2
-12-74

Dr-898

LA-5645

UC-70

Reporting Date: June 1974

Issued: June 1974

Guidelines for the Interim Storage of AEC-Generated Solid Transuranic Wastes

by

H-Division Staff
Environmental Studies Group
Waste Management Section

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

MASTER

UNITED STATES
ATOMIC ENERGY COMMISSION
CONTRACT W-7405-ENG. 36
DISTRIBUTION OF THIS REPORT IS UNLIMITED

Work supported by the USAEC Division of Waste Management and Transportation.

**Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy \$5.45 Microfiche \$1.45**

CONTENTS

I.	INTRODUCTION	1
II.	BACKGROUND	2
III.	ASSUMPTIONS	3
IV.	DEFINITIONS	3
V.	SUMMARY OF GUIDELINES	6
VI.	DISCUSSION OF GUIDELINES	8
A.	Establishment of Specifications for Package Materials and Package Construction	8
B.	Package Integrity	9
1.	Control of Internal Degradation	9
2.	Control of External Degradation	10
3.	Package Closure	12
C.	Exclusions from Waste Content	14
1.	Minimization of Volumes	14
2.	Combustible Materials	14
3.	Pyrophoric or Explosive Materials	15
4.	Spontaneous Combustion	16
5.	Toxic Chemicals	17
6.	Free Liquids	17
D.	Transuranic Content	18
1.	Minimization of Quantities	18
2.	Criticality	19
3.	Nuclear Heating	21
4.	Higher Contamination Levels	22
E.	Quality Control	23
1.	Packaging Materials	23
2.	Final Package	24
F.	Fire Control	25
1.	Fire Propagation	25
2.	Combustible Materials in Storage Facility	26
3.	Firebreaks	27
4.	Provisions for Firefighting	28
G.	Package Handling	28

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process shown, believed, or represented that its use would not infringe privately owned rights.

MASTER

17

1. Damage to Packages	28
2. Handling Methods	29
3. Control of Transport and Storage Environment	30
4. Radiation Dose Rate and Contamination	31
H. Storage Site Selection and Facility Design	32
1. Location - Protection of the Environment	32
2. Secondary Barriers	34
3. Control of Access	35
4. Flammable Gases	35
I. Storage Facility Operation	36
1. Operational Procedures	36
2. Monitoring	36
3. Acceptance of Packages	38
J. Records and Package Labeling	38
APPENDIX A: IMMEDIATE ACTION DIRECTIVE 0511-21	43
APPENDIX B: AEC MANUAL CHAPTER 0511	45
APPENDIX C: IMMEDIATE ACTION DIRECTIVE 7401-19	54

GUIDELINES FOR THE INTERIM STORAGE
OF
AEC-GENERATED SOLID TRANSURANIC WASTES

ABSTRACT

Guidelines have been developed to provide a basis against which to judge the adequacy of techniques and methods for the retrievable storage of AEC-generated transuranic-contaminated solid wastes. These guidelines apply to operations for packaging, handling, and storage of such wastes. Each guideline has been fully discussed with emphasis on the reasoning behind the guideline statement, problems that should be considered in developing a storage facility, and methods currently in use at AEC installations.

I. INTRODUCTION

The General Manager of the Atomic Energy Commission (AEC) issued an Immediate Action Directive (IAD 0511-21, see Appendix A) on March 20, 1970, requiring that wastes with known or detectable contamination of transuranic elements be segregated, packaged, and buried in such a fashion that they could be readily retrievable as contamination-free packages within an interim period of 20 years. The directive also specified that retrievability should continue to be possible beyond the 20-year period. The term "known or detectable contamination" was not defined, although a footnote referred to what could be detected by external measurements. The Directive acknowledged the need for instrumentation development to improve the lower limits of detection for plutonium compatible with the Directive requirements. The AEC Manual Chapter 0511 (AECM 0511), dated September 19, 1973, uses a lower limit for retrievable storage of ten nanocuries per gram (10 nCi/g) (see Appendix B).

While IAD 0511-21 refers to earth burial of the wastes, implying the package should be designed to meet the conditions

encountered in earth burial, AECM 0511 refers to storage of the wastes. The word "storage" is defined as "retention of radioactive waste in some type of man-made device, such as a tank or vault, in a manner permitting retrieval."

In implementation of the IAD, it became apparent that burial of wastes in the commonly used mild-steel drums would not meet the objective of recovery in 20 years due to accelerated corrosion of the drum. As a result, various storage methods have been developed or proposed to keep the packages out of contact with the soil. These include the asphalt pad at the Atlantic Richfield Hanford Company (ARHCO), the Idaho Transuranic Storage Area (ITSA) pad at the National Reactor Testing Station (NRTS), the asphalt-lined pit at the Los Alamos Scientific Laboratory (LASL), and the culverts at Savannah River. In each of these designs the packages are isolated from direct contact with the soil and are surrounded by air, although the design in each case requires covering the facility with a layer of soil. In essence, this type of facility is a storage warehouse. The questions

of long-term stability of the physical arrangement of the packages, fire and the spread of fire, criticality, and ventilation and filtering of off-gases from waste decomposition immediately arise. While these conditions are similar to those in plutonium storage areas, the concentrations of transuranic elements in wastes are low compared to materials in storage vaults, there is no defined need for personnel to routinely enter the waste storage facility, and the packaging of wastes and storage conditions are such that the risk of an untoward event, such as a fire, is low. Further, the earth cover provides a degree of protection not found in most storage vaults.

In order to assist in the implementation of the directives, the AEC commissioned the preparation of the following guidelines. These guidelines are intended to provide the general guidance for the handling and retrievable storage of solid transuranic wastes. As specifications are developed, they can be incorporated into the guidelines. Also, many specific operating guidelines are incorporated in existing AEC Manual Chapters, and no effort has been made to reference all of them in this document. The stated purpose of the AEC in providing the guidelines and the scope of the guidelines are as follows:

Purpose: To provide basic guidelines against which to judge adequacy of techniques and methods being practiced for the retrievable storage of transuranic-contaminated solid waste.

Scope: Covers operations at AEC production facilities for packaging, handling, and storage of retrievable transuranic-contaminated solid wastes (with secondary emphasis on shipment and retrieval). Transuranic wastes also contaminated with significant quantities of beta-

gamma emitters are not covered by these guidelines and should be handled as special problems.

Major technological advances in the future will provide additional input which can be utilized in augmenting and updating the currently used interim storage concepts and will lead to a unified waste management program that combines the interim storage designs with permanent repository concepts.

II. BACKGROUND

One of the early decisions in the effort to derive these guidelines was that the basis for each guideline be documented as fully as possible. This documentation is intended to assure that adequate consideration is given to important facets of the problem and that the user is provided with additional background information for his interpretation. In cases where no factual information was available, the approach taken was to document, as well as possible, the reasoning that led to the guideline. This documentation will serve as an aid to implementation of the suggestions as well.

The general nature of the guidelines permits flexibility in application so that different solutions to the overall problem can be considered and implemented. Many variables are present so that optimized systems can result from trade-offs among those of most importance to the particular installation. Thus, one can choose to specify packages that will withstand severely corrosive external and internal environments with less concern for control of the corrosive nature of the storage environment or of the waste materials in the package; or one can control the storage environment and waste materials and use packaging of lower quality; or one can use a combination of the above. However, it must be recognized that there has been no experience with storage of radioactive waste materials for periods of 20 years or more. Since one cannot rely on proven experience, the assurance

that the 20-year retrievable storage goal will be met lies in the engineering and operational practices used to implement these guidelines.

Early in the derivation of the guidelines the question of excluding combustible materials from the storage facility was reviewed. The review indicated that several potential problems in storage of combustible materials could be avoided completely by preoxidation. These potential problems include:

1. The requirement for eliminating certain types of oxidants and other reactive materials from the waste (a requirement difficult to enforce absolutely)
 2. The potential of gas formation through pyrolysis or radiolysis leading to possible buildup in an enclosed area
 3. The possibility, no matter how remote, of a fire in the storage area.
- As a result of these considerations, it is obvious that exclusion of combustibles would reduce the risks involved and could simplify the problem of storage. Methods leading to exclusion of combustibles should continue under active investigation. A final decision on exclusion of combustibles will require a more detailed and quantitative study of the various options. In the meantime, such combustibles are being produced and there is currently no proven technology for preoxidizing them. Since current AEC policies require that retrievable transuranic wastes must be stored, the guideline development effort has focused on the immediate goal of providing safe storage of these combustible materials.

III. ASSUMPTIONS

In the derivation of the guidelines, several assumptions were based upon AEC direction. These assumptions are important since they affect both the nature of the guidelines and the areas of applicability.

1. The guidelines were to be applicable to the wastes from current AEC

production or research and development sites. No consideration was to be given at this time to the wastes from commercial power reactors or to wastes buried in commercial disposal areas. This dictated that the main emphasis was to be on weapons-grade plutonium and heat-grade plutonium and their daughters as the transuranic elements of primary interest.

2. The guidelines were to be general in nature so that individual sites would have freedom to engineer the detailed implementation within the overall framework. Specifications could then be incorporated as they were developed.

3. The lower limit above which wastes were to go to retrievable storage was accepted as the 10-nCi/g level stated in AECM 0511.

4. The period of interim storage was accepted as 20 years from the time of package generation. However, it was recognized that longer periods may be needed if the design of a repository is slower than expected. Also, there may be situations in which shorter periods of storage may be advantageous for economic or safety reasons. The 20-year period was therefore accepted as an overall engineering goal.

IV. DEFINITIONS

In the development of the guidelines, it has been necessary to define a number of terms. These definitions and discussions of the definitions are given below in alphabetical order.

Combustible

A "material capable of being burned, except that if the only combustible content of a package is plastic lining or wrapping used for contamination control purposes around incombustible objects or materials, the contents of the package as a whole may be considered non-combustible." (AECM 0511)

A precise definition of the term "combustible" is difficult, if not impossible, to prepare. This difficulty

arises because the combustible nature of a given material is dependent not only upon the form of the material but also on the conditions of ignition which must be considered. Thus, a block of magnesium is normally noncombustible. However, if conditions are right it will ignite and burn with a high temperature. Magnesium turnings will ignite under conditions considerably less drastic than those required for a more massive piece of metal. It is the intent of this definition that emphasis be placed on combustion. However, one should not ignore the long-term phenomena of pyrolysis and thermal decomposition.

This definition of "combustible" is applied to a material under the conditions existing (or possibly foreseen) in the storage facility. Thus, extreme conditions and the method of packaging need not be included as factors in the determination of combustibility of the package. Further, the production of flammable gases need not be a consideration in determining combustibility of the waste material if the control of such gases can be accomplished by separate means. The overall intent of the definition is to consider those materials that may burn in the common sense of the word and that could lead to or add to, a fire if not properly protected. The principal type of material considered as combustible should be the organics, which are composed mostly of hydrogen, carbon, and oxygen. Those materials classed as fire-retardant, either by nature of the composition or because of treatment, should also be included since they will release heat and flammable gases if exposed to fire from other sources and can, therefore, add to the overall intensity of a fire.

Combustion

The rapid and self-propagating oxidation of materials in air, with the evolution of significant quantities of heat.

Contamination-Free

"A condition of the outer surfaces of stored containers, as determined by appropriate swipe surveys or direct radiation instrument surveys, sufficiently free of contamination so that under standard radiation work procedures for the site in question respiratory protection will not be required during container handling." (AECM 0511)

Interim Storage

The storage of wastes in a protected area while awaiting transfer to a repository for extended storage or for disposal.

Nonretrievable Solid Transuranic Waste

Any solid transuranic waste that contains, or is judged to contain, less than a specified quantity or concentration of transuranic elements (currently 10 nCi/g, as appears in AECM 0511) and that may be disposed of in a non-retrievable manner, but still under conditions that will permit control in a disposal area and minimization of any migration of the transuranic elements. Included in this category are wastes contaminated with high beta-gamma emitters.

Normal Retrievable Waste

Wastes containing more than 10 nCi/g of transuranic isotopes and less than the recovery limit for that type of material as determined by the site.

Process-Generated Wastes

Those wastes that are generated by, or are the result of, process operations in the enclosure defining the process lines and related equipment. In general, the contamination levels will be significant.

Radioactive Waste

"Materials of no value consisting of, including, or contaminated with radioactive material in excess of the levels or concentrations permitted in AEC Property Management Instructions for unconditional release of excess property." (AECM 0511)

Recovery

The reprocessing of contaminated materials for the purpose of reclaiming and reusing the transuranic elements which they contain.

Repository

"A Federally owned and operated facility for storage or disposal of specific types of radioactive waste from AEC sites and/or licensees." (AECM 0511)

Retrievable Solid Transuranic Waste

Any solid transuranic waste that contains, or is judged to contain, more than a specified quantity or concentration of transuranic elements (currently 10 nCi/g, as defined in AECM 0511) and must, as a result, be placed into interim storage for eventual disposition.

Retrievable Storage

"Solid waste generated at AEC sites and containing significant U-233 or transuranium nuclide contamination shall be stored at AEC sites, segregated from other radioactively contaminated solid waste and with combustible and noncombustible transuranium-contaminated waste packaged separately. The packaging and storage conditions shall be such that the packages can be readily retrieved in an intact, contamination-free condition for 20 years. The packages shall be suitably labeled so the waste they contain can be identified by cross reference to permanent records." (AECM 0511)

Room-Generated Wastes

Those wastes that are generated by, or are the result of, support operations in the room or area containing the transuranic processing facilities. These materials are usually of considerably lower contamination level than wastes generated in process lines.

Scrap

The feed materials for a recovery process, that is, the transuranic-

contaminated materials which are discarded from a process but which contain sufficient transuranic elements to warrant recovery (see IAD 7401-19, dated May 26, 1971, Appendix C).

