.

Contractors and visitors who are required to be qualified as radiation workers shall be required to be evaluated by in-vivo counting at the start of their residence and upon termination of residence at NES worksites. If contractors or visitors are resident at NES worksites for greater than one year, then they are required to be evaluated by in-vivo counting annually. △

C. Special Internal Dosimetry Evaluation

Personnel who are involved in radiological incidents shall have internal dosimetry evaluations when internal contamination is suspected, in accordance with the following criteria:

1. Contact with an RSC approved physician is required to assess the need for immediate medical action for contamination which exceeds the following levels above background:

Facial contamination	-	1,000	dpm; alpha, beta, and gamma
Nasal contamination	-	250	dpm; alpha, beta, and gamma
Wound contamination	-	50	dpm; alpha, beta, and gamma

△

2. A chest count and a urinalysis shall be required in the following circumstances:

   a. Nasal or mouth smears exceeding:

      1) 50 dpm alpha, or
      2) 1,000 dpm beta-gamma

      above background △

   b. Any detectable radioactivity on nasal or mouth smears, and either of the following:

      1) Facial contamination exceeding

a) 50 dpm alpha, or
b) 1,000 dpm beta-gamma or
above background

2) Skin or clothing contamination exceeding

a) 5,000 dpm alpha, or
b) 50,000 dpm beta-gamma
above background

c. Facial contamination exceeding
1) 100 dpm alpha, or
2) 2,000 dpm beta-gamma
above background

Internal dosimetry evaluations at levels of contamination lower than the above may be required by an RSO.

When in-vivo examinations are required as a result of an incident, the involved personnel shall be transported directly to the whole body counter facility as soon as practicable after the incident.

D. Dose Commitment

When an internal deposition is detected, the employees' dose commitment(s) shall be estimated by methods consistent with the assumptions and recommendations of the International Commission on Radiological Protection (ICRP) in ICRP-2 and ICRP-10A. The dose commitment shall be reported to the employee and shall become a part of his exposure history file. The dose commitment is defined as the dose equivalent received by specific organs assigned to the year in which the exposure was received resulting from uptakes (single or multiple) of radionuclides. The results of bioassays shall be calculated and recorded in MPC-hours.

E. Work Restriction

An employee may have his radiation work activities altered or limited as a result of:

1. Approaching the control levels of Section 2.1
2. Unknown exposure status
3. Increased potential for internal deposition such as an open skin break
4. Repeated violations of safety requirements

An RSO is responsible for implementing work restrictions when necessary. The employee's supervisor shall be notified in writing that a work restriction has been imposed within 24 hours of determining the need for a restriction. Copies of work restrictions will be maintained in the employee's dosimetry record.

Any employee who has exceeded the NES control levels of Section 2.1 shall not enter a controlled area that quarter/year without prior, written approval of the Radiological Safety Committee (RSC).

Any employee whose exposure status is unknown (e.g., lost dosimeter) shall not enter a controlled area until his current exposure status is determined by an RSO.

When an employee has an internal deposition of radioisotopes, excluding those medically induced, his radiation work activities shall be limited if the estimated dose commitment is greater than one-half the appropriate limit.

Employees who work with radioactive materials shall report any skin breaks which they may have to their immediate supervisor and/or health physics personnel before entering a controlled area. The Health Physics Supervisor (HPS) shall ensure the protection afforded the skin break is adequate for the nature of the work to be performed and the potential or existing contamination status of the work location. A clearly open wound shall be sufficient reason to prohibit entry to a controlled area, irrespective of protective clothing or medical dressings.

Skin breaks include unhealed wounds, open cracks from chapping, injuries such as lacerations, abrasions, punctures, and blisters or burns.

Safeguards shall be maintained by supervision to minimize the likelihood of accidental introduction of radioactive materials beneath the skin. If the

skin is broken while working with radioactive materials, the employee shall immediately report to his immediate supervisor who will have the skin break surveyed by an HPS. The HPS will determine if additional follow-up action is required.

The HPS, with the concurrence of an RSO, may allow a contaminated employee to go home when, in their judgement, further decontamination effort would not be beneficial. Suitable contamination control measures shall be invoked, and appropriate follow-up shall be continued until all detectable contamination has been removed. Only health physics personnel are permitted to administer personnel decontamination.

2.4 EXPOSURE RECORDS

The RSC shall assure that records are maintained to permit a ready accounting of an employee's accumulated radiation exposure. This occupational exposure record shall include:

A. Any known prior employment occupational exposure history

B. External and internal exposure received occupationally, including that received at other installations

C. Special dose evaluations and work restrictions

D. Reports of unusual exposure such as overexposure or incidents with potential for internal deposition

Each employee shall be informed of the results of all record dosimetry evaluations. Non-record exposure control information shall be preserved by the Radiation Records Control Officer (RRCO) for one year to enable exposure re-evaluation, if it should become necessary. Employee exposure records shall be retained by NES indefinitely. The NES records control program is detailed in Appendix D.

CHAPTER 3
CONTROL OF AREAS AND MATERIALS

3.1 RESTRICTED AREA CONTROLS

A. Controlled Areas

A controlled area is an area, described in physical barriers, which is posted with the prescribed caution signs for purposes of radiation protection. Entry into controlled areas will be limited by an appropriate Radiation Work Permit (RWP), as per Section 3.2.

The necessity for these controls may be based exclusively on radiation level, or may be a combination of surface contamination and radiation level or an area or airborne radioactivity. The size and number of controlled areas shall be minimized.

There are five (5) area posting classifications as defined below:

1. Radiation Area

A Radiation Area is an area, accessible to personnel, where there are radiation fields such that an individual could receive in any one hour a dose to the whole body in excess of 2.0 millirem, but not exceeding 100 millirem.

Each Radiation Area must be posted with a sign meeting applicable standards, including the radiation symbol and the words "CAUTION - RADIATION AREA" (Figure 3-1).

2. Surface Contamination Area

A Surface Contamination Area is an area accessible to personnel in which the limits for surface contamination below are exceeded. These values are taken as detectable above background.

Value in dpm/100cm^2	
Alpha	> 50
Beta	> 250
Gamma	> 250

Each Surface Contamination Area must be posted with signs meeting applicable standards, including the radiation symbol, and the words "CAUTION - SURFACE CONTAMINATION AREA" (Figure 3-2).

3. Airborne Radioactivity

Areas accessible to personnel will be posted as "AIRBORNE RADIOACTIVITY AREAS" if airborne radioactivity exists or is likely to exist in concentrations exceeding those specified in Appendix B, as per 10 CFR 20 limits, or in concentrations which, if averaged over a normal work week would exceed 25% of the specified concentrations (integrated exposure of 10 MPC hours).

Each Airborne Radioactivity Area must be posted with signs meeting applicable standards, including the radiation symbol, and the words "CAUTION - AIRBORNE RADIOACTIVITY AREA" (Figure 3-3).

4. High Radiation Area

A High Radiation Area is an area, accessible to personnel, in which there are radiation fields such that an individual could receive in any one hour a dose to the whole body in excess of 100 millirems. Each High Radiation Area must be posted with signs meeting applicable standards, including the radiation symbol, and the words "CAUTION - HIGH RADIATION AREA" (Figure 3-4).

5. Radioactive Materials

A Radioactive Materials Area is an area in which work with and/or storage of packaged radioactive materials is permitted. Each Radioactive Materials Area must be posted with signs meeting applicable standards, including radiation symbol, and the words "CAUTION -RADIOACTIVE MATERIALS" (Figure 3-5).

B. Identifying Controlled Areas

The boundaries of controlled areas, if not a permanent wall or fence, shall be clearly indicated by rope, or chain. Radiation warning signs printed in the standard yellow and magenta colors shall be posted to identify to personnel the actual or potential presence of radiation or contamination and to notify personnel of radiological conditions. In addition, requirements for entry into controlled areas shall be posted. The posting must be current, accurate, and credible in appearance.

The radiation symbol used on radiological signs and tags shall conform with American National Standards Institute Standard N2.1-1969. The radiation symbol in the standard colors (magenta and yellow) shall not be used for any purpose other than radiological controls.

All radiological posting shall be done by or at the direction of health physics personnel. Movement or removal of posted radiation warning signs, tags, or boundary markers by personnel other than health physics personnel or without their approval may be cause for disciplinary action.

Radiation warning signs or tags other than those approved for use by this manual shall be approved in writing by the Radoliological Safety Committee (RSC).

Controlled areas shall be posted with the appropriate signs such that posting is readily identifiable from all ordinary avenues of approach.

In laboratories or other areas where walls form the boundary of radiation areas and doors are the only access to the areas, signs shall be posted for the greatest visibility for personnel entering the area; normally, at eye level on access doors or on the wall adjacent to the entrance door on the latch side.

High Radiation Areas shall have physical boundaries which limit the entry of personnel, except at the planned entrance point. The entry point should be locked when the area is unoccupied. To prevent locking an individual in a High Radiation Area, one-way doors or crash hardware shall be used. In addition, the area must be searched for personnel at the end of each work shift and a head count performed to assure that all personnel have left the area. All personnel entering a high radition area shall sign a log sheet which is kept at the entry points. Health physics personnel shall accompany workers on the initial entry for each shift and shall check the log sheet at the end of each shift. ⚠

3.2 RADIATION WORK PERMITS

The Radiation Work Permit (RWP) (Figure 3-6) is used to delineate conditions and protective measures to prevent inadvertent exposure of personnel to radiation. RWP's are issued for a specific operation. The radiological conditions associated with the work to be performed are recorded on the RWP; also specified are the protective measures required to be utilized by personnel entering the designated area. The following requirements are established to assist in the proper use of the RWP:

A. The RWP is necessary for operations including a routine operation or maintenance cycle in controlled areas.

B. The RWP's are issued on an 8 hour-shift basis and may be extended up to three consecutive shifts. Extension into the second or third shift can be granted only if it is determined that radiological conditions have not been altered. If the conditions have been altered, a re-evaluation of the RWP is necessary and a new RWP shall be issued.

C. The Health Physics Supervisor (HPS) will determine the degree of monitoring and controls required for the work to be performed. This may include survey requirements, special dosimetry requirements, or required protective clothing and equipment.

D. Personnel who request the RWP will complete that portion which includes location and details of the job. The HPS will complete the sections on radiological hazards and controls. Prior to beginning the work specified, the RWP form must be signed by the operating supervisor, HPS, and the worker(s) indicating that they understand and will comply with the stated requirements.

E. A RWP is required for contract personnel performing any work at NES worksites in controlled areas or in areas where radioactive material may be present.

Prior to performing the work, the HPS will determine exposure estimates for the job. These estimates are to be included on the RWP. The exposure estimates should include an estimate of the time to perform the task and should control individual exposure within the administrative control levels of Section 2.1.

Following the completion of the specific operation the RWP was issued for, the results of any follow-up surveys, exposure control data, exposure of personnel involved with the RWP and any unusual or unanticipated radiological conditions associated with the job shall be included with the RWP on file with the Radiations Records Control Officer (RRCO) to enable exposure re-evaluation. If it should become necessary to perform the specific operation again, this data provides a means to review past performance of specific work to improve radiation exposure control on future work. (See Appendix D).

3.3 CONTAMINATION CONTROL

A. <u>Anti-Contamination Clothing and Equipment</u>

Anti-contamination (anti-C) clothing is worn by personnel to break the chain of contamination transfer and keep the body free from

contamination. Anti-C clothing as specified by an RWP shall be worn when either surface contamination or airborne radioactive contamination may exceed allowable limits.

Anti-C clothing of the following type shall be made readily available:

Cloth or disposable coverall
Rubber or disposable shoe cover
Rubber or disposable glove
Cloth or disposable hood
Half-face respirator, ambient air
Full-face respirator, ambient air
Eye goggles
Beta shield
Supplied-air breathing apparatus

Minimum protective clothing is shown on Table 3-1.

Additional clothing and protective equipment may be required by an RWP.

I. Operational Controls

A contamination control point is a location on the perimeter of a controlled surface contamination area or radiologically controlled area through which all entries and exits are made and where action is taken to prevent the spread of radioactive contamination to adjacent uncontaminated areas. The dimensions and material requirements depend on the type of work to be performed, the number of personnel involved, and the location of the work. All areas in excess of the limits for control specified in Section 3.1 shall be controlled in this manner.

The following are guidelines for establishing and maintaining controlled areas:

TABLE 3-1

PROTECTIVE CLOTHING REQUIREMENTS

Type of Radiation	Concentration Guide Limit [1] in DPM/100 cc Removable	Minimum Protective Clothing	Minimum respiratory Equipment
Alpha emitters	a. 50-500.	Shoe covers & gloves	None
	b. 501-1000.	Shoe covers, gloves, coveralls	None
	c. >1000, Inspection only	2 pairs of above plus hood	None
	d. (a - c) levels with standing water or spraying	(a - c) clothing with outer most coveralls, gloves, and boots to be made of plastic or rubber	Half-face respirator
	e. >1000, hands-on activities	Same as (c) above	Full-face respirator
Beta/Gamma emitters	a. 250-1000.	Shoe covers & gloves	None
	b. 1001-2500.	Shoe covers, gloves, coveralls	None
	c. >2500.	2 pairs of above plus hood	None
	d. (a - c) levels with standing water or spraying	(a - c) clothing with outer most coveralls, gloves, and boots to be made of plastic or rubber	Half-face respirator
	e. >2500	Same as (c) above	Full-face respirator

NOTE: Whenever personnel are working under conditions where beta radiation of <1.7 mev is determined by health physics personnel to be a potential eye hazard, eye goggles shall be worn. If the beta energy is >1.7 mev, a specific beta shield shall be used. No credit is taken for eye glasses or contact lenses.

a. The extent of the area of the control point and the locations for entry and exit should be clearly established.

b. Boundaries should be marked. Existing walls and equipment are useful as boundaries.

c. The deck of the contamination control point should be covered using paper, plastic sheet, or other material (e.g., an easily decontaminated floor covering) provided and labeled specifically for this purpose.

This is to provide an easily removable walking surface within the contamiantion control point to prevent tracking of contamination from the area. Caution is needed in using plastic sheet since it can be slippery, particularly if used in layers.

d. A "step-off pad" at the exit from the contamination control point shall be provided. This is to be used when removing clothing during exit from or upon entry to the area.

e. Easily accessible receptacles for radioactive waste and contaminated clothing should be provided at the contamination control point.

f. Instruments for monitoring personnel and equipment shall be on hand. Frisking is performed at the exit in a low radiation background and where the audible response of the frisker can be heard.

g. Radioactive material tags should be available to identify contaminated items being removed from the area.

h. Smoking, eating, or placing any object in the mouth is prohibited in contaminated areas.

i. Each person entering a Surface Contamination Area shall wear the protective clothing required for entry into the area as specified on the appropriate RWP.

2. Surface Contamination Guides for Special Operations

The limits specified in Section 3.1 do not apply to special operations where high levels of contamination are anticipated and special controls are used. Following are some examples of these special operations:

a. Operations inside small containment areas such as hoods, glove boxes, or enclosures where the surface and airborne activity is controlled by a local exhaust system. Only the hands enter the area, and supplemental surveys are obtained to ensure that contamination is not being spread to adjacent areas.

b. Operations inside large containment areas such as refueling floor tents used to cover the entire area. These areas have a filtered air handling system which will keep the containment area at a slightly negative pressure.

c. Operations in surface contamination areas where equipment has been intentionally designed or designated to come in contact with high levels of loose contamination. In these cases, the HPS will determine if the contamination control measures are adequate and that the general work area contamination levels are being maintained within NES limits.

Fixed radioactive contamination in surface contamination control areas will be posted based on the resulting area or contact radiation rate.

3. Controlling Contamination During Maintenance and Repair

This part identifies some of the problems which may be encountered in attempting to institute efficient detailed procedures for controlling radioactive contamination. Operating personnel are advised to employ initiative on a job-to-job basis in finding the most effective and economical contamination control procedure and in uncovering other contamination control problems not previously mentioned. Health physics personnel are available for recommendations and assistance. Work procedures will contain the instructions necessary to reduce the potential for spills and contamination spread.

One of the most effective means of controlling radioactive surface contamination is to use enclosures around the contaminated item to keep the radioactive material inside. Contamination containments should be used to the maximum extent practicable to control contamination. In many instances, it may be useful to use polyethylene sheets or bags around contaminated items to prevent contamination spread. The use of such enclosures allows workers to dispense with anti-C clothing, thereby improving their working efficiency. Polyethylene sheets and bags or glove-box-style portable containments may also be used to enclose contaminated materials to prevent contamination from getting outside the enclosure. The following rules apply to the construction of temporary containment enclosures around any operation which may contaminate adjacent areas to unacceptable levels or which may generate airborne radioactivity exceeding the concentration guides.

a. The enclosure shall be fire-retardant and shall consist of a fabric adequately supported with a frame or tied off to existing structural members. The fabric should be fire-retardant PVC or equivalent and the supporting structure should also be fire-retardant.

b. The enclosure must be complete on all sides and top and as nearly airtight as the situation permits. All seams will be sewn, glued, or sealed.

c. The enclosure should be large enough for proper completion of the job consistent with minimizing the contaminated area.

d. The entrance to the enclosure must be covered with an overlapping flap door which can be sealed.

e. In some cases, transparent windows may be installed to improve interior lighting or to provide visual access.

f. The enclosure should have at least one inlet filter installed.

g. Depending upon the radiological conditions anticipated, a high-efficiency particulate filtered exhaust system may be required. This system should provide five air exchanges per hour and maintain the enclosure atmosphere at a pressure lower than the surrounding (clean) area.

h. A change room enclosure may be required adjacent to the main enclosure.

i. Enclosures which are to be used in areas exposed to the weather should have a weather-resistant barrier in addition to the above requirements. The suggested barrier consists of 1/4-inch, fire-retardant, exterior grade plywood on the sides and top of the enclosure, with all seams sealed with tape. Also, a hinged plywood door may be used in addition to the flap door mentioned in Step 4 above. Both doors shall be kept shut when not in use. Suitably supported Herculite-type enclosures or equivalent may also be utilized in some outside applications.

j. The enclosure must be inspected and approved daily by health physics personnel prior to use. This approval and subsequent inspections shall be recorded in the appropriate logbook.

4. Maintenance of Radioactive Liquid Waste Systems

Contamination problems which may be associated with radioactive liquid waste disposal systems are as follows:

a. All piping in the liquid waste disposal system is potentially contaminated. Work on these systems requires a Radiation Work Permit and possibly continuous radiological surveillance to ensure control of surface contamination. Leaking valves, connections, and piping must be promptly repaired.

b. During work on radioactive liquid waste disposal systems, it is possible for piping or components to leak and spray radioactive liquid from the system. The resulting contamination may be deposited on a person working on the system. The requirements for wearing anti-C clothing to prevent contamination of personnel working on these systems will be established when completing the Radiation Work Permit for the job.

c. Disconnecting used components in a liquid waste handling facility may cause the spread of high levels of surface contamination since the radioactivity of crud trapped in connections may be high. Therefore, during disconnection, use should be made of polyethylene bags and sheets, tape, filtered bottles, drip pans, containment devices such as glove bags and other means to contain leakage.

B. Radioactive Decontamination

1. General

Decontamination may be required for tools and equipment, work areas, clothing, or personnel. Each of these subjects is discussed in the following articles. Alternatives to decontamination are also discussed in these articles. In some cases the alternatives may include storage for decay, disposal without decontamination, or restricted use without complete decontamination. By its very nature, decontamination generates radioactive waste. Therefore, in all decontamination operations, the disposal of the radioactive waste must be considered. To the extent practicable, the accumulation of large amounts of both solid and liquid wastes shall be minimized to reduce area radiation levels waste disposal cost. It should be noted that most loose surface radioactive contamination can be removed by washing with detergent and water. The general governing procedures for equipment and facility decontamination are presented in RCP-11.0, Guidelines for Facility Decontamination.

When large variations in surface contamination levels exist on contaminated surfaces, cleaning is done from less contaminated towards more contaminated areas. Cleaning solutions and cloths used in these decontamination operations will be disposed of as radioactive waste. During decontamination operations, precautions must be taken to limit the spread of contamination. These precautions would include wearing proper anti-C clothing and taking care not to splash solutions. Filtered exhaust ventilation or respiratory protection may also be required to minimize the contamination breathed by personnel performing the decontamination.

2. Decontamination of Personnel

Only health physics and qualified medical personnel are permitted to decontaminate personnel. Skin should be decontaminated using soap and water; scrub brushes should normally not be used because the skin

is relatively easy to abrade and contamination may be worked into the skin. Washing should be repeated several times, increasing water temperature and monitoring after each washing. If these procedures are not sufficient, further decontamination should be performed under the direction of medical personnel. The results of the decontamination must be recorded on the "Personnel Contamination and Internal Exposure Record" which will be retained in the employee's exposure file.

Contaminated wounds of any kind must be decontaminated under the direction of medical personnel.

CHAPTER 4
AIRBORNE RADIOACTIVITY

4.1 RESPIRATORY PROTECTION PROGRAM

A. General

All NES management personnel who have subordinate personnel working in controlled areas are responsible for maintaining concentrations of airborne radioactivity below the established limits (Appendix B). Health physics personnel will provide technical direction in placement and type of continuous and periodic air-sampling equipment required to detect and evaluate the levels of airborne radioactivity in work areas.

The respiratory protection program is the responsibility of the Radoliological Safety Committee (RSC). The RSO's responsibility is to implement the program. Respiratory protection equipment requirements will be specified on an RWP. Respiratory protection is addressed in the corporate "Occupational Health Manual" and in RCP-10.0, Airborne Safety Assurance Program.

Airborne radioactivity concentrations shall be minimized to the extent practical by the use of engineered controls (containment, ventilation, etc.). When establishing radiological controls for work involving potential airborne radioactivity, the first consideration should be to use techniques which will prevent airborne radioactivity and maintain loose surface contamination in controlled areas to as low as reasonably achievable levels.

B. Airborne Radioactivity Limits

Personnel shall not be subjected to concentrations of radioactive material in the air exceeding those specified in Appendix B or concentrations, which if averaged over a normal work week would exceed 25% of the specified concentrations (integrated exposure of 10 MPC hours), without the use of appropriate respiratory protective equipment.

The following concentration guide limits may be used for "in the field" evaluations by health physics personnel.

Type of Radioactivity	Concentration Guide uci/cc of Air
Alpha emitters	$<2 \times 10^{-12}$
Beta-gamma emitters	$<1 \times 10^{-9}$

C. Respiratory Protective Equipment

When airborne concentrations exceed the above limits, an air-purifying respirator is required as a minimum. The protection factor afforded is taken as 50. In situations where airborne concentrations of radioactive material exceed the stated concentration guides in Table 4-1, the full face mask, continuous flow, air line respirator of NIOSH/MSHA approval will be used. The air supply sources are the facility breathing air lines, via valves and connectors to air hose tubing to the wearer's "elephant trunk" flexible connection to the mask. The limitation of these supplied air respirator assemblies is that they cannot be used beyond the length of the supplied air line which would preclude its use in emergency escape from the facility.

The protection factor for particulates, gases and vapors afforded by a continuous flow, full face mask, atmosphere-supplying respirator worn in conjunction with the provisions of this manual is 2,000.

The self-contained breathing apparatus such as the recommended Scott Airpack will be made available by NES as described in the emergency action procedure (RCP-6.0). The compressed air bottle through a regulator valve feeds the continuous-flow full face mask. The limitation of the these respirators are the amount of compressed air within the bottle.

The protection factor for particulates, gases and vapors afforded by the self-contained breathing apparatus work in conjunction with the provisions of this manual is 5,000.

No other respiratory protection equipment will be used at airborne radioactivity concentrations above those listed in Appendix B unless supplied by a client for use at a client's facility in accordance with their respiratory protection program.

Additional general requirements with respect to the use of respiratory protective equipment is found in NUREG 0041 and Practices for Respiration Protectors, ANSI Z88.2-1980.

Table 4-1 contains a summary of the appropriate respiratory protective devices available from NES.

D. Respiratory Protection Maintenance Program

The maintenance program includes inspection, testing and repair, storage, inventory, issuance, surveys, decontamination, cleaning and disinfection, air quality checks, and maintenance of auxiliary equipment.

Inspections occur by the user prior to use and by a Health Physics Technician (HPT) prior to return to service. The user inspects for the total apparatus fit and function, and the HPT for the conformance to standard prior to packaging for reuse.

NES facility breathing air is periodically tested for quality and particulate radioactivity, as determined by the RSC.

Supplied and self-contained breathing apparatus is inspected once a month.

Masks for use are sealed in plastic bags and stored on shelves, other accessories which are ready for use are stored in bins.

TABLE 4-1

REQUIRED RESPIRATORY PROTECTIVE DEVICES

Type of Radioactivity	Concentration Guide Limit [1] in uci/cc air	Type of Device	Specific Recommendation
Alpha Emitters	a. $0 - 2 \times 10^{-12}$	a. None required	a. None required
	b. $>2 \times 10^{-12} - 4 \times 10^{-10}$	b. Ambient filtered air respirator	b. Cesco Model 95/96 with RC-80 Radionuclide cartridge
	c. $>4 \times 10^{-10}$	c. Supplied or self-contained air respirator	c. Scott Airpack
Beta/Gamma Emitters	a. $0 - 1 \times 10^{-9}$	a. None required	a. None required
	b. $> 1 \times 10^{-9} - 2 \times 10^{-7}$	b. Ambient filtered air respirator	b. Cesco Model 95/96 with RC-80 Radionuclide cartridge
	c. $> 2 \times 10^{-7}$	c. Supplied or self-contained air respirator	c. Scott Airpack

[1] Based on 10 CFR 20, Appendix B limits and the protection factors of 10 CFR 20, Appendix A and ANSI-Z88.2 (1980).

The self-contained breathing apparatus is stored in a container on a rack at designated areas.

The stock level of masks and respiratory protective accessories will be determined by the RSC.

Proper respirator fit is the most significant individual requirement of the wearer. Among the face pieces available are the MSA Clearvue and the Scottoramic by Scott, and the Cesco Model 95/96.

Employees who are required to be respirator qualified radiation workers are not permitted to have facial hair that may interfere with the proper sealing of respirators (i.e., beards, long mustaches, or long hair hanging into the face).

The standard check of fit is the ability to collapse the face piece by inhalation. The face piece should remain collapsed with the inlets blocked off. Subsequent assurance of fit is provided by the qualitative man test with challenge atmosphere, or its equivalent.

E. Respiratory Protection Training Program

Training is provided to all respirator users and individuals who direct the work of users in respirators. The training is conducted by NES. All personnel who are required to wear respirators must first pass a medical examination to certify their fitness to wear a respirator.

The individual conducting the respiratory protection program training is a qualified and experienced instructor with a thorough knowledge of the application and use of respiratory protective equipment and the hazards associated with radioactive airborne contaminants and experience in selection and use of respirators.

The training is provided annually at appropriate times to maintain a high degree of proficiency. Training and fitting records are maintained by the Radiation Records Control Officer (RRCO).

F. Air Sampling Program

Continuous monitoring and sampling for airborne particulate radioactivity shall be used in any area where personnel have a potential for exposure to airborne activity due to the radiological conditions of the area or specific operations being conducted in the area. Health physics personnel shall determine the need for continuous air monitoring. The continuous air monitors shall have a visual and audible alarm.

Requirements for response to an area air monitor alarm are:

1. All personnel who are not wearing respiratory equipment when the alarm occurs must immediately leave the area, standby in the general vicinity, and obtain a personal survey for contamination.

2. Health physics personnel will be notified.

3. Entry to the area is permitted for personnel who are wearing appropriate respiratory protection for the purpose of evaluating the source of airborne radioactivity or stabilizing it.

4. Personnel who are wearing respiratory protection when an alarm occurs may remain in the area only to stop operations which might be the source of the airborne radioactivity.

When personnel are working inside enclosures and using respiratory protective equipment, the Health Physics Supervisor (HPS) shall determine the need for continuously sampling of the air within the enclosure while the enclosure is occupied. These samples will be used to determine if workers have been exposed to concentration of radioactive material which exceed the protection provided by the respiratory protective equipment being worn.

There shall be stationary air samplers located throughout accessible areas under NES control. Many are in routine work areas. The samplers draw

ambient air through a filter. The samples are held 24 hours for short lived isotope decay and then counted for beta, gamma or alpha activity depending upon the area conditions and potential sources of airborne. The results are recorded in an Air Sample Log.

Depending on need and operational activity, the samples can be removed and analyzed, as needed. The number of samplers, their location, the frequency of filter change as well as other variables are under the control of a HPS.

There are plant chambers such as crane rooms which have higher radiation backgrounds and airborne activities which may exceed maximum permissible concentration (MPC) and vary with material movements in the chamber. These areas are not normally sampled. Personnel entries into these areas are covered by RWP's.

Breathing zone air samplers (BZAS) are available and are used when anticipated airborne activity is within the useful range of the sampler. Breathing air samples can also be taken with a regulated plant vacuum line connected to a person in respiratory equipment.

The results of the breathing zone air samples will be maintained in the employee's radiation history file and in the air sample log.

G. Personnel Exposure to Airborne Radioactivity

The following requirements are established for respiratory protection:

1. Personnel will wear respiratory protection in any area where the airborne radioactivity (excluding normal background) exceeds or is anticipated to exceed the concentration guides. The concentration guides for air are given in Table 4-1. The full-face respirators are to be used when the airborne activity may reach the concentration guide and/or when facial contamination could occur. For areas with high levels of loose contamination and expected airborne activity, full-face respirators with supplied air will be used.

2. When contaminated systems are opened and no containment is provided, respiratory protection will be used until airborne radioactivity does not or will not exceed the concentration guide during the operation.

3. Personnel will be trained in the proper use of respiratory equipment as part of the qualification requirements for radiation workers.

4. Prior to reuse, all respiratory protective equipment will be checked for damage and surveyed for contamination.

Since high airborne radioactivity may be accompanied by surface contamination, anti-contamination clothing shall be required as specified by the RWP.

Whenever personnel may be exposed to airborne radioactivity, area supervision shall ensure that the available ventilation systems are operating. Any repetitive operation which produces airborne radioactivity at a level requiring respiratory protection must be provided with appropriate ventilation and/or containment. The continuing use of respiratory equipment is not an acceptable alternate to adequate engineering controls.

Procedures in Section 3.2 of this manual will be followed to prevent the spread of radioactive contamination to minimize the possibility of radioactive particles becoming airborne.

Air monitoring surveys shall be performed at the following times:

a. Daily, or more frequently if necessary, in occupied surface contamination control areas or where work is being performed which may result in airborne radioactivity. Continuous air monitors may be utilized in place of this survey.

b. Before entering tanks or confined spaces where there is a high potential for airborne contamination.

c. When opening an internally contaminated system to the atmosphere.

d. Whenever airborne radioactivity levels are expected to be greater than the concentration guide.

Continuous monitoring for airborne particulate radioactivity shall be accomplished in any area where personnel have a high potential for exposure to airborne radioactivity due to the radiological conditions of the area or due to specific operations being conducted in the area. The continuous air monitors may be used for this purpose. If extension tubes are used on these units for local area monitoring, the sampling characteristics will change. These extension tubes should be as short as possible, with a minimum number of bends or obstructions. Whenever sampling extensions are added to these units, appropriate changes must be made to the alarm settings.

A portable airborne particulate sampler is used for grab sample air monitoring whenever installed samplers or continuous air monitors are not available or cannot be used. As some airborne particulate samplers do not remove all of the radioactivity with the filter, the exhaust from these units should be returned to the contaminated area or to a filtered ventilation system.

All airborne radioactivity areas will be posted as indicated in Section 3.1.

Records of the general air sampling system data, special samples, and investigations of high airborne radioactivity will be maintained for an indefinite period by the Radiation Records Control Officer (RRCO).

Personnel inadvertently exposed to concentrations of radioactivity in the air exceeding NES limits without respiratory protection equipment shall receive the appropriate bioassay and in-vivo examination (Section 2.3). Furthermore, the same evaluations shall be conducted in cases where workers are exposed to concentrations of airborne radioactivity which exceed the protection provided by respiratory protection equipment being worn.

H. Ventilation

All air handling systems designed to control radioactive material include absolute high-efficiency particulate air (HEPA) filters. Contaminated used filters shall be removed into plastic bags or by bag-out techniques. All air handling systems will be inspected, as per the prescribed documented schedule set forth in RCP-10.0, Airborne Safety Assurance Program for material accumulation.

Detectable levels of surface contamination can accumulate from settling out of airborne activity, even though the airborne activity itself does not cause significant concentrations of radioactivity. Therefore even though a ventilation exhaust air sample never indicated high airborne contamination, ventilation exhaust ducts are to be considered potentially contaminated. For similar reasons, if an exhaust blower is used in a contaminated area, surface contamination shall be checked on surfaces exposed to the exhaust of this blower. Exhaust blowers shall not be used to exhaust unfiltered air from surface contamination areas. To prevent the spread of radioactive contamination when using a blower in a surface contamination area, the intake to the blower must be through a (HEPA) filter.

Vacuum cleaners with HEPA filters may be used to clean items in surface contamination area. High airborne radioactivity and the spread of high levels of surface contamination have resulted from inadequate filtration of the vacuum cleaner exhaust air. Vacuum cleaners shall be made critically safe, when the maximum loading within the container can obtain a mass criticality, prior to using them in specified areas. Modifications, such as adding baffles to alter the container's geometry are acceptable.

When opening or resealing any integral part of a vacuum cleaner, either at the filter or upstream of the filter, the vacuum cleaner shall be dioctylphthalate (DOP) tested prior to reuse.

Hoods or openings into containment devices must have sufficient air flow into the openings to ensure that adequate containment is achieved. For existing units, the flow shall exceed 100 linear feet per minute. For new equipment a design velocity of 150 linear feet per minute is required.

CHAPTER 5
RADIOLOGICAL MONITORING

5.1 RADIOLOGICAL MONITORING METHODOLOGY

A. Radiation Surveys

Health physics supervisory personnel shall ensure that the appropriate survey instruments are available, functional, and calibrated using accepted standards for performing radiation surveys.

Radiation surveys shall be made by health physics personnel to determine whether abnormal radiation levels exist and to determine the extent and magnitude of radiation levels. Results of these surveys shall be provided to project management, identifying areas where corrective action is required. Follow-up surveys will be performed to assure appropriate corrective action has been taken.

Appropriate radiation surveys shall be performed in order to control radiation exposure during operations which may cause an increase in radiation levels.

Radiation surveys shall be performed in accordance with RCP-4.0, General Radiological Survey Procedure, in radiation areas, high radiations areas, and areas where radioactive material is stored.

Radiation surveys shall be performed in spaces surrounding controlled areas (including spaces above and below them if applicable) subsequent to movement of radioactive equipment or material. The boundaries shall be adjusted as necessary, as determined by on-site health physics personnel.

Boundaries of controlled areas which are established for a specific job and which will have a working existence of less than one month shall be surveyed each working day to ensure that radiation areas do not extend beyond posted boundaries.

The Radiological Safety Committee (RSC) shall establish and maintain a routine schedule for surface contamination surveys at NES controlled facilities. This schedule will define the areas to be surveyed and the frequency of the surveys.

During work with radioactive material, sufficient contamination surveys shall be taken to provide assurance that contamination control is maintained. The requirements for these surveys shall be included in the applicable operating procedure and/or radiation work procedures.

Any potentially contaminated item must be surveyed and released by health physics personnel before removal from a contaminated area.

B. Surveying For Personnel Contamination

Surveying for personnel contamination is the responsibility of and shall be performed by individuals who are trained and qualified as radiation workers. Health physics personnel shall survey all other persons. The instructions for using the equipment, the acceptable limits of contamination, and the action to be taken if any individual exceeds the limits shall be posted at each survey station.

If personal contamination is detected exceeding 100 dpm/100 cm^2 beta or any detectable alpha activity, health physics personnel shall be notified immediately. Contaminated individuals shall limit their movements as much as possible. Each instance of skin contamination will be investigated and documented.

Decontamination of personnel shall be conducted by or under the direction of health physics personnel in accordance with approved procedures (see Section 3.3).

NES shall monitor all contracted individuals involved at NES worksites. The exception to this rule is frisking oneself for radioactive contamination.

Frisking may be performed by qualified radiation workers or under the direction of a qualified radiation worker for individuals who are non-radiation workers (i.e., visitors).

5.2 RADIATION MONITORING EQUIPMENT

Portable radiation detection equipment is used for monitoring areas to determine radiation and contamination levels, thereby assisting in minimizing personnel radiation exposure.

The following safety precautions shall be observed by personnel using radiation survey equipment:

A. Experience has shown that personnel performing surveys sometimes receive more radiation exposure than the workers being monitored. Monitoring personnel have a responsibility for limiting their own exposure.

B. Only authorized personnel are permitted to repair these instruments.

C. Only personnel trained in the use of portable radiation monitoring equipment should be allowed to use this equipment. Adequate training will consist of instruction and demonstration on the use of an instrument and the meaning of its measurements, followed by a period of supervised use of the instrument. Supervisory personnel are responsible to ensure that personnel using the instruments are adequately trained.

D. Care shall be exercised to avoid damaging a radioactive check or calibration source and subsequently spreading or ingesting contamination.

E. To minimize the potential radiation exposure for an individual entering a radiation field of unknown intensity, the monitor shall start at a distance from the source with the instrument on the low scale and gradually approach the field. The instrument scales shall be switched as necessary to avoid off-scale readings.

Radiation detection equipment shall be calibrated and maintained by health physics personnel. Survey instruments in use by NES shall be calibrated every six months and after instrument repair. The battery check, if available, is to be utilized whenever the instrument is placed in service. Batteries are to be checked and if necessary, replaced during instrument calibration. Monthly battery checks are to be performed on instruments without internal battery checks. Survey instruments in use should be checked at least daily to verify that the instrument responds to radiation. The instrument must be checked to respond to a known dose or count rate rather than merely verifying that radiation causes an instrument response. Frisking instruments located at mandatory survey points should be checked daily to ensure proper operation. Evidence that a check was made will be maintained with the instruments.

The types and uses of specific radiation monitoring devices are listed in Table 5-1. These devices or their equivalent are specifically recommended.

TABLE 5-1
RADIATION MONITORING DEVICES

APPLICATION	SPECIFIC NES RECOMMENDATIONS
Personnel dosimetry, record	HARSHAW TLD/equipment
Personnel dosimetry, self-read	Atomic Products #019-100,200
Area radiation monitoring alpha	PRS-1,2 survey meter with AC3-7 probe
Area radiation monitoring beta/gamma	PRS-1,2 survey meter with HP-270, HP290 probes
Contamination monitoring beta/gamma	PRS-1,2 survey meter with HP-210, HP210AL probes
High level gamma radiation	Eberline Teletector G112A
Area exit surveys	Eberline Radiation monitor RM-20
Portable air sampling device	Eberline RAS-1
Isotopic analysis	Canberra Model 85 MCA with intrinsic germanium crystal
General field geiger counter	E-140N with gamma/beta probe

5.3 EFFLUENT AND ENVIRONMENTAL MONITORING

A. Effluent Monitoring

Radioactivity in airborne and liquid effluents released due to NES activities shall be monitored to ensure compliance with release limits specified in 10 CFR 20 to evaluate the effectiveness of controls, and to provide information on the type and quantity of radioactivity released by NES operations.

1. Airborne Radioactive Effluents

a. Ventilation exhausts from NES operations which are normally used for radioactive work shall be monitored in accordance with the following minimum requirements:

1) An air sampler, preferably a particulate filter type, shall be in continuous operation whenever air is being exhausted. In the event that the installed sampler is inoperable, temporary back-up monitoring shall be used until it is repaired.

2) The sample probe shall be located in the exhaust stack or duct downstream of any HEPA filter or any other particulate removal devices, such that a representative sample of air is obtained.

3) Procedures shall establish criteria for changing filters on ventilation exhaust samplers considering ventilation system usage and the analytical minimum detectable activity.

4) Contamination surveys shall be taken in plenum downstream of HEPA filters during routine filter

replacement to detect radioactivity build-up in ducts downstream of filters.

*5) A plant process stack is the primary gaseous waste release point and as such shall be monitored in accordance with the following additional requirements:

a) Continuously collected stack samples shall be analyzed at least every seven days for particulate radioactivity.

b) A continuously operating stack monitor shall be used to measure particulate radioactivity in stack gas.

c) If the stack sampler becomes inoperative, immediate repair shall be instituted to return the unit to service, and the stack monitor shall be used in the interim to determine particulate releases. If the stack monitor fails, a representative sample shall be collected each 8-hour shift and used to determine particulate radioactivity discharged.

d) Continuously collected samples shall be composited on a quarterly basis and analyzed for specific radionuclide content. Analyses shall be quantitative for the most important radionuclides (those primarily anticipated) and qualitative for less important nuclides (e.g., miscellaneous gamma emitters). The relative significance of a nuclide shall be determined based on consideration of quantities released, environmental pathways, and potential impacts on man and the environment.

*Section identified by an asterisk (*) are criteria identified by the technical specifications of the appropriate NES license.