Solid Radioactive Waste

Radioactive waste "material that is essentially dry but may contain sorbed radioactive fluid in sufficiently small amounts to be immobile when buried in dry soil." (AECM 0511)

Solid Transuranic Waste

Solid radioactive waste "contaminated with certain alpha emitting radionuclides of long half-life and high specific radiotoxicity to greater than 10 nanocuries/gram (10 microcuries/kilogram)... The radionuclides included are U-233 (with its daughter products), plutonium, and transplutonium nuclides except Pu-238 and Pu-241." (AECM 0511)

The inclusion of ²³⁸Pu and ²⁴¹Pu in the requirements for retrievable storage is at the discretion of the individual storage site. This is considered a policy definition to indicate which materials are involved, rather than a term definition. The inclusion or non-inclusion of the above mentioned isotopes as transuranic elements is an individual decision based upon the merits of the case. Thus, the use of the term Solid Transuranic Waste in the guidelines would apply only to wastes contaminated by those isotopes which by policy, either national or local, require interim storage.

Storage

"Retention of radioactive waste in some type of man-made device, such as a tank or a vault, in a manner permitting retrieval." (AECM 0511)

Storage Area

The area in which the storage facility is located (that is, the site of the storage facility).

Storage Facility

The actual place of storage of wastes. This may be an engineered structure such as a building or vault or a protected area in any other type of facility.

Temporary Storage

The storage of wastes for short periods of time while awaiting transport to or placement in the interim storage facility.

Waste Container

The device or devices, including liners and closures, used in the packaging of wastes.

Waste Package

The final configuration of the waste in its container as it is ready to be placed into interim storage.

V. SUMMARY OF GUIDELINES

Immediately following each guideline, in parentheses, is the page on which the discussion of the guideline will be found.

A. Establishment of Specifications for

Package Materials and Package Construction

Engineering specifications shall be established for all packages and packaging materials used for containment of retrievable solid transuranic wastes. (8)

B. Package Integrity

1. Control of Internal Degradation.

The combination of waste matrix and waste container shall be such that the package of waste can be readily retrieved in an intact, contamination-free condition for a 20-year period. (9)

2. Control of External Degradation.

The combination of waste packaging material and storage environment shall be such that the package can be readily retrieved in an intact, contamination-free condition for a 20-year period. (10)

3. Package Closure.

The package closure shall be sturdy enough that it will not be breached under normal handling conditions and will not serve as a weak point

for package failure. (12)

C. Exclusions from Waste Content

1. Minimization of Volumes. The volume of waste placed in retrievable storage shall be minimized to the greatest extent practicable. (14)

2. Combustible Materials. Combustible materials shall be excluded from the wastes to the maximum extent practicable. (14)

3. Pyrophoric or Explosive Materials. Positive steps shall be taken to assure that pyrophoric materials, explosive materials, and containers of compressed gases (including aerosol cans) are either excluded from all retrievable wastes or treated to remove their hazardous properties. (15)

4. Spontaneous Combustion. Positive steps shall be taken to assure that materials that could provide a source of internal oxygen (such as strong oxidants) or that could lead to spontaneous ignition (such as oils, greases, or solvents absorbed on cellulosic materials) are excluded from packages containing other combustible wastes. (16)

5. Toxic Chemicals. Highly toxic chemicals and their containers shall receive special handling, treatment, or both, and shall not be mixed with other wastes. (17)

6. Free Liquids. Free liquids shall be excluded from all retrievable wastes. (17)

D. Transuranic Content

1. Minimization of Quantities. The quantities of transuranic elements placed into retrievable storage shall be minimized to the extent practicable, considering not only the economics of storage and recovery but also the reduction of potential long-term environmental impact. (18)

2. Criticality. The quantity of fissile materials in individual packages shall be limited on the basis of analysis of the potential for criticality in the storage array planned, and in credible accident situations taking into account the actual materials in the waste. (19)

3. Nuclear Heating. The quantity of transuranic elements in an individual

package shall be limited such that the combination of internal package environment and possible waste deterioration from nuclear heating will not adversely affect the containment of the waste package. (21)

4. Higher Contamination Levels. Scrap materials that are reclassified as wastes and wastes containing levels of transuranic contamination above that of normal solid transuranic wastes can be placed into an interim storage facility only after an analysis of the facility shows that the higher level material can be safely stored there. (22)

E. Quality Control

1. Packaging Materials. A quality assurance program and quality control procedures shall be established to assure that all incoming packaging materials meet the engineering specifications. (23)

2. Final Package. A quality assurance program and quality control procedures shall be established to assure that the final package meets all guidelines and specifications. A seal that must be broken to open the package should be affixed before shipping to the interim storage area. (24)

F. Fire Control

1. Fire Propagation. Combustible materials shall be packaged or arranged in storage in such a manner that a fire occurring in one package will not propagate to another package. (25)

2. Combustible Materials in Storage Facility. The use of combustible materials in the interim storage facility external to the packaged wastes shall be kept to a minimum. When used, any such external combustibles shall not present a possible channel by which a fire can spread beyond the immediate vicinity of its point of origin. (26)

3. Firebreaks. Firebreaks shall be installed at appropriate intervals within the storage facility to prevent spread of fire. (27)

4. Provisions for Firefighting. The operator of the storage facility shall

maintain adequate provisions to detect and effectively fight any fire which could occur at the storage facility. (28)

G. Package Handling

1. Damage to Packages. Packages that are damaged to a point where the engineering specifications for the original package cannot be assured or where the damage prevents compliance with other guidelines shall not be placed into storage until they have been returned to a condition that meets all applicable guidelines. (28)

2. Handling Methods. All handling methods for waste packages should be designed to prevent damage to the packages. (29)

3. Control of Transport and Storage

Environment. The storage environment should be controlled to avoid adverse influence on the containment ability of the waste package throughout the handling, transport, and storage of transuranic wastes. (30)

4. Radiation Dose Rate and Contamination. The radiation dose rate and external contamination levels for the packaged wastes at the time of receipt at the storage facility, and at the end of the 20-year period, shall be such that the packages can be handled by individuals within the radiation exposure criteria established in AECM 0524. (31)

H. Storage Site Selection and Facility Design

1. Location - Protection of the Environment. In location and design of the facility an analysis shall be made and documented to provide reasonable assurance that the facility can be operated without undue impact on the environment, that the safety of the workers is adequate, and that the wastes can be retrieved without undue hazard or cost. (32)

2. Secondary Barriers. The design of the storage facility should provide a secondary barrier between the packages (which are regarded as the primary containment) and the groundwater and atmosphere. (34)

3. Control of Access. The area used for the interim storage of transuranic wastes

shall be adequately controlled to prevent ready access by unauthorized persons. (35)

4. Flammable Gases. The design of the facility shall be such that the concentrations of flammable gases, resulting from any waste degradation mechanism, shall not reach the lower explosive limit for such gases. (35)

I. Storage Facility Operation

1. Operational Procedures. All operations of a storage facility shall be covered by an approved and documented procedure. (36)

2. Monitoring. Provision shall be made for monitoring of the storage area for radioactive release and other parameters appropriate to the safety of the storage area. (36)

3. Acceptance of Packages. Acceptance standards for packages to be stored shall be defined. Such standards should include, but not be limited to, the types of packages to be accepted and the information to be supplied. The final decision as to the acceptance of any waste package should rest with the operator of the storage area. (38)

J. Records and Package Labeling

Each package of waste shall be labeled in such a manner that the package can be identified from a separate set of records. Such labels shall be designed to be legible after 20 years. Minimum information kept in the records shall be as follows:

1. General Information

- a. Package Identification
- b. Date of Packaging
- c. Source of Waste
- d. Location of Package in Storage
- e. External Radiation Level (neutron-gamma)

2. Package Contents

- a. Description of Waste Matrix
- b. Hazardous Chemical Content
- c. Combustible/Noncombustible Designation
- d. Estimated Weight and Volume of Contents
- e. Transuranic Element Content

3. Description of Package and Packaging Material (38)

VI. DISCUSSION OF GUIDELINES

A. Establishment of Specifications for Package Materials and Package Construction Guideline

Engineering specifications shall be established for all packages and packaging materials used for containment of retrievable solid transuranic wastes.

Many of the factors that influence interim storage of transuranic-contaminated solid wastes vary among the AEC waste management sites. The wastes may differ in composition, with significant differences in requirements for packaging, transport, and storage conditions. For this reason, many of the following guidelines are presented as general statements of goals. In this way, the individual storage location can develop a best overall solution for its specific problems.

In past years, waste materials were buried in areas carefully selected to minimize the possibility of environmental contamination. With the advent of the storage requirements, many burial practices and burial containers have continued in use, with modifications to provide assurance of retrievability. However, the degree of assurance is uncertain because of the lack of both detailed engineering analysis and long-term experience to provide the basis for engineering specifications. A detailed engineering analysis of the packaging and of its suitability for both the contained materials and the storage environment will result in an overall design with adequate safety margins to meet the basic objective. The design will give detailed specifications of materials, protective coatings, liners, and other features needed to permit survival of the package.

An integral part of the engineering analysis will be consideration of the

trade-offs possible. For example, a solution to the problem of preventing internal package degradation will involve trade-offs between the corrosion resistance of the packaging material and the properties of the waste materials. Treatment of the waste to generate a more inert material will have the effect of altering the specifications for corrosion resistance of the package. Similar trade-offs will exist between the corrosion-resistant properties of the outer package and the environment where the package will be stored. However, in all considerations of these types, one engineering design goal should be to meet the intent of the guidelines at the lowest cost.

The existence and detail of an engineering analysis and the resulting specifications indicate the degree of attention given to each of the problems of the waste generator. Adequate documentation on the derivation of specifications, including any changes for the waste package and other packaging materials, should be retained.

B. Package Integrity

1. Control of Internal Degradation.

Guideline

The combination of waste matrix and waste container shall be such that the package of waste can be readily retrieved in an intact, contamination-free condition for a 20-year period.

Deterioration of the container as a result of reactions with the contained wastes must be limited to assure the survival of the waste package. This limitation can be accomplished by the control of detrimental interactions between the wastes or their decomposition products and the total package (primary container plus liner or package coating). The mechanisms that could lead to deterioration include corrosion, radiolysis, pyrolysis, chemical attack, and, possibly, biological interactions. Due, in part, to the diverse materials in the waste matrix, assessment of potential interactions is

complex; and the solutions are currently uncertain.

Corrosion of the package from an internal source may be a major problem for some waste types. If external moisture is prevented from entering the package, dry, inert materials, such as some types of building debris and equipment, should require only structural strength and resistance to external corrosion in packaging to meet the requirements for interim storage. Other waste materials, however, have been shown to be incompatible with the containers which have been used for storage. At LASL, sludges from the liquid waste treatment plant have accelerated the internal corrosion of unprotected mild-steel drums to produce leaks within one year.¹ Corrosion could also result from nitric acid or other chemicals absorbed on the waste materials.

Many internal corrosion problems could be eliminated, or at least moderated, by the use of some inner liner or chemical-resistant package coating between the waste and the outer container. Several AEC sites employ some form of internal protection in an attempt to limit corrosion of the primary container. Rocky Flats now uses the 2.29-mm liner in drums placed into retrievable storage.² Mound Laboratory uses a 0.18-mm polyethylene liner in drums containing a mixture of sludge and concrete. At ARHCO the drums are internally coated with a chemical-resistant epoxy finish.³ An alternate solution might be the use of a corrosion-resistant primary container, such as a polyethylene drum, for certain highly corrosive waste types. The potential combustibility of such a container would probably confine its use to noncombustible materials (such as sludges) and might require a separate storage area from the combustible wastes. Should it become economically feasible, alteration of corrosive wastes to a more inert form might be the most desirable solution.

The problem of interaction with the container is not limited to the wastes alone, but also encompasses the products of the degradation of these wastes. Major sources of decomposition include radiolysis and pyrolysis, but the extent of the potential problem from these processes cannot be fully assessed at this time. The products of radiolysis of materials such as cellulose, plastics, and water are known; but the experiments were usually performed using gamma or neutron irradiation. The effects of alpha radiation, with its high energy and limited penetrability, on systems such as these have not been well investigated.

Studies of pyrolysis have demonstrated the production of gases and smoke at temperatures above 150°C for typical combustible waste materials (cheesecloth, latex, polyvinyl chloride, polyethylene).¹ Problems of heating may arise either from exposure to external heat sources such as solar radiation during temporary storage or from self-heating of the transuranic contaminants, particularly ²³⁸Pu. The possibility of pyrolysis should be decreased, however, by adherence to the guidelines on limitation of the nuclear heat generation and elimination of extreme external temperatures.

The products of both radiolysis and pyrolysis may include toxic, corrosive, and flammable gases. Polyvinyl chloride produces HCl, which can corrode even stainless steel (as would any other chloride contaminant). Polyethylene produces predominantly H₂ during radiolytic degradation, while cellulose produces various combinations of flammable hydrocarbons and organic acids. The production of these products in sufficient quantities to prove harmful is uncertain, but will depend upon the waste material present. An analysis of the importance of these degradation mechanisms should indicate any necessary provisions for the containment or control of such products. A potential problem associated with such decomposition is the possibility of a

breach in the package due to pressurization through gas production. To determine the probability of this situation occurring for any particular waste type will require adequate experimental information on the rates and the extent of gas production under the conditions prevailing in interim storage. In particular, the possibility of pressurization having occurred must be considered at the time of retrieval, whether or not breaching occurs; and caution must be exercised to avoid spread of contamination, especially if the waste material is to be repackaged or processed at that time.

Thus, it will be necessary for the waste producer to examine the types and combinations of materials to be stored. The packaging system must then be selected for the particular waste type as based on the potentially detrimental components of the waste matrix and the possible decomposition products. Other guidelines require exclusion of certain materials, such as acids, oxidants, and corrosive chemicals, from the waste matrix to decrease the chances of unfavorable interactions with the package. While the initial specifications derived to assure compliance with this guideline are likely to be based upon existing waste types, packaging materials, and processing techniques, consideration must be given to the development of new processing techniques which could produce other types of waste with different corrosive properties. Any specification derived for present waste types must be reviewed at the time of such process changes to assure that the changes in waste form will not invalidate previous conclusions. The specifications finally selected by any waste producer must balance containment ability and economic feasibility.