2. Liquid Radioactive Effluents

a. The concentration of radioactivity in contaminated liquid wastes must be determined prior to discharge. A representative sample of the collected liquid shall be obtained by those responsible for the operation of a particular system. The sample presented for analysis will be accompanied by a laboratory analysis form with the appropriate items completed. The sample will be analyzed for gross alpha and gross beta-gamma activity, and tritium. Procedures for ensuring that the sample is actually representative of the contents are included in the waste management system operating procedures. No additional liquid waste may be added to the sampled volume prior to or during discharge of the contents.

b. The type and frequency of sampling shall be determined by considering the purpose for which the data are being obtained (e.g., compliance with standards, compilation of release data, etc.). The method of sampling may be specified in the applicable regulation or permit.

c. The type of analyses to be performed on the samples shall be radionuclide specific. Gross radioactivity measurements are acceptable only under the following conditions:

1) When gross radioactivity releases are a small fraction of the concentration guides specified for "unidentified mixtures" and are of no health or environmental significance

2) When the relative concentrations of specific radionuclides are otherwise documented such that gross radioactivity measurements are truly indicative of the activity being released, or

3) When the activity of waste streams is so low as to preclude specific radionuclide measurements.

d. Sampling and analysis of release point effluents shall be conducted in accordance with the NES "Controlled Facility Radiological Monitoring Program" as detailed in Appendix C.

In addition to the effluent monitoring, on-site environmental samples shall be collected to ensure that radioactive liquids have not been inadvertently discharged.

In order to provide additional assurance that NES operations do not cause significant concentrations of radionuclides in the environment or significant radiation exposure to the general population, an environmental monitoring program shall be conducted at all permanent NES sites. The program shall include routine measurements of direct radiation exposure using film badges or TLDs and of radioactivity in environmental media (e.g., air, water, milk, etc.).

The program shall be designed to ensure that the important radionuclides and environmental pathways are monitored. The NES environmental monitoring program is presented in Appendix C.

5.4 RECORDS AND REPORTS

The results of all surveys are retained indefinitely by the Radiations Records Control Officer (RRCO). Radiation survey records shall be reviewed periodically so that trends will be detected as early as possible. All survey data shall be compiled on standard NES survey forms as shown in Appendix D.

On-site monitoring data shall be reported as required to demonstrate compliance with standards, or to aid in interpreting off-site data. Report format and typical reporting requirements are presented in Appendix C.

Radioactive effluent and On-Site Discharge Data Reports including the data forms, cover sheet, maps, and if necessary, explanatory information shall be submitted in accordance with instructions provided by the NRC. Maps should be included only when they reflect modifications (termination or start-ups, etc.) from previous years. A monitoring data report shall consist of:

1. A cover sheet listing the site, facility, report period, contractor(s), and address.

2. A summary providing pertinent descriptive and interpretative information which would serve to explain any facets of the data which are not adequately described on the forms.

3. Maps, 8-1/2 x 11 inch, showing the locations of effluent streams and on-site discharge points.

4. Completed Radioactive Effluents/On-Site Discharges/Unplanned Releases Form (see Appendix C).

Any data errors on the Radioactive Effluent/On-Site Discharge Form shall be promptly reported to the NRC using amended forms.

CHAPTER 6
RADIOACTIVE WASTE MANAGEMENT

6.1 GENERAL

A. Purpose

It is the policy of NES to minimize the amount of radioactivity discharged to the environment. This policy is implemented by a radioactive waste management program, designed to ensure that all radioactive wastes generated within the boundaries of the site and through qualified activities, are controlled from originating source to ultimate disposition and that releases to the environment are maintained as low as technically and economically practical. As a further precaution, environmental media are periodically monitored to ensure that an increase in radioactivity is not occurring at NES worksites.

B. Limits for Releases

Releases of radioactivity from on-site processes shall not result in concentrations at the site boundary in excess of the concentrations stated in Appendix B. Every effort shall be made to reduce concentrations as far below these limits as is practical.

The above concentration limits will be met by meeting the following specific effluent limits:

*1. Airborne Releases

Radioactivity released from a process building stack shall be limited to 0.1 microcuries per second of gross alpha plus gross beta, averaged over one month.

*Sections identified by an asterisk (*) are criteria identified in the technical specification of the appropriate NES license.

*2. Liquid Releases

Activity measured in natural streams including releases from all sources on a site shall not exceed either of the following:

a. Ten percent (10%) of the pro-rated concentrations listed in Appendix B averaged over any quarterly period; or

b. Twenty percent (20%) of the prorated concentrations listed in Appendix B, for any weekly composite taken in accordance with the NES effluent monitoring program (Chapter 5).

*3. Corrective Actions

If the radioactivity concentrations exceed the limits specified above, NES shall:

a. Take actions as are necessary to come into prompt compliance,

b. Make an investigation to identify the cause or causes for such levels of radioactivity,

c. Initiate and carry out a course of action to reduce such levels, and

d. Report actions taken.

*Sections identified by an asterisk (*) are criteria identified in the technical specification of the appropriate NES license.

6.2 LIQUID RADIOACTIVE WASTES

A. Control Requirements

Radioactive liquids shall be managed to meet the limits specified in Appendix B and to minimize their release to the environment. NES procedures shall implement the liquid waste management program by including the following basic requirements:

1. The total generation (gallons) of radioactive liquid waste shall be minimized.

2. The quantity of unprocessed radioactive liquid waste temporarily stored in tanks or holding ponds shall be minimized. However, liquid wastes to be batch processed may normally be accumulated until the batch size available can be economically processed.

3. Unprocessed and processed liquid wastes at NES working sites shall be managed to maintain the inventory as low as practical.

4. NES procedures shall include control methods designed to reduce the total radioactive discharged as liquid waste to levels as low as technically and economically practical.

*5. Dilution shall not be used to reduce concentration of liquid waste below the discharge limit, except as specifically authorized by the Radiological Safety Committee (RSC) or by the responsible client agents.

6. Radioactive liquids other than exempt quantity samples shall not be transported on public highways unless in compliance with applicable 49 CFR and applicable state transport and packaging regulations.

*Sections identified by an asterisk (*) are criteria identified in the technical specification of the appropriate NES license.

7. Equipment for radioactive liquid collection which is subject to bursting from exposure to freezing conditions shall be provided with freeze protection.

8. New radioactive liquid transfer systems design should provide for accessible leak detection devices to preclude unnoticed equipment or piping failures.

9. To minimize the cost and difficulty of radioactive liquid waste processing, the sources of water transferred to the waste treatment and disposal system shall be controlled based on the following requirements (applicable to existing systems to the extent practical, and to all new systems):

   a. Non-radioactive liquids shall not be transferred to radioactive liquid waste tanks since they unnecessarily increase the volumes of liquid to be processed. Sinks which drain to radioactive liquid holdup tanks shall be posted with signs stating, "DISCHARGE OF NON-RADIOACTIVE LIQUIDS IS PROHIBITED".

   b. Segregate radioactive liquids in order to minimize uncertainties as to methods or processing liquids containing mixtures of chemical contaminants; these liquids are usually more difficult to process. The following minimum requirements shall be followed, except when specified otherwise by procedure:

      1) Solutions containing decontamination chemicals, such as detergent, or citric acid-EDTA, shall not be added to water which does not already contain such chemicals. A small amount of chemical-laden water can make the entire contents of a tank difficult to process.

      2) Water which is known to contain oil or grease, or organic degreasing compounds such as freon or trichloroethylene,

shall not be mixed with water which is free of such compounds.

3) Small volumes of liquids generated in controlled areas which are normally non-radioactive shall be collected separately. Once confirmed to be with the release limits specified in Appendix B, these liquids are permitted to be discharged to a non-radioactive system.

c. Drains leading to radioactive liquid waste tanks shall be protected to prevent introduction of miscellaneous waste and debris to these tanks.

10. Portable liquid waste collection tank design shall prevent inadvertent or accidental draining within reasonable operating conditions and hazards.

11. Collection tanks shall be vented through a high efficiency filter and, if necessary, through a demister. Vents shall be properly located and unobstructed.

12. Anti-siphon design criteria shall be applied to systems used with waste collection tanks.

13. Written operating procedures for waste management system tanks shall include maintenance procedures which specify quality assurance inspection procedures and frequency of inspections. Frequency of tank inspections shall be based on criteria such as tank usage, (e.g., collection of corrosive chemicals), known buildup of a sludge and radioactivity or results of previous inspection. Deficiencies discovered during tank inspection shall be corrected prior to using the tank again for collection of radioactive liquids. Portable tanks which have not been used during the previous inspection period shall be inspected to prior to the next use. Documentation shall be in accordance with applicable quality assurance guidelines.

14. Radioactive liquid transfer hoses shall be periodically inspected for indication of deterioration or damage. Hose which has exceeded its safe useful life shall be removed from service and disposed of in a manner which prevents its reuse.

15. Liquid waste management procedures shall include criteria for decontamination of radioactive liquid collection systems, piping and associated connections for the purpose of:

    a. minimizing cross-contamination of subsequent batches of liquid,

    b. permitting maintenance of these items,

    c. reducing radiation levels in nearby spaces,

    d. minimizing the possible spread of contamination from disconnected components, and

    e. minimizing activity of discharges.

16. Transfers of radioactive liquids shall be conducted using procedures which include specific operating details. The extent of radiological controls required is commensurate with the potential for an incident or the subsequent radiological consequences. Spill control provisions shall be provided, including initial notification and immediate action requirements, with the written procedures.

B. Processing Low-Level Radioactive Liquids

The operation of radioactive liquid waste treatment and disposal systems shall include the following requirements:

1. Radioactive liquid waste treatment and disposal to the environment from NES working sites shall be in accordance with written operating procedures.

2. The treatment and disposal systems will be operated only by personnel who have been formally qualified by the project or activity responsible for the operation of a particular system.

3. Procedures shall be established for preventative maintenance of radioactive liquid systems. Quality assurance and documentation procedures will serve to preclude incidents caused by failed system components.

4. Areas which produce significant quantities of low-level radioactive liquid waste should be equipped with local processing systems where feasible to reduce the load on the main treatment and disposal system. Examples include filtration and ion exchange systems installed locally to permit recycling, or evaporators to reduce the flow of or eliminate highly contaminated liquids entering the main processing system.

C. Solidification of Low-Level Radioactive Liquids

Procedures shall be established for solidification of special radioactive liquid wastes that are difficult to process, such as those containing high concentrations of radioactivity, oil or grease, or certain chemicals (e.g., decontamination solutions). At a minimum, the solidification requirements shall include the following:

1. Consideration in selecting the location where solidification is performed to minimize transport of liquids to be solidified.

2. Solidification to be performed in containers which meet applicable 10 CFR 71, 49 CFR and state transporting and packaging regulations. Steel drums, when used, shall be new and meet applicable federal criteria for the prospective package contents.

3. Liquid wastes requiring solidification to be processed as soon as practical to avoid the possibility of containers leaking during storage.

4. Drums and other containers of solidified radioactive liquids to be disposed of as solid radioactive waste in accordance with Section 6.3.

5. New systems for immobilization of liquid radioactive waste will utilize Portland cement or a comparable solidification agent to fix the liquid waste.

6.3 SOLID RADIOACTIVE WASTES

A. Sources of Solid Waste

Solid radioactive wastes originating at NES worksites include, for example, such items as radioactive filters, expended activated charcoal or resin, demineralizers or resin catch tanks containing spent resin, metal scrap, dry trash, sampling planchets, filter papers, etc. resulting from radiochemistry and radiation monitoring operations, ventilation filers, and solidified liquid wastes. The following specify requirements for packaging and disposition of solid radioactive waste.

B. Solid Waste Packaging

Radioactive solid waste is classified as either high activity or low activity based on the exposure rate on contact with the waste containers. High activity ($\geq$200 mR/hr) radioactive solid waste requires shielding during collection or storage and shall be collected and packaged in accordance with operating procedures specific to the waste producing process. These procedures shall ensue that high activity wastes are collected and packaged in a manner that minimized occupational exposure, airborne radioactivity, and surface contamination levels to as low as reasonably achievable practical levels. Low activity (<200 mR/hr) radioactive solid wastes do not require shielding during collection or storage, but shall also be collected and packaged so as to minimize exposure and contamination. Where possible, non-radioactive waste will be segregated from radioactive waste during collection.

Procedures for packaging solid waste shall include the following requirements:

1. Documentation of proper container specification and condition prior to use.

2. Controlled designated radwaste staging areas for:

   a. Inventory control.

   b. Fire hazard reduction.

   c. Contamination and radiation control.

3. Specific airborne radioactivity controls in effect during volume reduction and container loading operations.

4. Specific measurement, monitoring and labeling requirements with respect to the type of waste being packaged.

5. Waste package inventory, storage, and routing documentation.

6. Materials prohibited from disposal as solid waste include the following:

   a. Explosives or pyrophoric material, and

   b. Liquids, except liquids fixed in solids by an approved solidification agent.

7. Waste form shall meet the requirements of and be classified by 10 CFR 61.

6.4 AIRBORNE RADIOACTIVE WASTES

A. Control Requirements

All air handling systems specifically designed to control radioactive materials which discharge to the environment must include HEPA filters. The air handling requirements for ancillary systems exhausting normally clean areas are evaluated on a case basis.

Air cleaning systems shall be properly maintained and used, and shall ensure that radioactivity released in effluents are within the limits specified in Appendix B or by the client facility operating license.

Used filters are normally radioactive and must be disposed of as solid radioactive waste.

B. Operations Limits

1. The sustained operating pressure differential across any HEPA filter in any of the exhaust ventilation systems shall not exceed 85% of the greatest pressure differential for which that filter design has been fabricated in accordance with the appropriate manufacturer requirements.

*2. Instrumentation monitoring the differential pressure across the operating HEPA filters in a ventilation system shall be operable during operation of the filter. If this instrumentation should become inoperable, operation of the filter may continue for 10 days, provided that the instrumentation monitoring the differential pressure across the HEPA filter and any roughing filter is operable.

*Sections identified by an asterisk (*) are criteria identified in the technical specifications of the appropriate NES license.

C. Surveillance Requirements

1. HEPA filters shall be visually inspected for damage prior to installation.

*2. If any of the filters currently in use are changed or modified, they shall be tested, prior to routine service, with particulates of an appropriate size to establish that the installed filters provide a collection efficiency of at least 99.95% for particulates 0.3 microns in diameter or larger.

*3. The differential pressure across the final operating HEPA filters (or HEPA plus roughing where the filters are within the same frame) shall be recorded by instrumentation.

4. In designing and installing new HEPA filter systems, the following requirements shall be met:

a. After installation of new filters, they shall be tested to ensure that they are 99.95 percent efficient in removing 0.3 micron (DOP) particles.

b. Installed filters shall be retested as required by the radiological conditions of the operations to be performed, or at least annually. If the retest frequency is greater than once annually, it will be specified in operating instruction specific to that system.

*Sections identified by an asterisk (*) are criteria identified in the technical specifications of the appropriate NES license.

c. Filters shall be replaced based on pressure drop, flow reduction, and/or radiation level criteria developed specifically for each air cleaning system to ensure its proper operation.

5. Filter installation and surveillance will be performed such that correct replacement, operation and testing will be documented to satisfy applicable quality assurance requirements.

6.5 RADIOACTIVE WASTE SHIPMENT AND DISPOSAL

All NES radioactive waste shipments shall be conducted in accordance with the packaging and transport guidelines of RCP-5.0, Guidelines for Radioactive Waste Disposal.

The shipment and disposal of low-level radioactive solid waste shall be subject to the following requirements:

A. Radioactive solid waste shall be disposed of only in land disposal sites approved by the Nuclear Regulatory Commission and or the appropriate Regional Compact Association.

B. Transuranic wastes (wastes contaminated with certain alpha emitting radionuclides of long half-life and high specific radiotoxicity to greater than 10 nanocuries per gram) will be packaged and stored separately for subsequent shipment to an approved disposal facility.

C. The volume of radioactive solid waste to be disposed of shall be reduced as much as is practical by minimizing the amounts of material which becomes contaminated during NES operations and by compaction of compressible radioactive solid waste.

6.6 RECORDS AND REPORTS

A. Monitoring Records

Records of results of effluent, on-site and environmental monitoring and sampling shall be maintained in good order by the Radiation Records Control Officer (RRCO).

B. Solid Waste Records

Records shall be maintained for all solid radioactive waste prepared for burial. The following information is required for each container as per the NES Radwaste Manifest:

1. Type of container (e.g., 55 gallon drum), and I.D. designator.

2. Radiation level and smear survey results.

3. General type of waste (e.g., spent resins, contaminated scrap), and its source.

4. Estimated isotopic content. Include special notation for TRU, SNM, or other waste requiring segregation or special handling.

5. Estimated activity content.

6. Volume and weight of filled container.

7. Any and all additional classification requirements of 10 CFR 61.

The above information shall be incorporated in the radioactive waste manifest system as prescribed by 10 CFR 20.

C. Testing and Documentation

Vital equipment and instrumentation will be tested and maintained in compliance with applicable quality assurance standards. Whenever possible, these items will be included in the written operating procedures. All records of tests and calibrations of radiological monitoring and related equipment shall be maintained by the RCCO.

CHAPTER 7
RADIOLOGICAL CONTROL PROCEDURES

7.1 OPERATIONAL PROCEDURES AND REVIEW REQUIREMENTS

Detailed procedures incorporating radiological and other safety considerations are required for the handling of radioactive materials. Preparation of such procedures by NES minimizes the problems encountered by requiring explicit planning in advance of actually performing the work. The written procedures become both a general guide and where needed a step by step listing for the personnel performing the operation. Prior to being issued for use, the procedure must be reviewed and approved in accordance with the NES Quality Assurance Manual 81A9002. The Radiological Safety Committee is responsible for promulgation of these procedures and is the governing authority concerning their scope, content, and application.

Environmental and occupation care and safety will be accounted for in the preparation of procedures, work plans, and designs which present actual or potential radiological/industrial safety hazards, or impacts to the environment.

7.2 PROCEDURE LISTING

The following procedures shall be maintained and revised as necessary by the Radiological Safety Committee. Revisions shall occur as required by changes in existing NES licenses, new license applications, regulatory alterations, or due to technological changes.

RCP-1	Radiological Quality Assurance and Control
RCP-2	Radiation Worker Handbook and Training Manual
RCP-3	Instrumentation Calibration Procedure
RCP-4	General Radiological Survey Procedure
RCP-5	Guidelines for Radioactive Waste Disposal
RCP-6	Emergency Actions Procedure
RCP-7	General Industrial Safety Procedure

RCP-8	Radiation Work Permit Procedure
RCP-9	Radiological Sample Shipment Procedure
RCP-10	Airborne Safety Assurance Program
RCP-11	Guidelines for Facility Decontamination
RCP-13	Receipt and Handling of Radioactive Materials (RAM) Packages

APPENDIX A

RADIOLOGICAL PERSONNEL QUALIFICATION STANDARDS

This appendix sets forth the requirements for specific health physics positions referred to in the NES Radiological Protection Manual. The requirements for each position conform with NRC requirements and recommendations from similar programs and conform with the recommendations of the National Council on Radiation Protection and Measurements (NCRP-59).

Health Physics Technician (HPT)

A Health Physics Technician (HPT) is required to perform much of the implementation duties associated with the NES Radiological Protection Manual. The qualifications of the HPT must include as a minimum formal training in health physics and at least two (2) years of practical health physics experience. The specific abilities required include:

1. A working knowledge of the units and measures used concerning radioactivity and radioactive materials.

2. A working knowledge of the types of radiation and the effects of specific shielding on those radiations.

3. Knowledge of the biological limits imposed by law and by NES on worker exposure.

4. A working knowledge of counting statistics.

5. A working knowledge of the principles of radiation detection and the appropriate devices used for each occasion.

6. A knowledge of the procedures, frequency, performance, and maintenance requirements to perform area radiation surveys.

7. A knowledge of the procedures, frequency, performance, and maintenance requirements to perform contamination surveys.

8. A knowledge of the procedures, frequency, performance, and maintenance requirements to perform airborne surveys.

9. An ability to perform contamination control requirements.

10. An ability to perform decontamination of personnel, equipment, and general areas.

11. A knowledge of emergency action measures and emergency response ability as per RCP-6.0, Emergency Actions Procedure.

12. A working knowledge of personnel exposure control.

Health Physics Supervisor (HPS)

The workscope delegated to a Health Physics Supervisor (HPS) requires both working with and managerial control of health physics activities performed by an HPT. The background requirements include a degree in health physics or the biological sciences and at least five (5) years of work experience in the health physics field. The training provided by the United States Naval Reactors program is sufficient to meet NES requirements. The working responsibilities necessitate that the HPS has abilities in addition to those of an HPT as per the following:

1. Knowledge of the biological effects of radiation.

2. Knowledge of correct procedure for receipt and shipment of radioactive material.

3. Ability to interpret airborne and radiation survey data.

4. Knowledge of the performance and evaluation of environmental monitoring.

5. Knowledge and ability to select specific instrumentation for a given situation.

6. Ability to calculate radioactive decay schemes, isotopic buildup, and equilibrium analyses.

7. Knowledge and ability to select specific personnel dosimetry and protective clothing for a given situation.

8. Recognition and anticipation of radiation and traumatic safety problems.

9. The ability to:
   - prepare and implement emergency plans
   - evaluate and implement respiratory protection plans and equipment use
   - evaluate and implement radwaste handling and packaging

Radiation Safety Officer (RSO)

The role of the Radiation Safety Officer (RSO) at NES is to provide specialized assistance and guidance to the operating departments and subgroups in the development and implementation of the radiation safety aspects of all programs and projects. The RSO also serves in an audit role to determine if established practices and procedures are being correctly employed and are adequate for each particular need.

The minimum requirements for the position of RSO follow accordingly and will depend upon the magnitude of the potential operations and hazards expected. He shall possess a combination of formal health physics training and practical work experience of not less than five (5) years. The American Board of Health Physics certifies professionals who meet its requirements. Such certification is sufficient training and experience in of itself for the RSO position at NES.

Specific applicant abilities:

1. An ability to communicate clearly by both verbal and written means.

2. Knowledge sufficient to understand the practical and theoretical aspects of health physics, including differential equations, nuclear particle interactions, and the currently known biological effects of all forms of ionizing radiation.

3. Knowledge of standards and current industry practices, including an ability to understand, interpret, and effectively apply each of the references to the NES Radiological Protection Manual (Appendix G).

4. Knowledge of the appropriate Nuclear Regulatory Commission regulations, recommendations and guidelines as well as those of all other regulatory bodies of concern.

5. The ability to perform any of the following functions:
   - performance of instrument calibrations
   - performance of shielding evaluations
   - calculation of internal/external exposures
   - design and conduct radiation worker training
   - design and conduct a bioassay program
   - perform any of the work functions of an HPS

6. The knowledge and judgment necessary to effectively manage a radiation safety program as outlined in this manual.

Radiological Safety Committee (RSC)

The Radiological Safety Committee (RSC) shall be composed of between three and seven members, each possessing some background and competence in radiation practices and/or personnel safety. Representing management shall be the President of

NES. His responsibilities and duties shall necessitate a knowledge of the administrative, operational, cost, and legal implications of committee decisions. The balance of the committee shall be composed of RSO's or their designates. The NES President shall act as committee chairman and shall not have a vote in technical committee decisions, including procedure approval, exposure evaluations, etc., but is present solely to provide the committee with the requirements of NES and to impose restrictions on committee actions by defining the limits of committee authority. The President shall have the authority to veto any and all committee decisions which are not technical in nature. Accordingly, decisions of policy are outside the scope of the committee RSO members.

APPENDIX B

MAXIMUM PERMISSIBLE LEVELS FOR UNRESTRICTED AREAS

The limiting amount of radiation and of radioactive material in an unrestricted area allowed by federal law is presented in 10 CFR 20. An NES area where the radiation or radioactive material levels are greater than these limits shall be considered an NES controlled area and is subject to the restrictions imposed by the Radiological Protection Manual.

Radiation Levels

The maximum amount of radiation an individual is allowed to receive in an unrestricted area is set by 10 CFR 20.105a at:

500 mRem/yr
2 mRem/hr
100 mRem/seven consecutive days

The limits imposed by NES in keeping with the ALARA philosophy are:

250 mRem/yr
2 mRem/hr
50 mRem/seven consecutive days

Effluents to Unrestricted Areas

NES shall not possess, use or transfer radioactive materials so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in 10 CFR 20.106 and shown here as Table 2. The concentrations specified may be averaged over a period not greater than one year.

Release of larger amounts to an unrestricted area will be permitted only upon NRC approval and NES fulfillment of the requirements of 10 CFR 20.106 (b)(c). The NRC may apply specific restrictions in excess of Table 2.

Effluents to Sanitary Sewage Systems

NES shall not discharge radioactive material into a sanitary sewage system unless the requirements of 10 CFR 20.303 are met. Specifically;

1. the material must be readily soluble or dispersible in water
2. the average daily quantity is less than Table 1, Column 2 or less than ten (10) times Table 3
3. The average monthly quantity is less than Table 1, Column 2
4. The gross quantity of the following is not exceeded:

   Hydrogen -3 = 5 curies/yr

   Carbon -14 = 1 curie/yr

   All other isotopes = 1 curie/yr

Specific Wastes

NES may dispose of the following material without regard to its radioactivity:

Hydrogen -3 Carbon -14	0.05 uCi/gm of media (used for liquid scintillation counting)
Hydrogen -3 Carbon -14	0.05 uCi/gm of animal carcass (provided non-use as food or feed)

Airborne Restrictions

NES shall maintain airborne radioactive material levels in all unrestricted rooms, enclosures, or operating areas at concentrations which, averaged over the number of hours in any week during which individuals are in the area, are less than or equal to 25 percent of the values in Table 1, Column 1.

CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope[1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-5}	8×10^{-14}	2×10^{-6}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-8}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 242m	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	3×10^{-10}	3×10^{-3}	9×10^{-12}	9×10^{-5}
	Am 242	S	4×10^{-8}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	5×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 244	S	4×10^{-6}	1×10^{-1}	1×10^{-7}	5×10^{-3}
		I	2×10^{-5}	1×10^{-1}	8×10^{-7}	5×10^{-3}
Antimony	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}		1×10^{-4}	
	A 41	Sub	2×10^{-6}		4×10^{-8}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-2}	3×10^{-11}	6×10^{-4}
		I	1×10^{-7}	2×10^{-2}	4×10^{-9}	6×10^{-4}
	Bk 250	S	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	5×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-8}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-2}	3×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	7×10^{-9}	4×10^{-4}
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
		I	7×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
	Cd 115m	S	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-4}	5×10^{-14}	4×10^{-6}

See 10CFR20, Appendix B for all footnote explanations

CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope[1]		Table I		Table II	
			Col. 1—Air ($\mu Ci/ml$)	Col. 2—Water ($\mu Ci/ml$)	Col. 1—Air ($\mu Ci/ml$)	Col. 2—Water ($\mu Ci/ml$)
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cf 250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 251	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 252	S	6×10^{-12}	2×10^{-4}	2×10^{-13}	7×10^{-6}
		I	3×10^{-11}	2×10^{-4}	1×10^{-12}	7×10^{-6}
	Cf 253	S	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
		I	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
	Cf 254	S	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
		I	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	(CO_2)	Sub	5×10^{-5}		1×10^{-6}	
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Ce 144	S	1×10^{-8}	3×10^{-4}	3×10^{-10}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Cesium (55)	Cs 131	S	1×10^{-5}	7×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-6}	3×10^{-2}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-8}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-8}	2×10^{-3}
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	6×10^{-9}	4×10^{-4}
	Co 58m	S	2×10^{-5}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-2}	3×10^{-7}	2×10^{-3}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	9×10^{-9}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
		I	2×10^{-10}	7×10^{-4}	6×10^{-12}	2×10^{-5}
	Cm 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	5×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cm 244	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cm 245	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 246	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 247	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	6×10^{-4}	4×10^{-12}	2×10^{-5}
	Cm 248	S	6×10^{-13}	1×10^{-5}	2×10^{-14}	4×10^{-7}
		I	1×10^{-11}	4×10^{-5}	4×10^{-13}	1×10^{-6}
	Cm 249	S	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
		I	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}

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CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope [1]		Table I Col. 1—Air (μCi/ml)	Table I Col. 2—Water (μCi/ml)	Table II Col. 1—Air (μCi/ml)	Table II Col. 2—Water (μCi/ml)
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-4}	3×10^{-11}	2×10^{-5}
		I	6×10^{-10}	7×10^{-4}	2×10^{-11}	2×10^{-5}
	Es 254m	S	5×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
		I	6×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
	Es 254	S	2×10^{-11}	4×10^{-4}	6×10^{-13}	1×10^{-5}
		I	1×10^{-10}	4×10^{-4}	4×10^{-12}	1×10^{-5}
	Es 255	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	4×10^{-10}	8×10^{-4}	1×10^{-11}	3×10^{-5}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	(T/2 = 9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Eu 152	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-5}
	(T/2 = 13 yrs)	I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-5}
	Eu 154	S	4×10^{-9}	6×10^{-4}	1×10^{-10}	2×10^{-5}
		I	7×10^{-9}	6×10^{-4}	2×10^{-10}	2×10^{-5}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
Fermium (100)	Fm 254	S	6×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
		I	7×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Fm 255	S	2×10^{-8}	1×10^{-3}	6×10^{-10}	3×10^{-5}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	3×10^{-5}
	Fm 256	S	3×10^{-9}	3×10^{-5}	1×10^{-10}	9×10^{-7}
		I	2×10^{-9}	3×10^{-5}	6×10^{-11}	9×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-4}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Germanium (32)	Ge 71	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Au 199	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-4}
Hafnium (72)	Hf 181	S	4×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
		I	7×10^{-8}	2×10^{-3}	3×10^{-9}	7×10^{-5}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		I	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		Sub	2×10^{-3}	....	4×10^{-5}	....
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-2}	3×10^{-7}	1×10^{-3}
		I	7×10^{-6}	4×10^{-2}	2×10^{-7}	1×10^{-3}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
	In 115m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-5}
		I	3×10^{-8}	3×10^{-3}	1×10^{-9}	9×10^{-5}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-5}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-3}	6×10^{-9}	2×10^{-4}
	I 126	S	8×10^{-9}	5×10^{-5}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	I 129	S	2×10^{-9}	1×10^{-5}	2×10^{-11}	6×10^{-8}
		I	7×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}

See 10CFR20, Appendix B for all footnote explanations

CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope [1]		Table I Col. 1—Air (μCi/ml)	Table I Col. 2—Water (μCi/ml)	Table II Col. 1—Air (μCi/ml)	Table II Col. 2—Water (μCi/ml)
	I 131	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	I 132	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	I 133	S	3×10^{-8}	2×10^{-4}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-5}
		I	3×10^{-6}	2×10^{-2}	1×10^{-7}	6×10^{-4}
	I 135	S	1×10^{-7}	7×10^{-4}	1×10^{-9}	4×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-5}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-2}	3×10^{-8}	8×10^{-4}
		I	1×10^{-6}	7×10^{-2}	3×10^{-8}	2×10^{-3}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-5}
Krypton (36)	Kr 85m	Sub	6×10^{-6}		1×10^{-7}	
	Kr 85	Sub	1×10^{-5}		3×10^{-7}	
	Kr 87	Sub	1×10^{-6}		2×10^{-8}	
	Kr 88	Sub	1×10^{-6}		2×10^{-8}	
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	1×10^{-7}	7×10^{-4}	4×10^{-9}	2×10^{-5}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-4}
	Pb 212	S	2×10^{-8}	6×10^{-4}	6×10^{-10}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	S	4×10^{-7}	4×10^{-3}	1×10^{-8}	1×10^{-4}
		I	4×10^{-8}	3×10^{-3}	1×10^{-9}	1×10^{-4}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-5}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-5}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-4}
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-5}	1×10^{-13}	3×10^{-6}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-2}	3×10^{-8}	2×10^{-3}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	7×10^{-4}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	4×10^{-4}

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CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope [1]		Table I		Table II	
			Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)	Col. 1—Air (μCi/ml)	Col. 2—Water (μCi/ml)
		I	2×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-2}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Pt 193	S	1×10^{-6}	3×10^{-2}	4×10^{-8}	9×10^{-4}
		I	3×10^{-7}	5×10^{-2}	1×10^{-8}	2×10^{-3}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-4}	7×10^{-14}	5×10^{-6}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-8}	4×10^{-2}	1×10^{-9}	1×10^{-3}
	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}
Potassium (19)	K42	S	2×10^{-6}	9×10^{-4}	7×10^{-8}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protoactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-3}	6×10^{-11}	2×10^{-4}
		I	8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
	Pa 231	S	1×10^{-12}	3×10^{-5}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}

See 10CFR20, Appendix B for all footnote explanations

CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope [1]		Table I Col. 1—Air (μCi/ml)	Table I Col. 2—Water (μCi/ml)	Table II Col. 1—Air (μCi/ml)	Table II Col. 2—Water (μCi/ml)
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-12}	3×10^{-8}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222 [3]		3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-2}	2×10^{-8}	2×10^{-3}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-5}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-5}
	Sm 151	S	6×10^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Selenium 34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-8}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
		I	3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Sr 89	S	3×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-6}
		I	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Sr 90	S	1×10^{-9}	1×10^{-5}	3×10^{-11}	3×10^{-7}
		I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}

See 10CFR20, Appendix B for all footnote explanations

CONCENTRATIONS ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope[1]		Table I Col. 1—Air (μCi/ml)	Table I Col. 2—Water (μCi/ml)	Table II Col. 1—Air (μCi/ml)	Table II Col. 2—Water (μCi/ml)
		I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
		I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}
Technetium (43)	Tc 96m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	3×10^{-5}	3×10^{-1}	1×10^{-6}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	Th 227	S	3×10^{-10}	5×10^{-4}	1×10^{-11}	2×10^{-5}
		I	2×10^{-10}	5×10^{-4}	6×10^{-12}	2×10^{-5}
	Th 228	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	1×10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-5}	1×10^{-12}	2×10^{-6}
		I	3×10^{-11}	1×10^{-3}	1×10^{-12}	[illegible]
	Th natural	S	6×10^{-11}	6×10^{-5}	2×10^{-12}	2×10^{-6}
		I	6×10^{-11}	6×10^{-4}	2×10^{-12}	2×10^{-5}
	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}

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Element (atomic number)	Isotope [1]		Table I Col. 1—Air (μCi/ml)	Table I Col. 2—Water (μCi/ml)	Table II Col. 1—Air (μCi/ml)	Table II Col. 2—Water (μCi/ml)
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
	W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	6×10^{-4}	3×10^{-12}	3×10^{-5}
		I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
	U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 234	S [4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 235	S [4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	U 238	S [4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	5×10^{-9}	3×10^{-5}
	U-natural	S [4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
	Xe 133	Sub	1×10^{-5}		3×10^{-7}	
	Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
	Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)	Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
		I	2×10^{-5}	1×10^{-1}	6×10^{-7}	2×10^{-3}
	Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-2}	4×10^{-9}	8×10^{-4}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10^{-6}		3×10^{-8}	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3×10^{-10}	9×10^{-5}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-13}	4×10^{-7}	2×10^{-14}	3×10^{-8}

See 10CFR20, Appendix B for all footnote explanations

TABLE III

ISOTOPE LIMITS IN MICROCURIES

Americium-241	.01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth 210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13 yr	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m	100
Osmium-191	100
Osmium-193	100

Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural) [1]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural) [1]	100
Uranium-233	.01
Uranium-234—Uranium-235	.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	.01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	1

APPENDIX C

NES FACILITY EFFLUENT AND ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

1. SCOPE

This program outlines the general requirements for NES owned and supervised facilities pertaining to environmental monitoring. Monitoring of the environment is defined as including area and contamination surveys, effluent release data, and random sampling of uncontrolled areas immediately adjacent to NES facilities for comparison with data taken prior to commencement of radiological operations.

This program shall ensure that the limits specified for uncontrolled areas in Appendix B are not exceeded. In addition, the data collected shall be useful in daily operations within the controlled areas of NES facilities in keeping doses ALARA and detecting adverse trends prior to their becoming health hazards.

2. ANNUAL REPORT FORMAT

A. The quality of the report shall be maintained at a high level in accordance with all NES publications and the NES Quality Assurance Manual for the Radiological Safety Program, 82A8002.

B. The title page shall include the name of the site, departmental or division usage, report period, address, and the individual(s) responsible for assembling the report.

C. The introduction shall provide a brief description of the site, the nature of its primary operation(s) and activity, and a general discussion of environmental features such as land and water usage. Pertinent demographic information that could be affected by site properties shall also be included.

D. A summary shall provide a concise evaluation and interpretation of the monitoring data contained in the report in relation to applicable standards and

requirements. Explanations, as appropriate, shall be provided of unusual occurrences or incidents or releases. This section should include discussion of any abnormal occurrences, such as flooding, fires, fish kills, altered adjacent land use, etc., which may have some impact upon the results of the testing program and the data contained therein. Summarization of population exposure estimates (on and off site) shall be included.

E. Monitoring data collection, analysis, and evaluation shall be detailed therein.

1. Include a brief description of the type and frequency of sampling, methods of analysis, and accompanying tables and graphs which clearly and accurately present the monitoring results. Quality assurance aspects should be discussed. A map showing the location of data points shall also be included.

2. As a general rule, data should only be presented for radioactivity and pollutants in media for which there are applicable standards or other meaningful bases for interpreting the results (e.g., background levels, upstream versus downstream concentrations). Interpretations shall be made, as appropriate, of how the environmental levels resulting from site operations compare to relevant parameters.

F. Reporting units and data formating shall make use of the following guidelines:

1. Radiological units:

*air = uCi/ml
*water = uCi/ml
*soil = a. uCi/sq.m or pCi/sq.m
b. uCi/g or pCi/g of dry sample weight
*sediment = uCi/g or pCi/g of dry sample weight
*food and vegetation = uCi/g or pCi/g of dry sample weight
*ionizing radiation = mrem/yr
*removable contamination levels = disintegrations/100 sq. cm

2. Metric Units:

Metric units may be used throughout the report for all numerical quantities. The CGS system is preferred.

G. References shall be listed for all standards and computational methods cited in the body of the report.

H. Distribution of the report shall be made as per an attached list as determined by the originator and as required by regulation.

3. RESPONSIBILITY

An RSO shall be appointed by the Radiation Safety Committee to be the originator of the annual report. The report shall be issued in April at each year, and will include data for the previous year from January through December. The RSC shall act as project manager and review the report prior to issuance as a controlled document.

APPENDIX D

RADIATION RECORDS CONTROL PROGRAM

1. SCOPE

A Radiation Records Control Program shall be implemented and maintained for all NES radiological operations. The record management, control, and access are the responsibility of the Radiation Records Control Officer (RRCO). The records necessary for maintenance in this program consist of the following:

A. Those specifically delineated in the Radiological Protection Manual.

B. Those prescribed in 10CFR20 and 10CFR30.

C. Those required by NES license(s).

D. Those specifically required by the NRC in addition to the above.

2. RECORDS OF SURVEYS AND RADIATION MONITORING

NES shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required. Such records shall be kept on NRC-FORM-5 or its equivalent. NES shall also determine the individual accumulated occupational dose to the whole body on NRC-FORM-4 or its equivalent. The doses entered on these forms shall be for periods of time not exceeding one calendar quarter. The records shall be kept in accordance with NES quality assurance practices and shall contain the survey and monitoring data prescribed in the Radiological Protection Manual.

The specific records kept include, as a minimum, those specified on Table D-1. The forms used are listed in Table D-2 and samples of each are attached to this Appendix.

Individual exposure records shall be maintained until the NRC authorizes disposition. Records of surveys and monitoring shall be maintained for two (2) years after execution of the survey except that the following records shall be maintained until dispositioned by the NRC:

A. Results of surveys for compliance with 10CFR20.103(a).

B. In the absence of personnel monitoring data, records of the results of surveys to calculate external exposure.

C. Records of the results of surveys used to evaluate the release of radioactive effluents to the environment.

3. BYPRODUCT MATERIAL AND MATERIAL DISPOSAL

NES shall maintain records showing the manifested results of all radioactive waste disposal efforts and effluent releases. The records of disposal are to be made pursuant to the requirements of 10CFR20.302, 303, 304 and 10CFR61. All NES owned by-product material and such material which is in receipt of NES shall have records kept showing the receipt, transfer, and disposal of such by-product material pursuant to the regulations of 10CFR Parts 30 thru 35.

The records include, as a minimum, those specified on Table D-1. The forms used are listed in Table D-2 and samples of each are attached to this Appendix.

Records of material disposal are to be retained indefinitely or until disposition occurs by the NRC.

4. PERSONNEL TRAINING

All radiation worker training shall be documented and retained in the Radiation Records Control Program. These documents include all training which satisfies the requirements of 10CFR19 and those of the Radiological Protection Manual.

Specifically, these records include periodic worker training courses, respiratory training and qualification, procedural training and qualifications, and equipment operation certification. These personnel training records shall be maintained for a period of not more than two (2) years after termination of the individuals' employment with NES or with the individuals' last assignment at an NES work site, whichever occurs first.

The records required are listed in Table D-3.