2. Control of External Degradation.

Guideline

The combination of waste packaging material and storage environment shall be such that the package can be readily retrieved in an intact, contamination-

free condition for a 20-year period.

If the waste package is to survive for the interim storage period, steps must be taken to protect the package from those external mechanisms that can cause deterioration. These mechanisms include corrosion of metals, aging of plastics, or the decomposition of materials such as wood.

The inability of certain combinations of package and storage environment to meet retrievable storage requirements has been demonstrated. For example, 210-liter mild-steel drums in shallow earth burial have been breached by the corrosive action of the soil in less than 20 years. Actual predictions of drum lifetimes in such an environment have been given as 3-7 years.² Information on the effects of earth burial as a storage environment upon wooden or plastic packaging materials is not presently available, but an untreated wooden package would not be expected to survive under such conditions at many locations. For these reasons the use of earth burial as a method of interim storage has been abandoned at most AEC sites, with waste storage being carried out in such a manner that soils are not in direct contact with the waste packages. However, there is only limited experience upon which to judge the storage environments in use today with respect to the corrosion of presently used packaging materials.

The degree and rate of degradation of a packaging material will be dependent upon the material used, any auxiliary protection afforded by a protective coating, and the environment in the storage facility. Specifications selected for any one of these three factors may decrease the need for limitation of the other two. Thus, as a first step, the selection of any working set of conditions requires the definition of those factors in the storage procedure that could influence external corrosion. From such considerations, specifications based upon a balance among the variables

can be developed.

Selection of the actual packaging material must be carefully considered in relation to the storage environment. For example, a wooden box in a damp environment may decompose rapidly, while the same box in a drier, controlled environment may last for many years. On the other hand, if the environment of the box is too dry, cracking of the wood may occur. Similarly, an unprotected mild-steel drum will undergo rapid corrosion in a damp atmosphere. Unrelieved stress in the currently used steel drum has been shown in LASL investigations¹ to be an important factor in the rate of corrosion of parts of this container. In this respect, any minor damage, such as denting of a steel container during handling, transport, or storage operations, may be significant to the survival of the package during the interim storage period.

In the situations described above, some degree of protection may be obtained by the use of preservatives for woods and paints or other coatings for any container materials. In fact, the steel drums used today for waste containment at AEC sites do have an outer coating of corrosion-resistant paint.^{2,3} However, in the handling of these drums the paint is often badly chipped or scratched. When the coating is undamaged, it has been found to give good long-term protection, even in the more corrosive environment of earth burial.² Wooden boxes used by Rocky Flats for storage of retrievable wastes at the NRTS are provided with a fiber glass outer coating as a means of protection from externally caused package degradation.⁴ One possible means of avoiding damage during shipment and retaining a complete protective coating on a waste package is the application of the coating to the package immediately prior to storage. Under conditions where a completely undamaged outer coating of known corrosion resistance could be guaranteed, less emphasis need be placed on the construction of the container and on control

of the storage environment.

Another method of control of external corrosion involves the storage environment itself. For example, strict control of temperature and humidity could minimize the possibility of external degradation of certain types of packages, resulting in a decreased need for control of the exterior coating system or the type of container construction material. Test data should be accumulated to assure that the storage environment is dry or that the packages are not adversely affected by the level of humidity. Alternatively, package protection via protective coating or the use of a corrosion-resistant construction material might provide adequate containment during interim storage. In addition, if complete definition of the storage environment is difficult because of the possible changing nature of storage requirements or the lack of facilities (for example, power or water) which are necessary to permit control, greater emphasis must again be placed on the package and coating systems.

3. Package Closure.

Guideline

The package closure shall be sturdy enough that it will not be breached under normal handling conditions and will not serve as a weak point for package failure.

The tightness of the closure mechanism on a waste container is important to the package integrity during handling and storage of retrievable transuranic waste. Health and safety considerations during handling, transport, and storage dictate containment of contamination. It is recognized that some containers are complex in design, with sealed inner containers to provide the containment barrier and with outer containers to serve as protection for the inner container. In any case, a goal for seal tightness should be to provide the protection needed to prevent any spread of contamination during handling,

transport, storage, and retrieval.

Process-generated waste is normally removed from the glovebox by bagging out into a polyvinyl chloride bag, which provides initial containment of contamination. Room-generated waste in many cases is collected in polyethylene bags, which would also provide initial containment. The requirement that all such waste be sealed in bags or containers before being placed in the storage container provides added protection against contamination spread if the closure of the primary container should somehow fail. Current evidence indicates that these small bags will not survive the 20 years due to degradation by various mechanisms, such as natural aging, chemical attack, radiolysis, and pyrolysis. Thus, this source of protection against contamination spread would not be available at the time of retrieval, and dependence would be on the primary container.

While free liquids are excluded from waste placed into storage containers, there are possible mechanisms for separation of liquids or formation of water during storage. From a standpoint of handling, liquid spillage from containers in storage or at the time of retrieval could present additional problems of contamination control. While the guideline does not specify gasketing for liquid seal, the assured presence of a closure, even if it should leak to some degree, will minimize these problems.

Discussion to this point has provided evidence that the storage container should be securely sealed. This guideline does not provide for or recommend an airtight seal, since there are conflicting factors relating to this decision. Considerations that would favor an airtight seal include the elimination of breathing of the package resulting in possible spread of contamination, intake of moisture leading to corrosion, and possible escape of flammable gases. On the other hand, the question of ability to assure a tight seal argues

against the requirement. Discussion of these points is amplified below.

During temporary storage and transport, variations in temperature and elevation can cause pressurization and depressurization of container by as much as ± 14 kPa under certain possible conditions. Gasketed closures on presently used DOT 17C or 17H mild-steel drums will not hold an internal pressure of 34 kPa for any significant period of time. Thus, package breathing does present a potential for contamination spread by escape of contamination during the "exhale" cycle. During storage with relatively constant pressure and temperature, one would expect a minimal breathing effect. Degradation of cellulose and plastics, however, might produce sufficient volumes of gas to provide a potential vehicle for contamination to escape from the container.

In the case of moisture intake from a humid environment by breathing through a closure, corrosion could be considerably different in various configurations, depending on the relationship between the outer container and the inner liner. In the case of the mild-steel drum with a heavy liner, condensation in the annular space could provide a condition for crevice corrosion. Although the heavy liner may be considered the primary container in this case, retrieval of such packages with a badly corroded outer container could be difficult.

The most complex consideration relates to gas formation in storage containers. Regardless of exclusions of certain chemicals and waste types (such as pyrophorics), there will be some chemical contamination of the basic waste types. Decomposition of waste materials, in particular the combustibles, through mechanisms such as pyrolysis, radiolysis, and chemical attack can result in gas formation. The quantity of transuranic elements, packing density of the waste material, waste matrix, nature of chemical contaminants, and ambient

temperature will have an effect on the type and rate of such gas formation.

If the container is to be tightly sealed (airtight), then it should be designed to hold whatever pressure is developed in a 20-year period. Because of the variables stated above, this pressure is difficult to determine. As a related problem, should an external fire develop near pressurized drums, even greater pressures developed by the heating would increase the probability of rupture, adding flammable gases as well as the contents of the package, if combustible, to the existing fire. This resulting increase in fire-loading external to the package could significantly increase the potential for fire spread. If the container is not airtight, gases could leak into the storage area environment, producing a potential fire condition from flammable or explosive gases. Depending on the rates of gas formation, ventilation of the storage facility may be required. The conflicting arguments provide additional support for the elimination of combustibles in storage, but further studies are needed to more clearly define the relative problems.

From a practical standpoint, attainment of an airtight container design appears difficult by any means other than a welded closure. Even with improved designs of gaskets, a seal that will hold required pressures now will not necessarily survive for 20 years. Further, the quality control program required to assure the seal on each package could be excessive, if not impossible.

When a decision is to be made concerning container design, the previously mentioned factors should be weighed according to the site requirements for interim storage. Furthermore, future treatment methods that may produce an inert waste matrix could obviate the necessity for elaborate package designs intended for absolute containment.

C. Exclusions from Waste Content

1. Minimization of Volumes.

Guideline

The volume of waste placed in retrievable storage shall be minimized to the greatest extent practicable.

Large tracts of isolated land areas are becoming less available than in the past for use as waste storage areas. At the same time, long-term surveillance and perpetual maintenance of large storage areas are becoming less practicable and less desirable. For these reasons, the AEC plan for radioactive waste management calls for reduction of the gross volume of wastes generated. In addition, AEC contractors are required to develop volume reduction technology and use volume reduction techniques wherever practicable.⁵ Use of volume reduction procedures is also a practical means of reducing the cost of shipping and storing retrievable wastes.

Volume reduction methods are currently in routine use at some AEC sites.¹ Procedures at Rocky Flats require compaction of wastes and a minimum of 36 kg per 210-liter drum. Size reduction at several sites is accomplished through cutting large pieces of equipment (such as gloveboxes) to fit into boxes, flattening empty metal containers (both drums and smaller material transfer cans), and crushing filters. Equipment to compact waste materials in drums is being tested before routine employment at both Rocky Flats and ARHCO.

Incineration is another means of reducing the volume of waste sent to retrievable storage. Incineration of combustible wastes for plutonium recovery is presently in use at ARHCO, Rocky Flats, and Los Alamos. In addition, biological wastes are normally ashed at ARHCO. Further development of incineration technology is required before any overall reduction in waste volume can be effected. At the present time, larger quantities of wastes at lower contamination levels may be generated

from the incineration process. Thus, while the volume of retrievable waste is decreased, the overall volume of waste produced may increase.

2. Combustible Materials.

Guideline

Combustible materials shall be excluded from the wastes to the maximum extent practicable.

The elimination of all combustible wastes from the retrievable storage facility would provide an ideal situation from a fire protection standpoint. The quantities of combustibles external to the packages can be controlled independently to the level where the probability of a fire is nonexistent. However, current studies indicate that the probability of a fire in the facility, even with significant quantities of combustible wastes present, can be made acceptably low by control of the contents of the packages and by proper packaging techniques. Since the complete exclusion of combustibles is not a practical objective at this time because of the lack of satisfactory and proven methods of treatment, the guidelines have been derived on the premise that such combustibles will be stored in separate packages from the non-combustibles.⁵ It must be admitted that the risk under this situation is higher than under the complete exclusion situation, and intuition would indicate that the risk should increase in some fashion as the amount of combustible materials increases. In addition, the configuration and conditions of the repository, which is to be the eventual resting place of these materials, are not now known. Thus, it cannot be ascertained whether such combustibles can be placed into a repository or whether treatment must be accomplished to reduce them to an inert form. This guideline calls for positive actions to minimize the quantities of such combustibles sent to storage and implies that the vigorous programs of the AEC to provide technology for

the complete elimination of combustibles through pretreatment or other means should be encouraged.

Actual methods of reducing the volumes of combustible wastes stored include incineration or precombustion by any method and other pretreatment methods such as chemical processing (for example, acid digestion). Considerable development is in progress to develop several of these methods for future applications.

Reduction of the volume of combustibles at the source is perhaps the best currently available means of attacking this problem. Techniques which could be considered here include the implementation of waste management procedures at the source of the waste to eliminate all unnecessary combustible materials from the system of operations. This includes, for example, the exclusion from contaminated areas of all packaging materials and other combustibles unnecessary to actual facility operations. Along this same line, a program of decontaminating combustible wastes (for example, rinsing, washing, wiping) in order to reduce the transuranic content below the 10-nCi/g level may result in some of the combustible waste being disposed of nonretrievably.

Consideration should also be given to the use of specific types of materials that are more easily treated or disposed of than those currently in use. For example, polyvinyl chloride and other halogenated plastic materials pose corrosion problems in incineration and some other precombustion techniques. The use of alternative types of materials, more easily precombusted, could be of great benefit.

3. Pyrophoric or Explosive Materials Guideline

Positive steps shall be taken to assure that pyrophoric materials, explosive materials, and containers of compressed gases (including aerosol cans) are either excluded from all retrievable wastes or treated to re-

move their hazardous properties.

In assessing the problems of storage of various materials, it becomes apparent that some items that may appear in the waste have properties that make them unacceptable for inclusion and they must be handled separately, either by treatment to destroy the undesirable properties or by special handling and separate storage from the bulk of the wastes. The materials described in this guideline are deemed to be improper for storage in any facility handling bulk wastes since they not only pose a potential threat to the individual package but could also serve to initiate an incident which could spread to the other wastes, either through direct involvement of the other waste packages or through the spread of contamination throughout the facility. To implement the guideline, positive steps for the exclusion of these materials are required since the difficulty of assuring compliance with complete exclusion is recognized. It is suggested that these positive steps could include procedural control, with adequate supervision of the procedures and their accomplishment, periodic audits of the contents of waste containers in areas where these materials are used, and control of the quantities of such materials brought into the area.

The elimination of pyrophoric materials, which could spontaneously ignite under conditions encountered in the handling, transport, and storage, will decrease the probability of fire. Among the pyrophorics often encountered are ferrous oxide, magnesium alloy, white or yellow phosphorous, and sodium. At least one fire has occurred in a drum containing pyrophorics when the drum was exposed to solar heating over an extended period of time.¹ Although the temperature limitations imposed by these criteria will decrease the chances of ignition in any waste material, pyrophorics exhibit enough uncertainty in behavior to warrant their exclusion from the storage

facility. Under certain circumstances, uranium and plutonium metals are also pyrophorics but must be considered separately. Only rarely is more than 1 gram of such materials disposed of at one time. The small quantities likely to be found are not considered to present an excessive fire hazard even in the presence of combustible materials.

Explosive and shock or heat sensitive materials shall also be excluded from storage since they may, under some conditions, cause rupture of the package and subsequent spread of activity. The same situation can occur with containers of compressed gases which could rupture upon exposure to heat or shock.

Protection of the integrity of waste packages and the storage facility must be considered for any waste management program. The eventual retrievability of the contaminated wastes will be facilitated by elimination of "high risk" materials, at least in their most hazardous forms, from the storage facility. Such materials should be handled separately as special waste types or treated to remove the risk in storing them.

4. Spontaneous Combustion.

Guideline

Positive steps shall be taken to assure that materials that could provide a source of internal oxygen (such as strong oxidants) or that could lead to spontaneous ignition (such as oils, greases, or solvents absorbed on cellulosic materials) are excluded from packages containing other combustible wastes.

Materials that could lead to ignition or rapid spread of a fire must not be placed into storage. It may be noted that this guideline, again, requires that positive steps on the part of the waste generator and packager be taken to exclude such materials. To some extent, the accomplishment of this goal for these

materials will be more difficult than for the explosives or pyrophorics because of the much wider occurrence of these materials in an operating facility and the consequent higher probability that a towel or rag, for instance, that has been used to clean up a spill of nitric acid will be discarded in the normal waste without adequate neutralization. This will create an added problem in the supervision of the area to assure that procedures are adequate and are followed.

Limitation of the oxygen available for combustion is one means of minimizing both the chance of a fire and the extent of fire if one does occur. Pure cellulosic materials, rubber, and most plastics contain no oxygen in a form available for combustion and cannot support a fire at oxygen concentrations below about 10%. One way to limit the degree of combustion is to package these materials tightly enough to limit the degree of combustion. However, the presence of materials that can supply oxygen internally through combustion or decomposition would negate the effect of the sealed package. Such materials include oxidants, inorganic nitrates (NaNO_3 , KNO_3 , HNO_3 , NH_4NO_3), and cellulose nitrate. Work at Los Alamos and Oak Ridge has indicated that small amounts of nitrate contaminants at the temperatures ordinarily encountered produce little chance of spontaneous ignition. However, the oxidants may react with other waste materials to effect decomposition and produce flammable gases. Some consideration has been given to excluding air by packaging in an inert atmosphere, but it would be difficult to assure the maintenance of the inert atmosphere over the interim storage period.

Flammable materials, such as organic oils, greases, and solvents, occurring as contaminants on combustible wastes should be eliminated since they represent a possibility of spontaneous ignition. The solvents, with their generally lower flash points, should be disposed of in some more

permanent manner, such as incineration.

This guideline is not intended to eliminate the disposal of oils and greases by absorbing them on some noncombustible material (Sorbal, diatomaceous earth, vermiculite) and treating the mixture as a solid waste. There are some reservations about this procedure because of the flammability of the oils and greases; but, pending further tests, the procedure is probably acceptable as long as the residue is well packaged in a noncombustible container with a closure tight enough to minimize the rate of access of air. The guideline is intended, however, to eliminate the placement of such absorbed oils or solvents in the same package with other flammable wastes. Non-flammable oils and greases, such as silicon-based lubricants, can probably be stored with other wastes by sorption on noncombustible materials.

An alternative solution to complete exclusion of these materials is pretreatment of the waste containing this material. For example, nitric acid and certain other oxidants can be neutralized or rinsed from the wastes prior to disposal. Certain other types of treatment of the wastes, such as compaction or pelletization, might create a condition in which wastes would not ignite even if they were contaminated with flammable materials, such as oils or greases. Further study is required before the reliability or feasibility of any such process could be specified.

5. Toxic Chemicals

Guideline

Highly toxic chemicals and their containers shall receive special handling, treatment, or both, and shall not be mixed with other wastes.

There are many chemicals which may be discarded, frequently in reasonably large quantities, that can lead to problems during handling, transport, storage, or retrieval. These materials include both the corrosive chemicals which can lead,

either singly or in combination with other materials and chemicals which may be in the package, to failure of the package. The presence of toxic chemicals could unnecessarily complicate handling at the time of retrieval, particularly if repackaging or treatment of the waste is involved. Such materials present safety hazards to the individuals handling the package. It should be noted that this guideline also includes the original containers in which such materials are received or stored at the laboratory. Such containers may retain a significant quantity of the original contents. Therefore, the unrestricted disposal of such containers into receptacles for other types of waste could lead to a situation where full or nearly full containers could be discarded by the same path by accident or by design.

Highly toxic materials that are contaminated with transuranics require a separate evaluation of the risks involved in storage. Treatment of the chemicals may be necessary to destroy their toxicity. Drums containing large quantities of KCN have been reported at the NRTS. Such materials should be treated to eliminate their hazardous properties before storage. In addition, containers for such chemicals should be rinsed before disposal to remove all remnants of the chemical. If it is not possible to make these materials innocuous, the records and/or labels for the waste packages must clearly indicate the hazardous nature of the contents.

6. Free Liquids.

Guideline

Free liquids shall be excluded from all retrievable wastes.

The term "free liquids" includes any liquid not absorbed on a solid material such that it will spill or drain from the container in the event of an accident or a loss of internal or external containment. The transuranic isotopes found as contaminants in solid wastes are fairly immobile under

dry conditions. In the presence of free liquids, however, the transuranics may be dissolved and carried from the containers and/or the storage facility into the environment. In addition, if some complexing agent is also dissolved in the free liquid, the transuranics may become even more mobile.

The exclusion of free liquids is also desirable from the standpoint of both facility and container stability. For example, free organic liquids in the storage facility may increase the fire hazard. Free water, as well as water vapor, will probably increase the rate of corrosion of mild-steel containers. Large quantities of water might even overcome the rust-inhibiting effects of various protective coatings. Also, the presence of other corrosive liquids might reduce the containment ability of both the container and the facility.

In addition, the presence of free liquids could present problems in handling. Waste packages will probably not be sealed in a manner to preclude leakage of significant volumes of liquids. Should a package be tipped or dropped during emplacement, contaminated liquid might spill onto other containers, fixtures in the storage facility, or the facility operators.

D. Transuranic Content

1. Minimization of Quantities.

Guideline

The quantities of transuranic elements placed into retrievable storage shall be minimized to the extent practicable, considering not only the economics of storage and recovery but also the reduction of potential long-term environmental impact.

A primary objective of the waste management program⁵ at AEC installations is to control the amounts of radioactive materials entering the environment by reducing the quantities of transuranic isotopes stored or disposed of. Among the methods of accomplishing this goal are the

following:

1. Treat the wastes to remove the radioactive contamination before they leave the plant, and recycle the recovered transuranic elements.

2. Design processes to minimize transuranic wastes and keep contaminated areas small.

Obviously, use of the first alternative as the sole method of control would be expensive and probably unrealistic. However, any steps, including established decontamination procedures, to reduce the quantity of transuranics in waste will lower the amount that must go into isolated storage and will minimize the contamination potential of an accidental release to man's environment. Reduction of the quantities of contaminants is particularly pertinent in dealing with the long-lived transuranic elements and their daughters, where consideration must be given to very slow migration mechanisms, infrequent and largely unpredictable changes in the isolation environment, and safeguards against the often unpredictable actions of man, who may well make use of environments currently deemed inaccessible. While the interim storage concept includes the possibility of further treatment of the wastes to reduce the transuranic element content at the time of retrieval, the establishment of appropriate treatment facilities will be expensive; and any steps to reduce the mobility of the transuranic elements placed into storage may increase the difficulty of such further treatment. Thus, prudence would dictate that appropriate steps be taken at the time of generation of the waste to reduce the quantities of transuranic elements to the practical minimum.

Currently, the recovery of plutonium is governed primarily by the economic comparison between the cost of recovery and the monetary value of the recovered material. External costs resulting from an accidental release of radioactivity from

controlled storage, in later retrieval operations, or from permanent storage have not been explicitly included. While such external costs will be small on a per capita basis, and even per unit time basis, they can become significant when considered over the lifetime of the radioactive materials, particularly when the factors mentioned above are considered. In addition, the risks posed by potential radiation exposures to the public are less well accepted by society than are the comparable or greater risks from air pollution, pesticides, or the other potentially hazardous agents developed and used by man. This guideline, therefore, states that factors other than the economic value of the recovered product must be included in the decision-making process when recovery and recycling of transuranic isotopes are considered.

The minimum practical quantity released (or the maximum practical quantity recovered) can only be defined by detailed study of the trade-offs involved in the actual performance of the various processes and the relative value placed on the externalized costs. It is clear, however, that society is placing greater emphasis on the externalized costs every day, and it behooves a governmental agency to take the lead in its practices to fully incorporate these considerations.

It is recognized that with present technology this guideline will appear to be in conflict with a goal of minimizing the waste volume since the recovery processes now used frequently produce a larger volume of waste material than was originally present. Since the current recovery processes are not 100% efficient, this larger volume may still contain contamination but, in some cases, may be below the retrievable limit. Again, trade-offs are necessary, with the possible increased volume and cost of handling this volume balanced against the reduction in risk occasioned by the lower amounts of radioactive materials requiring storage or disposal. In the long

run, application of this guideline should lead to improvements in recovery processes and critical examination of each waste stream and its origin, with a view to reducing the total transuranic element content.

The second method of minimizing the quantities of transuranic elements placed in retrievable storage involves the institution of good waste management practices in the processing areas. Procedures used in the areas and in the process lines can be designed to eliminate some materials which enter the waste streams. For example, unnecessary packaging material, which might become contaminated in an area where transuranics are handled, could be banned from the process areas. Plutonium production, fabrication, and recovery processes could also be modified to reduce the amount of contaminated wastes produced.

It should be noted that these guidelines were designed for the interim storage of wastes and not for the overall handling of waste problems. This guideline refers specifically to interim storage and not the problems of disposal of transuranics in concentrations lower than those specified as requiring storage. In general, dilution of the transuranics to place the final mixture below a concentration limit is an unacceptable practice. Since this guideline deals with very long-lived materials, it is important to recognize that the wording does not imply the minimization of the quantities sent to storage by means such as dilution, and disposal elsewhere is acceptable.

2. Criticality.

Guideline

The quantity of fissile material in individual packages shall be limited, on the basis of analysis of the potential for criticality in the storage array planned and in credible acci-

dent situations, taking into account the actual materials in the waste.

Criticality must be considered as a remote, but possible, occurrence in interim storage as several of the transuranic isotopes are fissile, in particular ^{239}Pu , ^{241}Pu , and ^{233}U . In general, current solid transuranic-contaminated wastes generated at AEC sites do not contain sufficient quantities of the fissionable transuranics to make criticality a serious problem in storage. Other potential problem areas such as general contamination escape, fire, and waste package corrosion have generally overshadowed the question of criticality. Nevertheless, controls must be established to assure against a criticality accident associated with the interim storage of transuranic-contaminated waste materials.

Criticality studies and calculations predicting sizes of critical arrays have been carried out in detail with regard to applications for Department of Transportation (DOT) Special Permits for shipments of transuranic wastes. These evaluations place limitations upon transuranic and waste content per individual package that can be transported in ATMX Series 500 and Series 600 railcars. Specifically, DOT Special Permit No. 5948 limits the transuranic (fissile) content to 200 g per 210-liter drum (or larger), 100 g per 115-liter drum, and 200 g/m³ in crates. No drum may contain more than 90 kg of graphite. Under these conditions it is not considered possible to have a criticality incident in any transport situation involving transuranic wastes contained in the limited array of an ATMX railcar.

The calculations to support DOT-SP-5948, carried out independently at Rocky Flats⁶ and Mound Laboratory,⁷ assume "worst case" situations for criticality. Each drum was assumed to contain a maximum 200 g of fissile material and 90 kg of graphite, and an array of such drums was considered to be fully reflected. Neither calculation

took into account the presence of any neutron-absorbing materials other than the steel drums. Using these assumptions, the calculations show that a cubic array of similar drums can become critical; but the size of such an array is considerably larger than could be present in an ATMX railcar.

Although these calculations showed that transuranic-contaminated wastes can be transported safely in ATMX railcars, they also show that in a "worst case" storage array of such packages, where the number of packages is not limited, criticality could possibly occur. In fact, however, the DOT limitations can be followed in storage with no criticality occurrence because typical waste packages contain a wide variety of materials, many of which are excellent neutron absorbers. Additionally, the assumption that all drums contain 90 kg of graphite is highly unrealistic. Calculations made at LASL for "typical" waste materials (for example, a mixture of cellulose, plastic, rubber, and polyvinyl chloride, or chemical treatment sludges) packaged in 210-liter drums (no liner), each containing 200 g of fissile material, indicate that they will not be critical in an array of any size.

Therefore, a suggested guideline to provide for assurance of criticality safety is that the limitations of fissile content of waste packages outlined in DOT-SP-5948 be followed in regard to acceptance of wastes for retrievable storage. For the reason presented above, there should be no possible means by which a critical array of such packages could be formed in any storage situation.

In general, transuranic wastes have not contained quantities of fissile material approaching the 200-g limit, largely due to "in-house" limits set for recovery of transuranics from potential waste materials. Only an occasional drum of waste sent to the NRTS for storage has contained more than

100 g of fissile material. (None were shipped in the first six months of 1973.) At less than 100 g of fissile material, even under "worst case" conditions, criticality cannot occur.

For the case of transuranic wastes shipped from Rocky Flats to the NRTS, one current requirement is that any 210-liter drum that contains more than 100 g of fissile material must be clearly identified by a colored band around the middle of the drum. Any drum so marked must then be isolated from any other similarly marked drum. This results in the physical separation of all packages containing fissile materials at a level for which an array of like packages (under optimal conditions) could conceivably approach a situation of criticality. This precaution is considered to present a generous backup control to the restrictions on fissile content outlined in DOT-SP-5948.

3. Nuclear Heating.

Guideline

The quantity of transuranic elements in an individual package shall be limited such that the combination of internal package environment and possible waste deterioration from nuclear heating will not adversely affect the containment of the waste package.

The effects of heating of either packaged wastes or packaging materials could result in containment loss. For example, it has been shown that long-term heating at even moderate temperatures (50-150°C) can result in increased rates of waste decomposition, gas formation, and possible package pressurization. For these reasons, the heating of wastes from external sources has been dealt with in a separate guideline. This guideline is specifically directed at heating effects caused by nuclear heating or the energy associated with the radiations (mostly alpha) from the transuranic elements or other radioactive

contaminants. Upon analysis of this problem, some limitation of quantities of certain transuranic materials or special control of storage conditions may be necessary.