Table D-1

RECORDS REQUIRED

Type of Record	Originator	Retention Period
NRC-FORM-5 individual exposures	RSO	indefinite
NRC-FORM-4 occupational whole body dose	RSO	indefinite
Annual Environmental Monitoring Report	RSC	indefinite
Quarterly Summary Exposure Report	RSC	indefinite
Occupation Exposure Report for Worker Termination	RRCO	indefinite
Report of Exposure to Visitors	RRCO	indefinite
Unusual Occurence Annual Report	RSC	indefinite
Unusual Occurence Report	RSO	indefinite
Health Physics Supervisor Logbook	HPS	2 years
Instrumentation Calibration Records	RSO	2 years
Radiation and Contamination Surveys	HPS	indefinite
Technical Guides and Procedures	RSO	2 years
Radiation Work Permits	HPS	2 years
Bioassay Reports	RSO	indefinite

Table D-2

NES SAMPLE FORMS LISTING

Form No.	Title	Revision
NES-270	NRC-FORM-4	6/77
NES-271	NRC-FORM-5	2/75
NES-272	Radiation Work Permit	0
NES-273	Radiological Field Survey Sheet	0
NES-274	Supplemental Field Survey Map	0

Table D-2 Continued

Form No.	Title	Revision
NES-275	Effluent Discharge Form	0
NES-276	Radioactive Waste Disposal Manifest	0
NES-277	Personnel Decontamination Record	0
NES-278	Equipment Decontamination Record	0
NES-279	Personnel Exposure Evaluation Report	0
NES-280	Air Sample Survey Report	0
NES-281	Equipment Certification Form	0
NES-282	RWP Request Form	0

Table D-3

PERSONNEL TRAINING RECORDS

Form No.	Record Type	Originator
NES-283	NES Radiation Worker Certification	RRCO
NES-284	Training Form A (procedures)	RSO
NES-285	Training Form B (lectures)	RSO
NES-286	Respirator Fit Test	RRCO
NES-287	Respirator Medical Examination	RRCO

APPENDIX E

FACILITY DESIGN

Properly designed facilities allow for a much higher degree of safety than can be obtained by dependence on administrative rules and procedures in inadequate facilities. While good design can never eliminate the possibility of accidental radiation exposure or contamination, the probability and magnitude of such accidents can be greatly reduced. Proper facility design is also the most effective approach in reducing unnecessary occupational exposures. Attention to the radiation protection and control aspects of facility design can also minimize operating difficulties imposed as a result of radiation exposure or safety problems.

The Radiation Safety Committee should participate in the planning and design stages of new or modified radiation facilities to ensure incorporation of proper radiation safety features. Competent review in these stages will permit the facility's operation within established safety standards and maintenance of radiation exposure at levels which are as low as practicable with minimal adverse operational effects.

Site Selection

The type and magnitude of potential radioactive material release and anticipated environmental radiation levels are the important factors in site selection. One can categorize site selection in two general ways. The first way is concerned only with external radiation, direct or scattered, such as that associated with a sealed source or activated materials. Within the limits established by the need to keep radiation levels as low as practicable, the most important consideration for the location of these devices is economic. A location below grade is likely to need less added shielding than one above grade. A facility located on a large, open reservation needs less shielding to reduce exposure to the members of the public than one located in a crowded urban environment.

The second way is concerned with release of radioactive materials to the environment during normal and abnormal operations. The design should preclude or minimize the

release of radioactive contaminants. Meteorological and hydrological parameters must be evaluated if radioactive materials will be released. Such analyses are particularly necessary for complex facilities such as reactors, decontamination centers, and fuel reprocessing facilities.

Facility Layout

Facility layout is an important aspect of design and an inherent aspect in the implementation of the as low as practicable philosophy. Functional portions of the facility need to be located properly, relative to each other, for efficient operations, for ease of movement of supplies, components, and equipment into and out of the processing areas, and for maintenance. The layout must also consider the movement of personnel into and out of the facility, as well as source storage and radioactive waste disposal. Facility layout is a major determinant in the prevention and control of accidents and in the control of occupational exposure.

A facility for handling significant quantities of unsealed radioactive materials is best designed with various zones of contamination control determined by the amount or type of radioactive material used and the potential for contamination. These zones should range from clean office and lunchroom areas to radioactive materials processing and containment areas, as described in Chapter 3.

Facilities in which high radiation areas will be present should be designed to reduce exposure to as low as practicable and to facilitate access control. The isolation of areas by increasing radiation levels will be important in attaining these goals.

Traffic patterns within the facility should be designated to keep work areas for significant quantities of radioactive material isolated from other personnel activities not related to these functions. A personnel monitoring area and a protective clothing change room should be established adjacent to the entrance to areas used for the handling of radioactive materials. In addition, facilities to decontaminate components, equipment, areas, and workers shall be necessary.

Facilities and equipment for the collection, isolation, handling, processing, and disposal of radioactive solid, liquid, and gaseous waste should be provided at a convenient location near the place of generation or use of these materials.

Equipment and System Design

In addition to designing the facility layout to maximize radiation protection and operational efficiency, it is important to consider specific equipment and system items. Some equipment may become highly radioactive or contaminated. Such equipment should be designed for accessibility, ease of maintenance, ease of removal and reinstallation, ease of decontamination, and other features to reduce the time needed in the vicinity of the equipment. Selection of materials should be considered so that induced activity and contamination levels can be minimized and decontamination efforts and service life are optimized.

Shielding

Appropriate shielding is necessary to reduce exposures to workers and the public to levels that are below dose limits consistent with the ALARA philosophy. The use factor of the radiation producing equipment, occupancy times, work load, and estimates of potential increases in these parameters should be taken into consideration. It is generally unwise to design shielding for radiation exposure at or near the allowable dose equivalent limits. Personnel may be irradiated additionally from the work inside the shield or from sources of radiation other than the one being shielded.

Various materials are used for shielding, depending on the type of radiation, the source term, and the desired final dose-equivalent rate. Although shielding should be an integral part of the initial layout of the facility, there are situations where the need for flexibility may be overriding, e.g., experimental facilities. In these situations, other items such as floor loading must be considered to assure that future additions can be accommodated. In some situations, changes in shielding are frequently difficult to accomplish and often cannot bring about the desired dose-equivalent rates without considerable effort, additional cost, and loss of planned work space. For these

reasons, it is wise to design shielding to accommodate all known future increases in workload.

Ventilation

Proper ventilation is necessary to control the movement of airborne radioactivity in order to prevent or minimize irradiation from internally-deposited radionuclides and the spread of contamination within the facility.

Operations that routinely produce airborne contamination should utilize engineered containment and ventilation systems to prevent airborne releases. Appropriate respirators may be used in accordance with the requirements specified in Section 6, but only when effective engineering controls are not feasible.

The design of the ventilation system should provide for proper air flow under all conditions including open and closed positions of doors and windows and changes in setup. The flow should always be from clean areas to contaminated areas. Recirculation of air should be avoided unless the system has been specifically designed for such use. Exhaust air filters or traps should be considered to assure that releases are as low as practicable. Filter systems should be designed for easy access, removal, contamination control, and in-place testing. Exhaust vents and stacks should be carefully engineered and located to avoid recirculation of exhaust air via intakes to the ventilation system. The design should also include provision for modifying the ventilation during an accident, e.g., containment, use of a redundant system, use of a by-pass system, and change in flow rates. Controls for the ventilation system should be located in an area that will be readily accessible in the event of an accident. Ventilation systems should be reviewed for fire protection requirements.

Radioactive Sources and Waste: Clean-up, Disposal, and Storage

In order to assure ease of clean-up, surface materials which are easy to decontaminate should be used. Sinks and drains for radioactive liquid waste should be provided for clean-up in radioactive work areas. Holding and sampling tanks, as well as processing

or radioactivity removal systems, may be required for contaminated waste drains and sinks to assure that radioactive effluents do not exceed permissible levels.

To reduce unnecessary exposure, storage areas for radioactive materials should be provided in areas separate from work places. Ventilation should be provided for storage areas for radioactive material when airborne releases are possible. Access to these areas shall be restricted to authorized personnel.

TLD DOSIMETRY

QUALITY ASSURANCE PROGRAM PLAN

Project Application	Copy No	Assigned To
8561-220		

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REVISION LOG

NUCLEAR ENERGY SERVICES, INC

DOCUMENT NO. 82A8004

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL

TABLE OF CONTENTS

1. SCOPE

The purpose of this Quality Assurance Program Plan (QAPP) is to ensure that measurements of personnel radiation exposures using the NES thermoluminescence dosimeter (TLD) system will be as accurate as possible. This QAPP is limited to the TLD system operated by NES and is not intended to impact the TLD program used by any customer dosimetry system that may be utilized by NES personnel working under customer supervision. This procedure and the instructions of the manufacturer will be used for the calibration of the TLD's and the TLD reader as well as for the operation of the TLD reader. This QAPP shall be performed in compliance with the NES Quality Assurance Program for the Radiological Safety Program, 82A8002.

2. SYSTEM DESCRIPTION

The TLD badge contains two LiF chips manufactured by the Harshaw Chemical Co. of Solon, Ohio approximately 1/8" x 1/8" x 0.035" contained in a holder card. The holder card is placed in a badge which gives an open window path to chip #1 and a shielded path, front and back, to the #2 chip. This allows the #1 chip to see both shallow (Beta) and deep (gamma) penetrating radiations while limiting the #2 chip to only deep penetrating radiations.

The TLD reader is a Harshaw Model 2000C Thermoluminescence detector. The detector heats the TL material (chip) using a reproducible, controlled temperature cycle. The emitted light is detected by a low noise, high gain photomultiplier tube which converts the light to a current signal.

3. RESPONSIBILITY

Primary responsibility for the proper operation of the TLD system rests with the Radiological Safety Officer (RSO), as defined in the NES Radiological Safety Programs, 82A8001.

4. TLD CALIBRATION (Deep Dose)

Each TLD chip will be calibrated to a National Bureau of Standards (NBS) traceable Co-60 source by exposing each chip to a known exposure and reading each chip on the

TLD reader. All chip 1 readings will be normalized to each other as will be the chip 2 readings. A calibration factor will be assigned to each individual chip. Any chip failing to fall within 10% of the median reading will fail the entire card. Each passing chip will then be exposed to a known low exposure and a known high exposure and put to a linearity test. Any chip failing this test ($\pm$10%) will fail the TLD card. Only TLD cards passing both of these tests will be placed into service. All TLD chips will be retested for linearity annually (within 13 months) and cards that fail will be removed from service. An investigation should be made to ensure that any person that had been assigned a TLD card that failed the annual recheck has his (her) radiation exposure reported correctly. The determination of correct exposure shall be reviewed and approved by the Radiation Safety Officer (RSO) and documented accordingly.

5. TLD CALIBRATION (SHALLOW DOSE)

After a TLD card has passed the above tests and both chips have been assigned calibration factors the card will be exposed to a calibrated beta source. Since the #2 chip is shielded only the #1 chip will be exposed to the beta radiation. The chip will be exposed to a known exposure and both chips will be read and multiplied by their appropriate calibration factors. The chip #2 result will be subtracted from the chip 1 result. The remaining chip 1 information will be compared with the actual beta exposure and a beta calibration factor will be assigned to the chip. The beta calibration factor will be checked annually (within 13 months).

6. MACHINE CALIBRATION

The TLD reader will be calibrated monthly. This will be accomplished using calibrated TLD's. Two (2) groups of badges will be exposed to a low and a high exposure respectively. The temperature will remain constant at 240°C and the high voltage will be adjusted until three (3) consecutive readings for the low and high exposures fall within $\pm$5% of the actual exposure. This calibration shall remain valid for any TLD's that must be read in the middle of a badging period (one month).

7. SYSTEM OPERATIONAL CHECK OUT

To ensure proper system operation several TLD's will be spiked each month to different exposures using a NBS traceable Co-60 source. If the results are not within ±20% of the actual exposure the system will require further investigation prior to use. Several TLD's will also be spiked and checked for beta exposure and tested using the same criteria.

The TLD reader has installed in it an internal C-14 light source. After the machine is calibrated several light source readings will be taken and an average reading calculated. While reading the TLD chips the light source will be periodically (no more than every 25 readings) checked to ensure that no drifting of the electronics has occurred.

8. SYSTEM CONTROLS

Calibrated TLD badges will be placed at various locations where TLD badges may be stored. These badges will be the system control badges and will be used as background exposure levels which will be subtracted from the TLD readings.

Prior to reading the TLD each badge that was placed into service during the past badging period will be frisked as a check for contamination and will also be visually inspected for any abnormalities. Any badge that appears to be damaged shall be removed from service.

9. SYSTEM BACK-UP

The #1 chip will be used as the deep dose back up chip should something happen to the #2 chip that would result in a loss of reading. Should the entire badge be lost or damaged an investigation shall be made to determine the individuals exposure for the badge period. Such determinations will be reviewed and approved by the Radiation Safety Officer.

10. AUDITS

An in-house audit shall be performed annually (within each 13 months) to ensure that the proper controls are maintained and to ensure that the dosimetry results are as accurate as is reasonably achievable. All such audit and calibration records shall be held by the Radiation Records Control Officer.

RCP-1.0

RADIOLOGICAL QUALITY ASSURANCE AND CONTROL PROCEDURE

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REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 82A8005

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL

RCP-1.0
RADIOLOGICAL QUALITY ASSURANCE
AND CONTROL PROCEDURE

1. SCOPE AND APPLICABILITY

This document describes the program for assuring the quality of radiological measurements and analysis in the field. The purpose of this document is to assure that:

1) Provisions are made for identifying those who are responsible for these operations.

2) The results of NES field measurements are relatable to the National Bureau of Standards (NBS) and therefore are comparable with other survey programs.

3) The precision and confidence level of survey results is adequate to insure that the results are valid.

This quality assurance program applies to all NES field survey measurements.

Quality assurance is described in "Quality Assurance Program for the Radiological Safety Program", 82A8002.

2. ORGANIZATION

A suggested organizational structure for Quality Assurance is as shown in Figure I. This structure relates to the management and operation of the site surveys including quality assurance policy and function.

FIGURE I

Structure for Quality Assurance

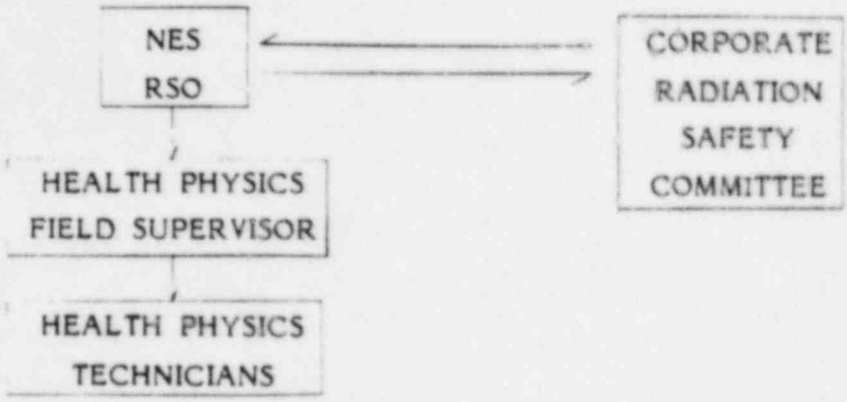
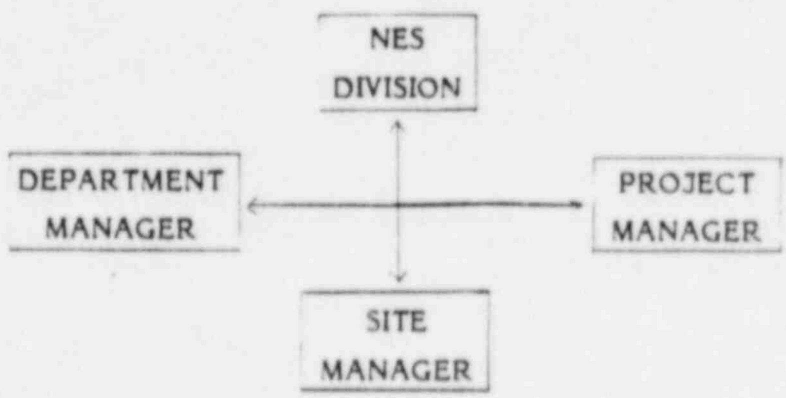


FIGURE III

NES QA Interfaces



2.1 NUCLEAR ENERGY SERVICES (NES)

Policies and Procedures governing work done are subject to review and approval by NES. NES is responsible to its client for the implementation of policies and procedures stated or referenced in this document.

2.2 PROJECT RSO

The Radiation Safety Officer (RSO) establishes policy, gives final approval, reviews audit reports and receives, reviews and approves reports of QA activities submitted by the radiological personnel.

2.3 CORPORATE RSC

The corporate Radiological Safety Committee (RSC) interfaces directly with the NES RSO. Their role is to identify quality assurance problems, to initiate, recommend, or provide solutions to QA problems, and to verify implementation of solutions.

2.4 SURVEY PERSONNEL

These individuals are responsible for the quality of their assigned work in accordance with approved procedure. It is the duty of an individual to report any condition which may adversely affect the quality of the work and to recommend any change which may improve the quality of the work.

All personnel assigned to work by NES at a work site are required to have demonstrated proficiency in the conduct of assigned work. Training records and/or certificates of proficiency are maintained and are available on request from the Radiation Records Control Officer (RRCO).

Personnel are deemed qualified by NES if they have demonstrated the required proficiency and/or their training demonstrates their ability to perform this work.

3. QUALITY CONTROL

3.1 SAMPLING

The accuracy of the devices used for sampling liquids, solids, or gases, including the measurements of sample flow rates and/or volumes, is determined by the appropriate procedure.

The frequency of sampling device calibration is specified by procedure and based upon the required accuracy, purpose, degree of usage, stability characteristics, and other conditions affecting the measurement as specified in procedure.

Tests are conducted to verify that sampling is representative by collection and analysis of replicate samples.

Procedures for sampling, packaging, shipping, and storing samples provide for the maintenance of the integrity of the samples.

3.2 RADIONUCLIDE STANDARDS

When available, NBS certified radiological standards shall be used to determine counting efficiencies of NES radiological counting equipment.

When NBS standards are not available, standards traceable to NBS calibration shall be used.

To the extent possible, reference standards are prepared in the same media and form as the unknown sample.

The minimum frequency of calibration is 12 months. Instrument performance data is monitored for indications of need.

3.3 PERFORMANCE CHECKS

Performance checks are performed as needed or as a minimum basis (daily). These include:

- Check source measurement
- Background measurement
- Blind replicate samples where feasible
- Known analytical blanks
- Spiked samples as blind duplicates where applicable

3.4 REVIEW, ANALYSIS, REPORTING DATA

Data shall be reviewed for consistency and accuracy. Unreasonable or inconsistent data will be investigated and reported on, including appropriate action taken.

3.5 AUDITS

Audits are performed where applicable. They are performed by a designated individual with no direct responsibilities in the areas being audited. They will be performed using standard NES checkoff lists for specific project audits.

Audits results are documented and reviewed by management having responsibilities in the areas being audited.

Follow-up action, including re-audit of deficient areas, is taken where indicated.

3.6 REPORTS

Reports of all QA-related activities shall be reviewed, approved, and acted upon by the NES RSO.

3.7 RECORDS

Records of all steps in performing radiological monitoring and analysis are maintained; specific records maintained will include:

- Operating Procedures
- Sample Collection
- Field Survey Results
- Reviews/Approvals
- Reports Submitted to NES
- Precision Checks of Equipment
- Instrument Calibration
- Audit Reports/Follow-up

- Training and Certifications
- Periodic QA Reports

All records shall be maintained in accordance with 82A8002. Development of these records are the responsibility of the specific Project Manager. Their retention and completeness is the responsibility of the RRCO.

RCP-2.0

RADIATION WORKER HANDBOOK

AND TRAINING MANUAL

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

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REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

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1	3/14/85	-	all pages noted with triangle blocks per CRA # 5165	

TABLE OF CONTENTS

1. INTRODUCTION

This manual is intended to convey the minimum necessary information needed by an NES employee who works or intends to work with radioactive materials. This includes field workers at nuclear power plants, nuclear research facilities, sites maintained under by-product license, etc.

The manual presents the basic definitions, terms, and responsibilities which are encountered in this field. It is intended to be used both by the novice and as a refresher for veteran radiation workers.

2. A SHORT COURSE IN NUCLEAR PHYSICS

An elementary knowledge of the nature of matter and radiation will aid in understanding of where radiation comes from and how to control it. It has often been observed that certain basic misconceptions lead to incorrect application of instruments, data, or risk assessment.

While details of atomic structure and elementary particle physics are not required here, a basic idea of the structure of the atom limited to our needs shall be presented. The atom consists of a small nucleus within a larger cloud of electrons. Electrons are negatively charged particles of small mass. The nucleus is composed of protons (positively charged) and neutrons (no charge) whose masses are close to each other, but are approximately 1800 times more massive than an electron.

Atoms can be presented by the following shorthand.

$_{92}U^{235}$ = Uranium
92 protons
235-92=143 neutrons
235 units of total weight
(electron weight is insignificant)

The same chemical element can have several isotopes, which vary only in the number of neutrons.

ex: U^{233}, U^{235}, U^{278} } All uranium, with 92 protons, but they have 141, 143 and 146 neutrons each.

Some isotopes are naturally unstable and become more stable (decay) by emitting radiation. Other isotopes can be made to be unstable and also decay by emission of radiation.

The types of decay radiation to be considered are:

beta	-	negatively charged, with a mass of an electron
alpha	-	positively charged, a package composed of 2 protons and 2 neutrons
gamma	-	electromagnetic radiation of no charge or appreciable mass
neutron	-	no charge, essentially an escaping particle from a nucleus which has too many to be stable

After an isotope emits radiation of these types it is more stable. It may emit any combination of the above radiations, and may do so simultaneously or in a series. The resulting atom may still be relatively unstable and perform further decay. This leads to the information of a series of "daughters" which ultimately lead to a stable (non-radioactive) isotope.

Each isotope decays at a constant rate. The time it takes for 1/2 of the original substance to decay into another substance is called its half-life. The radiation emitted during this decay is always the same both by type and energy for a given isotope. This combination of data is used to measure and guard against the radiation emitted in this process.

If radioactive material is inhaled, swallowed, or otherwise ingested, it will have a specific biological half-life. That is, a period of time after which the body has excreted one half of the original amount. The effective biological half-life can be represented as a combination of radioactive and biological reduction in the quantity of internally deposited material as follows:

$$T\ 1/2\ \text{eff.} = \frac{(\text{BIO T } 1/2)(\text{RAD. T } 1/2)}{(\text{BIO T } 1/2) + (\text{RAD. T } 1/2)}$$

Where

T 1/2 eff. = effective half-life of a radioactive substance in the body
Bio T 1/2 = biological half-life of the substance
RAD T 1/2 = radioactive half-life of the substance

3. DEFINITIONS

Activity	The number of nuclear transformations (disintegrations) occurring in a given quantity of material per unit time. (See Curie)
Alpha Particle	A charged particle emitted from the nucleus of an atom having a mass and a charge equal in magnitude to a helium nucleus; i.e., two protons and two neutrons (Symbol: α)
Analyzer, Pulse Height Multi-channel	An electronic circuit which sorts and records pulses according to height (also known as an MCA).
Atom	The smallest unit of an element that retains the chemical properties of that element.
Beta Particle	Charged particle emitted from the nucleus of an atom, with the mass and charge equal in magnitude to that of the electron (Symbol: β)
Calibration	Determination of variation from standard, or accuracy, of a measuring instrument needed to ascertain necessary correction factors.
Chamber, Ionization	An instrument designed to measure a quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume.
Contamination, Radioactive	Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful. This may interfere with an experiment or a procedure or be a source of biological hazard to personnel.
Controlled Area	A defined area in which the occupational exposure of personnel (to radiation) is under supervision.

Count (Radiation Measurement)	The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total number registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse. Note: Spurious count - In a radiation counting device, a count caused by any agency other than radiation.
Counting Ratemeter	An instrument which gives a continuous indication of the average rate of ionizing events.
Curie	The special unit of activity. One curie equals 3.700×10^{10} nuclear disintegrations per second. (Abbreviated Ci) Several fraction of the curie are in common usage: **Microcurie:** One-millionth of a curie (3.7×10^4 disintegrations per second) Abbreviated uCi. **Millicurie:** One thousandth of a curie (3.7×10^7 disintegrations per second) Abbreviated mCi. **Nanocurie:** One-billionth of a curie (37 disintegrations per second) abbreviated nCi. **Picocurie:** One-millionth of a microcurie (3.7×10^{-2} disintegrations per second or 2.22 disintegrations per minute) Abbreviated pCi.
Decay, Radioactive	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.
Detector, Radiation	Any device for converting radiant energy to a form more suitable for observation. An instrument used to determine the presence and the amount of radiation.
Disintegration,	A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. When numbers of nuclei are involved, the process is characterized by a definite half-life. (Symbol: dis or DIS)

Dose A general form denoting the quantity of radiation or energy absorbed. For special purposes it must be appropriately qualified. If unqualified, it refers to absorbed dose.

Absorbed Dose: The energy imparted to matter by ionizing radiation per unit of irradiated material at the place of interest. The unit of absorbed dose is the Rad. One rad equals 100 ergs per gram. (See Rad.)

Cumulative Dose (radiation): The total dose resulting from repeated exposures.

Dose Equivalent A quantity used in radiation protection. It expresses all radiations on common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the Rem.)

Dose Rate Absorbed dose delivered per unit time.

Efficiency (Counters) A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably, so it is well to ascertain which factors (window transmission, sensitive volume, energy dependence, geometry, etc.) are included in a given case.

Error, Statistical Errors in counting due to the random time-distributions of disintegrations.

Exposure A measure of the ionization produced in air by "X" or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in that volume element. The special unit of exposure is the roentgen (Abbreviated R). Several fractions of the roentgen are in common usage.

	Microroentgen: One-millionth of a roentgen (Abbreviated uR). Milliroentgen: One-thousandth of a roentgen (Abbreviated mR).
Fission	The process by which the nucleus of an atom is split into 2 or more other atoms, which releases energy.
Fusion	The process by which 2 or more light atomic nuclei combine to form another heavier nucleus.
Gamma Ray	Short wavelength electromagnetic radiation (range of energy from approximately 10 keV to 9 MeV) emitted from the nucleus. Also referred to as photons. (Symbol: γ).
Geometry Factor	The fraction of the total solid range about the source of radiation that is subtended by the face of the sensitive volume of a detector.
Half-life, Radioactive	Time required for half the amount of a radionuclide to decay into another nuclide. Each radionuclide has a unique half-life.
Ion	A positively or negatively charged atom or particle.
Isotopes	Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore the mass number. Almost identical chemical properties exist between isotopes of a particular element. The term should not be used as a synonym for nuclide. **Stable Isotope:** A non-radioactive isotope of an element.
Milliroentgen (mR)	A submultiple of the roentgen, equal to one-thousandth of a roentgen. (See Roentgen.)
Monitoring	Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in a region.

Area Monitoring: Routine monitoring of the radiation level or contamination of a particular area, building, room or equipment.

Personnel Monitoring: Monitoring any part of an individual for exposure to external radiation or of physical deposition of radioactive materials.

Nuclide — A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons (Z), number of neutrons (N), and energy content; or alternatively, by the atomic number (Z), mass number A = (N + Z), and atomic mass.

Rad — The unit of absorbed dose equal to 0.01 Joules/kg. in any medium or 100 ergs/gm. (See Absorbed Dose.)

Radiation — (1) The emission and propagation of energy through space or a material medium in the form of waves. For example, energy in the form of electromagnetic waves. The term radiation or radiant energy usually refers to electromagnetic radiation and is commonly classified according to frequency, as Hertzian, infrared, visible (light), ultra-violet, x-ray and gamma ray.

(2) By extension, corpuscular emissions, such as alpha and beta radiation, or rays of unknown or mixed type, as cosmic radiation.

Background Radiation: Radiation arising from a radioactive source other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present.

External Radiation: Radiation from a source outside the body-the radiation must be capable of penetrating the skin.

Internal Radiation: Radiation from a source within the body (as a result of deposition of radionuclides in body tissues).

Ionizing Radiation: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

Radioactivity — The property of certain nuclides to spontaneously emit particles or gamma radiation or of emitting "X" radiation following orbital electron capture or of undergoing spontaneous fission.

Artificial Radioactivity: Man-made radioactivity produced by particle bombardment or electromagnetic irradiation, as opposed to natural radioactivity.

Induced Radioactivity: Radioactivity produced in a substance after bombardment with neutrons or other particles. The resulting activity is "natural radioactivity" if formed by nuclear reactions occurring in nature, and "artificial radioactivity" if the reaction was caused by man.

Rem — A special unit of dose equivalent. The dose equivalent in REMs is numerically equal to the absorbed dose in RADs multiplied by the quality factor, the distribution factor, and any other necessary factors.

Roentgen (R) — The special unit of exposure. One roentgen equals 2.58×10^{-4} coulomb per kilogram of air. (See Exposure.)

Spectrum, Energy — A visual display or a plot of the distribution of the intensity of radiation of a given kind as a function of its energy.

Standard, Radioactive — A sample of radioactive material, usually with a long half-life, in which the number and type of radioactive atoms at a definite reference time is known. It may be used as a radiation source for calibrating radiation measurement equipment. Standards are traceable to those of the National Bureau of Standards.

Survey, Radiological — Evaluation of the radiation hazards incident to the production, use or existence of radioactive materials or other sources of radiation under specific conditions. Such an evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and sufficient

knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

X-ray — Penetrating electromagnetic radiations whose wave lengths are shorter than those of visible light. In nuclear reactions, it is customary to refer to photons originating in the extranuclear part of the atom as x-rays.

4. RIGHTS AND RESPONSIBILITIES

Radiation workers are protected by certain standards by the Federal Government. These standards are defined in Title 10 Code of Federal Regulations Parts 19 an 20. Conventional worker safety is controlled at the Federal level by standards published by the Occupational Safety and Health Administration (OSHA).

In accordance with 10 CFR 19, copies of both 10 CFR 19 and 10 CFR 20 must be posted in the work place. These documents present details of the following summarized standards. These standards are Federal law.

Each employee has the right to know what his yearly exposure to radiation has been upon request. This request shall be obeyed in writing. The worker also has the right to know his exposure at other times besides yearly (i.e., termination of a job, etc.)

NRC inspectors may consult privately with any worker for a free and open exchange of information. No employee shall be fired or otherwise penalized by his employers for speaking with the NRC officials. If a worker has a complaint under NRC jurisdiction, he shall be notified in writing of the determination by the NRC as to whether or not action will be taken.

In accordance with these regulations and NES policy, a radiation worker has a professional obligation to notify his supervisors and/or superiors of conditions or actions which he feels are in violation of these acts and endanger the safety of company personnel and/or the general public.

In accordance with 10 CFR 20, radiation exposure to workers and the public are limited to those as summarized below. Definitions of certain terms are included for clarification.

Radiation Worker:

1. Whole body: head, trunk, active blood forming organs, lens of eyes, or gonads....1250 mRem/calendar quarter
2. Hands and forearms, feet and ankles....18750 mRem/calendar quarter
3. Skin of whole body....7500 mRem/calendar quarter

In addition, the whole body dose shall not exceed 3000 mRem/calendar quarter Also, the total whole body dose shall not exceed

$$5 \times (N-18) \text{ where } N = \text{age of worker}$$

NRC-Form-#4 shall keep account of a person's lifetime dose (amount plus when and where received). In addition to exposure, 10 CFR 20 also addresses inhalation and/or ingestion of radioactive materials. Exposure to minors and the amount of permissible radiation in uncontrolled areas (i.e., to the general public) are also addressed.

Furthermore, 10 CFR 20 addresses radiation operating practices, sign postings, waste material release limits, and certain packaging limitations.

OCCUPATIONAL EXTERNAL RADIATION EXPOSURE HISTORY

See Instructions on the Back

IDENTIFICATION

1. NAME (PRINT – LAST, FIRST, AND MIDDLE)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (MONTH, DAY, YEAR)	4. AGE IN FULL YEARS (N)

OCCUPATIONAL EXPOSURE – PREVIOUS HISTORY

5. PREVIOUS EMPLOYMENTS INVOLVING RADIATION EXPOSURE – LIST NAME AND ADDRESS OF EMPLOYER	6. DATES OF EMPLOYMENT (FROM TO)	7. PERIODS OF EXPOSURE	8. WHOLE BODY (REM)	9. RECORD OR CALCULATED (INSERT ONE)

10. REMARKS

11. ACCUMULATED OCCUPATIONAL DOSE – TOTAL	

13. CALCULATIONS – PERMISSIBLE DOSE WHOLE BODY:

(A) PERMISSIBLE ACCUMULATED DOSE = 5(N–18) = ______ REM

(B) TOTAL EXPOSURE TO DATE (FROM ITEM 11) = ______ REM

(C) UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (A–B) = ______ REM

12. CERTIFICATION: I CERTIFY THAT THE EXPOSURE HISTORY LISTED IN COLUMNS 5, 6, AND 7 IS CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

EMPLOYEE'S SIGNATURE DATE

14. NAME OF LICENSEE

5. RISK

Radiation of various types are commonly used in medical practices (x-ray, cancer therapy) and the benefits derived are judged to exceed the risks involved. Radiation exposure to radiation workers not medically orientated is considered to entail risk increasing with dose and shall be limited by NES to doses as low as reasonably achievable (ALARA).

The risk from radiation varies with the amount, type, and energy of the radiation. It also varies with where on the body you receive it. For example, skin is good beta and alpha shield at moderate particle energies, but the lens of the eyes are sensitive to beta. Since your fingers and toes contain no vital organs or major blood producing areas, you can safely receive more gamma radiation there than is permitted to the trunk of the body.

Radiation damages cells. Enough radiation will damage enough cells to make you feel sick. Enough will kill you. Refer to Table 1 for a listing of effects at increasing dosage. Note that the level at which damage is first detectable is substantially larger than the amount you may legally be allowed to receive.

Radiation damage can be related by analogy to any number of common injuries. If you are hit by a baseball or by particle radiation (beta, alpha, neutron) you will be harmed. If you stay in the sun too long or receive gamma radiation, you will be harmed. The degree of harm is what matters in risk assessment. In both conventional and radiation injury, the body will repair itself to a degree. For example, if you lose a small amount of blood you will self-repair; if you receive a slight sunburn, you will self-repair. At low levels of blood loss (i.e., a cut finger) or low levels of radiation (i.e., below the legal limit) no noticeable harm is done to the person as a whole. Although there is a limit below which no detectable damage from radiation occurs, regulatory agencies have assumed conservatively that damage always occurs at any level of exposure.

The natural radiation background (sunlight, soil, food, air) exposes you to small amounts of radiation daily. It is thought this is where man has obtained his ability to repair low level radiation damage: we are subject to it all our lives. A comparison of common sources of exposure is shown in Table 2. The damage from radiation

measured or anticipated in the following tables indicates that such harm is an accumulation of probabilities. While the effect of individual particles or waves of radiation on a single cell may be calculated, the cumulative effect on a specific individual can only be estimated by comparison with known results of exposures to large populations.

The damaging effects of radiation fall into two categories:

Somatic - harm to the individual
Genetic - harm to future generations

In addition, the amount of time over which a radiation dose occurs determines the degree of damage:

Acute exposure - a large amount in a short time
Chronic exposure - a small amount over a long time

The effects of radiation damage are generally referred to by one of the following terms:

latent - damage showing up after time has elapsed (i.e., cancer, genetic damage)
immediate - damage showing up after or during exposure.

TABLE 2
SOURCES OF RADIATION
(1 rem = 1000 millirem)

	Annual Radiation Exposure (millirem/yr)
I. Natural Radiation Sources	
A. Cosmic (from outer space)	
Connecticut and Massachusetts	40
Colorado	120
B. Terrestrial (from the earths surface)	
Connecticut	60
Massachusetts	75
Colorado	105
C. Food Consumed and the human body itself	25
Subtotal	
Connecticut	125
Massachusetts	140
Colorado	250
II. Technologically Enhanced Exposures to Natural Sources	
A. Radioactivity in Building Materials (varies from wood frame to brick to stone)	12-34
B. Air Travel (round trip cross country)	4
C. Natural Gas (randon-222)	
Cooking (lung)	15
Heating (lung)	54

TABLE 2 (continued)
SOURCES OF RADIATION

(1 rem = 1000 millirem)

			Annual Radiation Exposure (millirem/yr)
	D.	Smoking (1 pack/day) - certain areas of lung	Up to 2000
		- whole body	2 to 20
III.	Man-made Sources		
	A.	Medical Uses of Radiation for Diagnosis (per capita)	103
		One Chest X-ray	30 to 70
	B.	Global Fallout from Nuclear Weapons Testing	2
	C.	Consumer Products (TV)	0.15 x hrs/day
	D.	Nuclear Power Station (within 50 miles)	0.1
		At Site Boundary	1 to 3

TABLE 4

Risks Which Increase Chance of Death By 1 in 1,000,000

Smoking 1.4 cigarettes	Lung cancer, heart disease
Drinking 1/2 liter of wine	Cirrhosis of the liver
Spending 1 hour in a coal mine	Black lung disease
Living 2 days in New York or Boston	Air pollution
Traveling 6 minutes by canoe	Accident
Traveling 10 minutes by bicycle	Accident
Traveling 300 miles by car	Accident
Flying 1,000 miles by jet	Accident
Flying 6,000 miles by jet	Cancer caused by Cosmic radiation
Living 2 months with cigarette smoker	Lung cancer, heart disease
Eating 40 tablespoons of peanut butter	Liver cancer caused by aflatoxin B
Drinking 30 12 oz. cans of diet soda	Cancer caused by saccharin
Eating 100 charcoal broiled steaks	Cancer from benzopyrene
Radiation exposure of 10 millirem (0.01 rem)	Cancer caused by radiation

TABLE 5

Average Risk of Fatality By Various Causes

Type of Event	Total Number Per Year (1)	Individual Chance Per Year (2)
Death (All Causes)	1,898,000	1 in 110
All Accidents	100,761	1 in 2,100
Motor Vehicle	47,038	1 in 4,600
Falls	14,136	1 in 15,000
Burns	6,338	1 in 34,000
Firearms	2,059	1 in 105,000
Electrocution	1,148	1 in 188,000
Lightening	160	1 in 1,400,000
Radiation effect 0.8 rem	None observed	1 in 12,500
Radiation effect 2.5 rem	None observed	1 in 4,000
Radiation effect 4 rem	None observed	1 in 2,500
Nuclear Power Plant		
Routine Release Health Effect Site Boundary Resident (50 yrs at 2 mrem/yr.)	None observed	1 in 5,000,000 (potential calculated)
Resident within 10 miles (50 years at 0.2 rRem/yr)	None observed	1 in 50,000,000 (potential calculated)

(1) Data from non-radiation effects is from 1979 World Almanac and is based on a U.S. population of 216,000,000.

(2) Chances for radiation effect fatalities are calculated. Chances for non-radiation fatalities are based on observed data.

TABLE 6

Chronic Individual Lifetime Chance of Fatality

Event Duration	20 Years	40 Years
Motor Vehicle	1 in 230	1 in 115
Falls	1 in 750	1 in 375
Radiation dose of 0.8 rem/yr	1 in 625	1 in 313
Radiation dose of 1.5 rem/yr	1 in 333	1 in 167(1)
Radiation dose of 2 rem/yr	1 in 250	1 in 125
Radiation dose of 2.5 rem/yr	1 in 200	1 in 100
Radiation dose of 3 rem/yr	1 in 167(1)	1 in 84
Radiation dose of 4 rem/yr	1 in 125	1 in 63

(1) The total dose of 3 rem/yr for 20 years is 60 rem. Any lifetime dose of 60 rem (i.e., 4 rem/yr for 15 years or 1.5 rem/yr for 40 years) causes the same lifetime risk.

TABLE 3

Comparative Occupational Risks

	Observed Fatal Injuries Per Million Worker-Years[1]	Observed Deaths From Occupational Diseases Per Million Worker-Years
All Industry	100	50 to 1,000[4]
Chemical	60	N/A
Electric Utilities	160	N/A
Construction	340	N/A
Lumber	360	N/A
Mining, Underground Coal	1,160	2,000 to 6,000
Mining, Surface	260	N/A
Underground Metal Miners[2]	N/A	12,400
Shipbuilding	60	N/A
Steel	120	5,700[5]
Transit	100	N/A
Wood Products	160	N/A
Asbestos Insulation Workers[3]	N/A	3,650
Uranium Miners[2]	N/A	2,320
Smelter Workers[2]	N/A	1,930
Commercial Nuclear Power Industry (Radiation related effects only)	None	From 40 to 80 (not observed, but based on statistical calculations)

N/A = Data Not Available

1 From "Work Injury Rates" (1977), National Safety Council.

2 "The President's Report on Occupational Safety and Health", Commerce Clearing House, May 22, 1972, pages 11 and 128.

3 Irving J. Selikoff and William J. Nicholson, "Deaths Among 17,800 Asbestos Insulation Workers in the United States and Canada, January 1, 1967, through January 1, 1977, "National Institutes of Health, 1978.

4 From U.S. HEW and U.S. NRC Staff Analysis of NRDC Petition PRM-2-6 to lower occupational radiation limits, July 1978. The most probably numbers are from 50 to 110.