The transuranic isotopes and many of their daughter isotopes decay via emission of high energy (up to 5.5 MeV) alpha particles. All decay energy is deposited directly in the waste matrix and the packaging materials. The calculated thermal outputs of certain transuranics and mixtures of transuranic isotopes are shown in Table 1.

These guidelines are limited in scope to consideration of the requirements of only AEC-generated wastes. For the case of weapons-grade plutonium, a limit of 200 g of fissile material per 210-liter drum is set by DOT as a transport limitation and has been suggested as a guideline for assurance of criticality safety in storage. At this maximum limitation of 200 g, the total thermal output is about 0.44 watt/package. Assuming conditions of a spherical package 0.9 m in diameter, containing a "typical" cellulosic waste matrix (assumed thermal conductivity = $4 \times 10^{-2} \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$) and homogeneous distribution of transuranic contamination throughout the waste matrix, a one-dimensional calculation indicates the maximum heat rise above ambient temperature at the center of the package will be only about 2.2°C. It is noted, however, that the possibility of localized heating due to a nonhomogeneous transuranic distribution has not been considered here.

Heat-source plutonium is a greater source of heat on a unit weight basis. In the situation where the 10-nCi/g limit is applied to the ^{239}Pu and ^{240}Pu content, the ^{238}Pu in a package containing 36 kg of waste would be about 16 mg with a heat output equivalent to about 4 g of ^{239}Pu . While this would pose no particular problem from uniform heating, quantities in excess of about 100 times this could result in significant heat loads. Solid particles of $^{238}\text{PuO}_2$ are also known to generate temperatures at the surface high enough to

TABLE I
POWER OUTPUT OF SOME PLUTONIUM ISOTOPES AND MIXTURES

<u>Source</u>	<u>Watts/g</u>	<u>Btu/hr-g</u>
^{239}Pu (pure)	0.002	0.006
Weapons-grade Pu (94% ^{239}Pu , 6% ^{240}Pu)	0.002	0.008
Heat source Pu (80% ^{238}Pu , 16% ^{239}Pu)	0.5	2.
High-burnup Pu (60% ^{239}Pu , 24% ^{240}Pu)	0.01	0.03

burn a hole in plastics or other organic materials. This can provide a mechanism for migration of the particles and for possible penetration of liners or protective coatings.

The thermal analysis required by this guideline can vary in detail depending upon the levels and types of transuranic element encountered in the wastes and the package and storage configuration. For relatively low heat loads a simple analysis such as that given above will suffice. However, where large quantities of transuranic elements with relatively high heat output (such as ^{238}Pu) are included, detailed calculations both for transport and storage arrays should be made.

4. Higher Contamination Levels Guideline

Scrap materials that are reclassified as wastes and wastes containing levels of transuranic contamination above that of normal retrievable wastes can be placed into an interim storage facility only after an analysis of the facility shows that the higher level material can be safely stored there.

The classification of materials as "waste" should be based on their negative

value relative to recovery-disposal costs. In some cases, administrative decisions are made to reclassify scrap materials containing significant quantities of transuranic elements as waste. This situation may arise from the current lack of recovery facilities or for other reasons involving economics, available storage space, or minimization of radiation dose to personnel.

If a decision to reclassify "scrap" as "waste" is based upon analysis (or correction of an earlier analysis) that indicates that the transuranic content is within the normal limits of retrievable waste, then the transfer of the material to retrievable storage can proceed. If, however, the actual transuranic content of the material is much higher than in normal retrievable waste, reclassification as waste should not be made until a determination has been made that full costs of storage and eventual disposal of the material as waste have been considered in the decision to abandon the recoverable values.

This guideline is concerned directly with the requirements for safe storage of this higher level waste material, which, because of its much higher level of contamination, has associated with it greater potential risks. For this reason, before the

higher level waste can be physically transferred to a retrievable storage facility, an analysis of the specific problems associated with its presence in the facility should be made and documented. One of the primary concerns associated with storage of highly contaminated wastes is the increased potential for the spread of contamination should package containment be lost. The breaching of even a single package of such material in a storage facility could result in all packages in the facility becoming highly contaminated.

In the event that the analysis indicates that all applicable guidelines are not satisfied or that the risk associated with the presence of the material in the facility is unacceptably high, the material should be placed into or left in scrap storage until such time as the necessary facilities are made available. At LASL, the NRTS, and Savannah River, a solution involving isolation and modular storage has been applied to this problem. At LASL, for example, a significant quantity of heat-source plutonium has been reclassified as waste, thus requiring retrievable storage. To accomplish this storage, a technique utilizing concrete casks has been instituted. Two packages of the waste material are being sealed in individual casks with each cask then effectively isolating these two packages from all others. At the NRTS, a sizable amount of high-level ^{233}U -contaminated waste will be stored on the ITSA pad and will be isolated from all other stored wastes, again limiting the extent of the contamination spread. At Savannah River, concrete culverts (1.8 m diam x 1.8 m high) have been used to contain both high-level wastes and scrap materials (several packages in each culvert). This general technique of isolation or modular storage is suggested as an excellent guideline for consideration where storage of such highly contaminated wastes must be accomplished.

E. Quality Control

1. Packaging Materials.

Guideline

A quality assurance program and quality control procedures shall be established to assure that all incoming packaging materials meet the engineering specifications.

A vital part of the retrievable storage plan is the establishment of engineering specifications for packaging materials and for package construction. Such specifications will be based upon the materials to be stored and the expected conditions of storage. In order to obtain assurance that the containers and other packaging materials used fulfill these specifications, it will be necessary to have a program of inspection of these items. Such programs are commonplace in the nuclear industry and are usually conducted at the time of receipt. In cases where adequate tests for specifications of the finished container (such as a specification based upon the method of manufacture) cannot be devised, inspections are conducted at the manufacturer's locations. In view of the importance of the packaging materials in assuring retrievability of the package and in minimizing package failure, some program of quality inspection and control should be established for these materials. In order to be effective, such a program should start with the purchase contract, which should include the specifications that packaging materials will be expected to meet upon receipt.

Past experience has indicated that if quality control procedures are absent, substandard containers might be used. Specifications for 210-liter drums (17C/17H) have been established by the DOT and have been given to drum vendors. However, many of the drums purchased have not met the specified quality, and these substandard drums have been used for waste storage. Since 1970, Rocky Flats has attempted to correct this situation.² Their specific

problems with faulty seams and drum-head sealing surfaces have been corrected through conferences with drum vendors and by establishment of a drum quality acceptance program. These drums are now produced under vendor quality control procedures and are again inspected and tested by the purchaser upon delivery.

One part of the overall quality control program for packaging materials should be a working agreement between the manufacturer and purchaser as to the detail of the manufacturer's quality assurance program. Moreover, records of the manufacturer's program should be available to the purchaser for inspection and review. These procedures have been initiated by both Rocky Flats² and ARHCO.⁸

The principal quality control procedures should involve both materials inspection and testing to determine final compliance with the engineering design specifications. This program need not be an operational part of the waste management program, but could be carried out as a normal function of a materials procurement group.

2. Final Package.

Guideline

A quality assurance program and quality control procedures shall be established at the waste packaging location to assure that the final package meets all guidelines and specifications. A seal that must be broken to open the package should be affixed before shipping to the interim storage area.

The quality assurance program for the packaging materials is designed to provide control of these incoming materials. In the packaging procedure, however, these materials are extensively handled, and the content of the wastes to be placed in storage must be controlled in order to provide an overall package that will meet the requirements for storage. Thus, a quality

control program intended to ensure that the other guidelines for packaging are indeed followed provides a final overall assurance that the package can safely be sent to the storage facility.

Such a control program can take many forms depending upon the management philosophy of the organization. Routine checks of the operating procedures can suffice in many instances. In others, written assurance from the person in charge of the waste generation area may provide additional control. In some cases, it may be desirable to have inspection of each package or spot checks of the contents and assembly of representative packages. An important item in the final check is a review of records for each package to assure that all required information is provided, in particular, the transuranic element content as measured or estimated by the generator. In addition, quality control procedures may also be necessary to assure that the guidelines concerning protection of the waste packages during temporary storage before shipping, during loading procedures, and during transportation to the storage area are met.

The seal for the package should be affixed at the conclusion of this program. This seal may serve several purposes. Firstly, it indicates that there has been no removal from or addition to the contents at any stage of the transportation, handling, or storage. It thus provides assurance to the package receiver at the storage facility that there has been no inadvertent or deliberate tampering with the package which could have resulted in a spread of contamination to other packages or to the public when en route. Secondly, the seal may serve as an identification tag for the package in compliance with the requirements for package labeling. Finally, for off-site shipments it may be attached as a security seal to meet safeguards requirements.

F. Fire Control

1. Fire Propagation.

Guideline

Combustible wastes shall be packaged or arranged in storage in such a manner that a fire occurring in one package will not propagate to another package.

If combustible wastes are placed in retrievable storage, there will be a finite probability of fire. Waste materials are composed of a variety of substances, including chemical contaminants. Therefore, they are potential candidates for spontaneous combustion and burning. Minimization of combustible wastes requiring storage and exclusion of materials and chemicals that can initiate combustion reduce the possibility of ignition. Nevertheless, should a fire somehow start in an individual waste package, it will be important to limit spread of the fire beyond its point of ignition.

Several techniques can be used to prevent the spread of fire from one package to another. The limitation of combustibles external to packaged wastes has been considered as a separate guideline. Others include the packaging of wastes in fire-resistant containers, spacing packages of combustible wastes, surrounding combustible waste packages with noncombustible packages, and, possibly, limiting the quantities of combustibles per package. Of these, the use of fire-resistant waste packaging appears to offer the best immediate overall solution. Spacing packages of combustibles, which AEC policy requires to be packaged separately from noncombustibles,⁵ could result in poor usage of storage space, with a resultant cost increase. Limiting the amount of combustibles in individual packages could effectively reduce the threat of fire spread when fire-resistant waste packaging is employed. The disadvantage of this method is the possibility of large cost increases. Surrounding packages of

combustibles with packages of noncombustibles would appear to be a viable technique.

In considering fire spread, the place to start is with the waste package itself. Available research shows the usefulness of having the primary waste package constructed of noncombustible materials with reasonably secure package sealing. H. W. Godbee⁹ has carried out studies of combustion with clean and chemically contaminated cellulosic and plastic wastes in 3-liter (0.1 ft³) plywood boxes and steel containers. While these packages may have been too small to give meaningful results for larger packages, he concluded that combustible wastes should be secure in noncombustible containers because there is insufficient oxygen in such containers to allow combustion to proceed to the point where the container could be breached.

Some comparative studies similar to the one above have been carried out with 3-m³ (standard 4'x4'x7') fiber glass-coated plywood boxes used to store some of Rocky Flats' wastes at the NRTS and with uncoated plywood boxes of the same size.⁴ Following ignition there was rapid self-extinguishment in both the coated and uncoated boxes as the oxygen was consumed. The only difference between the two was that the uncoated box was capable of venting the gases produced by combustion. These experiments indicate that completely airtight sealing is not strictly necessary for fire control. Package venting is allowable so long as the leakage of air into the package is at a rate low enough to minimize additional combustion. In fact, limited venting may be advantageous in preventing a container rupture from pressure buildup.

In the event that a fire in one waste package does succeed in breaching that package, the packaging materials must prevent the contents of adjacent packages from becoming additional fuel. Without additional fuel a fire will self-extinguish. It should be noted that the amount of combustibles external to the packaged wastes within the storage facility, if limited to a maximum

fire loading of 22 000 kcal/m² suggested in the following guideline, will have only a minor effect on the further spread of a fire originating in wastes contained in a single package in the event of breaching of that package.

There is a possible advantage in using small containers, whatever their specific type, for packaging of combustibles. By limiting the package volume, a limitation is placed upon the magnitude of a worst single package fire which all adjacent packages must withstand. The total heat from such a fire will be important in the potential breaching of adjacent packages of waste, as breaching of noncombustible containers will most likely occur via a pressurization mechanism. Again, this may be an advantage of containers capable of limited venting in that the potential effects of container breaching are prevented.

2. Combustible Materials in Storage Facility.

Guideline

The use of combustible materials in the interim storage facility external to the packaged wastes shall be kept to a minimum. When used, any such external combustibles shall not present a possible channel by which a fire can spread beyond the immediate vicinity of its point of origin.

An important feature of the storage facility design which may control the spread of any fire in a storage area is the amount, type, and arrangement of combustible materials external to the waste package. The use of such items as wooden pallets, plywood, plastic sheeting, or any other form of combustible material should be carefully reviewed. The ideal situation would involve the elimination of all combustibles external to the waste package in the storage area. However, for economic reasons, waste handling considerations, or other factors specific to a given waste type or storage site operation, this absolute exclusion

of external combustibles may be neither workable nor fully justifiable. Under these circumstances limitations on the amounts and types of uses of external combustibles are desirable in order to assure that no pathway exists for the spread of any possible fire.

On the ITSA pad at the NRTS, single layers of 9.5-mm (standard 3/8-in.) fire-retardant plywood and plastic sheet are used between each layer of 210-liter drums, and a single layer of 19-mm (standard 3/4-in.) fire-retardant plywood and plastic sheeting is used to cover the waste packages on the pad to keep soil from coming into contact with the packages. In the V-trench at AFHCO, no material was used to separate layers of drums, and metal sheeting was used as cover to prevent soil-package contact. Similarly, at Savannah River no combustible materials are used external to the waste packages stored in the concrete culverts.

Even the use of fire-retardant treated combustibles does not guarantee safety in storage. Treated materials such as woods can, in time, lose their fire-retardant properties through such natural aging processes as cracking of the wood, separation of layers, and other decomposition processes. Nevertheless, some limited benefit may be derived by the use of only fire-retardant treated combustibles where the external use of these combustibles is desirable.

One general rule applying to the use of external combustibles in a storage facility is that such materials should only be used where absolutely necessary and then within limits of an allowable external fire loading. A suggested guideline for limitation of external combustibles in the storage facility is that their use be confined to layers, each having a maximum fire loading of 22 000 kcal/m². Adherence to this guideline would limit the heat produced in a fire of external origin to a point where waste containers, if metal, would not be weakened or ruptured. The maximum temperature for such a condition would be

approximately 430°C for a period of less than five minutes. The heat-sink capability of metal containers would permit absorption and dissipation of this heat rapidly enough to reduce any possibility of container rupture. A listing of the approximate heat content values for typical types of materials that may be considered follows:

Cellulosic Materials	4 200 kcal/kg
Polyvinyl Chloride	5 300 kcal/kg
Rubber	8 600 kcal/kg
Plastics	8 900-9 400 kcal/kg

Layers should be separated from each other by at least 1 meter of noncombustibles and/or air. Combustibles sealed in a noncombustible package are considered a noncombustible layer. However, under some circumstances a primary package constructed of combustible materials may be used for certain waste types. For example, consideration might be given to the use of polyethylene or other plastic container for storage of process sludges. Under the restriction of this guideline, however, any combustible primary waste packaging materials must be included in the determination of the 22 000-kcal/m² limitation.

Despite the precautions and limitations discussed above, there is no guarantee that a fire external to the packages will not propagate through external combustibles. Sheets of plywood between layers of packages probably will not prevent a fire from spreading upward. Therefore, consideration should be given to the use of noncombustible materials such as metal sheeting, Transite (asbestos) board, or thin fiber glass sheeting.

3. Firebreaks.

Guideline

Firebreaks shall be installed at appropriate intervals within the storage facility to prevent the spread of fire.

The use of firebreaks in a storage facility containing combustible wastes is a basic technique to separate the storage area into smaller sections of risk. At the same time, the firebreaks can serve to limit the amount of air in each module. At the present time, the use of firebreaks is employed on the ITSA pad, where a 1-meter wall of soil is used to separate "cells" on the pad, each cell measuring 24 m x 46 m x 4.6 m (about 1 100 m² or 5 100 m³). Similarly, the prototype model of the V-trench at ARHCO was designed to have four compartments, each 7.6 m in length. This compartmented construction was, however, not followed through in the facility construction.

Many factors influence the need for and the size of areas to be separated by the use of firebreaks. The "need for" decision will depend upon the volume of actual combustible materials that must be stored. For the case where larger amounts of combustibles are present, decisions on limits for storage facility size should include consideration of fire loading within a given area; limitation on the amounts of contained transuranics; threat of fire; and costs of clean-up, decontamination, and repackaging of material should a serious fire somehow occur. (Note: AECM 0552 states: "Potential losses from a single fire exceeding \$100 000 are commonly viewed with serious concern while maximum potential losses exceeding \$1 000 000 are considered unacceptable.")

In establishing firebreaks, it is possible that some advantage could be derived from the proper intermixing of packages of combustible wastes with packages of noncombustible wastes in the storage area. In this way, the packaged noncombustibles might effectively provide a form of "internal" firebreak through separation of larger volumes of the packaged combustibles. This technique could be implemented through the stacking of combustibles and noncombustibles in alternate rows or by the establishment of small "pockets" of

combustibles separated by noncombustibles. In each case the effect would be to separate the stored combustibles into smaller groups to prevent the spread of a fire.

4. Provisions for Firefighting.

Guideline

The operator of the storage facility shall maintain adequate provisions to detect and effectively fight any fire which could occur at the storage facility.

Provided that all of the other guidelines regarding the prevention of fire within the stored wastes are followed, there should be assurance that any fire of serious consequence will not occur. Nevertheless, as added insurance there should be adequate means available to detect a fire and fight it and a capability of extinguishing the "worst case" fire.

Adequate provisions to fight a fire include the development of procedures for fighting fires in contaminated waste areas, as well as the availability of equipment and resources to fight a fire. A plan for the storage facility, in particular, should establish procedures for fighting fires in radioactively contaminated materials. The prime concern here is the immediate protection and safety of the personnel involved. Training of the personnel in such procedures is vital.

Equipment available may include standard firefighting equipment either from a nearby community or at the site itself if the site is isolated. For the case of an engineered storage facility, equipment could include an extinguisher system, such as a sprinkler system or perhaps an inert gas blanket, installed in the facility. Where wastes may be stored in a "facility" involving the use of an earth covering, earth moving equipment capable of keeping the facility enclosed, thus extinguishing the fire by cutting off the air supply, should also be available.

Finally, wherever there is a need for water as part of the firefighting requirements, provision must be made to have a water line leading directly to the storage site or to have adequate water storage at the site. Should a fire occur, consideration should be given to collecting and holding the spent water for monitoring and controlled disposal. If an inert gas blanket is used, consideration should be given to the need for filtering the gas to prevent escape of airborne contamination.

G. Package Handling

1. Damage to Packages.

Guideline

Packages that are damaged to a point where the engineering specifications for the original package cannot be assured or where the damage prevents compliance with other applicable guidelines shall not be placed into storage until they have been returned to a condition that meets all applicable guidelines.

Other guidelines have laid the basis for packages and their storage environments to meet the objective of retrievable storage. However, careful attention to all of these matters can be invalidated if packages are accepted in such a damaged condition that they would not meet the requirements for the finished package. The operator of the storage facility should, therefore, provide some package inspection and make provisions to reject or repair any packages that have been damaged beyond this point.

Certain types of damage to the container, to the seal, or to any additional protective coating might negate the engineering design and prevent the total package from meeting the goal of retrievability. Any damage incurred must not significantly reduce the ability of the package to survive under the conditions of storage. Thus, if a surface coating is necessary to control the external corrosion rate of a mild-steel

drum, scratched areas might reduce the life of the package. Dents might create stress areas which, if unrelieved, might serve as focal points for stress corrosion or stress-accelerated corrosion. Severe denting or crushing of metal containers will reduce the ability of the package to withstand even normal handling and may violate the integrity of the seal, thus increasing the possibility of contamination release. Fiber glass-coated plywood boxes may be scraped severely enough to expose the plywood.

The storage facility operator is responsible for the retrievability of the waste packages once they have been accepted at the facility. Since he will also be most familiar with the conditions at the facility, the responsibility of determining whether or not any package will remain intact for the 20-year period must rest with him. Unless the engineering specifications have provided a margin of safety with respect to possible damage, packages that the storage facility operator finds to be damaged beyond the specifications will require repair prior to storage. Such repair may take the form of either complete repackaging or, if possible, treatment to eliminate the damage.

Damage to a necessary external coating applied before shipment could be repaired by recoating the packages at the storage facility. Recoating can repair a large percentage of any scratched areas, but would not necessarily prevent localized stress corrosion in areas of more severe damage. Careful checking of the packages for contamination before shipping, and also at the time of receipt, would assure that no unacceptable level of surface contamination is covered by the coating. The cost of either repair or repackaging made necessary by damage incurred prior to acceptance at the storage facility should be borne by the waste generator.

An alternative solution involves the shipment of uncoated packages to the storage facility, where they could then be

coated. Any decision to follow this course of action would require cooperative action on the parts of both the waste generator and the storage facility operator.

2. Handling Methods.

Guideline

All handling methods for waste packages should be designed to prevent damage to the packages.

In order to minimize the number of packages rejected because of handling damage, the handling methods for the package must be considered as a part of the entire system. Poorly designed transport and handling techniques increase the chances of damage which will impair the ability of the package to survive the interim storage period.

In the past, transport methods have resulted in varying degrees of damage to the packages. "Humping" of the ATMX railcars containing drums from Rocky Flats previously had dented, crushed, or buckled the packages. Most of this damage has been alleviated as a result of studies of acceleration encountered and by the incorporation of cushioning devices such as airbags. Another system that helps protect waste packages in transport is the use of inner cargo containers within the ATMX cars. These inner containers also provide a simple method of removing the packages from the railcar and serve to reduce possible damage incurred during on-site transport from the rail area to the storage facility.

Handling of the packages during loading, unloading, and placement procedures is frequently effected through use of a forklift. Careless operation of the forklift may result in punctured packages. At the NRTS the forklifts have been modified by the addition of a device which encircles two drums and places them on the stack. This system eliminates the danger of puncture but does result in some paint loss. Another method that reduces the chances of a punctured package is the

use of pallets. At LASL, four drums of non-retrievable liquid waste treatment sludge are banded together on a wooden pallet. This unit is then lifted, with the fork-lift contacting only the pallet.

Handling of the packages at various stages of the storage operation should not contribute to the deterioration of those packages. A safe, economical method of handling should be developed in conjunction with the design of the package to assure that the engineering specifications continue to be met throughout the interim storage period.

3. Control of Transport and Storage Environment

Guideline

The storage environment should be controlled to avoid adverse influence on the containment ability of the waste package throughout the handling, transport, and storage of transuranic wastes.

The packaging of wastes at normal room temperatures and moderate humidities should present no particular problem for the generally encountered waste types, including combustibles. However, extreme temperatures and humidities at any point in the overall handling, transport, and storage procedure can result in harmful reactions in the waste or packaging materials. These reactions may result in destruction of some part of the package or decomposition or reaction of the contained wastes. Limiting the temperatures and humidities to which the waste package is exposed should minimize the extent of such potential sources of package degradation.

Most present methods of interim storage, which utilize a cover of a meter or more of earth, probably will protect the stored wastes from temperature extremes since the soil is a fairly good insulator.¹⁰ However, depending upon prevailing climatic conditions, any proposed above-ground storage structures could require temperature control systems. In any case, maximum

and minimum expected temperatures during any storage operation must be controlled within reasonable limits. No direct designation of temperature ranges is made here because of the diverse nature of the wastes and the unknown methods of packaging which may be used in the future.

However, extremes in temperature may cause problems during handling, transport, and temporary storage. One problem that may be encountered is the softening and melting of polyethylene liners in the waste packages. This will occur between about 100°C and 150°C (depending upon the density of the polyethylene).¹¹ The 2.29-mm polyethylene liner is intended to serve as the primary container should the steel overpack fail. Excessive heating can cause structural weakening of, and possible loss of containment by, the polyethylene, thereby negating the purpose of such a liner. Loss of containment ability could occur for the less rigid polyethylene liners and for the polyvinyl chloride bags used to protect process-generated wastes.

Another possibility of reaction from excessive heating occurs within the waste matrix. Increased temperatures might accelerate both thermal decomposition and chemical reactions of the wastes. The major constituents of the combustible wastes -- cellulose, polyethylene, and polyvinyl chloride -- are known to pyrolyze, with the production of various corrosive and flammable gases. Polyvinyl chloride decomposes above 100°C to produce HCl, which may attack the wastes, the liner, or the outer container if the liner is breached. Cellulose and polyethylene begin to decompose above 270°C to yield hydrogen, flammable hydrocarbons, and organic acids.¹¹ The presence of the flammable gases is undesirable since it would result in a design constraint on the storage facility to prevent accumulation. The National Fire Protection Association suggests that about 66°C is the highest safe temperature to which wood, a primary source of cellulose,

can be continuously exposed.¹¹ In addition to the possible problems created by the chemical properties of the evolved gases, their presence can pressurize the package. Evolution of sufficient volumes of gases, or the presence of sufficient heat to cause expansion of the contained gases, may also result in breaching of the package.

One of the major factors to be considered in this guideline is direct or indirect solar heating. Temperature control precludes heating of the packages by direct exposure to the sun, such as frequently occurs during temporary storage and transport. Fires due to solar heating of drums containing pyrophorics from Rocky Flats¹ and combustibles at ARHCO have been reported. In areas of intense solar radiation, temperatures inside black drums can exceed 100°C in the summer. Shipping or storing of wastes in enclosed facilities which can be heated excessively by solar radiation should also be avoided. Alternatively, the use of light-colored packages may minimize solar heating effects.

In storage areas where prolonged periods of subfreezing weather are encountered, some consideration should be given to the effects of extreme cold on certain waste types. For example, freezing and thawing of sludges, which contain 60% or more water, could cause separation of some free water from the solid material. In fact, the British and the Russians utilize natural freezing and thawing of their liquid treatment plant sludges to increase the sludge particle size and to effect settling prior to filtration.¹² Whether a separation would occur in the wastes and whether it would be hazardous to the storage facility is unknown. However, the very uncertainty that exists with respect to problems incurred at extremely low temperatures indicates a need to consider their occurrence during transport and within the storage facility.

Excessively high humidities may also cause containment problems, especially

through enhancement of corrosion rates of container materials. Unprotected mild steel, or painted mild steel that has been scratched and dented, is highly susceptible to corrosion. Several rust-inhibiting coatings can successfully eliminate or limit corrosion of mild steel. However, an alternate solution may be control of the humidity to which the packages are exposed. In either case, the corrosive effects of high humidities (including exposure to rain or snow) should be limited both before and after packages are placed in the storage facility.

4. Radiation Dose Rate and Contamination.

Guideline

The radiation dose rate and external contamination levels for the packaged wastes at the time of receipt at the storage facility, and at the end of the 20-year storage period, shall be such that the packages can be handled by individuals within the radiation exposure criteria established in AECM 0524.

For the safety of individuals shipping, handling, and storing transuranic wastes, the radiation levels and removable external contamination to which these individuals may be exposed must be controlled. Maximum allowable levels of radiation exposure to such individuals are established in AECM 0524. It is the obligation of waste management personnel to implement procedures to assure the safety of all operations personnel in the handling of the contaminated wastes.

Techniques are available which singly or in combination can provide the necessary controls. These techniques include:

1. Limitation of quantities of contaminants per waste package
2. Adequate package shielding
3. Waste handling procedures and methods that will not unnecessarily expose personnel involved.