5 Dr. Carol Redmond, University of Pittsburgh.

TABLE 7

Sources of Information on Risk of Cancer from Radiation

Type of Cancer	Cause of Exposure or X-ray Treatments	Exposure Date	Years After Exposure Considered	Number of Subjects	Average Dose (rem)
Leukemia	A-bombs, Japan	1945	5-25	23,979	130
	Spondylitis	1935-54	0-25	14,554	372
Bone	Ra^{226} intake	1915-35	11-56	775	17,000
	Ra^{226} treatments	1944-64	4-25	925	4,410
	Spondylitis	1935-54	6-27	14,654	372
Breast	A-bombs, Japan	1945	16-25	12,000	125
	Fluoroscopy	1940-49	10-30	243	121
Lung	Uranium mines	1920-63	6-50	4,146	4,680
	Fluorspar mines	1935-63	11-33	800	2.770
	metal mines		16-37	1,759	1,720
	Spondylitis	1935-54	6-27	14,554	400
	A-bombs, Japan	1945	16-25	19,472	133
Gastro-intestinal	A-bombs, Japan	1945	25	23,979	130
	Spondylitis	1935-54	11	14,554	375
Leukemia age 0-9	A-bombs, Japan	1945	6-24	4,507	112
	Thymus X-rays	1926-57	0-35	1,451	65
	Tinia capitis	1940-49	0-22	2,043	30

Reference: National Academy of Sciences, 1972, the Effects on Populations of Exposure to Low Levels of Ionizing Radiation (NAS 72).

6. RADIATION MEASUREMENT AND CONTROL

6.1 RADIATION MEASUREMENT

The first device issued to radiation workers for the purpose of measuring radiation is a film badge or thermoluminescent dosimeter (TLD). A TLD consists of: a holder, filters, and a teflon card that has the thermoluminescent material in it. The filters allow us to tell the difference between beta and gamma radiations. The teflon card contains material that is thermoluminescent; that is, the material gives off a small amount of light when it is heated, after having been exposed to ionizing radiation. The amount of light is proportional to the amount of exposure to radiation for the TLD. A film badge consists of a material which is exposed by radiation, and then developed much as conventional photographic film by a chemical process. 4

In conjunction with the film badge, we use a direct (self-reading) pocket dosimeter. This device enables us to determine at a glance how much exposure we have accumulated. The dosimeter is worn next to the film badge on the upper front portion of the body. By holding the dosimeter up to your eye, such that the end with the lens is toward your eye, and the end with the recessed pin is toward a light source, you can observe a scale. The scale is crossed at some point by a movable hairline. As the dosimeter is exposed to radiation, the hairline moves up the scale.

Remember to wear these devices each and every time you enter a radiologically controlled area. Unless told otherwise by Health Physics personnel, wear them on the upper front trunk portion of the body. Other dosimetry devices will be issued by health physics personnel when needed.

To determine your dose with a direct reading dosimeter, you subtract the initial reading from the final reading. That is if a dosimeter reads 10 mrem when you enter an area and reads 30 mrem when you exit, then your dose is 20 mrem. 4

The three most important methods to minimize your exposure in fulfillment of ALARA objectives are the proper use of time, distance, and shielding. Each of

these items are discussed in detail below.

6.2 TIME

The less time you spend in radiation areas, the less exposure to radiation you will receive. To fully utilize the time that is spent in radiation areas, all jobs should be pre-planned. Such pre-planning should include:

1. Making sure you have all the tools and equipment required for the job prior to entering the area.

2. Being familiar with the equipment either through job mock-up training or referring to a repair manual or plans prior to entering the area.

3. Knowing the radiation levels as well as component location prior to entering the area, and having stand-by personnel wait in low dose rate areas until needed.

4. Determining the Stay Time value.

6.2.1 Calculation of Stay Time

To determine your anticipated exposure prior to entering a radiation area, multiply the area radiation level by the amount of time to be spent in the area. Your exposure can thus be controlled by limiting the time you spend in the area:

Exposure = exposure rate x time

Stay time is defined as the maximum amount of time a worker is allowed to stay in a specific radiation area. The stay time depends on ALARA considerations and the individuals present accumulated exposure. For example,

John Smith

Quarterly exposure limit = 1250 mR
Present Quarterly Exposure = 1000 mR
Remaining Quarterly Exposure = 250 mR

Worker Area Radiation Level = 100 mR/hr
Safety Factor = 50 mR/hr

$$\text{Stay Time} = \frac{250 - 50}{100} = 2.0 \text{ hours maximum}$$

6.3 DISTANCE

By keeping as much distance between yourself and sources of radiation you can reduce the amount of exposure to radiation you will receive. Here are some suggestions:

1. Work at arms length from hot spots whenever possible.
2. Use long-handled tools if possible.
3. Remove item to be worked to an area lower in dose rate.

6.3.1 Radiation Exposure Reduction

Uniformly distributed radiation from a point source decreases approximately as the square of the distance. For example;

Assume a dose rate from a point source at 1 ft = 1 rem/hr

then, at 2 ft the dose rate = 250 mR/hr
at 4 ft the dose rate = 63 mR/hr

Radiation from a line source, like a long pipe, decreases approximately linearly with distance. For example;

Assume a dose rate from a line source at 10 ft = 500 mR/hr

Then at 20 ft the dose rate = 250 mR/hr
at 40 ft the dose rate = 125 mR/hr

Summary:

a. Point (infinite)

$$\text{Dose Rate}_2 = \frac{\text{Dose Rate}_1 \times (\text{Dist}_1)^2}{(\text{Dist}_2)^2}$$

b. Line (within 1/2 length)

$$\text{Dose Rate}_2 = \frac{\text{Dose Rate}_1 \times \text{Dist}_1}{\text{Dist}_2}$$

c. Plane (within 0.7 radius)

$$\text{Dose Rate}_1 = \text{Dose Rate}_2$$

6.4 SHIELDING

The third method of controlling/minimizing radiation exposure is by means of shielding. Generally, this is the preferred method because it results in intrinsically safe working conditions, whereas reliance on distance and/or time of exposure may involve continuous administrative control over workers.

The amount of shielding required depends on the type of radiation, the activity of the source and on the dose rate which is acceptable outside the shielding material.

The installation of the shielding material could be of the permanent type or of the temporary type.

Examples:

- Construction walls - permanent shielding
- Pre-design pipe wall thickness - permanent shielding
- Concrete blocks - temporary shielding
- Lead sheets/blankets - temporary shielding
- Lead shot - temporary shielding

If the shielding installation is of the temporary type radiation workers shall be cautioned never to move the temporary shield without the approval of Health Physics personnel.

6.4.1 Effectiveness of Shielding

The following paragraphs provide shielding effectiveness for α, β and γ radiation particles.

Alpha (α) particles are easily absorbed. A thin sheet of paper is usually sufficient to stop alpha particles and so they never present a shielding problem.

Beta (β) radiation is more penetrating than alpha radiation. In the energy range which is normally encountered (1-10 MeV) beta radiation requires shielding of up to 0.4 inches of aluminum for complete absorption.

One important problem encountered when shielding against beta radiation concerns the emission of secondary X-rays, which result from the rapid slowing down of the beta particle. This X-radiation is known as bremsstrahlung. In order to reduce the amount of bremsstrahlung, beta shield should be constructed of materials of low mass number (e.g., aluminum).

Gamma (γ) radiation is attenuated exponentially when it passes through any material. The dose rate to γ-radiation emerging from a shield can be written as:

$$D_t = D_o \exp(-\mu t)$$

Where

D_t = dose rate after passing through a shield of thickness t

D_o = dose rate without shielding

μ = linear absorption coefficient of the shielding material

t = thickness of shielding material

Half-Value Layer (HVL): The half thickness or half-valve layer for a particular shielding material is the thickness required to reduce the intensity to one half its incident value. Writing the HVL as t 1/2, the previous equation becomes:

$$\frac{Dt}{D_o} = 0.5 = \exp(-\mu\, t\, 1/2)$$

$$t\, 1/2 = \frac{0.693}{\mu}$$

Tenth Value Layer (TVL): The tenth thickness or tenth-value layer is simply the thickness required to reduce the intensity of a beam of gamma radiation to one-tenth its incident value. By a calculation similar to that carried out above it can be shown that:

$$t\, 1/10 = \frac{2.303}{\mu}$$

Some typical values of t 1/2 and t 1/10 for lead, iron and water are given in Table 6.3.1.

TABLE 6.3.1

APPROXIMATE VALUES OF t 1/2 AND t 1/10

γ - radiation	inches of lead		inches of iron		inches of water	
energy (MeV)	t 1/2	t 1/10	t 1/2	t 1/10	t 1/2	t 1/10
0.66 (Cs-137)	0.4	1.0	1.4	2.75	7.5	25.0
1.25 (Co-60)	0.78	1.8	1.9	3.7	15.0	27.0

6.5 AREA DESIGNATIONS

All controlled areas at NES work sites are divided into area categories as defined below. Categorization of areas workers know what kind of environment they are entering and provides written warning of radiological hazards at entrances to the specific areas.

- Radiation Area 2-100 mR/hr general field
- High Radiation Area >100 mR/hr general field
- Surface Contamination Area >50 DPM/100CM^2 alpha
  >500 DPM/100CM^2 beta/gamma
- Airborne Radioactivity Area >2 x 10^{-12}uCi/cc alpha
  >1 x 10^{-9} uCi/cc beta/gamma

7. CONTAMINATION MEASUREMENT AND CONTROL

7.1 CONTAMINATION

Contamination is radioactive-material in an area that it is not wanted. Contamination behaves just like any other form of material such as dirt, dust, and rust. Suppose that a piece of chalk were radioactive material, then chalk dust would be contamination. Protective clothing is worn to keep contamination off our bodies.

7.2 DETECTING CONTAMINATION

When a sensitive radiation detection instrument is used to locate contamination, that is called frisking (the instrument is referred to as a frisker).

After each exit from a contaminated area, you are required to pass a sensitive probe slowly over your body - Frisk. Normally, you will not find contamination on your body. If you <u>do</u> find contamination, stay where you are, and notify Health Physics. If necessary, they shall wash the contamination off, using soap and lukewarm water. After cleaning you will again be frisked to check for contamination. For example, if only a hand is contaminated, then washing only

the hands would be required. If simple cleaning does not work, more abrasive methods are employed.

If you place a contaminated tool next to the frisker you will see a response on the meter. The tool can be washed to remove the contamination (just like removing any dirt or grease).

You cannot use a frisker in an area where the radiation levels are elevated. The radiation in an area, which is called background radiation, will cause a large meter response. This situation leaves two choices: take the person or item to be frisked to an area low in radiation levels, or use what is called the swipe technique to detect removable contamination.

A swipe is a piece of material that is stuck to a paper. The swipe can be rubbed over an area to pick up contamination, taken to another area and frisked or counted. This method detects removable or loose surface contamination. NES limits for loose surface contamination, requiring the use of protective clothing are:

- 500 disintegrations per minute per 100 square centimeter or 500 DPM $/100cm^2$ (for contaminants that emit beta and/or gamma radiation).

- 50 DPM$/100cm^2$ (for contaminants that emit alpha radiation).

Even though an item has been swiped, and no contamination detected, the item still needs to be frisked. Certain porous items can have contamination fixed to them.

In a situation where airborne contamination is present, or an individual has possibly ingested contamination (as in cases of facial contamination) a whole body count will be required for the contaminated individual. This will tell just how much, if any, radioactive material is in the body, and from that, a calculation of the worker's dose can be made. NES routinely performs an internal exposure evaluation for potentially significant internal uptakes and adds the internal exposure to the current quarter whole body exposure record, if significant.

Airborne materials may occur as dust, fumes, smoke, vapor, or gas. The most common measurements are taken of particulate matter by suction onto filter paper. This air sampling may be divided into 'spot' or 'continuous' sampling, depending upon the collection time spent. Due to naturally occurring radioactive gasses in the atmosphere (Ra,Th) and their particulate daughters, a correction in the counted activity is made based on the short half-life of the naturally occurring gasses involved.

The estimated long-life activity count rate is determined by the following formula:

$$C_{LL} = \frac{C_2 - 0271\ C_1}{0.729}$$

when C_{LL} = long lived count rate
C1 = counter after 4 hours of decay
C2 = counts after 24 hours of decay

7.3 NES GUIDELINES FOR WORK IN CONTAMINATED AREAS

1. Do not eat, smoke, or drink in contaminated areas.
2. Do not enter an area that is contaminated without Health Physics approval.
3. Always wear protective clothing for work in contaminated areas.
4. Avoid contact on your face with any contaminated items (do not scratch your nose while in protective clothing).
5. Always be aware of actions that could cause airborne contamination. (Even if they are not your actions.)
6. Contain contamination to as small an area as possible by:
   - observing contamination postings.
   - using proper protective clothing removal procedures.
   - placing all contaminated tools and equipment in their proper places.
   - keep the areas as clean as possible by practicing good housekeeping.
7. Persons with open sores, wounds, or bleeding of any degree will not be allowed in contaminated areas.
8. Always wear respirators when required by posted signs or by Health Physics instructions.

7.4 AREAS SURVEYS

Survey maps are posted for your reference prior to entry to controlled areas. These surveys indicate contamination and radiation levels in the area, as well as identifying "hot spots".

7.5 RESPIRATORS

In most cases, when respiratory protection is required, a full face air purifying respirator will be used. However, steps are taken to eliminate the need for respiratory protection by minimizing airborne contaminants. Some of these steps include:

- The use of physical boundaries such as doors and tents to localize airborne contaminants.
- The use of filtered ventilation to remove contaminants from the air.
- The decontamination of grossly contaminated areas to prevent airborne contamination being caused by work in the area.

Here is a list of some specific cautions that are applicable to respirator use:

1. Contact lenses cannot be worn with respirators.
2. If dentures are worn while qualifying for respirators, they must be worn while working in a respirator.
3. Remember also that full face, air purifying respirators do not supply oxygen. Do not wear them into atmospheres that are immediately dangerous to your health, or into any area that may be deficient in oxygen.
4. Do not use air purifying respirators to fight fires.
5. Beards are not permitted if a respirator is to be worn. (This includes wearing a respirator in the respirator test booth).
6. If you are in an area, and for any reason your respirator fails to supply you air - remove the respirator and quickly exit the area.
7. Always wear the type of respirator prescribed by Health Physics.
8. Perform a negative pressure test each time a respirator is put on, prior to entering the work area. Health Physics personnel shall assist you in assuring a good fit.

7.6 MINIMIZING WASTE VOLUME

1. Radwaste receptacles are for contaminated trash only. Do not throw clean trash into these containers.

2. Avoid dumping solvents and oils down floor drains; as oil and solvents shorten the life of liquid radwaste treatment equipment and result in larger amounts of waste that is more difficult to process.

3. Notify your supervisor if you notice excessive leakage from pumps or valves.

4. All tools and equipment removed from Contaminated Areas must be check by H.P. personnel to determine if they are contaminated. Contaminated tools and equipment should be stored for future use, and contaminated trash should be disposed of as radwaste. Tools, equipment, and trash that are frisked "clean" may be stored or discarded as everyday non-radioactive material.

5. Whenever possible, use tools and equipment that are already contaminated. Re-use of contaminated tools and equipment will reduce the amount of radioactive material generated. If you do not know where to get tools that are to be used in contaminated areas - ASK your supervisor.

6. Do not put cloth type protective clothing (PC) in waste receptacles. If pc's are placed with radwaste, they will be disposed of as radwaste.

7. Be neat! By using drop cloths, catch bags and by picking up tools you can reduce the spread of contamination and thus reduce the amount of material required for area cleanup and decontamination.

8. Use only the materials required to clean the area. An excessive amount of bags, rags and solvent add to radwaste.

9. Use LSA boxes correctly:

   9.1 Do not put aerosol cans in LSA boxes. These cans should be placed in special drums designated for that purpose.

   9.2 Do not place bags or cans of water or any other fluid in LSA boxes, ask Health Physics for guidance in such cases.

   9.3 Unless you are told to by Health Physics, do not throw usable contaminated tools in LSA boxes.

8. EMERGENCY ACTIONS

8.1 CONTINUOUS AIR MONITOR ALARM

If a continuous air monitor alarms in the area you are in, you should:

- Stop all work, but do not leave equipment in a hazardous condition.
- Warn all others in the area.
- Leave the area and proceed to the designated area.
- Notify Health Physics.

8.2 AREA RADIATION MONITOR ALARMS

If you are in an area and an Area Radiation Monitor Alarms, here is what you should do:

- Leave the area immediately, making sure that all others in the area are aware of the alarm and leave also.
- Secure access to that area.
- Notify Health Physics.
- Check your dosimeter

8.3 PHYSICAL INJURY

Good sense must be applied when a first aid situation arises. You should not drag a slightly injured man out of a contaminated area and thereby contaminate other areas unnecessarily. Neither do we want a man to bleed to death by following normal dressing and frisking procedures. Notify Health Physics personnel!

All emergency response measures in controlled areas shall be carried out in accordance with RCP-6, "Emergency Actions Procedure".

9. REFERENCES

1. Kaplan, "Nuclear Physics"; Addison-Wesley, Mass. 1962.

2. Fitzgerald, etc.al., "Mathematical Theory of Radiation Dosimetry"; Gordon & Breach, New York, 1967.

3. Miner(ed), "Ionizing Radiation and the Cell"; New York Academy of Sciences.

4. Title 10 Code of Federal Regulations Part 19, "Notices, Instructions, and Reports to Workers; Inspections".

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

6. Title 29 Code of Federal Regulations Chapter XX, "Occupational Safety and Health Administration, Dept. of Labor", Part 1910.

RCP-3.0

INSTRUMENTATION MAINTENANCE PROCEDURE

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 7/30/84	J. Mezo 8/9/84	J. May 10/23/84		
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REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPPOVAL

RCP-3.0

INSTRUMENTATION MAINTENANCE PROCEDURE

1. SCOPE

This procedure has been developed to detail the NES approved methodology for radiological instrumentation calibration. All NES survey instruments, counting devices, and other equipment used for radioactivity detection and measurement requiring calibration by radioactive means shall be cared for and maintained by this procedure.

2. GENERAL MAINTENANCE

All survey equipment shall be visually inspected by the user prior to use. This visual inspection shall consist of:

- checking for loose parts or fittings
- checking for a current calibration sticker
- checking the battery (if any) for fully charged condition

After the visual inspection is complete and no defects or potential defects are found, the instrument is ready for use. Specific devices are to be used for the particular task at hand. Modification of any survey meter in the field to fulfill a function it is specifically not designed and/or calibrated for is prohibited.

Survey meters and their associated devices are often used in hostile environments. Hostile environments are defined as those where high temperature, low temperature, moisture, or other similar conditions exist which could potentially affect the operation or accuracy of the device. Users of this equipment will make provisions prior to the start of work to protect the device from these factors. Provisions may include limiting the time spent in a hot or cold area or the selection of a clean, dry equipment laydown area.

Contamination of instruments by radioactive materials is to be avoided or limited whenever possible. This may be accomplished by wrapping the device in clear plastic or by the use of masking tape on a probe. Protective coverings must not interfere

with the ability of the device to perform its function (i.e., covering a probe detection surface with a plastic sheet may effectively shield against the radiation or particle which the user wishes to measure).

The advice of the Radiation Safety Officer (RSO) or a Health Physics Supervisor (HPS) should be sought when use of radiation survey equipment is anticipated in hostile environments.

3. CALIBRATION

The calibration of radiation survey devices shall be conducted using calibration standards traceable to the National Bureau of Standards. Each instrument used for radiation surveys shall be calibrated at intervals not to exceed twelve (12) months. All calibrations shall be performed by individuals trained in these operations and who are recognized by the Radiological Safety Committee. Said individuals may be NES employees or contracted firms. Should personnel outside NES be employed in instrument calibration, the minimum records required shall remain the same as if calibration occurred in-house. These records include:

1. NES instrument calibration form NES-C-1
2. A certificate of calibration which details
   a. the date the calibration was performed
   b. the individual performing the calibration
   c. the specific standard by which the device was calibrated
   d. the expiration date of the calibration
   e. efficiency of the standard and method employed.

The original records as described, shall be held by the Radiation Records Control Officer (RRCO). The user shall confirm the calibration papers and the calibration sticker attached to the device agree and are up to date. No device shall be used for any purpose whatsoever after the calibration date has been exceeded.

The calibration sticker previously mentioned shall be attached by the RRCO at the time the device is calibrated. This sticker shall contain the following information:

a. Instrument Model #
b. Instrument Serial #

c. Calibration expiration date

d. Initials of the RRCO (or his designate)

RCP-4.0

GENERAL RADIOLOGICAL SURVEY

PROCEDURE

Project Application	Copy No	Assigned To
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APPROVALS

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REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 7/30/84	J. Meszo 8/8/84	J. May 14/27/84		
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REVISION LOG

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL
1	3/14/85	-	all pages noted with triangle blocks per CRA # 5166	

GENERAL RADIOLOGICAL SURVEY PROCEDURE

1. SCOPE

The objective of this procedure is to outline the required action to be taken while collecting radiological survey data in all forms and types.

2. GENERAL

This procedure must be used to ensure standardized techniques are employed and to ensure the comparability of data. This procedure is in compliance with the requirements of the NES "Radiological Protection Manual" 82A8C03.

3. RESPONSIBILITIES

3.1 PROJECT RADIATION SAFETY OFFICER

Review planned survey plan. Assure that complete documentation is kept on each survey point and type in the project files. Perform audits to assure compliance with this procedure.

3.2 PROJECT MANAGER/HEALTH PHYSICS SUPERVISOR

Responsible to ensure the methods of data collection are correct for the type of sampling being performed and are correctly executed. Ensure the data collected is stored in the calculation notebook for the project.

4. RESPONSIBILITIES

4.1 DIRECT INSTRUMENT SURVEY

Direct Beta-Gamma Contamination Survey: An Eberline PRS-1 or PRS-2 ratemeter/scaler and Eberline HP 190A GM detector (or equivalent) will be

used to make direct beta-gamma surveys to verify the presence or absence of beta and/or gamma contamination.

Perform system operational checks. Depress the "Battery Check" button and make sure that the meter reads in the "Battery O.K." region. If it does not, replace the batteries. Use the Eberline Sr-90 check source (or equivalent) to ensure that the instrument is responding properly.

Since the GM probe will respond to both removable surface beta contamination and, more penetrating, gamma radiation originating from areas other than that of interest, duplicate measurements will be made at each location to differentiate between the two types of radiation.

Hold the GM probe one meter from the surface of interest (with the window facing away from the surface) and note the count rate. Record it on the survey sheet. Hold the GM probe window 2 cm. from the surface of interest and note the count rate. Record it on the survey sheet. The beta count rate (an indicator of surface contamination) is obtained by subtracting the count rate obtained with the GM probe one meter from the surface.

<u>External Dose-Rate Survey:</u> Use the Victoreen Ionization Chamber (or equivalent) to perform exposure rate surveys. The general operating procedure is given below. The operation of each specific metering device shall be in accordance with manufacturer's specifications.

1) Turn the RANGE switch from "OFF" to "BATT" and make sure the meter reads in the "BATT O.K." green region. If it does not, replace the batteries.

2) Turn the RANGE switch to "1000", and allow the instrument to warm-up for 1 to 5 minutes.

3) After the instrument has warmed up, depress the "ZERO SET" button and adjust the "ZERO ADJUST" control until the meter reads zero. Release the "ZERO SET" button.

4) Turn the FUNCTION switch to "mR/hr" and the RANGE switch to "3mR/hr." Allow the instrument to set for approximately 1 minute.

5) Check the instruments response by using the "Operational Check Source", locateo on the outer side of the chamber end cap. Remove the end cap and turn it so the check source is facing the chamber. The meter should read just over 1 mR/hr.

6) If the instrument passes the operation check, it is ready for use.

7) With the FUNCTION switch set to "mR/hr" and the end cap on the instrument will read out directly in mR/hr. If an R/hr reading is desirable, the meter reading is divided by 1×10^{-3}.

8) Hold the instrument at the location of interest and allow the meter to stabilize. Note the reading.

9) Record all readings, calculations and survey locations on the appropriate survey forms.

4.2 REMOVABLE CONTAMINATION SURVEY PROCEDURE

A 4.7 cm. diameter Mohawk cloth filter paper disc (or equivalent) is passed over a representative portion of a section of a surface using moderate pressure with the tip of the thumb. (The judgement of "moderate pressure" is a matter of experience. In general as much pressure as possible should be used to accumulate activity on the smear, but without damaging the filter paper). Normally, the area of the portion smeared should by approximately 100 cm^2. Since the pressure-bearing portion of the filter paper disc is 1 cm. wide, the length of the smear should be 50 cm. This should be achieved by a Z or S pattern with legs that are appropriately 6" long. Unless otherwise specified, it will be assumed that the smear covers 100 cm^2. Any other area shall be as noted.

Care shall be taken to avoid excessive "loading" of the smear surface with dirt or wetness as this will result in low measurements of alpha activities. Duplicate smears shall be taken in 1 out of 20 locations to provide QA samples.

The smear surface shall be protected against loss of activity prior to counting by use of a "smear book" composed of waxed paper sheets or similar method. To prevent transfer of contamination, these books shall not be reused.

The smears shall be identified for future reference when counting. The reference data shall be capable of defining the approximate area in which the smear was taken.

The smears shall be counted under a suitable calibrated counter and calculation techniques appropriate for the activities present (Ex: Eberline HP-270 plus HP-210T counting tray).

The filter paper disc is placed in a counting planchet. The disc should be flat to avoid counting errors due to source geometry. If the filter paper is of necessity particularly dirty, it should be so noted on the data sheet, as this will reduce the detectability of alpha activity. Smears will be recounted in 1 of 10 smears for QA purposes.

4.3 SAMPLE SELECTION CRITERIA

- Briefly survey entire room area, noting significant and maximum area levels.
- Review historical data available.
- Select special area of interest based on above information.
- Take additional samples as follows in each room or facility:
  - Two floor (variable with room size)
  - Two wall (variable with room size)
  - Two table-counter top

- Sink
- Large equipment (2 smears)
- Small equipment (1 smear)
- All floor intersections (aisles)
- Aisles (Centers between intersections)

- Take perimeter surveys of areas immediately adjacent to known contaminated areas.

4.4 AIR SAMPLING PROCEDURE

High volume particulate air samples will be drawn using the staplex High Volume Air Sampler and Whatman Glass Fibre filters (11cm.) or equivalent.

1) Place the glass fibre filter into the sample retaining ring of the air sampler so that the smooth side of the filter will be facing outwards.

2) Place the filter-retaining ring combination on the air sampler and gently screw the ring on so as not to tear the filter.

3) At the desired location hold the air sampler at waist level and turn on the air sampler for a duration sufficient to draw a representative sample, (normally 10 minutes). The sample volume is calculated as follows:

$$10 \text{ min.} \times 20 \text{ CFM} \times 2.8 \times 10^4 \text{ ml/CF} = 7.2 \times 10^6 \text{ ml/sample}$$

4) After the air sample has been drawn and the air sample turned off, carefully remove the glass fibre filter and place it into a glassine envelope.

5) Label the envelope with:
   - Sample location
   - Sample time

- Sampling duration
- Name of person taking sample

6) Prepare the sample for counting as follows:

- Carefully remove the sample filter from the glassine envelope. Lay out the filter on a clean, hard surface. Be careful not to touch or disturb the surface of the filter.

- Place a planchet or similar object onto the filter and cut a 4.7 cm. disc out of the filter. This 4.7 cm. disc represents 25% of sample volume.

$$7.2 \times 10^6 \text{ ml.} \times 0.25 = 1.8 \times 10^6 \text{ ml/sample}$$

- Place the 4.7 cm. filter disc in a counting planchet, sample side up.

- The sample should now be stored for 48 hours to allow natural radon and thoron daughters to decay away. After which the sample may be counted for gross alpha-beta and/or gamma spectroscopy.

4.5 AIR SAMPLE PREPARATION AND ANALYSIS

4.5.1 Sample Screening: All samples entering NES laboratories will be immediately placed in the sample screening area. Samples will be segregated into high and low level samples in this area.

a) Sample Screening Area Shall Be:

- An area isolated from all counting equipment.
- An area as close as possible to the entrance of the laboratory.
- An area free from drafts or major personnel traffic.

b) Sample Screening Equipment:

- Stainless steel tray with raised edges.
- Absorbent tray liner paper.
- Rate meter with GM detector and/or alpha scintillation detector.
- Protective rubber or vinyl gloves.

c) Sample Screening Procedure:

- Perform all work over the stainless steel tray.
- With forceps and gloved hands carefully remove the sample from the sample envelope and place it on the tray facing up.
- Connect the appropriate detector to the ratemeter. Switch the rate meter to the "1X" scale.
- Place the appropriate detector window next to the sample. One centimeter away for the GM detector and as close as possible, without contact, for the alpha detector.
- Observe the count rate. Switch to higher scales if necessary. Levels between 0 and 500 cpm will be designated as low level samples. Levels greater than 500 cpm will be designated as high level samples.

4.5.2 <u>Sample Preparation:</u>

a) Smear Samples: With an indelible marker label the bottom of a stainless steel counting planchet with:

- Sample location
- Sample date

Carefully remove the smear from its paper holder with forceps and place it in the counting planchet sticky side down.

If the smear is wet, allow it to dry either by air or in drying oven as needed.

b) High volume air sample preparation: With an indelible marker label the bottom of a stainless steel counting planchet with:

- Sample location
- Sample data
- Air volume

Carefully cut out a circular portion of the air filter that will fit into a counting planchet and place it into a counting planchet facing up.

c) As an alternate method, high level smear and air samples may be sealed in aluminum sample storage cans for gamma spectroscopy counting or storage.

4.5.3 Sample Analysis:

a) Gross alpha and beta/gamma counting: High level samples will be counted using a portable alpha scintillation detector and/or GM detector. Low level samples will be counted using a gas flow proportional counter (or equivalent).

A background count should be made in order to determine the net count rate and the system Minimum Detectable Limit (MDL). See Attachment I for calculation of the MDL.

Select the counting time providing a sufficient MDL and count the sample according to the appropriate instrument users manual.

See Attachment I for calculation results.

b) Gamma Spectroscopy counting: Assemble the GeLi and/or NaI Counting System according to the appropriate instruction manual. Make background counts using a "clean" filter or smear placed in a stainless steel counting planchet or aluminum sample can depending on how the sample will be counted. This will be used for the determination of the net count rate and MDL of the GeLi System.

Place the stainless steel counting planchet or aluminum sample can containing the sample on the GeLi detector.

Acquire the sample spectrum for a time providing a sufficient MDL. Use the counting system to analyze the acquired spectra as specified by the appropriate software.

4.5.4 <u>Sample Storage:</u>

a) High and low level samples will be stored separately.

High level samples will be stored in a sealed container as far away from counting equipment as possible.

Low level samples should be stored away from counting equipment and the high level samples.

Samples will be removed from storage for analysis only.

b) Counting planchets will be stored in 25 sample cardboard planchet holders.

Each sample space on the cardboard holder will be labeled with the sample I.D. code.

A sample storage log sheet for each 25 sample holders will be made and will contain:

- Sample holder I.D. code
- Sample I.D. codes for each of the samples placed in the holder.
- Location of sample holder (i.e. high or low level storage)

c) Aluminum sample cans will be stored in cardboard boxes.

A listing of all sample I.D. numbers placed on the outside of each storage box.

A sample storage log sheet for each box will be made and will contain:

- Sample box I.D. code
- Sample I.D. codes for each of the samples placed in the box.
- Location of sample box (i.e., high or low level storage)

4.6 SMEAR AND DIRECT SURVEY REFERENCING PROCEDURES

All smears shall be located by:

- Room number/name designation
- Surface type
- Clarifying notes
- Personnel taking smear
- Date

Identifying information shall be recorded on the smear collection holders, the smear survey report sheet, and floor plans.

Surface types:

- F = floor
- S = sink
- T = table top
- E = equipment
- D = doorway floor
- I = floor intersections
- W = walls
- O = overhead equipment

ATTACHMENT I

1. MDL Calculation (minimum detectable limit)

$$MDL = 3 \sqrt{\frac{\text{total background counts}}{\text{(total count time) (counter efficiency)}}}$$

2. Calculation of smear results

$$\text{Net CPM} = \frac{\text{total counts-smears}}{\text{total count time}} - \frac{\text{total background counts}}{\text{total count time}}$$

$$\frac{\text{DPM}}{100\ \text{cm}^2} = \frac{\text{net CPM}}{\text{counter efficiency}}$$

counter efficiency should not be in root

3. Calculation of air sample results

$$\text{concentration (Ci/ml)} = \frac{\dfrac{\text{total observed counts}}{\text{total count time (min.)}} - \dfrac{\text{total background counts}}{\text{total count time}}}{\text{(counter efficiency) (sample volume) } (2.22 \times 10^6 \text{ dpm/Ci})}$$

4. Calculation of counting error

$$\text{(95\% confidence)} = 2 \; \frac{\text{source CPM}}{\text{count time}} + \frac{\text{background CPM}}{\text{count time}}$$

RCP-5.0

GUIDELINES FOR

RADIOACTIVE WASTE DISPOSAL

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 7/30/84	[signature] 8/8/84	[signature] 10/23/84		
1	[signature] 2/25/85	[signature] 3/1/85	[signature] 3/13/85		
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REVISION LOG

DOCUMENT NO. 82A8009

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL
1	3/14/85	-	all pages noted with triangle blocks per CRA # 5167	

TABLE OF CONTENTS

GUIDELINES FOR RADIOACTIVE WASTE DISPOSAL

The purpose of this procedure is to detail the legal requirements for and the methods to be used for the safe packaging and shipment of radioactive materials. This procedure is in compliance with the requirements of the NES "Radiological Protection Manual," 82A8003.

1. APPLICABLE REGULATIONS

Title 10 Code of Federal Regulation; Part 20
Title 10 Code of Federal Regulation; Part 61
Title 10 Code of Federal Regulation; Part 71
Title 49 Code of Federal Regulation; Part 173-178

U.S.E. Hanford Burial Grounds License
C.N. Barnwell Burial Grounds License
U.S.E. Beatty Burial Grounds License

2. CHARACTERIZATION OF WASTE

The following specific characteristics must be defined for each radwaste package:

1. Isotopes present by percent of weight and curie contribution.
2. Mass of waste and package.
3. Radiation level at package surface.
4. Total curies.
5. Physical form (solids, liquids, gas)
6. Chemical form (metal, homogeneous, cement, etc.)
7. Transport form (special/normal; type LSA, A, B(U), B(M)
8. Waste form class (A, B, C, stable, unstable)

Curie Level and Isotopic content shall be determined by either:

A. Direct sampling for laboratory analysis.

B. Operating history/calculations based on radiation.

Radiation level and weight data shall be measured for each package. The shipping manifest shall include all information per package for items 1-7 above, as well as a short verbal description of the waste.

Requirements of 10 CFR 61 shall be followed.

3. DEPARTMENT OF TRANSPORTATION (DOT) REQUIREMENTS IN PREPARATION AND OFFERING OF RADIOACTIVE MATERIALS FOR SHIPMENT

A. Definition of Radioactive Materials Subject to the Regulations

For purposes of transportation, radioactive materials are defined as those materials which spontaneously emit ionizing radiation and have a specific activity in excess of 0.002 microcuries per gram of material. All materials are to some degree radioactive. THE DEMARCATION OF 0.002 MICROCURIES PER GRAM ALLOWS A DISTINCTION BETWEEN MATERIALS NOT NORMALLY CONSIDERED RADIOACTIVE AND THOSE WHICH ARE REGULATED AS RADIOACTIVE IN TRANSPORTATION.

B. Best Approach to Using the Regulations

A primary consideration for achievement of safety in the transportation of radioactive materials is the use of proper packaging for the specific radioactive material to be transported. In order to determine the packaging requirements, a prospective shipper or package designer must answer ALL of these questions:

1. What radionuclides are being shipped? 49 CFR 173.435 contains a listing of over 250 specific radionuclides. Certain "ground rules" for dealing with unlisted or unknown radionuclides, or with mixtures of radionuclides, appear in 49 CFR 173.433. ⚠

3. What is the form of the radionuclide?

a. Is the material in special form?; or

b. Is it in normal form?

The terminology which has been introduced in asking these three questions is explained in the succeeding paragraphs.

C. Special Form Radioactive Materials

Materials are considered "special form" when they meet the requirements of 49 CFR 173.469. As illustrated in Figure 1, "special form" materials are limited to materials which, if released from a package, might present a hazard of direct external radiation. However, due to their "high physical integrity," they would present very little hazard, if any, as a result of the spread of loose radioactive material (contamination). This high physical integrity could be the result of a natural property of the material, such as its being in massive, nondispersable solid form, or an acquired characteristic, such as being sealed into a very durable capsule (encapsulated).

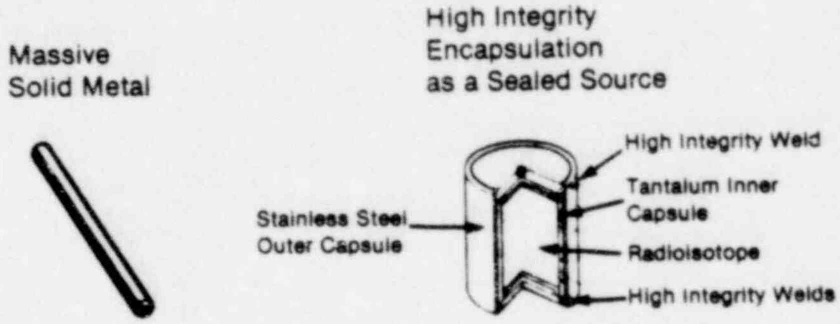
Special form encapsulations must have at least one external physical dimension which exceeds 5mm. This minimum dimension requirement makes the capsule more easily seen and recovered in the event of an accident/incident.

Special form encapsulations are required to be so constructed that they can only be opened by destroying the capsule. This requirement is intended to prevent the inadvertent loosening or opening of the capsule, either during transport or following an accident. The "special form" materials are much less likely to spread contamination in the event of package failure. Therefore, the regulations generally allow substantially larger quantities of such materials to be placed in given packagings than when the materials are in "normal form."

Figure 1 - **"Special Form" R.A.M.** (49 CFR 173.403 (z) and 173.469 (a))

May Present a Direct Radiation Hazard if Released From Package, but Little Hazard Due to Contamination

"Special Form" R.A.M. May Be "Natural" Characteristic, i.e., Massive Solid Metal, or "Acquired" Through High Integrity Encapsulation



For purposes of <u>export</u>, a shipper must furnish to the foreign consignee a certificate of competent authority for the special form material. Such a certificate will <u>only</u> be issued by the DOT, Office of Hazardous Materials Regulation, upon receipt of a specific petition and <u>only</u> when a certificate is required by a shipper to fulfill a need. Such a need will be in the case of foreign shipments only, such as pursuant to paragraph 803 of the International Atomic Energy Agency (IAEA) regulations. 49 CFR 173.476, relating to certain special form requirements, is quoted below:

49 CFR 173.476 Approval of special form radioactive materials.

(a) Each shipper of special form radioactive materials shall maintain on file for at least one year after the latest shipment, and provide to the MTB on request, a complete safety analysis, including documentation of any tests, demonstrating that the special form material meets the requirements of 49 CFR 173.469. An IAEA Certificate of Competent Authority issued for the special form material may be used to satisfy this requirement.

(Approved by the Office of Management and Budget under OMB control number 2137-0516.)

(b) Prior to the first export shipment of a special form radioactive material from the United States, each shipper shall obtain a U.S. Competent Authority Certificate for the specific material. Each petition shall be submitted in accordance with 49 CFR 173.471(e) and must include the following information:

(1) A detailed description of the material, or if a capsule, a detailed description of the contents. Particular reference must be made to both physical and chemical states:

(2) If a capsule is to be used, a detailed statement of its design and dimensions, including complete engineering drawings and schedules of material, and methods of construction; and

(3) A statement of the tests that have been made and their results; evidence based on calculative methods to show that the material is able to pass the tests; or other evidence that the special form radioactive material complies with 49 CFR 173.469. Documentation of tests shall be kept on file for one (1) year dated from the last shipment.

(c) Paragraph (a) and (b) of this section do not apply in those cases where A_1 equals A_2 and the material is not described on the shipping papers as "Radioactive Material Special Form, n.o.s."

In determining if an encapsulation passes the test requirements for special form (49 CFR 173.469), an option is available. In addition to the leaching acceptance test which is performed over a seven-day period, some capsules may be acceptance tested by volumetric means. If an encapsulation has an internal void of at least 0.1 ml (.006 in^{-3}), it may be leak tested using techniques such as the vacuum bubble or helium leak tests. Any volumetric leak testing technique may be utilized, provided that it has a sensitivity of at least:

(1) 1.3×10^{-4} atm-cm^3/s for solid contents; or

(2) 1.3×10^{-6} atm-cm^3/s for liquids or gaseous contents.

All tests are based on air at 77° and one atmosphere pressure differential.