All of these techniques shall be utilized to ensure that the internal and external radiation dose incurred by facility personnel during storage or retrieval shall be kept as low as practicable and within limits set forth in AECM 0524. Since waste form, packaging requirements, contamination level, isotopic composition, and other radioactive isotopes present will vary for different waste generation sites, the use of these methods will also vary. For example, if weapons-grade plutonium is the only waste contained for storage, it is unlikely that the external radiation flux will present a handling problem. On the other hand, containers of high activity heat-source plutonium or of ^{233}U containing ^{232}U will require procedures dictating greater control in order to protect personnel.

The waste handling procedures will include monitoring to ensure that adequate safety measures are being taken as well as to define the need for precautionary measures. Along the same lines, records of the isotopic transuranic content of the waste and a description of the package will be utilized in establishing the necessary safety precautions. Consideration should also be given to possible future increases in the external radiation flux (for example, at the end of the 20-year storage period) arising from the ingrowth of daughter products of certain transuranic nuclides and to the influence of this ingrowth of activity on later handling procedures.

Depending on the on-site handling procedures of the packaged wastes, two major sources of external radiation exposures are evident:

1. Whole body exposure - a prime consideration for personnel involved in mechanical manipulation of waste or for personnel remaining in the storage area for long periods of time
2. Hand and forearm exposure - a major consideration in hand manipulation of smaller containers.

Limits for removable external package contamination are not specifically outlined in AECM 0524. However, the DOT requirements for shipment of radioactive materials do set forth gross surface contamination limits. These limits must be met for any waste packages being shipped off-site. They may be applied to on-site storage in the absence of more restrictive on-site controls. These limits have been implemented by the transportation industry without apparent difficulty.

H. Storage Site Selection and Facility Design

1. Location - Protection of the Environment.

Guideline

In location and design of the storage facility an analysis shall be made and documented to provide reasonable assurance that the facility can be operated without undue impact on the environment, that the safety of the workers is adequate, and that the wastes can be retrieved without undue hazard or cost.

Because of the remote possibility of an accident at the facility, selection of a site for transuranic waste storage requires consideration of the public welfare, as well as some degree of public convenience. Attainment of this goal requires an analysis of factors of both an environmental impact statement and a safety analysis report. When the study has been made and documented, it should then be possible to balance the various factors and select an optimum location and design for the storage facility. This analysis should also identify those ongoing monitoring programs needed to demonstrate the reasonable assurance of safety.

An important determination in the selection of any site for a storage facility is the identification of mechanisms and pathways by which contamination could be transported to man's environment.

Analyses of both regional and local site ecology, hydrology, meteorology, geology, and seismicity will provide the inputs necessary to these determinations.

The planning of a storage facility will require both the identification of natural phenomena in a proposed area and the determination of the probability of occurrence and the magnitude expected. These data can then be used in the determination of the adequacy of a proposed site and construction requirements to assure containment during interim storage.

Assuming that all the above considerations have been satisfied, the actual threat to the storage facility from a major earthquake will be small. The most important consideration is that any storage facility should not be located on a major active fault. At a distance from such a fault, the primary effects of a possible earthquake would be movement of the packages and, perhaps, minor damage. Prevention of damage in this situation could be effected through packaging and stacking methods. The methods of storage currently being used at various AEC installations include the use of close-packed stacking arrays which could minimize shifting of the packages during an earthquake. If such wastes were stored in a manner that provided considerable free space, they could fall, with the possible result of some damage to the packages. However, if the packages used actually meet the specifications required for transport, a minor amount of shifting or tumbling may be inconsequential. Finally, even the breaching of several packages would not necessarily lead to a major spread of contamination within the facility. However, the possible need to repackage or restack some packages following a major earthquake should be considered.

Flooding of a storage site could spread contamination to adjacent areas. This problem may be most serious if contamination borne by flood waters is carried into lakes or rivers. In an arid climate the

the possibility of flash flooding in gullies or other depressions exists. Steps should be taken to provide adequate slope and surface drainage to avoid water collection. Proper landscaping of the area, including the construction of dikes or other flood control devices, should be considered where necessary. Along these same lines, both the depth of the water table and any possible movement and fluctuations in depth of the water table must be considered.

The possibility of violent wind storms, such as tornadoes, must be considered, although such events would probably have limited effect upon the storage facilities in use today once they have been closed off. Of particular interest, however, is the method of temporary storage before the wastes are transported or placed into the storage facility. Here the packages are frequently stacked in a location that exposes them to the weather. Wastes stored in this manner are particularly vulnerable to violent winds, and the advisability of using open storage of this type will depend on the wind conditions expected. In addition, the open end of facilities such as the ITSA pad and the proposed asphalt-lined pit at LASL may be especially susceptible to violent winds. For earth-covered facilities landscaping and soil fixation will prevent soil erosion and minimize the chances that the wastes will be uncovered. For example, erosion-retardant grasses currently are used at ARHCO and NRTS to prevent soil movement.

Another possible area for concern would be any ecological consequences (both radiological and nonradiological) of construction and/or operation of the proposed storage facility. Here, however, it must be noted that there are no planned releases of radioactive or chemical contaminants at the storage facility, nor would significant doses of penetrating radiation be expected outside of the actual facility.

There are three closely interrelated factors that require more detailed analysis: population distribution in the

surrounding area, transportation requirements of the waste material, and land usage. The population density in the proposed area should be small enough that the overall consequences of even an improbable accident will be small. This need suggests not only that the facility should be located in a sparsely populated area, but that there should also be a suitable buffer zone of unused land between the facility and the nearest habitation. Such conditions do prevail at most AEC facilities, where the storage areas are located on large government reservations.

The second factor to be considered is transportation availability and routing for the movement of waste materials from the generation site to the storage facility. The method of transportation used must be selected to ensure the greatest safety to the general public.

The third factor, present land usage, is also inherently related to public welfare and convenience. Consideration must be given to the protection of land being put to profitable or recreational use. The use of public or private recreational lands should also be avoided to minimize interference with the rights of the public. A strong argument can be made for the possible use of land containing facilities previously used for other nuclear activities and which may already be contaminated, thereby requiring permanent custody and perpetual care.

2. Secondary Barriers

Guideline

The design of the storage facility should provide a secondary barrier between the packages (which are regarded as the primary containment) and the groundwater and atmosphere.

While massive failures of waste packages are not expected, it is prudent to design the storage facility so that uncontrolled release of contamination will not occur even in minor failures. The primary

escape pathways are air and water. Some method of secondary containment should be considered to prevent leakage into the environment. The secondary containment could also serve to support the waste packages in the facility.

Secondary containment for packages of transuranic-contaminated wastes has been implemented at AEC sites in several ways. At ARHCO, when the concrete-lined V-trench was filled with packaged wastes, it was covered with metal sheet and 1.2 m of soil. At the NRTS the procedure is similar. Here, wastes are stored on an asphalt pad and enclosed with layers of plastic sheet, plywood, and approximately 1 meter of soil. At Savannah River, drums of waste are enclosed in concrete culverts which are sealed at both ends and buried. Each of these systems prevents ready release of moisture to the environment and can provide a means of collecting any moisture for monitoring.

When filled and covered, each of the above storage facilities may be a nonventilated unit. The possible production and buildup of combustible gases from radiolysis and other waste degradation mechanisms in such an enclosed storage area must be considered. Ventilation of the facility may be required if the concentration of such gases attains a level of 10% of the lower explosive limit. Under these conditions the use of HEPA filtration may be necessary to maintain an adequate degree of secondary containment.

The problem of free water entering the storage facility has been considered as a part of the engineering design for storage at ARHCO and NRTS. Thus, at both sites the actual facility (the secondary containment) is such that any free water within the facility will drain to a collection point where the water will be held for analysis prior to possible release. Provision for collection of runoff water is suggested for the design of secondary containment methods.

3. Control of Access.

Guideline

The area used for the interim storage of transuranic wastes shall be adequately controlled to prevent ready access by unauthorized persons.

The area selected for the interim storage of AEC-generated transuranic wastes will be on land owned by the Federal government and identified by the posting of appropriate signs. This, in itself, can provide some control of public access to the storage facility. It does not, however, preclude entry, either accidental or deliberate. The presence of contaminated material can present a potential hazard through direct exposure to trespassers. If the trespasser removes contaminated material from the facility, he may indirectly expose others.

Although the storage facility, especially after it is filled, should prevent ready access to any of the contaminated materials, there is still the chance of exposure to transuranics (or any products of degradation of the waste materials) should an unsuspecting person engage in some activities in the area. In addition, the possibility of deliberate removal of materials exists. For example, some tool or piece of equipment might invite theft, or contaminated material might be removed for political or criminal purposes.

In order to prevent any public access to contaminated material, adequate control procedures must be instigated. It is not sufficient that the storage facility be on a fenced government reservation. Adequate surveillance is not feasible for the large areas included in many of these reservations. Also, many people not acquainted with the storage facility have access to such areas. Instead, the immediate area about the facility should be fenced in such a manner that individuals cannot readily enter, either accidentally or deliberately.

4. Flammable Gases.

Guideline

The design of the facility shall be such that the concentration of flammable gases, resulting from any waste degradation mechanism, shall not reach the lower explosive limit for such gases.

It is known from laboratory experimentation that flammable gases are generated from radiolysis, pyrolysis, and other waste degradation mechanisms operating upon typical solid waste matrices, such as cellulose, polyethylene, polyvinyl chloride, other plastics, rubber, and even water. For example, H_2 is a major product of radiolysis for most of the above materials. In addition, radiolysis of cellulose, as well as of some rubber and plastic materials, can generate significant quantities of low molecular weight gaseous hydrocarbons. Flammable mixtures of these products in air are found to range from about 2% to 8% of the gas by volume. For H_2 a mixture of 4% by volume in air is combustible.

Several problems exist in attempting to correlate the results of laboratory experiments with the types of situations encountered in the storage of transuranic-contaminated solid wastes. At present, it is not possible to make realistic predictions for the actual rates of gas production in these materials by the above mechanisms. In the case of radiolysis, for example, the rate of production of various gases will depend not only upon the amount of transuranic contaminant present, but also upon such factors as the exact composition of different wastes present, the manner in which the waste matrix and transuranic contaminant are intermixed, and even the packing density of the contained waste. Pyrolysis and other decomposition mechanisms will be dependent upon temperature and chemical contaminants present.

For these reasons, appropriate measures need to be taken only if a problem

materializes. In fact, sufficient quantities of flammable gases to invoke this requirement may not be produced in the 20-year period. Thus, a requirement that the storage facility be ventilated, based upon the mere possibility of a future problem, may be unwarranted as well as unnecessarily costly. A provision in waste package specifications for containment of all gases produced may also be unreasonable in light of the many unknown factors. However, in order to prevent any violent propagation of fire, a limit of 10% of any explosive gas mixture is suggested as the point at which some form of corrective action must be taken. Since many of the gases considered have very low explosive limits, the 10% value might be expected to provide a sufficient safety margin to permit safety measures to be taken. Provision for monitoring the storage facilities for such gases is called for as part of these guidelines.

This guideline for required corrective action is considered adequate to allow both a decision for and an implementation of the necessary action before a real problem develops. Gases, if generated, may tend to collect in the storage area in pockets containing locally higher concentrations. Again, the limit of 10% of the explosive mixture should be sufficiently low that even if such localized pockets are formed, they will not contain a flammable gas mixture.

I. Storage Facility Operation

1. Operational Procedures.

Guideline

All operations of a storage facility should be covered by an approved and documented procedure.

Written operating procedures are already required at AEC facilities. All operations carried out at the waste storage facility must be covered by a documented and approved standard procedure. Areas to be covered by such procedures at a storage facility should include, but should not be

limited to, storage facility monitoring, package inspection, waste handling, acceptance of packaged waste, and emergency procedures covering the occurrence of fires or other potential untoward events. The operating procedures should also include documentation of the site definition of normal retrievable waste. Such a definition can be used to determine special cases requiring additional safety analyses before storage. Procedures to be used should be approved through the standard managerial channels of the operating contractor.

2. Monitoring.

Guideline

Provision shall be made for monitoring of the storage area for radioactive release and other parameters appropriate to the safety of the storage area.

Monitoring of the storage environment will be useful in determining conditions existing within the storage facility. Different forms of monitoring can define environmental storage conditions that may cause package corrosion, detect situations that could pose problems to retrieval operations, and help maintain safety at the storage site. Maintenance of records on the monitoring data and periodic comparison of the results to determine any observable trends are advised. In addition, procedures should be established to correct any unsatisfactory condition detected by the monitoring program. Such corrective actions may include the need for visual inspection of the packages to determine the extent of any damage. Some items for which monitoring in the storage facility would be particularly appropriate are described below.

a. Airborne Contamination

In the event of a major breach of waste packages, monitoring of the air in a storage facility for airborne contamination may detect the condition. In a ventilated storage facility, monitoring of the exhaust air should be carried out in

a manner to ensure that airborne contamination levels are as low as practicable. In a completely closed facility, air monitoring need be carried out only at periodic intervals, or whenever personnel must enter the facility for any purpose.

Extensive continuous monitoring of a storage facility for airborne radioactivity need not be required because information obtained by this technique would be of a limited nature anyway. Thus, minor losses of package integrity would probably not be detectable and by themselves would pose little threat. On the other hand, a major loss of package integrity would probably be detected by the limited use of properly situated monitoring equipment (for example, at a ventilation port).

Along these same lines, some monitoring for airborne radioactivity outside of the storage facility is suggested to provide routine assurance that the environmental concentrations of airborne contamination meet the AEC guidelines. At an AEC installation such monitoring would be a normal part of the environmental monitoring program.

b. External Penetrating Radiation

Whenever a storage facility is entered or waste packages handled, normal monitoring procedures should be followed for the safety of the personnel involved. During the period of interim storage, levels of penetrating radiations from certain stored transuranic wastes may actually increase due to the growth of ^{241}Am into the isotopic mixture.

c. Air Analysis for Combustible and Corrosive Gases

The possibilities of producing combustible and/or corrosive gases from several waste decomposition processes has been discussed. In the case where the storage facility is well ventilated (for example, a forced air system), monitoring for these gases may not be necessary. However, if the facility is to be closed off, as is presently done at the NRTS, ARHCO, and

eventually at LASL, monitoring for buildup of these gases will be essential.