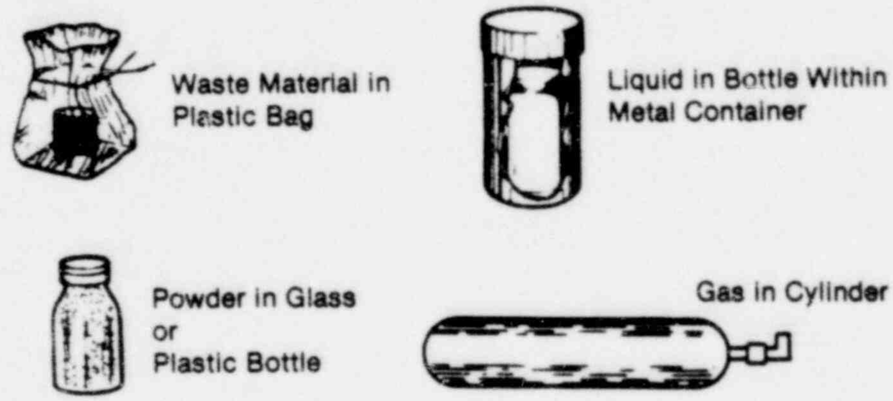
D. Normal Form Radioactive Materials

Illustrated in Figure 4 are "normal form" radioactive materials which are, therefore, ANY radioactive materials that do not qualify as "special form."

Figure 2 - Normal Forms Radioactive Materials 49 CFR 173.403(s)

Normal Form Materials May Be Solid, Liquid or Gaseous and Include any Material Which Has *Not* Been Qualified as Special Form

Type A Package Limits are A_2 Values



E. Quantity Limits and Packagings

Having considered the type, quantity, and form of the radioactive material, it is now appropriate to consider the packaging requirements. Packaging types are "Type A," "Type B," "excepted," and "strong, tight," all of which will be explained.

THE A_1 and A2 SYSTEM

The present regulations use A_1 and A2 values as points of reference for quantity limitations for every radionuclide. This system replaces the

former Transport Group system that was used for limitations when the radioactive materials were in normal form.

Every radionuclide is now assigned an A_1 and an A_2 value. These two values (in curies) are simply the maximum activity of that radionuclide that may be transported in a TYPE A package. Table 1 gives examples of A_1 and A_2 values for typical radionuclide. The A_1 value is the number of curies for a particular radionuclide when in Special Form. The A_2 value is the number of curies if the radionuclide is not in Special Form--i.e., the material is in Normal Form.

In previous regulations, the activity limitations for Special Form was the same for all radionuclides. Now the limitation for each radionuclide depends primarily on the penetrating radiation emitted by the material when encapsulated.

Under the former regulations, every radionuclide was assigned to one of seven transport groups (I through VII). The assignment of a radionuclide to a group was based on the radiation hazard that would occur if some of the material was taken into a person's body. The activity limit for all radionuclides in a transport group was established by the radiotoxicity of the most hazardous radionuclide in the group. Under the present system, the A_2 limit for each radionuclide is established on the basis of the hazard that would result if that individual radionuclide was ingested, inhaled or absorbed through the skin.

The Limited Quantity, Low Specific Activity (LSA), Type A, Type B, and Highway Route Controlled Quantity provisions in the regulations all relate to A_1 and A_2 values as points of reference for activity limits or thresholds. In the case of Type B quantities, they are simply defined as a quantity exceeding the appropriate A_1 or A_2 value for the radionuclide(s) of interest.

For mixtures of radionuclides, certain rules are specified for determining whether the Type A quantity has been exceeded (see 49 CFR 173.433(b)). △

In most cases, the "ratio rule" may be applied. This involves dividing the activity of each radionuclide present by its A_1 or A_2 value (as appropriate) and summing the resulting fractions. If the sum is 1.0 or less, then the mixture does not exceed a Type A quantity.

TABLE 1
DEPARTMENT OF TRANSPORTATION LIMITS
TYPE A MATERIALS

§ 173.435 Table of A_1 and A_2 values for radionuclides.

Symbol of radionuclide	Element and atomic number	A_1(C_i) special form	A_2(C_i) normal form
^{227}Ac	Actinium (89).	1000	0.003
^{228}Ac		10	4
^{105}Ag	Silver (47)	40	40
^{110m}Ag		7	7
^{111}Ag		100	20
^{241}Am	Americium (95)[1]	8	0.008
^{243}Am		8	0.008
^{37}Ar (compressed or uncompressed).	Argon (18)	1000	1000
^{41}Ar (uncompressed).		20	20
^{41}Ar (compressed).		1	1
^{73}As	Arsenic (33)	1000	400
^{74}As		20	20
^{76}As		10	10
^{77}As		300	20
^{211}At	Astatine (85).	200	7
^{193}Au	Gold (79)	200	200
^{196}Au		30	30
^{198}Au		40	20
^{199}Au		200	25
^{131}Ba	Barium (56)	40	40
^{133}Ba		40	10
^{140}Ba		20	20
^{7}Be	Beryllium (4).	300	300
^{206}Bi	Bismuth (83).	5	5
^{207}Bi		10	10
^{210}Bi (RaE)		10	4
^{212}Bi		6	6
^{249}Bk	Berkelium (97).	1000	1
^{77}Br	Bromine (35).	70	25
^{82}Br		6	6
^{11}C	Carbon (6)	20	20
^{14}C		1000	60
^{45}Ca	Calcium (20).	1000	25
^{47}Ca		20	20
^{109}Cd	Cadmium (48).	1000	70
^{115m}Cd		30	30
^{115}Cd		80	2[illegible]
^{139}Ce	Cerium (58)	100	100
^{141}Ce		300	25
^{143}Ce		60	20
^{144}Ce		10	7
^{249}Cf	Californium (98).	2	0.002
^{250}Cf		7	0.007
^{252}Cf		2	0.009
^{36}Cl	Chlorine (17).	300	10
^{38}Cl		10	10
^{242}Cm	Curium (96)	200	0.2
^{243}Cm		9	0.009
^{244}Cm		10	0.01
^{245}Cm		6	0.006
^{246}Cm		6	0.006
^{56}Co	Cobalt (27)	5	5

[1] The figures for uranium include representative values for the activity of uranium-234 which is concentrated during the enrichment process. The activity for thorium includes the equilibrium concentration of thorium-228.

§ 173.435

Symbol of radionuclide	Element and atomic number	$A_1(C_i)$ special form	$A_2(C_i)$ normal form
57_{Co}		90	90
$58m_{Co}$		1000	1000
58_{Co}		20	20
60_{Co}		7	7
51_{Cr}	Chromium (24).	600	600
129_{Cs}	Cesium (55)	40	40
131_{Cs}		1000	1000
$134m_{Cs}$		1000	10
134_{Cs}		10	10
135_{Cs}		1000	25
136_{Cs}		7	7
137_{Cs}		30	10
64_{Cu}	Copper (29)	80	25
67_{Cu}		200	25
165_{Dy}	Dysprosium (66).	100	20
166_{Dy}		1000	200
169_{Er}	Erbium (68)	1000	25
171_{Er}		50	20
$152m_{Eu}$	Europium (63).	30	30
152_{Eu}		20	10
154_{Eu}		10	5
155_{Eu}		400	60
18_{F}	Flourine (9)	20	20
52_{Fe}	Iron (26)	5	5
55_{Fe}		1000	1000
59_{Fe}		10	10
67_{Ga}	Gallium (31)	100	100
68_{Ga}		20	20
72_{Ga}		7	7
153_{Gd}	Gadolinium (64).	200	100
159_{Gd}		300	20
68_{Ge}	Germanium (32).	20	10
71_{Ge}		1000	1000
3_{H}	Hydrogen (1) See T-Tritium.		
181_{Hf}	Hafnium (72).	30	25
$197m_{Hg}$	Mercury (80).	200	200
197_{Hg}		200	200
203_{Hg}		80	25
166_{Ho}	Holmium (67).	30	30
123_{I}	Iodine (53)	50	50
125_{I}		1000	70
126_{I}		40	10
129_{I}		1000	2
131_{I}		40	10
132_{I}		7	7
133_{I}		30	10
134_{I}		8	8
135_{I}		10	10
111_{In}	Indium (49)	30	25
$113m_{In}$		60	60
$114m_{In}$		30	20
$115m_{In}$		100	20
190_{Ir}	Indium (77)	10	10
192_{Ir}		20	10
194_{Ir}		10	10
42_{K}	Potassium (19).	10	10
43_{K}		20	10
$85m_{Kr}$ (uncompressed).	Krypton (36)	100	100
$85m_{Kr}$ (compressed).		3	3
85_{Kr} (uncompressed).		1000	1000
85_{Kr} (compressed).		5	5
87_{Kr} (uncompressed).		20	20
87_{Kr} (compressed).		0.6	0.6
140_{La}	Lanthanum (57).	30	30
LSA	Low specific activity material—see § 173.403.		
177_{Lu}	Lutetium (71).	300	25
MFP	Mixed fission products.	10	0.4
28_{Mg}	Magnesium (12).	6	6
52_{Mn}	Manganese (25).	5	5
54_{Mn}		20	20
56_{Mn}		5	5
99_{Mo}	Molybdenum (42).	100	20
13_{N}	Nitrogen (7)	20	10
22_{Na}	Sodium (11)	8	8
24_{Na}		5	5
$93m_{Nb}$	Niobium (41).	1000	200
95_{Nb}		20	20
97_{Nb}		20	20
147_{Nd}	Neodymium (60).	100	20
149_{Nd}		30	20
59_{Ni}	Nickel (28)	1000	900
63_{Ni}		1000	100
65_{Ni}		10	10
237_{Np}	Neptunium ([illegible]).	5	0.006
239_{Np}		200	25
185_{Os}	Osmium (76).	20	20
191_{Os}		600	200
191_{mOs}		200	200
193_{Os}		100	20
32_{P}	Phosphorus (15).	30	30
230_{Pa}	Protactinium (91).	20	0.8
231_{Pa}		2	0.002
233_{Pa}		100	100
201_{Pb}	Lead (82)	20	20
210_{Pb}		100	0.2
212_{Pb}		6	5
103_{Pd}	Palladium, (46).	1000	700
109_{Pd}		100	20
147_{Pm}	Promethium (61).	1000	25
149_{Pm}		100	20

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§ 173.435

Symbol of radionuclide	Element and atomic number	$A_1(C_i)$ special form	$A_2(C_i)$ normal form
210_{Po}	Polonium (84)	200	0.2
142_{Pr}	Praseodymium (59)	10	10
143_{Pr}		300	20
191_{Pt}	Platinum (78)	100	100
$193m_{Pt}$		200	200
$197m_{Pt}$		300	20
197_{Pt}		300	20
238_{Pu}	Plutonium (94)[1]	3	0.003
239_{Pu}		2	0.002
240_{Pu}		2	0.002
241_{Pu}		1000	0.1
242_{Pu}		3	0.003
223_{Ra}	Radium (88)	50	0.2
224_{Ra}		6	0.5
226_{Ra}		10	0.05
228_{Ra}		10	0.05
81_{Rb}	Rubidium (37)	30	25
86_{Rb}		30	30
87_{Rb}		Unlimited	Unlimited
Rb (natural)		Unlimited	Unlimited
186_{Re}	Rhenium (75)	100	20
187_{Re}		Unlimited	Unlimited
188_{Re}		10	10
Re (natural)		Unlimited	Unlimited
$103m_{Rh}$	Rhodium (45)	1000	1000
105_{Rh}		200	25
222_{Rn}	Radon (86)	10	2
97_{Ru}	Ruthenium (44)	80	80
103_{Ru}		30	25
105_{Ru}		20	20
106_{Ru}		10	7
35_{S}	Sulphur (16)	1000	60
122_{Sb}	Antimony (51)	30	30
124_{Sb}		5	5
125_{Sb}		40	25
46_{Sc}	Scandium (21)	8	8
47_{Sc}		200	20
48_{Sc}		5	5
75_{Se}	Selenium (34)	40	40
31_{Si}	Silicon (14)	100	20
147_{Sm}	Samarium (62)	Unlimited	Unlimited
151_{Sm}		1000	90
153_{Sm}		300	20
113_{Sn}	Tin (50)	60	60
$119m_{Sn}$		100	100
125_{Sn}		10	10
$85m_{Sr}$	Strontium (38)	80	80
85_{Sr}		30	30
$87m_{Sr}$		50	50
89_{Sr}		100	10
90_{Sr}		10	0.4
91_{Sr}		10	10
92_{Sr}		10	10
T (uncompressed)	Tritium (1)	1000	1000
T (compressed)		1000	1000
T (activated luminous paint)		1000	1000
T (adsorbed on solid carrier)		1000	1000
T (tritiated water)		1000	1000
T (other forms)		20	20
182_{Ta}	Tantalum (73)	20	20
160_{Tb}	Terbium (65)	20	10
$96m_{Tc}$	Technetium (43)	1000	1000
96_{Tc}		6	6
$97m_{Tc}$		1000	200
97_{Tc}		1000	400
$99m_{Tc}$		100	100
99_{Tc}		1000	25
$125m_{Te}$	Tellurium (52)	1000	100
$127m_{Te}$		300	20
127_{Te}		300	20
$129m_{Te}$		30	10
129_{Te}		100	20
$131m_{Te}$		10	10
132_{Te}		7	7
227_{Th}	Thorium (90)	200	0.2
228_{Th}		6	0.008
230_{Th}		3	0.003
231_{Th}		1000	25
232_{Th}		Unlimited	Unlimited
234_{Th}		10	10
Th (natural)		Unlimited	Unlimited
Th (irradiated)[5]			
200_{Tl}	Thallium (81)	20	20
201_{Tl}		200	200
202_{Tl}		40	40
204_{Tl}		300	10
170_{Tm}	Thulium (69)	300	10
171_{Tm}		1000	100
230_{U}	Uranium (92)	100	0.1
232_{U}		30	0.03
233_{U}		100	0.1
234_{U}		100	0.1
235_{U}		100	0.2
236_{U}		200	0.2
238_{U}		Unlimited	Unlimited
U (natural)		Unlimited	Unlimited
U (enriched) < 20%		Unlimited	Unlimited
20% or greater		100	0.1
U (depleted)		Unlimited	Unlimited

Symbol of radionuclide	Element and atomic number	A_1(Ci) special form	A_2(Ci) normal form
U (irradiated)[3]			
^{48}V	Vanadium (23)	6	6
^{181}W	Tungsten (74)	200	100
^{185}W		1000	25
^{187}W		40	20
^{127}Xe (uncompressed)	Xenon (54)	70	70
^{127}Xe (compressed)		5	5
^{131m}Xe (compressed)		10	10
^{131m}Xe (uncompressed)		100	100
^{133}Xe (uncompressed)		1000	1000
^{133}Xe (compressed)		5	5
^{135}Xe (uncompressed)		70	70
^{135}Xe (compressed)		2	2
^{87}Y	Yttrium (39)	20	20
^{90}Y		10	10
^{91m}Y		30	30
^{91}Y		30	30
^{92}Y		10	10
^{93}Y		10	10
^{169}Yb	Ytterbium (70)	80	80
^{175}Yb		400	25
^{65}Zn	Zinc (30)	30	30
^{69m}Zn		40	20
^{69}Zn		300	20
^{93}Zr	Zirconium (40)	1000	200
^{95}Zr		20	20
^{97}Zr		20	20

[1] For shipments solely within the United States the A_1 value is 20 curies for americium and plutonium contained in Am-Be or Pu-Be neutron sources or in nuclear-powered pacemakers.

[2] The values of A_1 and A_2 must be calculated in accordance with the procedure specified in § 173.433 of this subchapter, taking into account the activity of the fission products and of the uranium-233 in addition to that of the thorium.

[3] The values of A_1 and A_2 must be calculated in accordance with the procedure specified in § 173.433 of this subchapter, taking into account the activity of the fission products and plutonium isotopes in addition to that of the uranium.

NOTE 1: Quantities exceeding Type A package limits require Type B packaging.

NOTE 2: Highway Route Controlled Quantities are defined in 49 CFR 173.403(1).

"Type B Packages," "Highway Route Controlled Quantities," and "Fissile Radioactive Materials" present more unusual and specific problems for packaging and carrier's operational controls. These materials are additionally controlled by the packaging standards as promulgated by the Nuclear Regulatory Commission in Title 10 CFR Part 71.

F. Limited Quantities, Instruments and Articles

The A1 and A2 values are also used as a basis for defining the package quantity limits for limited quantities and both the item and package limits for instruments, as illustrated in Table 2. Packages containing materials within these quantity limits are excepted from some of the requirements which apply to Type A packages. These exceptions include not having to provide specification packaging, shipping papers, certification, marking or labeling. However, there are a number of conditions which the limited quantity, instrument or article must meet. They include:

1. Activity limits per package and, if appropriate, per instrument or article;

2. The materials must be packed in strong, tight packages that will not leak <u>ANY</u> of the radioactive material during conditions normally incident to transportation;

3. The radiation level at any point on the external surface of the package cannot exceed 0.5 millirem per hour;

4. The external surface of the package must be free of significant removable contamination;

5. For instruments or articles, the radiation level at 4 inches from any point on the surface of the unpackaged instrument or article may not exceed 10 millirem per hour; and

6. A prescribed description of the contents on a document which is in or on the package or forwarded with it. The words "Caution - Radioactive Materials" shall appear clearly on the inner package surface or - if there is no inner package - on the outer package surface. ⚠

TABLE 2

ACTIVITY LIMITS FOR LIMITED QUANTITIES, INSTRUMENTS AND ARTICLES

Nature of Contents 1/	Instruments and Articles		Materials
	Instrument and article limits 1/	Package limits	Package limits
Solids			
Special form	$10^{-2}A_1$	A_1	$10^{-3}A_1$
Other forms	$10^{-2}A_2$	A_2	$10^{-3}A_2$
Liquids			
Tritiated water			
< 0.1 Ci/liter	-	-	1,000 curies
0.1 Ci to 1.0 Ci/l	-	-	100 curies
> 1.0 Ci/liter	-	-	1 curie
Other liquids	$10^{-3}A_2$	$10^{-1}A_2$	$10^{-4}A_2$
Gases			
Tritium 2/	20 curies	200 curies	20 curies
Special form	$10^{-3}A_1$	$10^{-2}A_1$	$10^{-3}A_1$
Other forms	$10^{-3}A_2$	$10^{-2}A_2$	$10^{-3}A_2$

1/ For mixture of radionuclides see 49 CFR 173.433(b).

2/ These values also apply to tritium in activated luminous paint and tritium absorbed on solid carriers.

Refer to Sections 173.421 through 173.424 for the complete requirements pertaining to these materials.

The U.S. Postal Service has revised its rules for mailable radioactive materials. The mailable amounts of material are one-tenth the values listed in the DOT regulations. Other additional restrictions apply to mailable materials and the Postal Regulations should be consulted for complete specifications.

G. Low Specific Activity (LSA) Materials

Low specific activity materials are those materials which present a relatively low hazard as a result of their limited radioactive concentration. Some of these materials are listed by name, such as uranium ores and concentrates, as well as unirradiated natural or depleted uranium. Other materials must meet certain limitations related to their radioactive concentration. For example, tritium oxide in aqueous solutions (tritiated water) cannot exceed 5.0 millicuries per milliliter. The allowable radioactive concentration for other materials with uniformly dispersed activity is related to the A_2 values of the radionuclides present. The relation is as follows:

If the A_2 of the radionuclide is:	The maximum activity PER GRAM of material is:
not more than 0.05 curie	0.0001 millicurie
more than 0.05 to 1.0 curie	0.005 millicurie
over 1.0 curie	0.3 millicurie

When mixtures of radionuclides are present, they must be subjected to the "ratio" rule to determine if the mixture is LSA. For uniform mixtures of nuclides, the following formula will determine if the mixture is defined as LSA:

$$\frac{APG_1}{0.0001} + \frac{APG_2}{0.005} + \frac{APG3}{0.03} \leq 1.0$$

Where:

APG_1 = the total activity (in millicuries) per gram of material of all nuclides present with an A_2 value of less than 0.05 curie.

APG_2 = the total activity (in millicuries) per gram of material of all nuclides present with an A_2 value of more than 0.05 but less than 1.0 curie.

APG_3 = the total activity (in millicuries) per gram of material of all nuclides present with an A_2 value exceeding 1.0 curie.

If the above summation for a given uniform mixture is less than or equal to 1, then the mixture may be classified as LSA.

Because of their low radioactive concentration, these materials usually can be safely carried without regard to the total activity of the material in a single package. Most low-level radioactive waste shipments are comprised of LSA materials. There are TWO WAYS in which LSA materials can be transported.

- Nonexclusive use shipments - "essentially Type A packages"

The first method, "nonexclusive use" transportation, requires that the material be transported in essentially a Type A package. "Essentially a Type A" package means a package that must survive the physical tests, such as the drop and compression tests for Type A packages - but which is excepted from some of the general Type A requirements. The actual test requirements are found in 49 CFR 173.465. Although the packages are excepted from certain design requirements, their integrity must be equal to a Type A.

- Exclusive use - "strong, tight package"

LSA materials which are transported by conveyances assigned for the "exclusive use" of the consignor may be shipped in packages that are of less rigorous construction. Users of the exclusive use provision MUST ENSURE that there will be no loading or unloading of the material except under the direction of the consignee or consignor. The limitation on loading and unloading, plus the requirement that the material be in exclusive use, safely allows the exception from certain packaging test requirements. Exclusive use LSA, therefore, is allowed to be made in the so-called strong, tight package.

TABLE 3
RADIOACTIVE MATERIALS PACKAGES
MAXIMUM RADIATION LEVEL LIMITATIONS
(SEE 49 CFR 173.441(a) AND (b)

RADIATION LEVEL (DOSE) RATE AT ANY POINT ON EXTERNAL SURFACE OF ANY PACKAGE OF R.A.M. MAY NOT EXCEED:

A. 200 MILLIREM PER HOUR.

B. 10 MILLIREM PER HOUR AT ONE METER* (TRANSPORT INDEX MAY NOT EXCEED 10).

UNLESS THE PACKAGES ARE TRANSPORTED IN AN "EXCLUSIVE USE" CLOSED TRANSPORT VEHICLE (AIRCRAFT PROHIBITED) - THEN THE MAXIMUM RADIATION LEVELS MAY BE:

A. 1000 MILLIREM PER HOUR ON THE ACCESSIBLE EXTERNAL PACKAGE SURFACE.

B. 200 MILLIREM PER HOUR AT EXTERNAL SURFACE OF THE VEHICLE.

C. 10 MILLIREM PER HOUR AT TWO METERS** FROM EXTERNAL SURFACE OF THE VEHICLE.

D. 2 MILLIREM PER HOUR IN ANY POSITION OF THE VEHICLE WHICH IS OCCUPIED BY A PERSON.

* 3.3 feet.

** 6.6 feet.

There are no specific test requirements for the strong, tight packages. However, a performance criteria must be met--there can be no release of radioactive content during transportation and like any other package of hazardous material, the requirements of Section 173.24 must be met. Materials which are consigned as exclusive use LSA shipments MUST have the packages marked "Radioactive LSA." And the vehicle on which they are being transported MUST be placarded with the RADIOACTIVE MATERIAL placard.

H. Type A Packaging

In Figure 3, there is an illustration of "Typical Type A Packaging Schemes." Type A packaging is that which must be designed in accordance with the applicable general packaging requirements as prescribed in the regulations (49 CFR 173.24, 173.411, 173.412), and which must be adequate to prevent the loss or dispersal of its radioactive contents and to maintain its radiation shielding properties if the package is subjected to normal conditions of transport. The regulations prescribe (49 CFR 173.465) the performance criteria to simulate normal and rough handling conditions of transport. Typically, the Type A packaging prescribed in the regulations is the performance-based DOT Spec. 7A (49 CFR 178.350) Type A general packaging for which each shipper must make his own assessment and certification of the particular package design against the performance requirements. The regulatory framework, therefore, provides for the use of Type A packaging without prior specific approval by DOT of the package designs via the use of DOT Spec. 7A performance specification. Additionally foreign-made Type A packages are acceptable internationally, provided they are so marked as Type A and comply with the requirements of the country of origin. It should be noted that the shipper of each DOT Spec. 7A is required to maintain on file for at least one year after the latest shipment, and be prepared to provide to the Department, a complete certification and supporting safety analysis demonstrating that the construction methods, packaging design, and materials of construction are in compliance with the specification (see 49 CFR 173.415). The

information in this file must show, through any of the methods given in 49 CFR 173.461, that all of the requirements of 49 CFR 173.24, 173.463 and 173.465 are met. The file must also relate the contents of the package(s) being shipped to the contents which were used for testing purposes.

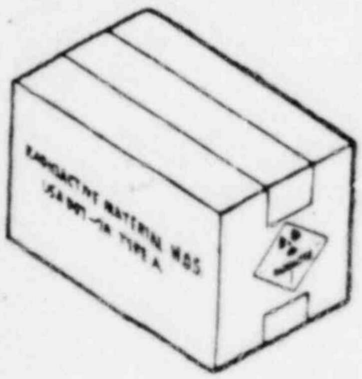
NES shall meet the requirements for Type A packaging by either or both of the following approaches for compliance to the above stated criteria:

a. Physical Testing - A satisfactory demonstration of compliance as stated in 49 CFR 179.461.

b. Engineering Evaluation - NES mathematical evaluation to ensure the package design is responsive to and compliant with 49 CFR 173 by acceptable analysis.

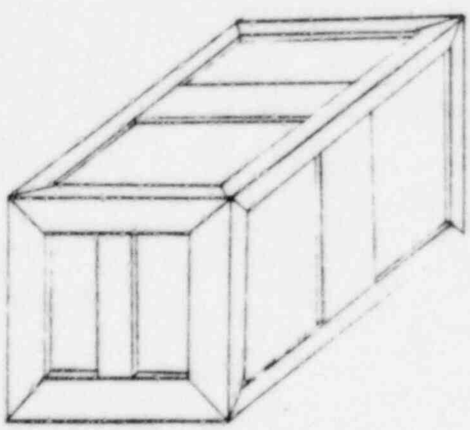
Figure 3 - Typical Type A Packaging

Package Must Withstand Normal Conditions (49 CFR 173.465) of Transport Only Without Loss or Dispersal of the Radioactive Contents.



FIBERBOARD BOX

METAL DRUM



WOODEN BOX

NOTE: A useful reference in evaluating whether certain DOT specification package designs meet the requirements of DOT Spec. 7A is listed in Section VIII, Reference 10. It is the shipper's responsibility to ensure that all details of the package which is offered for transport complies with the Spec. 7A requirements. This includes ensuring that the package evaluation is complete (49 CFR 173.415(a)) and that the packaging and contents offered for transport have been included in the evaluation.

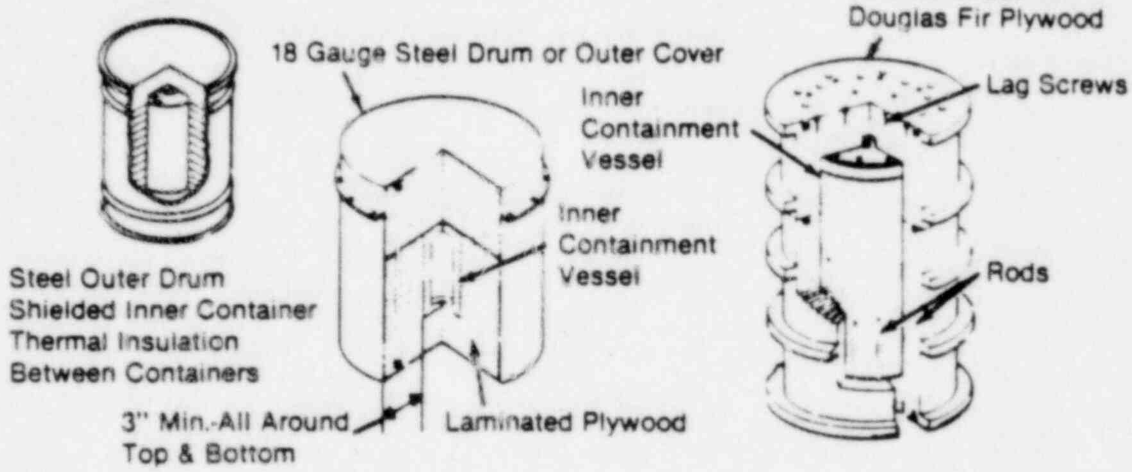
I. Type B Packaging

Type B Packaging (see Figure 4) must meet the general packaging requirements and all of the performance standards for Type A packages. In addition, it must withstand certain serious accident damage test conditions. After the tests, there must be only limited loss of shielding capability and essentially no loss of containment. The performance criteria which the package designer must use to assess Type B packaging against these empirically established hypothetical accident test conditions of the transport are prescribed in the Nuclear Regulatory Commission regulations (10 CFR 71.73) and include the following:

1. A 30-foot free drop onto an unyielding surface.
2. A puncture test which is a free drop (over 40 inches) onto a six-inch diameter steel pin.
3. Thermal exposure at 1,475°F for 30 minutes.
4. Water immersion for eight hours (for fissile materials packaging only).

Figure 4 - Typical Type B Packagings

Package Must Stand Both Normal (49 CFR 173.465) and Accident (10 CFR Part 71) Test Conditions Without Loss of Contents.



Except for a limited number of specification Type B packagings (e.g., DOT-6M) described in the regulations, all Type B package designs require PRIOR APPROVAL of the U.S. Nuclear Regulatory Commission or Department of Energy (DOE). (See 49 CFR 173.471 for standard requirements and conditions pertaining to NRC approved packages and 49 CFR 173.7 for DOE certified packages.)

3. Fissile Radioactive Materials

In addition to considerations for the radioactive content, shippers of fissile radioactive material must also take into account certain other packaging and shipment requirements to ensure against nuclear criticality due to the fissile (fissionable) nature of the materials. The design of the packaging for fissile radioactive material, the transport index to be assigned (if Fissile Class II), and any special procedures for packaging are prescribed in 49 CFR 173.451 through 173.459 of the DOT regulations and in 10 CFR 71 of the USNRC regulations. Each fissile radioactive materials package design (except for the DOT Spec. 6L, 6M, and Spec. 20 PF-1, 20 PF-2, 20 PF-3, and 21 PF-1 and 21 PF-2) must be reviewed and approved by the USNRC prior to its first use. The packaging must be such to ensure against

nuclear criticality (an unplanned nuclear chain reaction) under both normal and hypothetical accident test conditions, and prevent loss of contents in transportation. Fissile radioactive material packages are classified into one of three groups, according to the degree of control which must be exercised to assure nuclear criticality safety, as shown in Table 4.

TABLE 4
SHIPMENT CONTROLS FOR FISSILE RADIOACTIVE MATERIALS
(49 CFR 173.455)

1. Fissile Class I - Packages may be transported in unlimited numbers (Transport Index is based only on external radiation levels).

2. Fissile Class II - Number of packages limited by aggregate maximum of transport indexes of 50 (50 unit rule). No single package may exceed a transport index of 10. Transport index shall be based on criticality or external radiation level basis, whichever is most restrictive.

3. Fissile Class III - Shipments of packages which do not meet the requirements of Fissile Class I or II. Controlled by specific arrangements between the shipper and carrier. (See 49 CFR 173.457(b)).

K. Highway Route Controlled Quantities

Certain quantities of radioactive materials known as "Highway Route Controlled Quantities" are subject to additional controls during transportation. A Highway Route Controlled Quantity is defined as an amount of material in a single package which exceeds either: (1) 3,000 times the A_1 quantity, for special form material; (2) 3,000 times the A_2 quantity, for normal form materials; or (3) 30,000 curies, WHICHEVER IS LEAST. Packages containing a Highway Route Controlled Quantity of radioactive material are subject to specific routing controls which apply to

the highway carrier. The carrier must operate on preferred routes that are in conformance with 49 CFR 177.825. The carrier must report to the shipper the route used in making the shipment. The shipper is required to report the routing information to the Materials Transportation Bureau (MTB) per 49 CFR 173.22(c).

In determining if a package contains a Highway Route Controlled Quantity of material, first identify the radionuclide being transported. After identifying the radionuclide, determine if it is in special form or normal form. If the material is in special form, multiply the A_1 value for the radionuclide by 3,000. Compare this answer with 30,000 curies. The lower of the two values is the Highway Route Controlled Quantity for that radionuclide in special form. If the contents of the package being shipped exceeds the Highway Route Controlled Quantity, the package must be transported under the specific route control requirement. For example, suppose a shipper has a package of Cobalt 60 in special form. The A_1 value for Cobalt 60 is seven curies--7 x 3,000 = 21,000 curies, 21,000 curies is less than 30,000 curies. Therefore, 21,000 is the Highway Route Controlled Quantity for Cobalt 60. Packages containing 21,000 or more curies of Cobalt 60 in special form are subject to specific routing controls. Treat other radionuclides similarly in deciding if the package is subject to specific routing controls. Remember, the Highway Route Controlled Quantity relates to the content of a package--not to the sum of contents of all packages in a shipment.

L. Control of Radiation During Transport - Transport Index (T.I.), Vehicle Limits, and Separation Distances

The regulations prescribe that the maximum permissible dose rate for packages of radioactive materials offered for transport shall not exceed 200 millirem per hour at any point on the external surface of the package, and the transport index may not exceed 10. The highest dose rate at one meter away from any accessible exterior surface of the package equals the "Transport Index," or T.I. If the shipper assures that the package will be transported on a conveyance as "exclusive use," a higher maximum dose

rate is allowed. The radiation level limitations are summarized in Table 3. (See page 21)

To control the radiation level resulting from accumulations of multiple numbers of packages in the transportation environment, the regulations require that the carrier shall maintain certain prescribed separation distances between radioactive materials packages and other areas occupied by persons and/or photographic film (since film may be fogged by radiation). For film, these separation distances are based on the storage time and the transportation index; and for separation from people, the distances are based solely on the T.I. No package offered for transport (on other than "exclusive use" vehicles) may have a T.I. exceeding 10. However, the T.I. per package limit is decreased to 3.0 for packages carried aboard passenger-carrying aircraft. T.I.'s of 10 and 3 are based on standards for limiting personnel exposure, and to prevent "fogging" of "fast" photographic film.

The total of the T.I. of all packages in any single transport vehicle or storage location generally may not exceed 50. Exceeding the 50 T.I. per vehicle limit is authorized only for certain specific types of shipments which are carried under the special requirements of "exclusive use" vehicles (49 CFR 173.403(i)), which impose additional responsibilities on the shipper. The shipments that qualify most often for the 50 T.I. exception are "exclusive use" shipments of low specific activity radioactive materials (49 CFR 173.425(b) and (c)) or the occasional "hot" package that cannot meet the 10 T.I. limit (49 CFR 173.441(b)). In either case, the special arrangements between the shipper and carrier must satisfy all requirements, including those of 49 CFR 173.403(i) and 173.441(b). △1

The regulations provide graded tables of stowage distances for stowage in accordance with the cumulative transport index. These tables are found in the carrier sections of the regulations (49 CFR 174.700, 175.701 through 175.703, 176.708, and 177.842).

The transport index (T.I.) system, together with tables of separation distances, provides control by the carrier over the radiation exposures to personnel handling the packages, and to casually exposed persons in the vicinity of accumulations of packages.

The T.I. system is also designed to provide the means to assure criticality safety. It limits the amount of fissile materials in one location under nonexclusive use conditions (the 50 T.I. upper limit). This prevents conditions that would support a nuclear "chain reaction," or "go critical." For such fissile materials, the shipper must determine, in accordance with regulatory criteria (49 CFR 173.455(b)), the appropriate T.I. based on nuclear criticality safety. For purposes of transportation, the shipper then must assign to the package the T.I. value. Use of the higher T.I. value based on either the nuclear criticality safety criteria or the radiation level limitation (as described earlier) is required.

During transportation, the carrier still makes reference to the T.I. and stowage tables, even though the T.I. for fissile materials may be based on criteria other than the external radiation levels. For this reason, the absence of measurable external radiation from certain types of fissile radioactive materials packages would not necessarily constitute an "overlabeling" violation.

M. <u>Warning Labels</u>

Each package of radioactive material, unless excepted, must be labeled (49 CFR 172.403) on two opposite sides, with a distinctive warning label. Each of the three label types bears the unique trefoil symbol (Figure 5) recommended by the International Commission on Radiation Protection (ICRP) in 1956. It has been adopted by the American National Standards Institute as the standard radiation symbol (N2.1-1969). The labels alert persons that the package contains radioactive materials and that the package may require special handling. A label with an <u>all white background color</u> indicates that the external radiation level is low and no special handling is required. If the <u>upper half of the label is yellow</u>, the

package may have an external radiation level or fissile properties requiring consideration during transportation. If the package bears a yellow label with three stripes, the transport vehicle must be placarded RADIOACTIVE. Placarding is discussed in more detail in Section 4. The criteria which the shipper must consider in choosing the appropriate label are listed in Table 5.

Figure 5 - Package Labels

Radioactive-White I (See §172.436)	Radioactive-Yellow II (See §172.438)	Radioactive-Yellow III (See §172.440)

For all labels, vertical bars on each label are in red. Each label is diamond-shaped, four inches on each side, and has a black solid-line border one-fourth inch from the edge. The background color of the upper half (within the black line) is white for the "I" label. It is yellow for the "II" and "III" labels.

The regulatory provisions in 49 CFR 172.403(f) and (g) applicable to the use of these labels are:

> Each package required by this Section to be labeled with a RADIOACTIVE label must have two of these labels affixed to opposite side of the package.
>
> The following applicable items of information must be entered in the blank spaces on the RADIOACTIVE label by legible printing (manual or mechanical) using a durable weather resistant means of marking.

"Contents" - The name of the radionuclide, as taken from the listing of radionuclides in 49 CFR 173.435 (symbols which conform to established radiation protection terminology are authorized, i.e., ^{99}Mo, ^{60}Co, etc.). For mixtures of radionuclides, the most restrictive radionuclides on the basis of radiotoxicity must be listed as space on the label allows.

"Activity" - Units shall be expressed in appropriate curie units, i.e., curies (Ci), millicuries (mCi) or microcuries (uCi) abbreviations are authorized). For a fissile material, the weight in grams or kilograms of the fissile radioisotope also may be inserted in addition to the activity.

"Transport Index" - (See 49 CFR 173.403(bb)).

TABLE 5

RADIOACTIVE MATERIALS PACKAGES LABELING CRITERIA

49 CFR 172.403

Transport Index (T.I.)	Radiation Level at Package Surface (RL)	Fissile Criteria	Label Category 1/
N/A	RL ≤ 0.5 millirem per hour (mrem/h)	Fissile Class I only No Fissile Class II or III	White - I
T.I. ≤ 1.0	0.5 mrem/h < RL ≤ 50	Fissile Class I, Fissile Class II with T.I. ≤ 1.0, No Fissile Class III	Yellow - II
1.0 < T.I.	50 mrem/h < RL	Fissile Class II with 1.0 < T.I., Fissile Class III	Yellow - III

1/ Any package containing a "Highway Route Controlled Quantity" (49 CFR 173.403 of this subchapter) must be labeled as Radioactive Yellow - III.

At this point, it is appropriate to offer the following word of caution:

Figure 6 - Caution - Do Not Confuse the Following:

Radioactive Materials Package Labels (49 CFR 172.403 and 172.436 through 172.440)

Radioactive White - I

Radioactive Yellow - II

Radioactive Yellow - III

With:

Fissile Classes I, II, or III (49 CFR 173.455)

N. Contamination Control

The regulations prescribe limits (49 CFR 173.443) for control of removable (non-fixed) radioactive contamination, as shown in Table 6. In general, the contamination levels MUST be kept as low as reasonably achievable and the significant contamination level LIMIT is applicable to any package offered for transportation. It also applies to any transport vehicle which is being released after having been used to transport either an "exclusive use" load under the provisions of 49 CFR 173.443(c) or a bulk shipment of LSA materials (49 CFR 173.425(c)).

The limits shown in Table 6 (and 49 CFR 173.443) are for the activity measured on a wipe taken on the package surface. Measuring techniques other than wiping may be used in accordance with 49 CFR 173.443.

TABLE 6

REMOVABLE EXTERNAL RADIOACTIVE CONTAMINATION - WIPE LIMITS

Contaminant	Maximum Permissible Limits uCi/cm^2	Maximum Permissible Limits dpm/cm^2
Beta/gamma-emitting radionuclides; all radionuclides with half-lives less than ten days; natural uranium; natural thorium; uranium-235; uranium-238; thorium-232; thorium-228 and thorium-230 when contained in ores or physical concentrates....................	10^{-5}	22
All other alpha-emitting radionuclides..	10^{-6}	2.2

uCi/cm^2 = microcuries per square centimeter.
dpm/cm^2 = disintegrations per minute per square centimeter.

O. Other Shipper Requirements

As a brief review, the shipper must (1) select the proper packaging for the specific contents; (2) consider the radiation level limits; (3) consider the contamination limits; and (4) label correctly. In addition, the shipper must also ensure compliance with the following:

1. Package Markings - The outside of the package must be marked with (a) proper shipping name; (b) identification number as shown in the list of hazardous materials (see 49 CFR 172.101); and (c) the appropriate specification number (see 49 CFR 173.24(c)(1)(i)) OR Type B or fissile packaging certificate number, when applicable. Most of the pertinent regulatory requirements for marking of all hazardous materials packages are found in 49 CFR 172.300 through 172.308. The special requirements for radioactive materials are quoted below:

"49 CFR 172.310 Radioactive materials.

(a) In addition to any other markings required by this

subpart each package containing radioactive materials must be marked as follows:

Gross Weight	(1)	Each package of radioactive materials in excess of 110 pounds (50 kilograms) must have its gross weight plainly and durably marked on the outside of the package.
Type A And Type B	(2)	Each package of radioactive materials which conforms to the requirements for Type A or Type B packaging (49 CFR 173.403 of this subchapter) must be plainly and durably marked on the outside of the package in letters at least 1/2-inch (13 mm.) high, with the words "TYPE A" or "TYPE B," as appropriate. A packaging which is not in compliance with these requirements may not be so marked.
Exports USA (With Specification Or Certificate Identification)	(3)	Each package of radioactive material destined for export shipment must also be marked "USA" in conjunction with the specification marking, or other package certificate identification (see Section 173.471, 173.472, and 173.473 of this subchapter)."

The proper shipping names for radioactive materials are listed in Table 9.

Spec. 7A must also be marked in accordance with 49 CFR 178.350-3. Where a duplication of marking requirements exist (such as between the 49 CFR 178.350-3(a) requirement to mark the package "Radioactive Material" and when the marked shipping name contains the words "Radioactive Material"), the markings need not be duplicated.

TABLE 9

MOST COMMONLY USED SHIPPING NAMES FOR RADIOACTIVE MATERIALS*
(FROM HAZARDOUS MATERIALS TABLE, 49 CFR 172.101)

Radioactive Material, Limited Quantity, n.o.s.**	UN 2910
Radioactive Material, Instruments, and Articles***	UN 2911
Radioactive Material, Fissile, n.o.s.	UN 2918
Radioactive Material, Low Specific Activity or LSA, n.o.s.	UN 2912
Radioactive Material, Special Form, n.o.s.	UN 2974
Radioactive Material, n.o.s.	UN 2982
Uranium Hexafluoride, Fissile (Containing more than 1% U-235)	UN 2977
Uranium Hexafluoride, Low Specific Activity	UN 2978

* Refer to 49 CFR 172.101 for other proper shipping names.
** n.o.s. means "not otherwise specified."
*** Underlined words are not part of the proper shipping name.

2. Shipping papers - As with other hazardous materials shipments, certain elements of information must be included on the shipping papers (see 49 CFR 172.200 through 172.204).

The information required on the shipping papers is important to the carrier and consignee. It also is of great value to emergency response personnel in the event of an accident.

a. Requirements (49 CFR 172.202(a)(1))

NOTE: Enter in order listed below:

(1) Proper shipping name form 49 CFR 172.101;

(2) Hazard class (see 49 CFR 172.202(a)(2)), hazard class from Column 3, 49 CFR 172.101, except when the hazard class is contained in the shipping name;

(3) Identification number (see 49 CFR 172.202(a)(3) from Column 3A, 49 CFR 172.101);

(4) Net quantity of material by weight or volume as stated in 49 CFR 172.202(a)(4) and (c). For most radioactive materials packages, it is not required to list the weight or volume. The requirements of 49 CFR 172.203(d) provide better indications of potential hazards and controls required. These requirements include the package contents as measured in curies and the transport index. A listing of weight or volume measurements of radioactive materials is usually needed only for establishing transportation charges;

(5) Radionuclide(s) contained in package (abbreviations are allowed). For a mixture of radionuclides, only those radionuclides which comprise 1% or more of the total activity in the package must be listed;

(6) Physical and chemical form of material, or statement that the material is "special form" (if it is special form). A generic description of material, such as protein, carbohydrate, enzyme, or organic salt, is authorized if exact chemical form is difficult to specify;

(7) Activity in curies (Ci), millicuries (mCi), or microcuries (uCi). If the package contains a "Highway Route Controlled Quantity," those words must also be shown on the shipping papers;

(8) Category of RADIOACTIVE labels applied to package;

(9) Transport index of the package if labeled RADIOACTIVE Yellow-II or RADIOACTIVE yellow-III;

(10) The information required in 49 CFR 172.203(d)(1)(vi) must be included if the shipment is "fissile" radioactive material;

(11) The identification markings shown on the package must appear on the shipping paper if the package is approved and certified by the Nuclear Regulatory Commission or the Department of Energy, OR is certified by DOT or other National Competent Authority for international shipment.

(12) Other information as required by the mode of transportation or subsidiary hazard of the material. (See 49 CFR 172.203.)

b. <u>Other Information and Examples of Shipping Paper Entries</u>

The regulations require that certain specific descriptive information must be included on shipping papers. While there is no specification for shipping paper format, the first three entries of the description must be in a specific order (see above). Other descriptive information is allowed, such as the functional description of the product. However, other information must not confuse or detract from the required descriptions of the hazardous materials.

The following are some example entries of different ways shipments can be described on shipping papers:

(1) One (1) box, Radioactive material, special form, n.o.s., UN 2974, Radiographic camera, Iridium-192, 60 Ci, Radioactive Yellow-II, 0.6 transport index, USA/9028/B(U), Cargo aircraft only.

NOTES: Physical and chemical form is not listed since material is "special form."

The Hazard class is not listed following the proper shipping name since it is contained in the shipping name.

(2) One (1) carton, Radioactive material, n.o.s., UN 2982, ^{60}Co, 30 mCi, liquid, cobalt in 50 ml 5% hydrochloric acid solution, transport index 1.8, Radioactive Yellow-III and corrosive.

(3) One (1) box, Thorium nitrate, Radioactive material, UN2976, 15 kg, Th natural, solid (powder), thorium nitrate, 1.3 mCi, Radioactive White-I and Oxidizer labels, Cargo aircraft only.

NOTES: Since the material is specifically listed in 49 CFR 172.101, there is no "n.o.s." in the proper shipping name and the hazard class Radioactive material is entered.

Although this material meets the definition of LSA (49 CFR 173.403), it must be packaged and shown on shipping papers as specifically listed material. It must meet packaging requirements as an oxidizer as required in 49 CFR 173.419.

(4) Three (3) drums, Radioactive material, LSA, n.o.s., UN 2912, non-compacted solid debris and waste, ^{137}Cs, ^{60}Co, and ^{90}Sr, solid as inorganic salts or elemental, 0.04, 0.01, and 0.005 mCi total, respectively; Drum Nos. 731, 680, and 541. See attached forms for details. Exclusive use instructions attached.

These items are addressed in 49 CFR 173.421-173.424 and are excepted from the detailed shipping paper description. They must be documented for transport as required by 49 CFR 173.421-1 by including a notice in, on, or forwarded with the package. The notice must include the name and address of the consignor or consignee and a specific statement which is selected on the basis of the proper shipping name for the package. The following example illustrates the notice on a shipping paper. The specific statement required by 49 CFR 173.421-1 is shown in quotes.

One (1) carton, Ajax Model 123 Monitor, "This package conforms to the conditions and limitations specified in 49 CFR.

For packages not acceptable for transportation on passenger-carrying aircraft:

"This shipment is within the limitations prescribed for cargo-only air."

For packages acceptable for transportation on passenger-carrying aircraft:

"This shipment is within the limitations prescribed for passenger aircraft."

Since radioactive materials (other than Limited Quantities) can be carried on a passenger-carrying aircraft only if they are intended for use in research or medical applications, a statement to that effect must be included in the signed certification for shipment by passenger-carrying aircraft.

3. Shipper's Certification - The shipping papers must include a certificate signed by the shipper. This certification must appear on the paper that lists the required shipping description.

a. The following statement is required by 49 CFR 172.204(a) and must be used for all hazardous materials shipments except for those by air.

"This is to certify that the above-named (or herein-named) materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation."

b. For air transportation, the following language may be included on shipping papers in place of the statement in example (a) above.

"I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and in proper condition for carriage by air according to applicable national governmental regulations."

The requirements and limitations for carriage of radioactive materials aboard aircraft are prescribed in 49 CFR 175.75(a)(3), 175.700 through 175.705.

4. Security Seal - The outside of each Type A or B radioactive materials package must incorporate a feature, such as a seal, which is (a) not readily breakable and which, while intact, (b) will be evidence that the package has not been illicitly opened (49 CFR 273.412(b)). For this requirement, the package

designer may need to be skilled and creative. This is especially true for packages, such as fiberboard cartons and wooden boxes. The regulations also require that "inner shield closures must be positively closed to prevent loss of contents." A padlock is not effective as both a security seal and a closure mechanism. Most padlocks are not even a good security seal, let alone a closure device. It is usually not possible with most types of padlocks to ascertain if they have been illicitly opened. The best approach toward meeting the dual requirements, especially for Type B packages, is: (a) serially numbered lead wire seals, IN COMBINATION WITH (b) such closure mechanisms as slotted screw-in plugs, bolted flanges, and positive action shutter mechanisms.

5. Small Dimension - The smallest outside dimension of any radioactive materials package (other than excepted quantities) must be four inches or greater (49 CFR 173.412(a)).

6. Liquid Packaging Provision (49 CFR 173.412(n) - Liquid radioactive material must be packaged in a leak-resistant inner container. In addition, the packaging must be adequate to prevent loss or dispersal of the radioactive contents from the inner container if the package were subjected to the 30-foot drop test prescribed in 49 CFR 173.466; and enough absorbent material must be provided to absorb at least twice the volume of the radioactive liquid contents. Care should be exercised by the package designer to assure that the positioning of the absorbent material about the liquid-containing vessel is such that the "absorber will absorb" in the event of leakage from the vessel. For packages with liquid contents exceeding 50 cm^3, an alternative is provided to the use of the absorbent in that a secondary outer leak-resistant containment vessel may be utilized. The outer containment vessel must have the ability to retain the radioactive contents under normal conditions of

transport, assuming the failure of the innermost primary containment vessel. The package also requires a marking indicating the upward position of the inside packaging (49 CFR 172.312).

7. Surface Temperature of Package - Maximum surface temperature limits on packages, resulting from radioactive thermal decay energy of the contents, are prescribed in 49 CFR 173.442. The limit is either 122°F or, in the case of exclusive use shipments, 180°F.

8. Quality Control Requirements (49 CFR 173.474 and 173.475) -The regulations also prescribe certain quality control requirements for the construction of radioactive materials packagings (49 CFR 173.474) and before each shipment of a package (49 CFR 173.475). With regard to packages of liquids containing in excess of Type A quantity, destined for shipment by air, an additional requirement (49 CFR 173.475(g)) is imposed such that the containment system of each package offered for shipment must be tested to assure that it will remain leak-free in a specified ambient reduced atmosphere).

   For Type A packages of the fiberboard box variety, sealing tape and the consignor's labels offer opportunities for compliance IF they can provide positive evidence that the package has not been opened.

4. ADDITIONAL INFORMATION

4.1 DISCREPANCIES IN RADIOACTIVE MATERIALS SHIPMENTS

This discussion is intended to serve as an aid to both shippers and carriers. Noncompliance in radioactive materials shipments is generally either of a safety related nature, i.e., improper packaging, excessive radiation or contamination, or an administrative nature, i.e., improper shipping paper description, illegible

labels, etc. Items of noncompliance which deserve special attention in order to avoid are:

A. By Shippers

1. Excess radiation levels (49 CFR 173.403(bb)) -Fortunately, this item is not noted frequently. It is one of the most serious type of shipper violations of the safety requirements for transportation of radioactive materials. Excessive radiation levels on packages of radioactive materials indicate inadequate planning, procedures, and/or practices. They are generally the result of:

a. An unsatisfactory monitoring of the entire package.

b. Using inadequate radiation measuring instruments.

c. Using instruments that are not properly calibrated.

d. A failure to properly secure a shielded closure mechanism, a faulty closure mechanism, etc.

e. Use of packagings for materials for which they were not designed. For example, putting radioactive materials into a container that exceeds the shielding capabilities of the package, or placing materials into a container that is not compatible with the material's physical or chemical properties. For 'special form' sources, this results in a potential for excessive radiation levels. For dispersible, normal form radioactive materials, a hazard may be present due to both excessive radiation, as well as possible dispersal of loose contamination. The very short half-life of some radioisotopes occasionally presents problems in transportation. Some suppliers load more than the total quantity allowed for shipment, so that the

radiation levels at the actual time of shipment will be within the limits, taking into account radioactive decay. This is a violation if the package is offered for shipment too soon, that is, before the material has decayed to legal limits.

2. Improper Packaging - This is also a most serious safety item. It is closely related to the excessive radiation level in that an improper package may not incorporate sufficient thickness of shielding for the material. Another example of improper packaging is the use of a packaging not authorized in the regulations or under an exemption or other specific approval.

Safety may be affected even when an approved package is utilized, IF IT IS NOT IN ITS PROPER CONDITION AS REQUIRED BY ITS DESIGN. Good quality control practices by shippers of radioactive materials are of paramount importance. A relevant requirement of 49 CFR 173.22 reads as follows: △

"The person shall determine that the packaging or container has been manufactured, assembled, and marked..."

The above provision is cited as a reminder to shippers. No package will perform during transportation as intended by its original design, unless it is in its proper design condition. It must be "as good as new" when offered for transportation. The quality control requirements of 49 CFR 173.474 and 173.475 serve to clarify these aspects. △

3. Lack of Security Seal (49 CFR 173.412(b)) - This requirement is sometimes misunderstood by shippers of radioactive material. It is really a performance type requirement, wherein--

"The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened."

On some types of packages, i.e., steel drums, hinged lid boxes, etc., provision of a security seal is fairly simple. On many other types, i.e., wooden boxes, fiberboard cartons, much more thought and ingenuity in designing a seal to meet the requirements will be necessary. The use of padlocks as a security seal may not, in all cases, be appropriate. Many types of padlocks may be opened and closed again without knowledge of the consignee.

4. Improper Labels - Incorrect labeling of radioactive materials packages is a common deficiency. The most frequent error is "overlabeling." A YELLOW-III label is used where a WHITE-I or YELLOW-II label is prescribed. The three labels are used to indicate the degree of control the package requires. "Overlabeling" signals incorrect hazard warning information.

5. Illegible/Incorrect Label Notations - This item should speak for itself. Needless to say, shippers should exercise care to insert legible, durable entries on the labels. These entries call for noting the "contents," "activity," and "transport index." The name of the radionuclide or its abbreviation must be entered on the Contents line exactly as on the list of radionuclides in 49 CFR 173.435. Clearly indicate the exact number of curies, millicuries or microcuries on the Activity line. Finally, the "transport index" must be rounded up to the next highest tenth as prescribed in 49 CFR 173.403(bb).

6. Improper or Incomplete Shipping Paper Description - The basic requirements for the shipping paper description are prescribed in Subpart C of 49 CFR Part 172. The first, second, and third elements on the shipping paper must always be the applicable "proper shipping name," "hazard class," and "identification number," exactly as listed in the table in 49 CFR 172.101. Any other required description or information (not inconsistent therewith) may follow. However, there are at present 16

different proper shipping names for radioactive materials in the hazardous materials table. The most commonly used names are listed in Table 9. The most appropriate name must be used. Care should be exercised to properly enter the other information as required by 49 CFR 172.203(d). When the shipment involves a radioactive material prohibited from transport by passenger-carrying aircraft, the description shall also include the words "cargo aircraft only."

7. Inadequate Provision for Liquid Contents - The regulations prescribe certain additional packaging requirements for liquid radioactive materials. As required by 49 CFR 173.412(n) and 49 CFR 173.466(a)(1), these are basically the "performance" requirements. The package must withstand a 30-foot-drop test without loss of liquid contents. Absorbent material must be present to absorb the liquid contents in the event of breakage of the primary liquid container for contents which do not exceed 50 cm^3. A double containment vessel system that will survive all applicable testing may be used as an alternate packaging when the contents exceed 50 cm^3. The package orientation marking (example: "This side up ↑ ") is also required.

B. By Carriers

1. Acceptance of Consignments Without Shipper's Certification - The regulations applicable to the carrier specify that shipments of regulated hazardous materials may NOT be accepted unless accompanied by the appropriate certification. The shipper must certify that the material has been properly packaged, marked and labeled in accordance with the regulations. This certification must be signed by the shipper. it is a legal representation to the carrier that the safety

requirements of the shipment are in order. Needless to say, originating carriers must not accept hazardous materials which are offered to them without this certification.

2. Failure to Prepare Proper Shipping Paper Description - Each of the carrier regulations permit carrier-prepared manifest, way bills, etc., to include the proper shipping description and an indication of the type of label applied. In may cases, carriers, in preparing their shipping papers, do not accurately copy these essential items of information from the shippers' papers.

3. Acceptance of Radioactive Materials Consignments Exceeding the 50 Transport Index Maximum Per Vehicle and Inadequate Separation Distances - In many cases, carriers either do not appear to be aware of this limitation or they blatantly fail to follow it. Each of the carrier regulations contain a table which prescribes certain segregation distances and in certain cases, stowage times for accumulations of radioactive materials packages. These distances and times are based on the total transport index. These segregation controls are intended to provide a safe separation distance of radioactive materials packages from areas occupied by persons or photographic film.

4. Failure to Properly Placard Transport Vehicles - For any rail or highway vehicle transporting any quantity of radioactive materials packages bearing the radioactive YELLOW-III label, the carrier is required to display the RADIOACTIVE placard. Intentional failure to placard vehicles is a very serious offense.

5. Inadequate Vehicle Safety - Other safety regulations, such as those of the Bureau of Motor Carrier Safety, 49 CFR Parts 390-397, play an important role in the safe transport of radioactive and other hazardous materials. Even though shippers and carriers may be in full compliance with the Hazardous Materials Regulations, an unsafe vehicle can increase the risks to the public and the transport workers. Inspections have often disclosed vehicle safety violations of greater possible consequence than the hazardous materials violations. Be certain that the transporting vehicle is in proper condition before accepting a shipment.

IAEA REGULATIONS (AS AMENDED)

The IAEA (International Atomic Energy Agency) has published the "Regulations for the Safe Transport of Radioactive Materials," Safety Series No. 6, 1973 Edition (as amended). These regulations have now been accepted and adopted (either wholly or in part) by most nations as their standard for both national and international regulations. The United States revised the DOT regulations as of July 1, 1983, to achieve a substantial conformity with the 1973 IAEA standards.

ADDITIONAL DRIVER TRAINING

In addition to the standard NES training for radiation workers, NES radioactive waste transport drivers must pass an annual written examination on the contents of this document. Also, NES shall issue in writing notices of substantive changes to transport regulations to said drivers throughout the year. This shall insure driver intimacy with the requirements for safe and legal transport of radioactive materials.

REFERENCES

To supplement this procedure the following publications relating to transportation of radioactive materials are listed:

1. IAEA "Regulations for the Safe Transportation of Radioactive Materials," Safety Series No. 6, 1973 Edition (as amended), International Atomic Energy Agency, Vienna, Austria.

   Availability: Unipub, Inc.
   1180 Avenue of the Americas
   New York New York 10038

2. "The Safe Transport of Radioactive Materials," edited by R. Gibson 1966.

   Availability: Pergamon Press, Inc.
   44-01 21st Street
   Long Island City, New York 11101

3. "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants," U.S. Atomic Energy Commission (NRC), Wash-1238, December 1972.

4. "Draft Environmental Impact Statements on Transportation of Radioactive Materials by Air and Other Modes," (NUREG-0170), U.S. Nuclear Regulatory Commission, Office of Standard Development, March 1976.

5. "Survey of Radioactive Material Shipment In the United States," BNWL-1972, Battelle Pacific Northwest Laboratories, Richland, Washington.

6. "Evaluation of Radiation Emergencies and Accidents--Selected Criteria and Data," Technical Report Series No. 152, IAEA, Vienna, Austria, 1974.

7. "Certification of ERDA Contractors' Packaging With Respect to Compliance with DOT Specification 7A Performance Requirements," - Two reports by Mound Laboratory, Monsanto Research Corporation, as follows:

Phase II Summary Report - June 12, 1979, MLM 2228.

Phase II Summary Report (Supplement No. 1) - April 15, 1976, MLM 2228, (Suppl.1).

Availability: National Technical Information Service
U.S. Department of Commerce
Springfield, Virginia 22161
(703) 557-4650

RCP-6.0

EMERGENCY ACTIONS PROCEDURE

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 8/10/84	J. Mezo 8/28/84	J. May 10/29/84		
1	C. Marino 2/27/85	J. Mezo 3/1/85	J. May 3/12/85		
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REVISION LOG

NUCLEAR ENERGY SERVICES, INC

DOCUMENT NO. 82A8016

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL
1	3/14/85	-	all pages noted with triangle blocks per CRA # 5168	

FORM # NES 208 2/80

RCP-6
EMERGENCY ACTIONS PROCEDURE

1. SCOPE

This procedure details the actions to be taken in the event of an emergency in a radiologically controlled area. Complementary industrial safety directives and first aid actions are specified in RCP-7. "General Industrial Safety Procedure" 82A8011.

2. GENERAL

The following procedure describes the response by NES personnel to abnormal events classified as emergency in nature and requiring immediate response while within a controlled area. The responsibilities of all parties are specified in the appropriate event description. These responses are in accordance with standard industrial practice and comply with NES quality assurance guidelines.

3. EMERGENCY EVENTS

A. <u>Accidental Spillage of Radioactive Liquids</u>

Should liquid radioactive or contaminated materials be accidentally released from their tank, piping, or other container the following actions shall be taken. NES personnel are to follow the instructions below which have been developed using the SWIMS acronym:

"S" = Stop the spill
"W" = Warn other personnel
"I" = Isolate the spill area
"M" = Minimize personnel exposure
"S" = Secure the appropriate equipment

Stop The Spill-

If the spill has occurred from a source which may or is continuing to add material to the spill, take such measures as necessary to stop the spill, such as closing a valve or blocking the path of the fluid with absorbent material. A balance of risk to the individual must be weighed for potential personnel risk in these actions versus the potential safety and economic cost if no of if limited actions are taken. If mechanical action is needed, such as closing a valve or disabling a pump, knowledge of the effect on the total system or machinery involved is required prior to such actions.

Warn Other Personnel-

Others in the immediate area and those entering the area must be told of the event to enable all personnel to take the appropriate response actions. Health physics personnel must be notified as soon as possible.

Isolate The Spill Area-

Non-vital personnel shall be kept out of the immediate vicinity, if necessary by having someone posted at the entrance to the area. Personnel who have been contaminated shall remain in the immediate vicinity to prevent the spread of contaminants until health physics personnel release them. An exception to this is when the ambient radiation levels are high or of a traumatic injury requiring leaving the are has occurred.

Minimize Personnel Exposure-

The event may be such as to include both a radiological and a chemical hazard. Personnel shall remain in the immediate vicinity until health physics personnel arrive both to assist in spill control and

to be available for surveying of exposed individuals. The nature of the spill, both chemical and radiological, and the need to monitor the spill shall dictate how close personnel should remain.

Secure The Appropriate Equipment -

Ventillation or other operating equipment may be selected for shutdown due to the nature of the spill and to prevent further occurrence. Knowledge of the systems and equipment involved is necessary prior to taking such action.

B. Airborne Radioactivity Alarm or Release

In the event an area airborne alarm is sounded within a vicinity or in some other manner personnel become aware of an airborne release within any closed structure, all personnel shall leave the area immediately. Prior to leaving the area, all equipment shall be secured prior to leaving the area which, if left in its existing condition, would be cause for a safety hazard.

Personnel who are wearing ambient air respiratory equipment shall also be required to leave the area unless prior planning by health physics as specified in the Radiation Work Permit has accounted for the event. Personnel wearing self-contained or supplied air breathing apparatus shall be allowed to remain in the area at the discretion of health physics personnel at the scene. In the absence of immediate health physics support, ALL personnel shall leave the area.

Health physics personnel will take samples and evaluate any unplanned alarms or releases of airborne radioactive materials prior to allowing personnel to return to the area. Normal airborne area controls will then apply.

C. Fire In A Controlled Area

Areas shall be evacuated by all non-emergency personnel when a fire, heavy smoke, or similar fumes occur in a controlled area. Health physics, operational

and/or fire response personnel shall be immediately notified. This is true for all fire events, including those where personnel in the immediate vicinity have extinguished a minor event, such as a wastebasket fire.

1. When possible the fire shall be extinguished by personnel in the immediate vicinity rather than allowing it to grow into larger proportions while designated personnel are on their way.

2. The designated fire watch personnel during potentially hazardous work activities (e.g., welding) shall have respiratory and fire fighting equipment on hand for an initial response to an event.

3. If a fire cannot be rapidly extinguished, a fire detail shall be requisitioned by the lead health physics individual available:

   - fire detail shall wear self-contained respiratory equipment, protective clothing, and any other items deemed necessary by the lead health physics individual
   - the primary function of the fire detail shall be to evacuate personnel from the fire area
   - the secondary function of the fire detail shall be to save valuable equipment and properly without endangering their own or other lives
   - the tertiary function of the fire detail is to minimize the spread of contamination outside the controlled area

4. Fire extinguishing agents such as CO_2, foam, or dry chemicals are preferred as this minimizes the volume of potentially contaminated liquids.

5. All firefighting personnel shall be surveyed prior to exiting the event area except for those in need of immediate medical assistance outside the controlled area. Minimization of the spread of contamination will be kept in mind at all times.

   NOTE: Charcoal filter cartridges will clog rapidly upon exposure to any form of smoke. Remove charcoal filtered respirators and then

leave the area if you are in a smoked environment. Remove any respirator and then leave the area if the device becomes clogged or difficult to breathe through.

D. Radiation Alarm or Exposure

Upon initiation of an area radiation alarm, all personnel shall exit the area immediately.

1. Workers will insure that all others in the area have also heard the alarm.

2. Any equipment which, if left in its present condition, would present a safety hazard, shall be secured prior to leaving the area. 1

3. Personnel shall be posted at the entrance to the area and prevent access by others to the area until the arrival of health physics personnel.

4. Health physics personnel shall be notified immediately after completion of the first three steps.

Upon a worker finding his personnel dosimeter offscale or reading unexpectedly high, he shall leave the area immediately, even if only one of several of his dosimeters has gone offscale. 1

1. The worker in question will warn others in the area or any on the spot health physics personnel that this has occurred prior to his leaving the area.

2. Other workers in the area will immediately check their own dosimetry.

3. Health physics personnel, if not on the spot, shall be informed upon leaving the immediate area and the worker shall wait at the area exit or as per the instructions of the cognizant health physics personnel.

E. Emergency Notification

In the event of a radiological emergency, notification of the event to NES shall be made as follows:

Monday through Friday between the hours of 8:00 a.m. EST and 4:45 p.m. EST, call

John R. May
Radiation Protection Officer
(203) 796-5308

At all other times, call

John R. May
Radiation Protection Officer
(203) 775-6539

RCP-7.0

GENERAL INDUSTRIAL SAFETY PROCEDURE

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 7/31/84	J. Trezo 8/1/84	J May 10/2/84		
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REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 82A8011

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL

RCP-7

GENERAL INDUSTRIAL SAFETY PROCEDURE

1. SCOPE

This procedure outlines the generic aspects of industrial safety which pertain to and fulfill the requirements of the federal Occupational Safety and Health Administration (OSHA) as presented in 29CFR1910 (as revised) and the requirements of the corporate Occupational Health Manual (1983).

2. GENERAL

Industrial safety is defined herein as including preventative and response actions involving traumatic, radiological, and emergency events. Each of these areas is discussed below.

3. RESPONSIBILITIES

All individuals are responsible for their own safety, that of their employees and subcontractors, and that of their fellow workers. Management personnel at NES bear the particular burden of effectively educating employees concerning good practices and an awareness of potential and actual hazards.

4. INDUSTRIAL SAFETY REQUIREMENTS

4.1 GENERAL PROVISIONS

A. All personnel shall comply with the requirements of this procedure for all NES work activities.

B. Supervisory personnel shall be responsible for taking corrective actions concerning occupational health, safety, and environmental deficiencies resulting from their operations.

C. NES Departmental Management will periodically inspect or have inspected all worksites. Deficiencies noted by said inspections will be noted in writing to the specific project manager for corrective actions.

Deficiencies or violations which endanger "life" or "limb", as determined by NES, shall be immediately corrected and work shall not proceed until such corrective measures are in place.

D. When specified by NES, project managers shall perform safety inspections of their own operations and equipment to assure compliance with the requirements of this procedure and all applicable state, federal, local, and client regulations. Documentation shall be maintained for all safety and health inspections performed on NES projects. Inspection records shall be held by and made available through the Radiation Records Control Officer of NES.

E. Specific Material Exclusions

Unless otherwise set forth in NES procedures and specifically approved by NES, materials used shall not contain the following:

2-Acetylaminoflourine	Acrylonitrile
4-Aminodiphenyl	Inorganic Arsenic
Asbestos	Benzene
Benzidine	bis-Chloromethyl ether
3,3' Dichlorobenzidine	4-Dimethylaminoazobenzene
Ethyleneimine	Hydrazine
Methylchloromethyl ether	4,4' Methylene bis
Mercury	4-Notrobiphenyl
H-Nitrosodimethylamine	beta-Propiolactone
Toluene	Trichloroethylene
Vinyl Chloride	Xylene
Fungicides	Herbicides
Organic Peroxides	Pesticides
Polychorinated byphenyls	Rodenticides

F. Permits

As applicable, permits shall be required for the following work. It is the responsibility of the project manager to arrange for or have arranged for

these permits at least 24 hours in advance of their need.

1. Flame permit - prior to use of any open flame, heat, or spark producing device, a flame permit shall be approved by the appropriate Department Manager. The permit will be issued to cover specific operations and must be renewed for each change in the workscope at hand. Open fires and refuse burning are prohibited.

2. Excavation/Penetration Permit - at least 24 hours prior to any excavation work or penetration of enclosed spaces (floors or walls) a permit shall be obtained for such actions from the Department Manager.

3. Asbestos Work Permit - a permit shall be obtained for any work involving the removal, handling, or disposal of any material containing asbestos. Waste asbestos shall be handled in accordance with the directives of the Waste Management Department Manager.

4. Respirator Permit - all work requiring a respirator for other than radiological reasons shall be required to obtain a permit from the Department Manager for usage prior to the commencement of work. All such respirators shall be NIOSH/MSHA approved and all personnel needing respirators shall be trained to the satisfaction of the NES Radiological Safety Committee. Written approval of usage required for each individual prior to use.

5. Confined Space Entry Permit - an entry permit for work inside spaces potentially subject to poor ventilation. This shall include, but is not limited to tanks, vessels, reactor drains, double bottoms, sewers, boilers, pits, and vents. An assigned NES safety individual or the project manager shall survey the area prior to commencement of work and give or decline written approval. The following general guidelines shall be followed:

a. lifelines shall be worn at all times
b. a watcher shall stand by at all times
c. transformers for equipment shall remain outside the area and be grounded outside the area
d. ground-fault circuit interrupters (GFCI's) shall be installed on all 120 VAC, single phase, 15-20 ampere receptacle outlets inside the area
e. supplied or self-contained air shall be used for abrasive cleaning or painting operations.

6. Radiological Work Permit - all work in radiation areas or with radioactive materials in greater than exempt quantities shall be required to obtain a permit (RWP) prior to commencement of work as per Procedure RCP-8, Radiation Work Permit Procedure.

4.2 INDUSTRIAL HYGIENE REQUIREMENTS

All work performed under NES supervision shall ensure that personnel exposures to toxic or harmful physical agents do not exceed the limits specified by (1) Subpart Z of 29CFR1910, or (2) the current threshold limiting values of the American Conference of Governmental Industrial Hygienists (ACGIH), or (3) the U.S. Air Force standard for exposure to noise.

Personnel may be required to wear personal monitoring devices in order to assure compliance with the above. All such devices shall be supplied and maintained by NES. Additional limits to those mentioned above may be set by the Project Manager or Department Manager for a particular workscope.

4.3 ASBESTOS WORK

Any and all work with asbestos requires development of an asbestos-worker medical surveillance program as described in 29CFR1910.1001. This will assure worker training for the appropriate NES procedures and safety practices.

4.4 ENVIRONMENTAL PROTECTION PRACTICES

Disposal of environmentally hazardous materials by dilution into storm sewers, sanitary sewers, site drains, or by disposal at a landfill is expressedly prohibited without the written authorization of NES interdepartmental management.

All hazardous materials shall be packaged in accordance with written NES procedures and shall be stored, handled, and disposed after approval by the Waste Management Department.

Materials brought to NES worksites by its subcontractors shall be considered the property of and responsibility of said contractor. The contractor is responsible for meeting the hazardous waste regulations of 40CFR 261-265. Additional requirements may be issued by NES.

Equipment used with concrete shall be washed only in areas designated by the Project Manager.

5. BASIC SAFE PRACTICES

The listing of the following basic safe practices is in no way intended to be all inclusive nor to release subcontractors from compliance with the applicable requirements of documents list in paragraph 3.1.

4.1 FIRE PROTECTION

A. Flammable and Combustible Liquids

Flammable and combustible liquids in quantities greater than one gallon shall be kept in approved metal safety cans. An approved safety can is one which is approved by Factory Mutual or Underwriters Laboratory. It is a container of not more than five gallons capacity, with a flash-arresting screen at each opening (fill and dispensing), spring-closing lid and spout cover, and so designed that it will safety relieve internal pressure if subjected to fire exposure. Flammable liquids which are viscous and extremely hard to pour may be used and handled in original shipping

containers. Liquids that are required to be chemically pure may remain stored in the vendor's receptacle (normally a one pint glass bottle). Permission must be obtained from the work administrator before quantities in excess of five gallons of flammable or combustible liquid may be stored on site. Flammable or combustible liquids shall not be stored in corridors leading to exists, stairways, or similar areas intended for the safe passage of pedestrian or vehicular traffic.

B. Combustible Materials

1. Quantities of combustible materials shall be kept at a practical minimum and combustible products shall not be allowed to accumulate to the extent of creating a fire hazard as determined by NES.

2. All flammable materials shall be stored a minimum of ten feet from all buildings in a neat and orderly manner in an area designated by the work administrator.

4.2 GASES

A. Compressed gas cylinders shall be properly and legibly marked with name of the gas. When transporting, moving or storing compressed gas cylinders, valves shall be closed and protection caps shall be in place and secured. All cylinders shall be secured to prevent accidental falling.

B. All oxygen cylinders shall be stored separately from fuel gas cylinders. Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials, a minimum distance of 20 feet or by a solid non-combustible barrier at least 5 feet high having a fire-resistance rating of at least one-half hour (ex. oxygen and fuel gas cylinders secured and separated on a cart). Compressed gas cylinders shall not be taken into confined spaces.

C. Cylinders of compressed, flammable gases or oxygen shall not be stored inside NES buildings overnight without the prior approval of the work

administrator. When approved, cylinders stored must have valves closed, regulators removed, capped, and must be placed in a location approved by the work administrator. The location shall be well ventilated, segregated from sources of ignition or heat, and located a safe distance from vehicular traffic.

4.3 ELECTRICAL

A. All portable electrical tools with metal frames shall be Underwriter Laboratory approved of the self-grounding type or equipped with an Underwriter Laboratory approved system of double insulation.

B. Temporary electrical wiring used for lights and power shall comply with the National Electrical Code and the National Electrical Safety Code. All temporary electrical wiring installations, tie-ins and pick-ups must be approved by NES.

C. Personnel shall install ground fault circuit interrupters (GFCI's) on all 120 volt, single phase, 15 and 20 ampere receptacle outlets which are used on construction operations. Receptacles on a two-wire, single phase portable or vehicle-mounted generator rated not more than 5 KW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with GFCI's.

D. All branch circuits, including receptacle fixtures, power supplies and switch legs that are installed, modified or repaired shall be grounded by using a continuous ground wire which shall extend from each receptacle, fixture or switch leg to the ground bus on the respective power panel. As a minimum the size of the ground and neutral conductors shall be the same size as the power lead. Mechanical grounding through conduit, water pipes, building steel, or flexible encasement is not considered to be an equivalent or acceptable means of grounding.

E. All electrical panels, power sources, or disconnects and switches installed, repaired or modified shall be labeled with the voltage contained in the equipment.

F. All electrical installations having more than a single source of power shall be so labeled.

4.4 TOOLS AND EQUIPMENT

A. All tools and equipment shall be in good condition. Tools with mushroomed heads, split handles, or other defects which impair their strength or render them unsafe for use will not be allowed on the site.

B. Wheels, belts, cutters, etc., shall be properly guarded. Abrasive wheels and rotating blades shall not be operated in excess of manufacturer's rated or recommended speeds.

C. Scaffolding, rigging and staging shall be inspected and conform to the applicable sections of 29CFR1910 and 29CFR1926. Deficiencies shall be corrected by the project manager.

D. Straight and extension ladders shall have safety feet and shall be tied, blocked or otherwise secured to prevent their being displaced. Working from the top two steps of any straight or extension ladder is prohibited. The use of wood or plastic ladders is recommended, but metal ladders may be permitted when approved by the work administrator. Side rails for ladders shall extend not less than 36 inches above the work surface landing.

E. Only climbing devices and work platforms that comply with the applicable section of 29CFR1910 and 29CFR1926 shall be used to gain access to elevated work areas. Climbing on ducts, pipes, structural members, and similar equipment shall not be permitted.

F. Whenever aerial lifts are to be used in the performance of work, a stand-by person shall be stationed at ground-level to assist the lift operator in the event of an emergency or as required by the lift operator. Any person assigned stand-by responsibility for aerial lift operation shall be qualified

to operate the device. Aerial lifts include vehicle mounted elevating and rotating work platforms such as aerial ladders, extensible boom platforms, articulating boom platforms, vertical towers, and a combination of any of these devices.

4.5 PERSONAL PROTECTION

All safety equipment apparel shall be furnished by NES unless otherwise provided in a subcontract.

A. Personnel are required to wear head protection equipment (hardhats, helmets) when there is a possible danger of head injury from impact, flying of falling objects, or electrical shock and burns. Hardhats/helmets (e.g., MSA or equivalent for Rad Con work) shall be worn by personnel working in an area where any personnel are working off ground level on a ladder, platform, lift or any such devices. This requirement shall apply to all personnel within an area identified and posted as a hardhat area as described in this paragraph and 3 or 4.

B. Hardhats/helmets for protection against the impact and penetration of falling objects shall meet the requirements of ANSI Z89.1, Safety Requirements for Industrial Head Protection, latest edition.

D. Posting - Entry into hardhat areas shall be restricted by physical barriers such as roping off or equivalent means. Points of entry shall be clearly identified by a warning sign posted in the entrance as described below or equivalent:

DANGER	white letters red background
Hard Hat Area	black white background black letters

(minimum size: 10" x 14")

D. Where it is not practical to rope off a hardhat area, one person shall be designated as a watch stander to control entry into the lift area. He shall ensure that personnel wear a hard hat at all times they are in the lift area. Crane operators using cranes with controls at floor level may be designated as watch stander provided they are aware of these requirements.

E. Approved eye and face protection meeting the requirements specified in ANSI Standard 487.1 shall be worn whenever machines or operations present potential eye or face injury from physical or chemical agents.

F. All welding operations shall be shielded by fire resistant barriers to prevent personnel exposure to ultra-violet light ray emissions and to contain welding sparks.

4.6 GENERAL PRACTICES

A. Materials, tools or debris shall not be placed in personnel or vehicular traffic lanes, nor block fire alarms, extinguishers, fire doors, fire exits or any other fire protection equipment.

B. Protruding nails associated with subcontractors' work shall be removed or otherwise rendered safe.

C. All spills of materials shall be contained and cleaned up immediately. Any hazardous conditions caused by such spills shall be corrected as soon as possible. Abrasive materials shall be placed on all surfaces made slippery by oil, ice, etc.

D. All inclined walkways shall have nailed cleats or abrasive surfaces to provide sure footing.

E. The project manager shall use such warning signs as appropriate to identify dangerous conditions.

F. Only trucks or vehicles identified with permanent type lettering will be allowed on site. No privately owned vehicles will be admitted until proper certification and evidence of required insurance coverage have been filed with and approved by NES and a vehicle pass has been secured from NES Site Security (when appropriate).

If vehicles remain on site during non-working hours, the vehicles must either remain within the perimeter security fence or if outside the fence, they must be within view of the security guard house. Keys must remain in the vehicles left inside the fence; keys for vehicles left outside must be turned over to the NES security guard.

During all non-working hours, mechanical equipment operating outside the perimeter of the security fence shall be rendered inoperable to unauthorized persons by utilizing one of the following precautions:

1. Mechanical equipment that is key operated shall be moved to a designated location within view of the site security forces. The equipment doors and ignition shall be locked. Keys shall be tagged with equipment identification data and turned over to the security forces for safekeeping.

2. Mechanical equipment that is not key operated shall be moved inside the security fence.

3. Mechanical equipment that cannot be moved without significant work delay may be left in its present location provided prior written approval of such action is obtained from NES. In addition, said

equipment, if key operated, shall be locked (doors and ignition) and also rendered inoperable. If not key operated, other means of rendering the equipment inoperable (such as removal of the rotor) shall be done. Keys and parts removed for this purpose shall be tagged with equipment identification and location data and turned over to the security forces for safekeeping.

G. Approved means of access shall be provided for all work areas.

H. All employees and subcontractors of NES shall conduct themselves in a proper manner. Horseplay, practical joking, etc., are prohibited.

I. All "No Smoking" rules shall be strictly followed.

J. Unusual and potentially hazardous conditions, especially those involving danger to individuals, or potential damage to property, shall be reported immediately to the work administrator.

K. All platforms or scaffolds shall have guard rails and toe boards in compliance with 29CFR1910 and 1926 regulations. All staging shall have safety cleats.

L. Whenever it is necessary to perform work within four (4) feet of the unprotected edges of flat roofs, and personnel elects to not wear safety belts and lifelines, NES shall provide and install a fall protection system on open sides of this roof where employees are exposed to potential falling hazard of four (4) feet or more above the adjacent floor or ground level. This protection system shall be installed prior to beginning work on these roofs, and shall comply with the requirements of Construction Safety and Health Regulations 29CFR 1926.500, Guardrails, handrails, and covers, current edition. The subcontractor shall provide detailed specifications of this protection system to NES for information. Approved safety belts and lifelines shall be worn by all personnel when working within four (4) feet of the unprotected edges of these roofs while installing or removing the fall

protection system. Safety belts, lifelines, and lanyards shall be selected, used, and secured in accordance with Construction Safety and Health Regulations 29CFR 1926.104, Safety belts, lifelines, and lanyards, current edition. An unprotected edge is one which does not have a barrier, such as a roof parapet, fence, or similar device, which is at least 36 inches high and is capable of withstanding a 200-pound load with minimum deflection.

M. High voltage components shall be effectively guarded and labeled to prevent accidental contact with energized components. Instruments used for trouble shooting energized circuitry shall be equipped with insulated probes to prevent direct electrical contact.

6. EMERGENCY EVENTS

When an emergency strikes, first aid treatment to individuals and effective physical actions concerning equipment, facilities, and containers associated with the event can often mean the difference between life and death, as well as severe monetary loss.

Physical actions concerning equipment operation is often best left to qualified operating personnel. A knowledge of first aid, however, can help all employees handle emergencies that may occur at work or at home. Certified training courses in first aid and cardiopulmonary resuscitation (CPR) are encouraged for all NES employees.

The following guidelines are excerpted from the Occupational Health Manual.

6.1 GENERAL FIRST AID INSTRUCTIONS

Keep the victim lying in a comfortable position - his head level with his body - until you know whether the injury is serious.

The following procedures should be activated immediately whenever indicated:

A - Restore breathing and maintain open airway.
B - Control Bleeding.

C - Prevent and treat for shock (see shock).

D - Prevent infection and further injury.

E - Provide the physician with as much history and information as possible about the injury or illness. Record all pertinent data.

These must be treated immediately before anything else is done. Then look for wounds, burns, factures, dislocations.

- Keep the victim warm
- Send someone to call for help
- Stay calm - reassure victim
- Do what needs to be done in the logical order
- Don't do more than you are qualified to do.

The following instructions are presented in alphabetical order.

A. Abdominal Pain

There are many causes of abdominal pain. Some, like appendicitis, are quire serious and require immediate medical care. If symptoms are severe, seek medical attention promptly.

B. Amputation

In the event that a limb such as a finger, hand, toe or foot is severed from the body in an accident, place the severed limb in a clean cloth and place in a plastic bag. Pack ice on the outside of the bag. If a second bag or container is available the ice should be placed in this second bag.

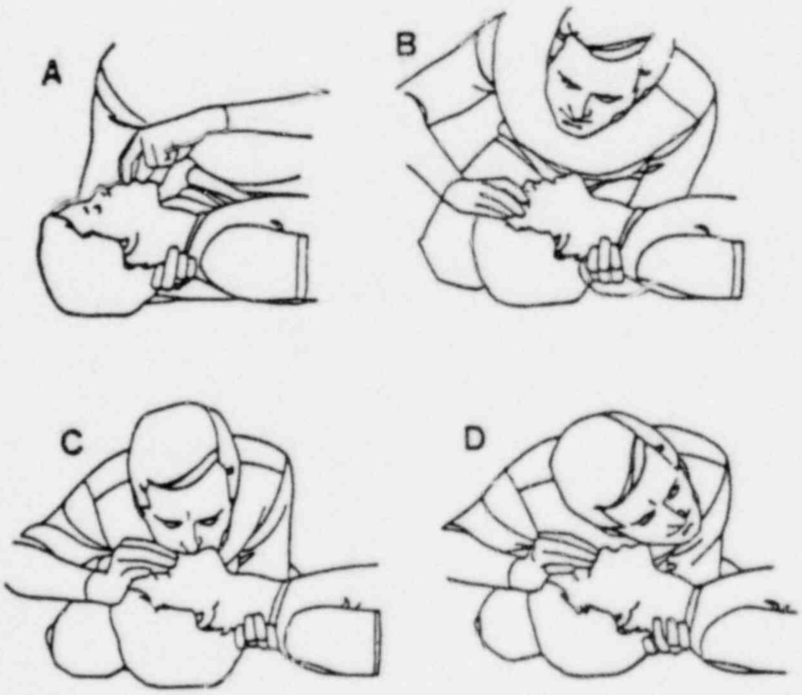
Call the hospital to notify them of a victim with a severed limb. When possible, the limb should be taken with the victim to the hospital.

Remember - the first concern is the victim. Control bleeding and treat for shock. The second concern is the limb.

C. Artificial Respiration - Cardiopulmonary Resuscitation (CPR)

In any serious emergency, the first priority is to determine if the victim is breathing. This can be done by placing the side of your face and ear very close to the victim's mouth and nose to feel for air being exhaled by the victim. Also lock to see if the victim's chest rises and falls. Determine if the victim's heart is beating by checking for a pulse at the carotid artery in the neck.

Mouth-to-Mouth Resuscitation



1. Lay victim on his back on a firm, rigid surface. Quickly clear the mouth and airway of foreign material.

2. Tilt the victim's head backward by placing one hand beneath the victim's neck and lifting upward. Place the heel of the other hand on the victim's forehead and press downward as the chin is elevated.

3. With the hand on the victim's forehead, pinch victim's nostrils using your thumb and index finger. Take a deep breath. Place your mouth tightly around the victim's mouth and give four quick breaths. Then give approximately 12 breaths per minute - one breath every five seconds until you see the victim's chest rise.

4. Stop blowing when the victim's chest is expanded. Remove your mouth from the victim's and turn your head toward the victim's chest so that your ear is over the victim's mouth. Listen for air leaving his lungs and watch his chest fall. Repeat breathing procedure.

Continue Mouth-to-Mouth breathing until victim is breathing well on his own or until medical help arrives.

D. Drowning Victim

If a drowning victim's stomach is bloated with swallowed water, turn him face down for a moment, place both hands under his abdomen and lift. After water is empties, or if no water is emptied after approximately ten seconds, return the victim to his back.

E. Cardiopulmonary Resuscitation (CPR)

CPR is a basic life-support technique used when the victim is not breathing and it is possible that his heart has stopped beating.

A simple method of remembering the order of action to take if the victim is not breathing and there is no heartbeat is the use of the "ABC's").

Airway
Breathing and
Circulation

Although opening the victim's airway(A) and restoring breathing(B) (mouth-to-mouth) can be done by following the fundamentals stated here, restoring circulation(C) if the heart has stopped beating must be learned from a qualified instructor in the classroom. To restore circulation:

1. Check neck carotid artery for pulse

2. If no pulse is felt, begin cardiac compression. For one rescuer, give 15 compressions (80 per minute); then two quick breaths. For two rescuers give 5 compressions (60 per minute) for every breath.

F. Bleeding

Venuous bleeding, dark red in color, is a steady flow and can usually be stopped by applying pressure.

Arterial bleeding is bright red and usually spurts from the wound and is more difficult to control.

1. Direct pressure if the first step in controlling bleeding. To apply direct pressure:

   a. Place a compress of the cleanest material available over the entire wound and press firmly with the palm of your hand. If no dressing is available use open hand.

b. Continue to apply steady pressure.

c. If blood soaks dressing, add another pad. DO NOT remove blood soaked dressing.

d. If bleeding continues, elevate the limb above the level of the victim's heart.

- If fracture is suspected, DO NOT raise limb.

e. Apply a pressure dressing if bleeding stops or slows, placing knot over the compress.

2. <u>Pressure points</u> should be used only if bleeding does not stop or slow with the use of direct pressure and elevation and in conjunction with direct pressure and elevation.

a. To apply pressure point to stop severe bleeding from the <u>arm</u> use the brachial artery:

Grasp victim's arm bone midway between the armpit and the elbow with your thumb on the outside of victim's arm and with the flat surface of your fingers on the inside of the arm where you feel the artery pulsating. Squeeze fingers firmly toward your thumb against the arm bone until bleeding stops.

b. To apply pressure point to stop severe bleeding from the <u>leg</u> use the femoral artery:

Lay victim on his back if possible with leg elevated. Place the heel of your hand on the front center part of the thigh at the crease of the groin. Press down firmly.

TREAT FOR SHOCK

NOTE: Never use a tourniquet except in life-threatening situations where severe bleeding cannot be stopped by direct pressure on the proper point. The risk of losing a limb is secondary to saving his life.

G. Bruise

Bruises occur when a fall or blow to the body causes small blood vessels to break beneath the skin.

1. Apply cold compress or ice bag to the bruise to decrease bleeding and swelling.

2. After 24 hours, moist heat (or a warm bath) to the bruises area may aid healing.

3. If bruise is severe and painful with swelling, seek medical attention.

H. Burns

The objectives of first aid for burns are to relieve pain, prevent infection and prevent or treat for shock.

1. First-degree burns injure only the outside layer of skin. Symptoms are:

   - Redness
   - Mild swelling - no blisters
   - Pain

   Treatment:

   - Put burned area under cold water or apply cold water compress until pain decreases.

2. Second-degree burns - A burn that causes injury to the layers of skin beneath the surface of the body. Symptoms are any one or all of the following:

- Redness - moist appearance to skin
- Blisters
- Swelling that lasts for several days
- Pain

Treatment:

- Put burned area in cold (not iced) water or apply cold-water compresses until pain subsides.

- Dry gently and cover with sterile or clean bandage.

- Seek medical attention. DO NOT break blisters or apply home remedies, sprays, etc.

3. Third-degree burns - A burn that destroys all layers of the skin

a. Symptoms are:

- White or charred appearance. (At first, burn may resemble a second-degree burn.)

- Destroyed skin

- Minimal pain because nerve endings have been destroyed.

DO NOT remove clothes that are stuck to the burn.

DO NOT put ice or ice water on a third-degree burn.

DO NOT apply any medication unless ordered by a physician.

b. Immediate Treatment:

- Be sure victim is breathing.
- Cover burned area with thick, sterile dressing. Clean linen can be used.
- Call an ambulance.
- If hands are burned, elevate higher than the victim's heart.
- Elevate burned legs or feet. DO NOT allow victim to walk.
- Treat for shock.
- Cover with light blanket.
- Be calm and reassuring.

4. Chemical Burns

Chemical burns of the skin:

Treatment:

- Quickly flush burned area with large quantities of running water for at least five minutes. Act quickly - use a shower, garden hose, tub or buckets of water.
- Continue to flush with large amounts of water while removing clothing from burned area.
- After flushing, follow instructions on label of chemical causing burn, if available.
- Seek medical attention.

Chemical burns of the eyes - are very serious and may lead to blindness if immediate action is not taken. Damage can occur in one to five minutes.

Treatment:

- Flood the eye thoroughly with water for 10 to 15 minutes. Be sure to lift and separate eyelids so that all parts of the eye will be reached by the water.

- If the victim is lying down, pour large quantities of water from the inside corner of the eye outward, keeping the eyelids open.
- Do not allow victim to rub eyes.
- Cover eyes with clean cloth or sterile dressing.
- Seek medical attention immediately, preferably an eye specialist (ophthalmologist)

I. Choking

1. Symptoms:

- Gasping or noisy breathing
- Victim grasps his throat
- Inability to talk
- Difficulty in breathing - coughing - breathing may stop
- Skin becomes pale, white, gray or blue
- Victim has panic expression
- May become unconscious

If the victim can speak, DO NOT interfere in any way with the victim's efforts to cough out a swallowed or partially swallowed object.

2. Immediate Treatment:

a. If the victim cannot breathe and is standing or sitting, stand behind and slightly to one side of him and support his chest with one hand. With the heel of the other hand give four quick, very forceful blows on the back between the victim's shoulder blades.

b. If the victim is lying down, kneel beside the victim and roll him onto his side so that he is facing you. Place the victim's chest against your knees for support. With the heel of your hand give

four quick, very forceful blows on the victim's back between the shoulder blades.

c. If the above procedures do not dislodge the object and the victim is standing or sitting, stand behind the victim with your arms around his waist. Place your fist with the thumb side against the victim's stomach slightly above the navel and below the ribs and breastbone. Hold your fist with your other hand and give FOUR quick, forceful upwards thrusts. This maneuver increases pressure in the abdomen which pushes in the lugs and will hopefully force out the object. DO NOT squeeze with your arms, just use your fists.

d. If the victim is lying down, turn him on his back. Kneel beside the victim and put the heel of one hand on the victim's stomach slightly above the navel and below the ribs. Keep your elbows straight. Put your free hand on top of the other to provide additional force. Give FOUR quick, very forceful upward and backward thrusts in an attempt to dislodge the object.

e. If this gives no results, repeat the back blows and the upward abdominal thrusts until the victim coughs up the object or becomes unconscious. Look to see if the object appears in the victim's mouth or top of his throat. Use your fingers to pull it out.

3. If the victim is <u>unconscious</u> and <u>becomes</u> unconscious:

a. Place victim on his back on a rigid surface.

b. Open the victim's airway by extending the head back. Try to restore breathing with mouth-to-mouth respiration.

c. If still unsuccessful, turn the victim on his side and give FOUR quick, very forceful blows on his back between the shoulder places.

c. If still unsuccessful, turn the victim on his side and give FOUR quick, very forceful blows on his back between the shoulder places.

d. If still unsuccessful, turn the victim on his back and give FOUR quick, forceful upward abdominal thrusts.

e. If these procedures fail, grab the victim's lower jaw and tongue with one hand and lift up to remove the tongue from the back of the throat. Place the index finger of the other hand inside the victim's mouth alongside the cheek. Slide your fingers down into the throat to the base of the victim's tongue.

   Carefully sweep your fingers along the back of the throat to dislodge the object. Bring your fingers out along the inside of the other cheek. Be careful not to push the object further down the victim's throat.

   DO NOT attempt to remove the foreign object with any type of instrument or forceps.

f. Repeat all of the above steps until the object is dislodged or medical assistance arrives. DO NOT give up!

J. Convulsions (Seizures)

Although convulsions appear alarming, they rarely cause serious problems in themselves. Injuries may result from falling or striking objects during the seizure.

Convulsions are a series of uncontrollable muscle movements during a state of total or partial unconsciousness. Most convulsions last less than a few minutes.

Treatment:

1. If victim starts to fall, try to catch him and lay him down gently.

2. Remove any objects that a victim could strike.

3. If breathing stops and does not start again momentarily after the seizure, maintain an open airway. Be sure victim's tongue is not blocking his throat. Restore breathing if necessary.

4. DO NOT interfere with convulsive movements.

5. DO NOT force object such as spoon or stick into mouth.

6. Stay with victim while he recovers.

7. Seek medical attention promptly - especially if a second convulsion occurs.

K. Dental Emergencies

1. Toothache

   Give aspirin or similar medication. Do not apply whole aspirin to affected tooth. Refer to dentist.

2. Knocked-out Teeth

   a. Place a cold compress or ice bag on the face to relieve swelling.

   b. Wrap the tooth in a wet cloth and take the victim and tooth to the dentist as soon as possible.

L. Dislocations

A dislocation occurs when the end of a bone is displaced from its joint, the result of a fall or a blow to the bone.

1. Symptoms:

- Swelling
- Deformity at the joint
- Pain upon moving part or inability to move the part
- Tenderness and discoloration around the area

2. Treatment:

- Place victim in a comfortable position.
- Immobilize injured part in the position in which it was found.
- DO NOT attempt to put a dislocated bone back into place.
- Seek medical attention promptly

M. Ear Injuries

A ruptured eardrum can be caused by a loud blast, head injury, infection, diving into water or from an object poked into the ear. Bleeding or other fluids from the ear canal may mean a serious head injury. Symptoms may be one or all of the following:

- Bleeding from inside the ear canal
- Pain
- Hearing loss

Treatment:

- DO NOT put anything into the ear or try to stop flow of blood from the ear.

- Loosely cover outside of each with a bandage to catch flow of blood.
- Place victim on injured side allowing block to drain.
- DO NOT move victim if neck, head or back injury is suspected.
- Seek medical attention promptly.

N. Electric Shock

1. There is a risk of injury to the person who is trying to help. It is extremely important to remain calm. DO NOT touch the victim directly until the electric current is turned off or the victim is no longer in contact with it - otherwise the first aider risks electrocution to himself.

   To remove the victim from source of electricity:

   a. If possible, turn off the electric current by removing the fuse or by pulling the main switch. If this is not possible, or victim is outside, have someone call the electric company to cut off the electricity.

   b. If it is necessary to remove the victim from a live wire, be extremely careful. Stand on something dry such as a newspaper, board, blanket, rubber mat or cloth, and, if possible, wear dry gloves.

   c. Push the victim away from the wire with a dry board, stick or broom handle, or pull victim away with a DRY rope looped around victim's arm or leg. NEVER use anything metallic, wet, or damp. DO NOT touch victim until he is free from the wire.

2. If victim is not breathing:

a. Open Airway

1) Lay victim on his back on a firm surface such as the floor or the ground.
2) Quickly clear the mouth and airway of foreign material.
3) If there is no neck injury, gently tilt victim's head backward by placing one hand beneath the victim's neck and lifting upward. Place the heel of the other hand on the victim's forehead and press downward as the chin is elevated.

b. Restore Breathing

1) Keep victim's head tilted backward.
2) With hand that is placed on victim's forehead, pinch nostrils using the thumb and index finger.
3) Open your mouth widely and take a deep breath.
4) Place your mouth tightly around victim's mouth and give four quick breaths. Then blow into his mouth approximately 12 breaths per minute for an adult. Quantity is important so provide plenty of air - one breath every five seconds until you see the victim's chest rise. (Seconds are counted "one-one thousand, two-one thousand, three-one thousand," etc.)
5) If the victim's mouth cannot be used due to injury, remove hand under victim's neck and close his mouth; then place your hand over his mouth. Open your mouth widely and take a deep breath. Place your mouth tightly around the victim's nose and blow into it. After you exhale, remove your hand from the victim's mouth to allow air to escape.
6) Moderate resistance will be felt with blowing. If chest does not rise, airway is not clear and more airway opening is needed. Place hands under victim's lower jaw and thrust lower jaw forward to that it juts out.

7) Watch closely to see when victim's chest rises, and stop blowing when the chest is expanded.

8) Remove your mouth from victim's mouth or nose and turn your head so that your ear is over victim's mouth. Listen for air leaving his lungs.

9) Repeat blowing air into victim until he is breathing well on his own or medical assistance arrives. In electric shock artificial respiration may be required for a long time. Don't get discouraged.

c. Restore Circulation

1) Check neck artery for pulse. Check below left nipple in infants.

2) If no pulse is felt, begin cardiac compression. This should be done by those professionally trained and MUST be done in conjunction with artificial respiration. (For one rescuer, give 15 compressions (80 per minute); then two quick breaths. For two rescuers, give five compressions (60 per minute) for every one breath. Repeat until medical attention arrives)

d. Get medical help promptly.

O. Eye Injuries

(See Chemical Burns for eyes)

Penetrating injuries are extremely serious and can result in blindness.

Act quickly and calmly:

1. Keep victim quiet, preferably lying on his back.

2. Call an ambulance.

3. Cover both eyes with a sterile (or clean) dry dressing. DO NOT press foreign object if one is sticking into the eyeball.

4. Telephone ahead to an eye specialist.

5. Keep victim lying on his back while riding to the hospital.

Foreign objects resting or floating are often easy to remove using the moistened corner of a cloth or facial tissue.

1. If particle remains, flush eye out with warm water or appropriate eye wash.

2. If particle remains, gently cover the eye with a sterile or clean compress.

3. Seek medical attention promptly, preferably an eye specialist.

Cuts to the eye, including eyelid, can be very serious.

Immediate action should be taken:

1. Cover the injured eye with a sterile pad or clean cloth but do not apply pressure. Cover the other eye to prevent eyeball movement.

2. Seek medical attention immediately, Preferably an ophthalmologist.

Blunt injuries - (Black Eye) resulting from a hard direct blow to the eye, such as a moving ball, fist, etc. need medical attention by an ophthalmologist even though the injury may not look serious. There may be internal bleeding in the eye.

1. Apply cold compresses to the injured eye.

2. If possible, keep victim lying down with eyes closed.

3. Seek medical attention.

Contact Lenses - In eye injuries in which the victim is wearing contact lenses, the lenses should be removed by a physician, preferably an ophthalmologist, as soon as possible.

P. Fainting

Fainting is a brief loss of consciousness due to a reduced blood supply reaching the brain. Recovery usually occurs within a few minutes.

Symptoms may precede or occur during fainting:

1. Pale, cool or damp skin

2. Dizziness

3. Nausea

4. Weak feeling

To prevent fainting:

1. Have victim lie down with legs elevated 8 to 12 inches, or sit down and bend forward so that his head is between his knees.

2. Bathe face or forehead with cold cloth.

3. Be calm and reassuring.

4. Use spirits of ammonia ampoule briefly under nose.

If fainting has occurred:

1. Keep victim lying down

2. Maintain an open airway - check for breathing

3. Bathe face with cold cloth

4. Observe victim after he regains consciousness

5. If no breathing, begin mouth-to-mouth

6. Seek medical attention

Q. Fever

A fever - elevated temperature - is the body's way of indicating that something is wrong within it.

The average normal oral temperature is 98.6°(F) (37°C). Slight changes in temperature are usually not significant. A major increase in temperature (to approximately 102°F or over) may indicate a serious condition and the victim should see a doctor.

An aspirin or a non-aspirin medication is helpful in reducing the slightly elevated temperature.

R. Fractures

A fracture may be closed or open.

In a closed fracture, the bone does not penetrate the skin.

In an open fracture, the bone may stick out through the skin and is more serious because of bleeding.

Always suspect a broken bone if any of these symptoms appear:

1. Victim felt or heard a bone snap.

2. Pain or tenderness, particularly to the touch, at the site of the injury or when moving the affected part.

3. Difficulty in moving the injured part. However the bone may be broken even if victim can easily move the injured part.

4. Abnormal or unnatural movement of the injured part.

5. Victim feels grating sensation of bone ends rubbing together.

6. Swelling in the area of the injury.

7. Deformity of the injured part.

8. A difference in the shape or length of a bone in comparison to the same bone on the other side of the body.

9. Bluish discoloration at the site of the injury.

Treatment:

1. ABC's - Maintain an Airway, Restore Breathing and Circulation if necessary.

2. Stop any severe bleeding. Gently and loosely apply large sterile (or clean) dressing over exposed bone end.

3. Treat for shock.

4. Call an ambulance promptly.

5. Always suspect a broken neck or spinal injury if victim is unconscious, has a head injury, neck pain, tingling or paralysis in the arms or legs.

6. DO NOT move this victim until ambulance arrives with proper equipment.

7. If victim must be moved, immobilize the injured part first. For example, tie the injured leg to the other leg.

S. Head Injuries

A - With all serious injuries maintain an open Airway,

B - Restore Breathing and,

C - Circulation if necessary.

All head injuries must be taken seriously as they can result in brain or spinal cord damage. Most head injuries are caused by a fall, a blow to the head, or sudden stopping as in an automobile or truck accident. Some symptoms may not occur immediately, but those to look for are:

1. A cut, bruise, lump or depression in the scalp

2. Possible unconsciousness, confusion or drowsiness

3. Bleeding from the nose, ear or mouth

4. Clear or bloody fluid flowing from the nose or ears

5. A pale or reddish face

6. Headache

7. Vomiting

8. Convulsions

9. Pupils of the eyes unequal in size

10. Difficulty in speech

11. Restlessness and (possibly) confused behavior

12. A change in pulse rate

13. Any one or all of the above may be present

Treatment:

1. Maintain an open airway. Be very careful as there may be a possibility of a broken neck. Restore breathing if necessary by mouth-to-mouth resuscitation.

2. Do not move the victim more than is absolutely necessary. Handle the victim very carefully.

3. Keep victim lying down if possible.

4. If victim's face is red and there is NO evidence of a neck or back injury (with a neck or back injury the victim cannot move is harms hands, fingers and/or legs, feet and toes; there will be pain in neck or back), elevate head and shoulders slightly with a pillow or rolled blanket but be sure breathing is not impaired.

5. If victim's face is pale, keep the head level with the rest of his body.

6. If there is no evidence of a neck or back injury, turn the victim's head to the side to allow secretions to drain.

7. Control serious bleeding. Gently apply compress to bleeding area and bandage in place.

8. DO NOT give victim anything by mouth.

9. Seek medical attention promptly, preferably at the nearest hospital emergency room. If someone else other than trained medical personnel must take victim to the hospital, transport victim lying down. Place pads or other suitable material on each side of victim's head to keep it from moving side to side.

NOTE: If victim did not lose consciousness at the time of the injury and did not seek medical attention, symptoms of brain damage should be noted, particularly headache, unequal pupils, convulsions or "not feeling well". Medical attention should be sought promptly.

T. Heart Attack

A heart attack is a life-threatening emergency. If occurs when there is not enough blood and oxygen reaching a portion of the heart due to a narrowing or obstruction of the coronary arteries that supply the heart muscle.

Symptoms may be any one or all of the following:

1. Central chest pain that is severe, crushing (not sharp), constant and lasts for several minutes.

2. Chest pain that moved through the chest to either arm, shoulder, neck, jaw, mid-back or pit of stomach.

3. Heavy sweating

4. Nausea and vomiting

5. Extreme weakness

6. Victim is anxious and afraid

7. Skin is pale. Fingernails and lips may be blue.

8. Extreme shortness of breath (mild to severe)

9. Pain may be mistaken for indigestion.

If victim is unconscious and not breathing, or is having difficulty in breathing - IMMEDIATE TREATMENT IS:

A - Open Airway

B - Restore breathing - (mouth-to-mouth)

C - Restore circulation using CPR

1. Loosen any tight clothing such as ties and belts.

2. Keep warm - but not perspiring.

3. Reassure victim.

4. Do not offer food or fluids - do not use ammonia inhalants.

5. If victim is conscious, place in a comfortable sitting position.

6. Call for an ambulance.

7. If victim has difficulty breathing or shortness of breath, oxygen may be used.

NOTE: Not all chest pains are symptoms of a heart attack. Chest pain may be due to strenuous exercise, infection, muscle spasm or excitement. These pains are usually sharp and may repeat but usually last only a few seconds. Chest pains may also be caused by tension, pneumonia, fractured ribs, gas, bruise, strained muscles, etc. But - it is always a good idea to report any chest pains to a doctor.

U. Heatstroke (Sunstroke)

Heatstroke is a life-threatening emergency. It is a disturbance in the body's heat-regulating system caused by extreme high body temperature due to exposure to heat.

Symptoms are any one or all of the following:

1. Body temperature extremely high (often 106°F or higher)

2. Skin is red, hot and dry. Sweating is absent.

3. Rapid and strong pulse

4. Possible unconsciousness or confusion

If body temperature reaches 105°F

1. Undress victim and put him into a tub of cold water (not iced) if possible. Otherwise, spray victim with hose, sponge bare skin with cool water or rubbing alcohol, or apply cold packs to victim's body.

2. Continue treatment until body temperature if lowered to 101°F or 102°F.

3. Do not overchill. Check temperature constantly.

4. Dry off victim once temperature is lowered.

5. Seek medical attention promptly, preferably at the nearest hospital emergency room.

V. <u>Heat Exhaustion</u>

Heat exhaustion can occur after prolonged exposure to high temperatures and high humidity. It is NOT a life-threatening emergency.

Symptoms are:

1. Body temperature normal or slightly above normal

2. Skin is pale and clammy

3. Heavy sweating

4. Tiredness, weakness

5. Dizziness - possible fainting

6. Headache

7. Nausea or vomiting

Treatment:

1. Move victim into shade or to a cooler area

2. Have victim lie down

3. Raise victim's feet 8 to 12 inches

4. Loosen victim's clothing

5. If victim is not vomiting, give clear juice or sips of cool salt water (1 teaspoon of salt per glass). Give victim half a glass of liquid every 15 minutes for one hour. Stop fluids if vomiting occurs.

6. Place cool wet cloths on victim's forehead and body.

7. Use a fan to cool victim or, if possible, remove victim to an air-conditioned room.

8. If symptoms are severe, become worse or last longer than an hour, seek medical attention promptly.

W. Hyperventilation

Hyperventilation, often caused by tension or emotional upset, is overbreathing due to a feeling of not getting enough air into the lungs. The level of carbon dioxide in the blood is lowered by the increased respiration causing one or all of the following symptoms:

1. Lightheadedness

2. Numbness and tingling in hands, feet, and around mouth

3. Difficulty in getting a deep, satisfying breath

4. Possible convulsions

If uncertain of condition:

Place a paper bag loosely over the victim's nose and mouth so he can rebreathe the air and carbon dioxide mixture. Have victim breathe in and

out of the bag for 4 or 5 minutes. Seek medical attention if breathing does not return to normal.

NOTE: It is a good idea to refer victim to a doctor to determine the underlying cause of hyperventilation.

X. Poisoning

ABC's - Open airway, restore breathing and circulation if necessary.

It is extremely important to call a Poison Control Center or hospital emergency room or a doctor for instructions if someone has swallowed a poison. Give the following information:

1. Victim's age

2. Name of the poison

3. How much was swallowed

4. When

5. Instruction on container (if available)

Y. Shock Due to Injury

Traumatic shock is a life-threatening situation in which the body's vital functions are seriously threatened by insufficient blood, or oxygen in the blood, reaching the body tissues. Injuries that result in loss of blood, loss of body fluid, too little oxygen reaching the lungs, loss of nervous control, severe infections or heart problems can lead to shock. Shock is a medical condition secondary to serious illness or injury.

The following symptoms may develop:

1. Pale or bluish skin, cook to the touch

2. Moist and clammy skin

3. Weakness

4. Rapid (over 100 beats per minute) and weak pulse

5. Anxious and apprehensive

6. Pupils widely dilated

7. ctim may become unresponsive in late stages

8. Possible unconsciousness in severe cases

NOTE: The severity of shock may very from a moment's weakness to death! IMMEDIATE TREATMENT is:

1. Maintain an open airway

2. Treat cause of shock such as breathing difficulties, bleeding, sever pain, etc.

3. Keep victim lying down

4. Cover victim only enough to prevent loss of body heat - Keep patient comfortable

5. Seek medical attention promptly

   - If the victim is pale with clammy skin, <u>obvious</u> blood loss, elevate the feet 8 to 12 inches.

- If the victim has difficulty breathing or chest pain, elevate the head and shoulders. DO NOT elevate feet.

Z. Sprains

A sprain is an injury to the ligaments which support the joints. The ligaments may be stretched or completely torn by overextending or twisting.

Symptoms of a sprain are:

1. Pain and swelling in joint

2. Tenderness when touched

3. Some discoloration - black and blue around joint

If uncertain the injury is a sprain or a broken bone, treat as a fracture -

1. Placing ice packs or cold cloths over affected area

2. Support injured joint with a sling and bandage

3. Seek medical attention to rule out a broken bone

AA. Strains

A strain results from pulling or overexerting a muscle. Back strains are common injuries. Rest may ease the discomfort.

If pain or swelling increases, seek medical attention.

AB. Wounds

An open wound is an injury in which the skin is broken.

A puncture wound results from a sharp object such as a nail, large splinter, etc. piercing the skin and underlying tissue.

Abrasions or scratches can become easily infected since the outer protective skin layer is destroyed in the area.

A avulsed wound results when tissue is torn away - such as the loss of a finger nail.

The objectives in treating an open wound are:

1. Stop the bleeding
2. Prevent infection
3. Prevent or treat for shock
4. Seek medical attention if:
    a. The wound is severe
    b. Bleeding does not stop
    c. Foreign material or object is imbedded in wound
    d. There is any doubt about tetanus immunization.

Treatment:

1. If bleeding is severe:

    Use direct pressure. DO NOT clean a large severe wound or apply any medication.

2. If bleeding is NOT severe:

   a. Wash your hands thoroughly with soap and water before handling the wound to prevent further contamination of the injury.

   b. If cut is still bleeding, apply direct pressure over the wound with a sterile or clean cloth.

   c. When the bleeding has stopped, wash the wound thoroughly with soap and water to remove any dirt or other foreign material near the skin's surface. Gently scrubbing may be necessary. It is very important to remove all dirt, etc. to prevent infection. Foreign particles close to the skin's surface may be carefully removed with tweezers that have been sterilized.

   d. DO NOT attempt to remove any foreign material that is deeply imbedded in a muscle or other tissue as serious bleeding may result. This must be done by a doctor.

   e. Rinse the wound thoroughly under running water.

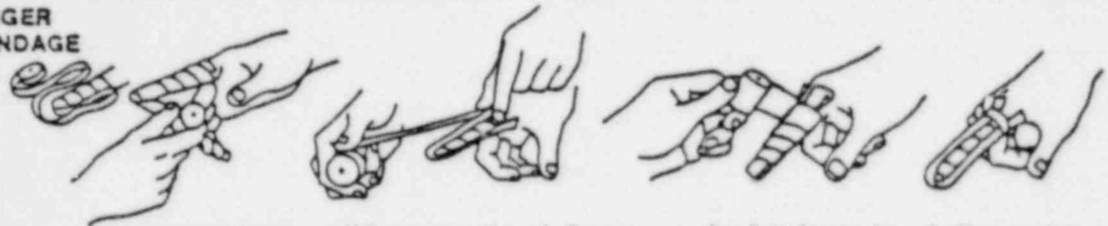
   f. Pat the wound dry with a sterile or clean cloth.

   g. DO NOT apply ointments, medication, antiseptic spray or home remedies unless told to do so by a doctor.

   h. Cover the wound with a sterile dressing and bandage in place. It the cut is slightly gaping, apply a butterfly bandage.

bandaging

FINGER BANDAGE

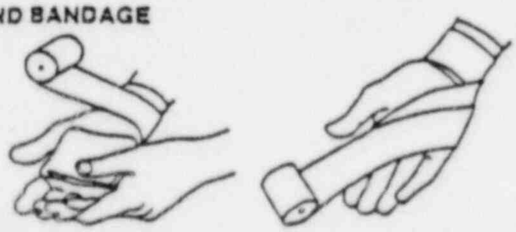


Wrap bandage from base toward tip of finger so that turns overlap.

When near tip of finger make several loops from tip to base of finger.

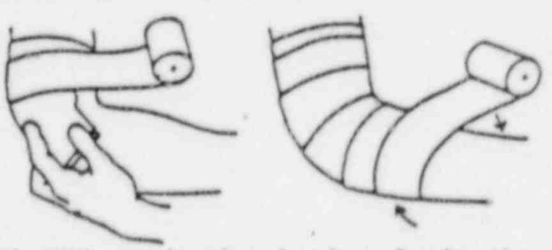
Anchor loops by winding as before and secure bandage with narrow strips of adhesive tape.

HAND BANDAGE



(1) Start around wrist and work toward base of thumb. (2) Bandage across palm continuing to base of fingers. (3) Return bandage to wrist and secure with adhesive tape or knot.

ELBOW (OR KNEE) BANDAGE



(1) With conforming bandage begin above slightly bent joint. (2) Bandage downward to cover limb for several inches below joint. Reverse direction, bandage upward to above joint and secure.

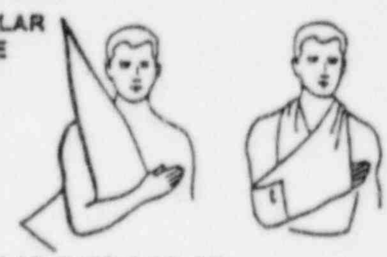
FOREARM (OR LEG) BANDAGE

(1) Anchor bandage at wrist or ankle. (2) Each turn overlaps 1/3 of preceding turn. (3) Secure by adhesive tape or knot below elbow or knee.

TRIANGULAR BANDAGE, FOREHEAD AND SCALP

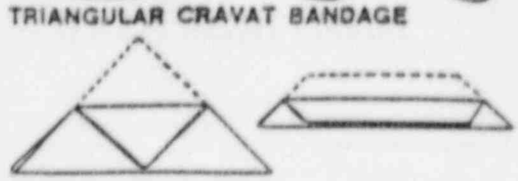
(1) Place base of triangle above eyebrows and point of triangle dropped over back of head. (2) Cross ends of triangle at back of head . . . carry forward and tie over forehead. (3) Tuck point of triangle behind crossed part of bandage.

TRIANGULAR BANDAGE SLING



TRIANGULAR BANDAGE OF FOOT OR HAND

TRIANGULAR CRAVAT BANDAGE



6.2 MEDICAL DIRECTIVES

MEDICAL DIRECTIVES are written procedures, approved and signed by the physician who has been designated by management as the physician responsible for the medical direction of the employee health program. Medical Directives serve as the medical authorization for the certified first aider and/or registered nurse in giving emergency care to employees for occupational injuries and illnesses.

After the Directives have been reviewed and signed, any additional instructions written in by the physician should be noted by the nurse, safety coordinator and responsible first aiders.

The Medical Directives should be signed annually by the physician. They should be reviewed at least annually by those persons authorized to render first aid.

MEDICAL DIRECTIVES AND PROCEDURES FOR EMERGENCY CARE OF OCCUPATIONAL INJURIES AND ILLNESS

Name and Address of Physician:

____

____

____

Name of Nurse/Safety Coordinator in Charge:

____

____

Names of Certified First Aiders and Shift Responsibility:

____

____

____

____

____

____

APPROVED:

______________________	______________________ M.D.
Date	Signature

REVIEWED AND UPDATED:

______________________	______________________ M.D.
Date	Signature
______________________	______________________ M.D.
Date	Signature
______________________	______________________ M.D.
Date	Signature

RCP-8.0

RADIATION WORK PERMIT PROCEDURE

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 7/30/84	J. Theis 8/9/84	J May 8/9/84		
1					
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REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 82A8012

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL

RCP 8.0

RADIATION WORK PERMIT PROCEDURE

I. SCOPE

The purpose of this procedure is to instruct radiation workers at NES in the correct usage of and responsibilities for the NES Radiation Work Permit (RWP). This permit was developed for the control of worker entry into controlled areas at locations where NES is responsible for controlled area management. All RWPs are issued via this procedure in accordance with the NES Radiological Protection Manual.

A copy of the work permit is attached Figure 8.1. The present form incorporates many features found in the nuclear industry and has been designed to clearly and explicitly detail the following information:

- A clear and understandable description of the work intended to be performed in a radiation controlled area.

- Explicit instructions to all personnel entering the controlled area for this work effort as to:

  1. the protective clothing requirements
  2. the radiation monitoring requirements
  3. special health physics instructions
  4. maximum time allowed in the area

- Information concerning the radiological conditions of the area to be worked in including:

  1. area radiation levels
  2. removable contamination levels
  3. airborne radiological hazards
  4. hot spots of particular hazard

- An official record of the authorized individuals who are permitted to work in the area.

- An official record of the supervisory personnel who have authorized this work and determined the above conditions and requirements

2. ISSUING AUTHORITY

The NES RWP is issued by health physics personnel after receipt of request to work in a controlled area. The request can be made by any individual who has passed the NES radiation worker training course. This request must be made in writing on the form attached (Figure 8.2).

After an appropriate request has been written, it is submitted to the governing health physics supervisor. At NES worksites this is the Radiation Safety Officer (RSO) or a Health Physics Supervisor (HPS). This individual shall be aware of the latest radiological survey data available prior to determining RWP requirements. If such data as the health physics supervisor feels is necessary to ensure worker safety and employment of the ALARA philosophy is not available, additional surveys of the area shall be taken prior to determining RWP requirements. After the health physics supervisor has the appropriate survey data at hand, he shall specify the radiological requirements for the work on the RWP. The RWP will then be reviewed and signed by the immediate supervisor of the individual who submitted the original RWP request. Both this supervisor and the health physics supervisor shall be responsible for ensuring that all radiological hazards or potential hazards have been identified and addressed.

3. RADIATION WORKER RESPONSIBILITY

The individual radiation worker is responsible for maintenance of his or her dose ALARA. Each individual who shall enter the controlled area for the work specified on an RWP shall sign in on that RWP prior to entry and sign out upon exit.

Signature on the RWP signifies that the individual has read and fully understands the content of the RWP. This includes the nature of the hazards present and the scope of work to which that RWP is addressed. No other work may be performed under the

auspices of an RWP beyond that specifically stated on the RWP itself. Emergency and first aid response actions temporarily supercede this ruling as detailed in NES procedures RCP-6.0 and RCP-7.0 (82A8010 and 82A8011).

Upon signing the RWP, the individual is additionally responsible for entering the following information correctly onto the RWP:

- Social security number
- TLD and/or film badge number
- Time entering the area
- Pocket dosimeter reading at the time of entry
- Time leaving the area
- Pocket dosimeter reading at the time of exit
- The net exposure as recorded on the dosimeter(s)

Note: If more than one dosimeter is used, the largest net value shall be recorded.

Each individual shall be responsible for knowing the RWP number they are entered on. No individual shall enter a controlled area on more than one RWP without written permission of the cognizant RSO. An individual must sign in and out as described above each time an area is entered, even under the auspices of the same RWP. Each individual is responsible for obtaining the necessary training and/or certification needed to enter the controlled area and meet the RWP requirements as described. This includes current training and/or certification as a radiation worker, respiratory fit tests, physical examinations, and any other requirements necessitated by the restrictions of the RWP.

4. RWP USAGE

An authorized RWP normally expires 24 hours after issue. The permit may be reissued each 8-hour shift by the requesting individual, supervisor, and health physics supervisor without having additional radiological surveys performed. Should any radiological surveys be performed in the course of an 8-hour shift, the health physics supervisor is responsible for taking the latest such data into account for consideration of requirement changes.

RWPs used in the same area for the same workscope may have the same RWP number day after day. In addition, a single RWP may be used for limited work scope (inspection & supervision only) for a seven day period. These 'blanket' RWPs may be reissued in the same manner as standard RWPs.

Three copies of an RWP are generated. The original is posted at the entry to the controlled area to ensure correct worker preparation (clothing, dosimetry, etc.). The second copy is for the customer (if any). The final copy is retained by the issuing health physics supervisor and shall be transmitted to the NES Radiation Records Control Officer as required or at the termination of the project.

5. VISITOR RESTRICTIONS

Visitors to NES controlled areas are defined as all individuals other than radiation workers. Visitors are not allowed to perform any work function other than observation. Formal inspections and hands-on activities are not allowed. In addition, visitors are not allowed to enter airborne areas except under emergency conditions. Visitors shall follow the following entry requirements:

A. Sign in and out on an RWP for that area
B. Wear a film badge and carry the pocket dosimetry specified by the RWP.
C. Wear the protective clothing specified by the RWP
D. Be physically escorted by a radiation worker at all times (limit of 4 visitors per radiation worker)

nes A UNIT OF Quadrex
NUCLEAR ENERGY SERVICES

NES RADIATION WORK PERMIT

Location:	Date	RWP #

Description of Work:

Other Requirements:

- ___ welding
- ___ asbestos
- ___ system tagging
- ___ other permits

Protective Clothing Requirements

Head	Hands	Feet	Body	Respiratory
___ cloth hood	___ plastic gloves	___ clothboots	___ cloth suit	___ ½ face w/ ________
___ plastic hood	___ cotton liners	___ rubbers	___ plastic suit	___ full face ________
___ faceshield	___ heavy gloves	___ plastic boots	___ ________	___ supplied air
___ goggles		___ ________	___ ________	___ self-contained air
___ ________		___ ________		

Monitoring

- ___ pocket 0-200mr
- ___ pocket 0-500mr
- ___ pocket 0-1000 mr
- ___ pocket 0-5000 mr
- ___ TLD
- ___ film badge
- ___ extremity badges
- ___ pocket air sample

- ___ HP initiate job
- ___ HP continuous
- ___ HP intermitant
- ___ HP body exit
- ___ HP material exit
- ___ buddy system

Radiological Conditions

Location	area levels			working time	
	general area radiation	remov. contam.	hot spots	limit in minutes	basis

Area Air Levels :

HP Instructions :

Supervising Authority and Permission

shift #1 ____ to ____	shift #2 ____ to ____	shift #3 ____ to ____
Customer ________	Customer ________	Customer ________
Supervisor ________	Supervisor ________	Supervisor ________
HP Supervisor ________	HP Supervisor ________	HP Supervisor ________

RWP REQUEST FORM

I. NEW RWP

ORIGINATOR: ______________________

COMPANY: ______________________

PROJECT NO: ________ WORK STARTING ________ ________

DATE: ________ WORK ENDING ________ ________

LOCATION: ______________________

WORK DESCRIPTION:

II. RWP RENEWAL

RWP NO: ____________ REQUEST BY: ____________

WORK STARTING: ____________ ____________

WORK ENDING: ____________ ____________

CHANGES TO WORK DESCRIPTION:

RCP-9.0
RADIOLOGICAL SAMPLE SHIPMENT PROCEDURE

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

TITLE / DEPT. - SIGNATURE - DATE

REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 7/30/84	J. Mezo 8/13/84	J May 10/29/84		
1	CJ Marino 2/25/85	J. Mezo 3/1/85	J May 3/14/85		
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REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 82A8013

REV. NO.	DATE	PAGE NO.	DESCRIPTION	APPROVAL
1	3/14/85	-	all pages noted with triangle blocks per CRA # 5169	

RCP - 9.0

RADIOLOGICAL SAMPLE SHIPMENT PROCEDURE

1. SCOPE

The objective of this procedure is to set forth measures to control the packaging and shipping of radioactive or potentially radioactive samples.

2. GENERAL

This procedure must be used to prevent violation of federal regulations and limitations.

3. RESPONSIBILITIES

3.1 PROJECT RADIATION SAFETY OFFICER

Review plans for sample shipment. Assure that complete documentation is kept on each sample and each shipment in the project file. All documentation shall be submitted to the Radiation Records Control Officer for storage. Perform audits to assure compliance with this procedure.

3.2 PROJECT MANAGER/HEALTH PHYSICS SUPERVISOR

Responsible for the execution of this procedure and the completion and storage in the calculation notebook of all appropriate shipping papers and records.

4. REQUIREMENTS

4.1 EXEMPT QUANTITIES

Samples of radioactive material which have an activity less than or equal to 0.002 microcuries/gram are exempt from D.O.T. regulations of transport. 1

Samples defined as per 49 CFR 173.421 as "limited quantity" are exempt from the requirements of that subpart and from the specification packaging, shipping paper and certification, marking, and labeling requirements of that subchapter if they meet the requirements stated therein. These requirements include:

- a. transport in strong-tight packages that will not leak any of the contents during conditions normal to transportation
- b. radiation level < 0.5 millirem/hr at all exterior points
- c. removable contamination < 49 CFR 173.443 (a) limits
- d. the outside of the innerpackage (on the outside of the package if no inner package exists) shall be marked "Radioactive"
- e. quantity < 15 grams U-235 (except as per 49 CFR 173.424)
- f. meets all additional requirements of 49 CFR 173.421-1

Samples are exempt from licensing requirements to the extent specified in 10 CFR 30.14 if concentrations are less than those specified in 10 CFR 30.18.

4.2 GREATER THAN EXEMPT QUANTITIES

Quantities of radioactive material in excess of the DOT limitations of Section 4.1 of this procedure, shall be packaged and shipped in accordance with RCP-5.0, "Guidelines for Radioactive Waste Disposal". Materials in excess of the exempt criteria of 10 CFR 30.18 shall be packaged in accordance with 10 CFR 30.41.

reference to 10 CFR
30.14 + 30.18
all screwed up.

NUCLEAR ENERGY SERVICES, INC. DOCUMENT NO. 82A8014 REV. 1

A UNIT OF QUALCORP

RCP-10.0

AIRBORNE SAFETY ASSURANCE PROGRAM

Project Application	Copy No	Assigned To
8561-220		

APPROVALS

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REV NO	PREPARED BY	Project Manager	Radiation Safety Officer		
0	C.J. Marino 8/8/84	[signature] 8/27/84	[signature] 11/29/84		
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REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

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RCP-10.0
AIRBORNE SAFETY ASSURANCE PROGRAM

1. SCOPE

The NES Airborne Safety Assurance Program has been established to provide protection to NES employees and contracted personnel against airborne hazards and to provide the basis of all training and recordkeeping necessary to ensure that safety.

2. GENERAL

The following program is excerpted from the corporate Occupational Health Manual, Section 17. This program is in compliance with the requirements of the federal Occupational Health and Safety Administration (OSHA) and incorporates the guidelines of the American Nuclear Standards Institute ANSI-Z88.2. Exposures of workers to airborne radioactive materials in restricted areas shall follow the guidelines of Regulatory Guide 8.15.

3. RESPIRATORY PROTECTION PROGRAM

3.1 RESPIRATORY PROTECTION REQUIREMENTS

The Occupational Safety and Health Administration has set maximum exposure standards for many airborne toxic materials. If employee exposure to these substances exceeds the standard, federal law requires that feasible engineering controls and/or administrative controls be installed or instituted to reduce employee exposure to acceptable levels. If these controls do not prove feasible, or while they are being installed/instituted, NES shall provide appropriate respiratory protection for the employee.

Respiratory protection is also necessary for routine but infrequent operations, non-routine operations in which the employee is exposed briefly to high concentrations of a hazardous substance, e.g., during maintenance or repair activities, or during emergency conditions.

3.2 RESPIRATORY PROTECTION PROGRAM

Providing respiratory protective equipment to the employee, however, is only one aspect of NES' responsibility pertaining to the use of respiratory protective equipment as a control measure. A respiratory protection program must be implemented.

3.3 RESPIRATORY PROTECTIVE EQUIPMENT SELECTION

Respirator selection is critical to an effective program. The proper selection of respiratory protective equipment involves three basic steps:

1. The identification of the hazard

2. The evaluation of the hazard

3. The selection of the appropriate approved respiratory equipment based on the first two considerations.

3.4 IDENTIFICATION AND EVALUATION OF THE HAZARD

Identification and evaluation of the hazard forms the basis for a decision on the need for the respiratory program. If a survey of operations and work environments indicates that no employees are being exposed to containment concentrations exceeding established limits (OSHA standards) then a respirator program is not required. In-house evaluation with an industrial hygiene survey may have indicated the need for respiratory protection equipment. This applies to both radiological and non-radiological hazards.

A walk-through survey of the worksite to identify processes, or worker environments where respirators may be required, is the next step in the respirator selection process.

3.5 APPROVED RESPIRATORY PROTECTIVE EQUIPMENT

When purchasing respiratory protective equipment, be sure to purchase approved equipment for the particular containment. An approved respirator is one that has been tested and found to meet minimum performance standards by the Mine Safety and Health Administration and the National Institute for Occupational Safety and Health (NIOSH).

A NIOSH approved respirator contains the following:

1. An assigned identification number placed on each unit, e.g., TC-21C-101.

2. A label identifying the type of hazard the respirator is approved to protect against.

3. Additional information on the label which indicates limitations and identifies the component parts for use with the basic unit.

3.6 ISSUANCE OF RESPIRATORY PROTECTIVE EQUIPMENT

Where practical, the user should be given respiratory protective equipment for his/her exclusive use. A record of issuance shall be maintained. Any respirator permanently assigned to an individual should be permanently marked to indicate to whom it was assigned. △

3.7 FITTING OF RESPIRATORY PROTECTIVE EQUIPMENT

It is essential that respiratory protective equipment be properly fitted to the employee when it is issued. For that reason, NES shall provide several respirators to choose from. △

There are two types of fitting tests - qualitative and quantitative tests. Qualitative tests are fast, usually simple, but not as accurate an indicator of improper fit as the quantitative test. The quantitative test requires testing equipment, setup and a specially trained operator.

Two qualitative fit tests, the positive pressure fit test and the negative pressure fit test, can be used as a quick check of the fit of the respirator facepiece before beginning or during work in the hazardous atmosphere. These tests would apply only to air-purifying respirators.

Facial hair lying between the sealing surface of a respirator facepiece and the wearer's skin will prevent a good seal. Beards and sideburns can prevent satisfactory sealing and shall be removed prior to respirator use. The negative pressure developed in the facepiece of non-powered air-purifying respirators during inhalation can lead to leakage of contaminants into the facepiece when there is a poor seal. Individuals who have stubble - even a few days' growth may permit excessive leakage of containment, - a moustache, sideburns, or a beard that passes between the skin and the sealing surface shall not wear a respirator.

Industrial safety glasses may cause a fitting problem, if the temples pass through the facepiece to face seal.

Contact lenses shall not be worn while wearing a respirator, especially in a highly contaminated atmosphere. A properly fitted respirator (primarily a full facepiece respirator) may stretch the skin around the eyes, thus increasing the possibility that the contact lens will fall out. Contaminants also penetrate the respirator clouding soft lenses and may cause severe discomfort.

3.8 MAINTENANCE OF RESPIRATORY PROTECTIVE EQUIPMENT

On-going maintenance of respiratory protective equipment is an important part of the program. Wearing poorly maintained or malfunctioning equipment may be as dangerous as not wearing a respirator.

While OSHA places a strong emphasis on the importance of an adequate maintenance program, it does permit the tailoring of the maintenance program to the type of plant and hazards involved. All maintenance programs should

follow manufacturer's instructions and should include provisions for:

Cleaning and disinfecting of equipment
Storage
Inspection for defects, and
Repair

Cleaning and disinfecting -

When respirators are used daily for several hours, they should be cleaned and disinfected daily. When they are used occasionally, periodic cleaning and disinfecting is appropriate. Individual workers who maintain their own respirator should be trained in the cleaning of respirators.

Respirators should be washed in a detergent containing a bactericide. To prevent dermatitis, the respirators should be rinsed thoroughly in clean water. Dry on an open rack.

Storage -

After cleaning and drying the respirator, it should be placed in a resealable plastic bag. A wall-mounted cabinet or an employees locker shelf is appropriate for storing when not in use.

Repair -

Replacement of parts and repair of air-purifying respirators should, in most cases, present little problem. Replacement parts must be those of the manufacturer of the equipment and repairs made by qualified individuals.

NOTE: REGULATIONS REQUIRE SELF-CONTAINED BREATHING APPARATUS EQUIPMENT BE RETURNED TO THE MANUFACTURER FOR ADJUSTMENT OR REPAIR.

Inspection -

An important part of a respirator maintenance program is the inspection of the devices. If performed carefully, inspections will identify damaged or malfunctioning repairs.

All respiratory protective equipment must be inspected -

before and after each use; and
during cleaning

Equipment designated for emergency use must be inspected -

after each use

during cleaning; and

at least monthly.

3.9 RECORDKEEPING-INSPECTION

A record must be kept of inspection dates and findings for respirators maintained for emergency use.

Listed below are some of the primary defects to look for in inspection of the components of the respirator. When appropriate, information within the parentheses are suggested actions to be taken.

1. Disposable respirator-check for:

   - holes in the air filter (obtain new disposable respirator)

   - straps for elasticity and deterioration (obtain new disposable respirator)

2. Air-purifying respirators

Rubber facepiece-check for:

- excessive dirt (clean all dirt from facepiece)
- cracks, tears or holes (obtain new facepiece)
- distortion (allow facepiece to "sit", free from any constraints and see if distortion disappears; if not, obtain new facepiece)

Headstraps-check for:

- breaks or tears (replace headstraps)
- loss of elasticity (replace headstraps)
- broken or malfunctioning buckles or attachments (obtain new parts)

Inhalation valve, exhalation valve-check for:

- detergent residue, dust particles, or dirt on valve (clean residue with soap and water)
- missing, damaged or defective valve cover (obtain valve cover from manufacturer)

Filter element(s)-check for:

- proper filter for the hazard
- approval designation
- missing or worn gaskets (order replacement)

- worn threads (replace filter or facepiece, whichever is applicable)

- cracks or dents in filter housing (replace filter)

4. RESPIRATORY PROTECTION EVALUATION

Two important aspects of the respirator program are the periodic surveillance of the work areas requiring usage of respirators, and an evaluation of the overall respirator program for effectiveness.

Many things such as changes in operation or process, implementation of engineering controls, temperature, and air movement can affect the concentration of the substance(s) which originally required the use of respirators. To determine the continued necessity of respiratory protection or need for additional protection, measurements of the contaminant concentration should be made whenever the above changes are made or detected. A record of these measurements shall be kept.

The following are questions to be answered by the Radiological Safety Committee (RSC) when the program is evaluated, at least annually - or when changes are made in its implementation.

1. Is program responsibility vested in one individual who is knowledgeable and who can coordinate all aspects of the program?

2. What is the present status of the implementation of engineering controls, if feasible, to alleviate the need of respirators.

3. Are there written procedures covering the various aspects of the respirator program?

4. Are work area conditions and employee exposures properly surveyed?

5. Are respirators selected on the basis of hazards to which the employee is exposed?

6. Are selections made by individuals knowledgeable of selection procedures?

7. Are only approved respirators purchased and used and do they provide adequate protection for the specific hazard and concentration of the contaminant?

8. Has a medical evaluation of the prospective user been made to determine ability to wear respiratory protective equipment?

9. Have respirators been issued to the users for their exclusive use, and are there records covering issuance?

10. Is the best fitting respirator issued?

11. Is the fit tested at frequent intervals?

12. Are those users who require corrective glasses properly fitted?

13. Are users prohibited from wearing contact lenses when using respirators?

14. Are respirators cleaned and disinfected after each use or as frequently as needed?

15. Are proper methods of cleaning and disinfecting utilized?

16. Are respirators stored properly?

17. Are respirators inspected before and after each use and during cleaning?

18. Are qualified individuals/users instructed in inspection techniques?

19. Is replacement or repair only done by experienced persons with parts designed for the respirator?

20. Are workers trained in proper respirators usage and care?

4.1 MEDICAL PROGRAM FOR RESPIRATOR USER

So that the examining physician can render a qualified opinion regarding respirator usage by an employee, the physician, initially, should be given the following information:

- Type of equipment to be used
- Tasks that the employee will perform while wearing the respirator
- Length of time the user will wear the equipment
- Substance to which the employee will be exposed

The following medical tests should be considered by the examining physician in the evaluation:

- Pulmonary function test
- Chest X-ray
- Eye test
- General physical examination
- Electrocardiogram
- Blood tests
- Medical tests specific to the substance to which the employee will be exposed.

4.2 MEDICAL FACTORS

Medical factors to be considered by the examining physician in determining

the prospective user's ability to wear a respirator are:

- Emphysema
- Asthma
- Chronic bronchitis
- Heart disease
- Deep facial scars
- Poor eyesight or hearing
- Lack of use of fingers or hands
- Claustrophobia
- Lack of teeth or dentures

4.3 THE FITTING OF RESPIRATORS

For safe use of any respiratory protective device, it is essential that the user be properly instructed in its use. Supervisors as well as workers must be so instructed by competent persons.

OSHA requires that all employees be trained in the proper use of the device assigned to them.

Each respirator wearer should be given training which would include:

a. an explanation of the respiratory hazard and what happens if the respirator is not used properly

b. a discussion of what engineering and administrative controls are being used and why respirators still are needed for protection

c. an explanation of why a particular type of respirator has been selected

d. a discussion of the function, capabilities, and limitations of the selected respirator

e. instruction in how to don the respirator and to check its fit and operation

f. instruction in the proper wearing of the respirator

g. instruction in respirator maintenance

h. instruction in recognizing and handling emergency situations

Supervisory personnel should periodically monitor the use of respirators to insure that they are worn and maintained properly.

The employee using the respirator tests it for fit each time it is put on. The respirator fit can be checked by one of the following methods: 4

- Positive Pressure Test:

Close the exhalation valve and gently exhale into the facepiece. The facepiece fir is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators, this method of leak testing requires that the wearer first remove the exhalation valve cover and then carefully replace it after the test.

- Negative Pressure Test:

Close off the inlet opening of the canister or cartridge(s) by covering with the palm of the hand(s) or by replacing the seal(s). Inhale gently so that the facepiece remains in its slightly collapsed condition and if no inward leakage of air is detected, the fit of the respirator is considered satisfactory.

- Stannic Chloride Smoke Test:

The most frequently used qualitative fit test is the irritant smoke test. An irritant smoke tube (glass tube 12cm long by 1cm diameter, filled with stannic chloride-impregnated pumice) is used to produce a very irritating smoke when air is blown through the tube. The smoke is directed at the facepiece seal and leakage is indicated by irritation of the throat and lungs. If the respirator does not fit properly, the irritating "smoke" will be inhaled and the wearer will cough or sneeze involuntarily. The fact that the fit test is measured by an involuntary reaction on the part of the wearer makes this test more acceptable.

To carry out this test in a "controlled" condition a large plastic bag can be hung from the ceiling and the wearer can step under it. The respirator wearer should close his eyes during the fit test. Light puffs of smoke can be introduced into the top and side of the plastic bag away from the wearer's face. If there is no evidence of leakage, the smoke tube should be held closer to the wearer's face and smoke density increased. Any time leakage is detected, the tester should stop and the wearer should adjust the facepiece and head straps of the respirator. NOTE: Only 3 or 4 puffs of "smoke" are required. CHARCOAL FILTERS must be used on the respirator for this test.

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A UNIT OF QUALCORP

RCP-11.0

GUIDELINES FOR FACILITY DECONTAMINATION

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0	C.J. Marino 8/2/84	J. Thef 8/29/84	J. May 10/29/84		
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FORM # NES 204 3/84

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RCP-11.0
GUIDELINES FOR FACILITY DECONTAMINATION

1. SCOPE

The object of this procedure is to provide guidelines for the decontamination of equipment and facility structures. This guidance shall include proper sequencing of work activities, accepted methods and chemicals, and release criteria for the termination of decon activies.

2. SEQUENCING AND PROCESS SELECTION

Each project requires a decontamination plan specific to that effort. The factors to be considered by the Task Engineer prior to proceeding further in this procedure are listed for reminder in Table 1.

The logic for process selection has been outlined by W. Manion in "Decontamination Methods as Related to Decommissioning of Nuclear Facilities", 9/80. Major elements of the logic network used are:

A. thorough knowledge of the nature of the contamination.

B. cost/benefit analysis of the processes employed.

C. laboratory verification or field data for the processes.

A schematic of the total effort involved in such tasks is presented in Figure 1. A general guideline for all programs is presented below for tailoring to the specific project at hand. For our purposes, internal piping contamination shall be ignored as this subject is presented in detail elsewhere and is even more severely dependent upon the nature and operation of the facility in question than general area contamination as treated herein.

3. AREA DECONTAMINATION

Proceed with decontamination of the following items in the following order.

Application:
1. Roofs
2. Ceilings
3. External Pipe Surfaces
4. External Large Equipment Surfaces (>10 ft^2)
5. Walls
6. Floors

Sequence:
1. Portable Source Removal and Survey
2. Vacuum Loose Debris and Survey
3. Industrial Detergent Wash and Survey
4a. Paint Stripping and Survey
4b. Material Etching and Survey
5. Surface Scarifying
6. Gross Removal

The sequence should be employed under the following guidelines.

a. Proceed from method 1-6 in order until release criteria are met.
b. Omit those steps which knowledge of the contamination will indicate are superfluous.

A running log of operations shall be kept and include all pertinant information (manhours, exchanges, surface description) needed to determine the efficiency of the selected approach.

4. EQUIPMENT DECONTAMINATION

A detailed analysis of individual solvents and processes is presented in Shippingport Engineering Study 12.3, 1982. The following methods are applicable to equipment decontamination, beginning with less destructive methods.

		Relative Cost
Hand Wash with Nylon Brush	Smearable	Low
Hand Abrasion with Wire Brush	Smearable	Low
Ultrasonic Agitation	Smearable	Moderate
Vibratory Agitation	Smearable	Moderate
Electric Driven Wire Brush	Fixed	Low
Hydrolance	Smearable	Moderate
Acid Etching	Fixed	Moderate
Freon Cleaning	Smearable	Moderate
Electropolishing	Fixed (Conducting Metal Only	High
Vacuum/Blasting	Fixed	High

All the above methods are generally improved when use is made of either intermittent soaking in solvents, elevated temperatures, or both. A listing of recommended solvents and reagents is presented in Table 2. It should be emphasized that these are surface decontamination techniques and are of no use for removing internal activation products.

NES shall prepare and implement work procedures for equipment decontamination activities. These specific procedures shall address all of the following items as requirements. △

1. Disposal:

   Materials used to decon must be disposed of as radioactive waste. Minimize such waste without causing further spread of contamination by using all surfaces of cleaning clothes, changing surfaces often and use very little water and detergent in cleaning.

2. Isolation:

Areas where equipment is to be decontaminated shall be roped off as controlled surface contamination areas to prevent or minimize tracking.

3. Limit Spread of Contamination:

Washing from low activity into high activity areas, perform frequent glove and clothes changes, take care not to splash solutions and wear anti-C clothing and air-fed hood when necessary. These requirements will limit the spread of contamination to surrounding areas and to personnel.

4. Ventilation:

During decon operations, Hepa filtered exhaust ventilation shall be required to minimize the airborne particulate activity, in the immediate area and to the outside environment.

5. Vacuum Cleaners:

Use of vacuum cleaners employing high efficiency filters, shall be required when contamination levels are high and the decon area/spot is dry.

5. RELEASE CRITERIA

Specific projects or facilities may have definitive release criteria, in terms of radiation and contamination levels, specified by the licensee, the NRC, or other entity. Criteria for "unrestricted release" at facilities under NRC domain shall use the values and approach specified in "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use," 6/82 NRC/DFCMS, or as otherwise required by the NRC as illustrated in Table 3.

TABLE I

FACTORS INFLUENCING SELECTION OF A DECONTAMINATION PROCESS

System Related

1. Required degree of decontamination
2. Material type and geometry
3. Contamination characteristics (in-situ chemical and mechanical properties and extent of contamination)
4. Plant operating history

Solvent Related

1. Corrosion effect (if pertinent)
2. Decontamination effectiveness (DF)
3. Solvent stability
4. Fluid volume generated (single or multiple stage process)
5. Waste processing requirements (liquid, solid and airborne)
6. Process duration
7. Redistribution of contaminants
8. Process cost, including waste processing

Application Related

1. Methods of application (chemical addition to coolant or complete solvent addition; recirculation or soak)
2. Process temperature
3. Occupational exposure due to method
4. Industrial safety
5. Impact on system integrity during use
6. Use of existing waste processing facility or need for new facility
7. Impact of effluent releases on general public and environment

FIGURE 1

DECONTAMINATION AT DECOMMISSIONING -
PROGRAM EVALUATION LOGIC NETWORK

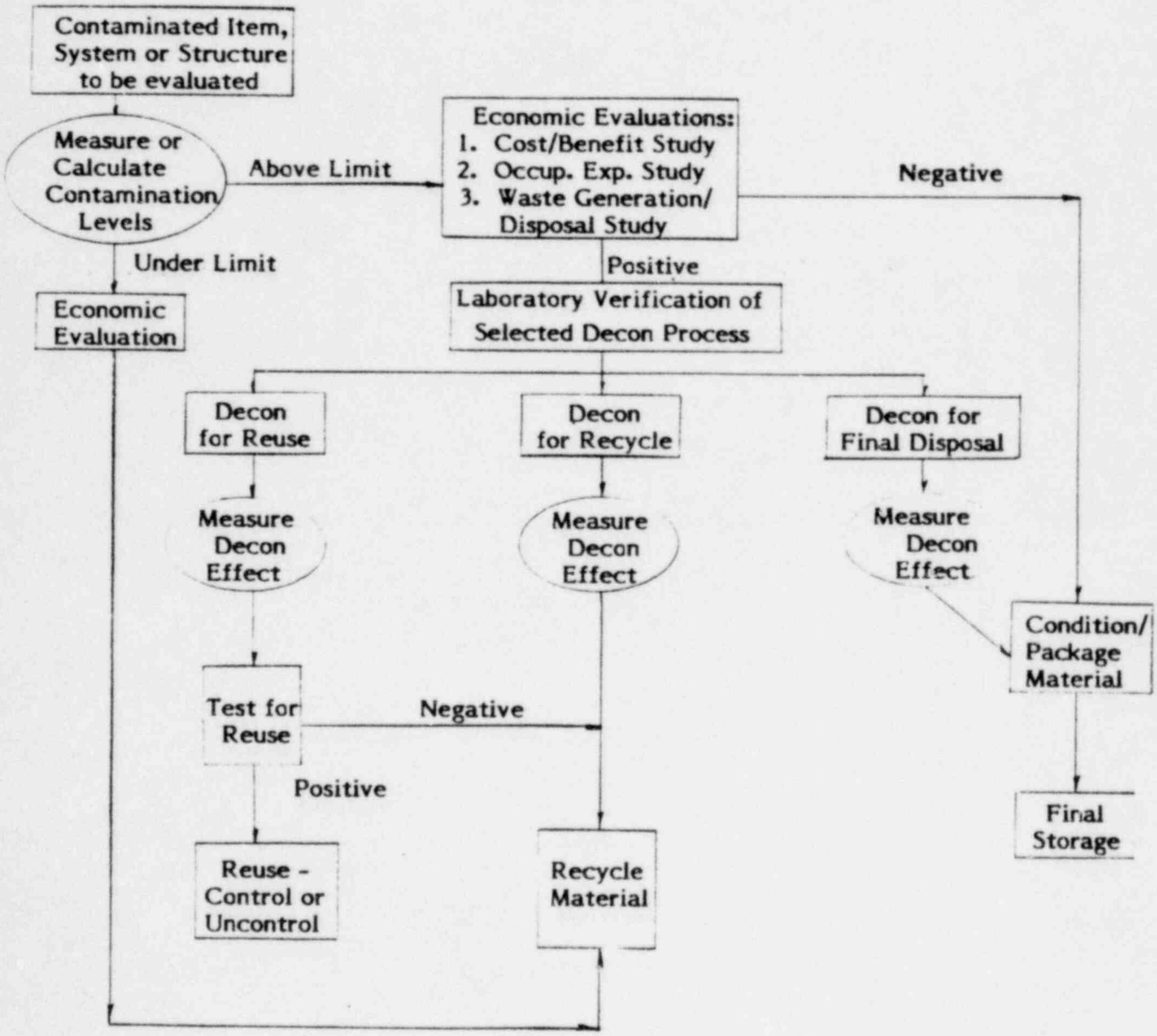

TABLE 2

SOLVENTS AND REAGENTS

ITEM	APPLICATION
NUTEK -600EL	Loose contamination, 6.25% solution
-315	100% solution
-316	100% solution
-700	25% solution
Amway-Industroclean	Loose contamination, soak or brush
-3D	Concrete surfaces, soak or brush
Turco-4324NP	Loose contamination, 2% soln, mop or steam cleaner
NUTEK-69B	Semi-fixed, 20% soln, soak or brush
Turco-4306D	Semi-fixed, spread on wedded surface
Turco -6017 -5873 -5351	Epoxy stripper, squeege or sponge mop
Concresive 6003	Epoxy stripper, squeege or sponge mop
Ferratone	Metal/rust etching; apply gel directly or dilute in water
Radiacwash	Loose contamination (industrial strength type), clothing
NUTEK-N118	Internal piping surfaces, soak at elevated temperatures
Turco-4521/4502	Internal piping; multiple rinses at elevated temperature
Nitric Acid	20%-60% solution (380-1, 140gm/l) soak for fixed contamination etching
Alara 1146DECON	Strippable coating for protection
Zip-Strip	Paint stripping gel, soak and brush
Muriatic Acid	Concrete etching & dissolving, soak and brush

TABLE 3

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[b c]	MAXIMUM[b d]	REMOVABLE[b e]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Pa-226, Pa-228, Ra-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous emission) except Sr-90 and others noted above.	5,000 dpm βγ/100 cm^2	15,000 dpm βγ/100 cm^2	1,000 dpm βγ/100 cm^2

A.
Where surface contamination by both alpha-and beta-gamma-emitting nuclides exists, the limits established for alpha-and beta-gamma-emitting nuclides should apply independently.

B.
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 observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

C.
Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

D.
The maximum contamination level applies to an area of not more than 100 cm^2.

E.
The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

RCP - 13.0

RECEIPT AND HANDLING OF RADIOACTIVE MATERIALS (RAM) PACKAGES

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APPROVALS

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0	C.J. Marino 2/19/85	[signature] 2/27/85	[signature] 3/12/85		
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NES
A UNIT OF QUADREX

REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

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RCP - 13.0

RECEIPT AND HANDLING OF RADIOACTIVE MATERIALS (RAM) PACKAGES

1. PURPOSE

The objective of this procedure is to set forth measures and guidelines to control the receipt and handling of packages containing radioactive materials at NES' facilities or at temporary job sites covered by the NES By-Product Materials License(s).

2. SCOPE

The activities covered by this procedure are:

- Receipt and acceptance of RAM packages
- Storage of RAM packages
- Opening of RAM packages.

3. RESPONSIBILITIES

3.1 RADIATION SAFETY OFFICER

The NES Radiation Safety Officer (RSO) is the only individual responsible and authorized for the acceptance and disposition of any RAM package(s) shipped to an NES facility or NES temporary job site. The RSO's primary responsibility is to maintain full compliance with the NES By-Product Material License(s) for all the activities described in Section 2 of this document.

In addition, the RSO shall assure that complete documentation and duplication of records are kept for each incoming RAM shipment, its contents and its disposition.

3.2 RADIATION RECORDS CONTROL OFFICER

The NES Radiation Records Control Officer (RRCO) is responsible for the possession and safekeeping of all records associated with the acceptance and handling of RAM shipments.

3.3 SITE MANAGER

The NES Site Manager is responsible for the implementation of this procedure. He will supervise the activities within the scope of this procedure and will follow the radiological controls and health physics practices stated by the RSO. The RSO or his designee shall provide health physics coverage to the Site Manager and his personnel during the handling of RAM packages.

4. REQUIREMENTS

4.1 RECEIPT AND ACCEPTANCE OF RAM SHIPMENTS

4.1.1 Advance Notification

The NES RSO shall be notified seventy-two hours in advance of any incoming RAM shipment to an NES facility or temporary job site by the shipper. The information to be supplied to the RSO may be transmitted by telephone communication but written confirmation shall be received by the RSO prior to the arrival of the RAM shipment.

The data contained in the Advance Notification shall be as a minimum:

- Name, location and telephone number of the shipper
- RAM license number of the shipper
- Name of the carrier
- Time of arrival (estimated) of NES facility
- Type of shipment

- Physical description of packages and contents
- Radiological data of packages and contents
- Total amount of radioactive isotopes and concentrations
- Assurance by the shipper of compliance with applicable DOT and NRC regulations.

4.1.2 Conditional Acceptance

A Conditional Acceptance for the incoming RAM shipment may be granted to the shipper by the NES RSO after review and evaluation of the data stated in Section 4.1.1 of this document.

The Conditional Acceptance will be given to a shipper no later than twenty-four hours after receipt of the Advance Notification by the RSO. The information contained in the conditional acceptance will be:

- Copy of the NES By-Product Materials License
- Name, location and telephone number of the NES facility
- Condition(s) to be met for final acceptance of the RAM shipment (i.e., confirmation of the data supplied in the advance notification upon arrival of the shipment).

In addition the RSO will send copies of the Advance Notification and Conditional Acceptance to the NES Site Manager and the RRCO.

4.1.3 Site Preparation

The NES Site Manager upon notification by the RSO of the incoming RAM shipment will make arrangements for the off-loading and immediate storage of the RAM packages. Site Health Physics personnel shall be prepared to perform the required radiological surveys upon arrival of the RAM shipment

4.2 STORAGE OF RAM PACKAGES

4.2.1 Designation of Storage Area

A RAM storage area will be designated prior to the arrival of the RAM shipment. The RSO or his designee shall inspect the planned storage area and if accepted they will set the proper radiological controls taking into consideration the disposition of the RAM packages.

4.2.2 Storage Documentation of RAM Packages

An entry number will be prepared for the incoming shipment in the RAM Storage Log Book. A copy of the Advance Notification shall be part of the record. All movements of RAM shall be recorded in the log book.

4.3 OPENING OF RAM PACKAGES

The following requirements shall be complied with prior to the opening of any RAM package.

- Designation of a controlled working area
- For NES transport casks (empty), the NES Site Manager shall have in his possession the required handling and maintenance procedures
- Health Physics personnel shall have proper data of the internal contamination of the container (if an NES cask) and/or the contents (if a container with contaminated equipment)
- Health Physics personnel shall issue a Radiation Work Permit in accordance with Document 82A8012
- Health Physics personnel shall institute radiological controls in the working area

- Health Physics personnel shall provide coverage to all decon workers
- Work procedures have been approved and are available to work supervisors and Health Physics personnel
- Required tools and spare parts (if applicable) are in the working area
- All required support systems and services are installed (i.e., compressed air, temporary lights, electrical ground connections, etc.)
- All NES decon/maintenance personnel have been briefed on the workscope and on the existing radiological conditions/controls
- All personnel involved with opening of RAM packages have satisfied the requirements of Document 82A8006.

5. PROCEDURE

5.1 RECEIPT AND ACCEPTANCE OF RAM PACKAGES

Upon arrival of the RAM shipment to an NES facility, the following step by step evaluation shall be performed:

1. Loaded vehicle shall be parked outside the off-loading area.
2. Carrier's driver shall submit the following documentation to the NES Site Manager (or his designee):
   - Straight Bill of Lading
   - RAM Shipment Manifest

- Entry Radiological Survey of the vehicle (shipper's location)

- Exit Radiological survey of the load and vehicle (shipper's location)

- Special instructions (if applicable).

3. NES shall compare the data submitted by the driver (5.1.1.2) with the data previously submitted in Section 4.1.1 - Advance Notification.

   Technical Note 1: If there is an agreement between the two sets of data, proceed to Step 6 below.

   Technical Note 2: If there is a disagreement between the two sets of data, proceed to Step 4 below.

4. The NES RSO shall contact the shipper and resolve any discrepancies and non-conformances. The outcome of this communication will be for NES site personnel to proceed with Step 6 below or with Step 5 below.

5. The RAM shipment is not accepted. All documentation submitted by the carrier's driver shall be returned to him. Proper records shall be kept of this evaluation.

6. NES' Health Physics personnel shall perform the following radiological surveys of the load and vehicle. Use the NES VEHICLE SURVEY FORM (Figure 5-1).

   NOTE: Mark with (x) - Survey Type: ENTRY

   - Contact readings of the vehicle

   - Contact readings of the RAM packages

   - Take and count smears of the surfaces of the vehicle and RAM packages.

CAUTION: a) Contact readings of RAM package(s) in excess of 200 mrem/hour shall be notified to the NES RSO.

b) Smear counts in excess of
$2.2\ dpm/cm^2$ ($\beta.\gamma$)
and/or $2.2\ dpm/cm^2$ (α)
Shall be notified to the NES RSO. The NES RSO shall take proper measures and actions if any of a) and/or b) occurs. Site personnel shall stop implementing this procedure and shall await directions from the RSO.

7. Health Physics personnel have determined from data gathered in Step 6 (above) that the load and vehicle represent no radiological hazard to the NES site personnel.

8. The NES Site Manager or his designee shall inspect the RAM packages for:

   - Damage and/or leakage
   - Proper DOT labels
   - Integrity of external seals (if applicable)

   Any non-conformance resulting from this inspection shall be notified to the NES RSO. NES site personnel shall not proceed with this procedure until directions form the RSO have been received.

9. The NES Site Manager or his designee shall proceed to unload the vehicle only after Step 8 has been satisfied.

10. NES site personnel shall properly rig and lift off the vehicle's RAM packages.

11. RAM packages shall be immediately placed in the storage area (previously designated).

12. Health Physics personnel shall perform an exit survey of the off-loaded vehicle.

13. The NES Site Manager or his designee shall release the off-loaded vehicle and shall provide the following documentation to the driver:

    - Signed Straight Bill of Lading (as co-signee)
    - Entry and Exit Vehicle Survey Forms.

14. The NES Site Manager shall document the records of the above evaluations in the RAM Storage Log Book.

5.2 STORAGE OF RAM PACKAGES

NES site personnel shall perform the following step by step activities in the RAM storage area, upon placement of a RAM package:

1. The NES Site Manager or his designee shall supervise that the RAM package(s) is carefully placed in the designated area.

2. NES personnel shall remove all DOT labels and markings.

3. Health Physics personnel shall place new tags and signs. As a minimum the following signs and information shall appear on the surface of the RAM package(s):

    - Radioactive Materials signs/labels

    - Control tag(s) stating:
      - assigned entry number
      - contact surface dose readings
      - description of contents
      - disposition instructions

4. The NES Site Manager or his designee shall inspect the RAM Storage Log Book's entry for the RAM package just placed in the storage area. All proper records and documentation shall appear in the particular entry.

5.3 OPENING OF RAM PACKAGES

The following step by step operations shall be performed whenever a RAM package is to be opened:

1. All the requirements stated in Section 4.3 of this document have been satisfied.

2. Survey and record results of all tools and equipment before they are placed in the controlled working area.

3. Perform work activities in accordance with the approved Work Procedure(s) and in compliance with the issued Radiation Work Permit (RWP).

   - Radwaste generated by the decon/maintenance activities shall be properly surveyed, segregated, packaged, and disposed of (see Document 82A8009).

   - Upon completion of the work activities all tools and equipment shall be surveyed for determination of contamination. Decon as necessary.

   - All NES personnel entering the controlled working area shall frisk and survey themselves and/or be surveyed by Health Physics personnel.

   - Upon termination of the work activities, Health Physics personnel shall survey the working area and if no violations are found the RWP shall be terminated.

CAUTION: Health Physics personnel shall notify the NES Site Manager of violations found in the working area.

NOTE: The RWP shall not be terminated until Health Physics personnel are satisfied that no radiological hazards are present in the working area.

- The NES Site Manager or his designee will properly document the work activities, results, findings and disposition of the opened RAM package.

- The RSO shall be kept informed of the handling activities of RAM packages at any NES facility or temporary job site.