At the least, periodic monitoring of a closed storage facility will be necessary, with gas samples being removed from the storage environment and analyzed. Potentially hazardous gases, if produced in sufficient quantities to escape individual waste packages, may build up concentration in the storage area over long periods of time, thus necessitating only periodic monitoring. Another characteristic that may be associated with such gas production in the facility is the possible tendency of gases to form in pockets rather than to mix homogeneously throughout the facility.

d. Smoke Detection

Assuming guidelines relating to the presence of and use of combustible materials in the storage facility are adequately followed, there should be reasonable assurance that a fire will not occur in the storage area. Nevertheless, in any situation where combustibles are present in the facility, consideration should be given to the use of smoke monitoring as another means of continued checking on the storage environment. As with the use of equipment for monitoring airborne radioactivity, smoke monitoring equipment should be used in such a way that fire could be detected in areas where combustibles are present.

e. Temperature and Humidity

The rate at which external sources will cause deterioration of the waste packages will depend on the temperature and humidity in the storage environment, as well as on the type of packaging material and any external protective coating that may be present. Should external package corrosion be found to be progressing at an excessive rate under one set of environmental conditions, some definition of those conditions will be of value in effecting necessary changes. If a storage facility is designed to provide direct control of temperature and humidity conditions, monitoring of these conditions will be necessary to maintain control throughout

the facility.

f. Collection and Analysis of Runoff Water

Any runoff water from a storage facility should be collected and analyzed, because the presence of free water indicates a potential problem and is an important subject for monitoring. Thus the rate of package degradation could be increased if groundwater entered the facility or if free water originated from the actual stored wastes when package containment had already been lost (a remote possibility). At any rate, all free water leaving a storage facility should be collected and monitored before it is released to the outside in order to ensure that contamination is not allowed to escape.

3. Acceptance of Packages

Guideline

Acceptance standards for packages to be stored shall be defined. Such standards should include, but not be limited to, the types of packages to be accepted and the information to be supplied. The final decision as to the acceptance of any waste package should rest with the operator of the storage area.

Once the waste packages have been accepted at the storage facility, it is the responsibility of the facility operator to maintain the safe handling and retrievability of the packages. The methods of handling and storage of the wastes should be organized to provide compliance with AEC standards and with these guidelines. In order to ensure adequate functioning of the storage facility, the operator must be able to specify which packages will be accepted.

Procedures for arranging the waste packages, unloading them from the transport vehicles, and stacking them in the prescribed array will be established by the facility operator. The stacking arrangement, types of handling equipment, and environment prevailing in the storage facility

will contribute to the requirements placed on package acceptability. Maintenance of the retrievability of the packages may require limitation of the acceptable weight of any container to prevent possible damage to the lower packages in a stack. In addition, it will be necessary to exclude packages sufficiently damaged to hinder the safe storage of the wastes. For these reasons, the facility operator must be able to set the acceptance standards of waste packages at the storage site.

However, decisions concerning the types of packages should not be made arbitrarily by the facility operator. Consideration should also be given to the procedures and needs of the waste generator. Operator-generator communication should result in flexibility at each end of the waste handling process so that workable compromises between existing storage conditions and available package types can be reached.

In addition, the operator must have some control over the information supplied by the waste generator. Although certain information on each package is required by these guidelines, the operator may feel that supplementary data are necessary to ensure the safe operation of the facility.

J. Records and Package Labeling

Guideline

Each package of waste shall be labeled in such a manner that the package can be identified from a separate set of records. Such labels shall be designed to be legible after 20 years. Minimum information kept in the records shall be as follows:

1. General Information

- a. Package Identification
- b. Date of Packaging
- c. Source of Waste
- d. Location of Package in Storage
- e. External Radiation Level
(neutron-gamma)

2. Package Contents

- a. Description of Waste Matrix
- b. Hazardous Chemical Content

- c. Combustible/Noncombustible Designation
 - d. Estimated Weight and Volume of Contents
 - e. Transuranic Element Content
3. Description of Package and Packaging Material

The AEC plan for management of radioactive waste requires the labeling of waste packages and record-keeping on wastes disposed of.⁵ Such informational requirements can serve several purposes. During the period of storage of waste materials and at the time of their retrieval, it will be important to be able to identify them. If, for example, certain types of packages are found to be failing and repackaging or closer surveillance becomes necessary, it should be possible to identify all like packages and their location in storage. Actions to be taken at the time of retrieval have not been defined and probably will not be until further details on the final repository concept and requirements are available. It is possible that further treatment to immobilize the wastes will be used at this time or that the standards set for the permanent repository will require recovery of at least a portion of the contained transuranic elements. Actions to implement such a recovery process will require information on the types and quantities of materials in storage, as well as the ability to locate those wastes that require each type of handling or treatment. Thus, it appears that some system of providing such information must be a vital part of the overall storage concept.

Current record-keeping and package-labeling practices vary among the different storage sites. A system in which the coordinates of the burial site are recorded for each shipment, along with the place and date of origin of the waste materials, has been used in the burial of nonretrievable wastes at Los Alamos. This system has been useful in allowing recovery of specific

shipments in which valuable material has been inadvertently included in the waste package. Idaho Falls is setting up a comprehensive record system in which all available information on each package of retrievable waste is stored in a computer and is coded against the label on the package.

Several different methods could be used to implement this information system. For example, use of individual storage areas for each waste category and each packaging type would obviate the need for separate records or even for marking individual packages, since the source of the waste could be identified by its location in the storage area. However, this would be expensive; and much of the information listed above, such as the transuranic content of the package, would not be available. Similarly, a system in which the waste category and type of packaging are designated by a coding system involving the shape, size, and color of the package would eliminate the need for individual package records; but the difficulty of providing a large number of separate packages and packaging materials seems to override the advantages. Thus, a separate computerized record of each package, coded to the package by an identifying label containing a package identification number, appears to be the most desirable system. For a small operation, the records might be kept manually; but a computerized system would allow easier access to the data at the time of retrieval and would permit detailed planning of the retrieval operation or any additional treatment required.

Information areas requiring further clarification are discussed below:

1. Location of Package in Storage

At the time of package retrieval, operations will be greatly facilitated if the locations of packages of a given category are known. Ideally, one might visualize a storage facility where the individual categories of waste are stored in separate areas so that all waste of one type can be

easily located and moved. However, such a program may be difficult to execute because of the cost and the differences in waste category definition which occur between sites and with time at the individual sites. This means that some sorting of waste materials may be required at the time of retrieval if different treatments or permanent repository criteria are applied to different categories of waste.

2. Description of Waste Matrix

If waste treatment is to be carried out at some future time, data concerning the exact materials and quantities of materials in each package will be required. This information would permit segregation of the packages by contents and allow design of the treatment processes to deal with the specific materials. If the material is to be transferred directly to a permanent repository without treatment, only general information, such as waste type, may be needed. It must be assumed at this time that future treatment is a possibility and that information on package contents must be kept in adequate detail to permit planning for this contingency.

The question of detailed knowledge of the contents immediately arises. Some materials, such as the liquid waste treatment sludges, can be well characterized when the process and the uniformity of the resulting product are known. However, in this situation detailed definitions of the terms used at different AEC sites become necessary. The degree of knowledge of exact package contents may vary from one site to the next, depending upon other needs which may control segregation and sorting. At Rocky Flats, the room and process-generated waste is sorted into a large number of categories of defined materials in order to permit better measurements of the transuranic element content of the packages. At other locations such extensive sorting is currently not done. Moreover, there appears to be no real need at the present time to require detailed sorting for the

sole purpose of the 20-year storage. However, if such sorting is done for any purpose, each of the defined waste categories should be retained as an identified waste type in order to simplify later treatment.

Each waste-generating site should establish definitions of the individual waste categories placed in retrievable storage and should provide for appropriate identification of packages according to these categories. Further, to provide for changes in character of the work and/or the processes used, these definitions should be updated at least annually (or whenever there is a significant change in a waste stream). For unique types of wastes for which a defined waste category has not been established, the actual contents of the package should be listed in the record.

3. Combustible/Noncombustible Designation

At the time of retrieval, treatment may be possible for combustible wastes. For this reason, a designation of combustible or noncombustible material will be valuable in providing an initial identification of packages containing combustibles. These materials can then be more easily separated from all other waste forms. Any later separation by specific waste material can be made using the waste definition supplied for the record.

4. Estimated Weight and Volume of Contents

At Rocky Flats, a minimum quantity of waste per package is specified; and any package containing less than this quantity is returned to the originator. This concept appears to be workable and would serve to minimize the storage space required for the wastes.

The information on the quantity of waste in the package will be useful in the scheduling of retrieval and possible treatment operations. In addition, the cumulative information will provide a better indication of the overall performance of the waste management system and the potential

impact of possible changes in processes or waste handling. Therefore, it is recommended that weights and volumes of the packaged waste materials become a part of the record.

5. Transuranic Element Content

At all locations, some method of assay of the waste packages for the content of transuranic elements is used. Currently, the sensitivities that are attainable vary with package size and contents and are well above the 10-nCi/g level used to define retrievable wastes. Thus, packages bearing no data on the quantity of transuranic content are going into retrievable storage on the basis of an administrative decision that they might be contaminated above the retrievable limit. However, information relating to the package measurement at the time of shipment should be preserved in the records for that package. At a minimum, this will permit ready identification of those packages that have higher transuranic element contents so that decisions on possible recovery of transuranics to some minimum level can be made if required. Current developmental work indicates a possibility of assaying to the 10-nCi/g level in low-density wastes packaged in cardboard boxes. Such a measurement, made before the waste is placed into its actual storage container, may prove to be valuable for obtaining actual levels of contamination for the purposes of inventory and retrieval.

Frequently, additional information on the isotopic composition of the transuranic element mixture in the package can be obtained from this measurement or from other sources (such as the area from which the package originates and the types of materials handled in this area). Such information is also of value in estimating radiation dose rates or other hazards and should be preserved by the same system. Whenever possible, the actual transuranic element isotopic analysis should be provided, and concepts such as "gross alpha" or "plutonium-239 equivalent" should be discouraged.

6. Description of Package and Packaging Materials

The materials specifications of the packages (including liners, gaskets, and coatings), as well as descriptions of closure and sealing methods, will be required in the planning and execution of efficient retrieval operations. In addition, if experience indicates that a particular type of packaging with a given type of waste category is suffering an abnormal failure rate, such data will be valuable not only in the identification and solution of the problem but also in plans for possible repackaging operations should they become necessary.

ACKNOWLEDGMENTS

The guidelines for the interim storage of solid transuranic wastes were derived in the Health Division of the Los Alamos Scientific Laboratory, and the work was supported by the USAEC's Division of Waste Management and Transportation. This work was carried out in the Waste Management Section of LASL's Group H-8, Environmental Studies, under the direction of L. J. Johnson (Group Leader) and J. A. Mohrbacher (Special Consultant). Many individuals throughout the Laboratory have been involved in the derivation of these guidelines. Principal authors include E. B. Fowler (H-7), J. W. Healy (H-Division Office), D. E. McCurdy (H-8), R. Mulkin (CMB-11), K. A. Pashman (H-8), J. L. Warren (H-8), and M. L. Wheeler (H-8).

The authors wish to acknowledge the guidance and technical review offered by the Division of Waste Management and Transportation and by other AEC administrative and contractor personnel. Review comments were received from the Division of Operational Safety, the Division of Production and Materials Management, Oak Ridge Operations Office and the Oak Ridge National Laboratory, Savannah River Operations Office, Idaho Operations Office, Richland

Operations Office and contractors, Albuquerque Operations Office, Dayton Area Office and Mound Laboratory, and Rocky Flats Area Office.

REFERENCES

1. E. B. Fowler et al., "Transuranic Waste Research and Development Program," Los Alamos Scientific Laboratory report LA-5281-MS (May 1973).
2. P. A. Patton and J. W. Lindsay, "Improvements to a 55-gallon DOT 17C Shipping Container for Alpha-Emitting Transuranium Waste," Rocky Flats report CRDL 950703-001 (December 1972).
3. "Specification of Procurement of 55-Gallon Drums for Storage of Radioactive Materials," Atlantic Richfield Hanford Company report HWS-8828 (August 1972).
4. J. W. Lindsay and W. E. Donning, "Improvements to a Plywood Container Used for Shipping Alpha-Emitting Transuranium Wastes," Rocky Flats report CRDL 950612-001 (April 1972).
5. "Plan for the Management of AEC-Generated Radioactive Waste," U. S. Atomic Energy Commission report WASH-1202(73) (July 1973).
6. F. E. Adcock, "ATMX-600 Railcars for Radioactive Waste Shipments," Rocky Flats report RFP-1411 (January 1970).
7. E. P. McDonald and J. R. Griffin, "Documentation of DOT-SP-5948 for ATMX-500 and ATMX-600 Railcar Packaging," Mound Laboratory report MLM-1912 (April 1973).
8. R. A. Kennedy, "Design Criteria Transuranic Dry Waste Burial Containers," Atlantic Richfield Hanford Company report ARH-2239 (March 1972).
9. H. W. Godbee, "Spontaneous Combustion, Oxidation, and Pyrolysis of Combustible Solid Wastes Containing Transuranium Elements in Combustible and Noncombustible Containers," Oak Ridge National Laboratory report ORNL-4768 (May 1972).
10. M. D. Keller, Compiler, "Geologic Studies and Material Properties Investigations of Mesita de Los Alamos," Los Alamos Scientific Laboratory report LA-3728 (November 1968).
11. E. B. Fowler, Compiler, "Transuranic Waste Repository Studies," Los Alamos Scientific Laboratory report LA-5127-MS, Vol. I (December 1972).
12. C. B. Amphlett, Treatment and Disposal of Radioactive Wastes (Pergamon Press, New York, 1961), p. 125.

APPENDIX A
IMMEDIATE ACTION DIRECTIVE 0511-21

Form AEC-333
(7-61)

Published in advance of incorporation in
AEC Manual 0511
File and retain in Manual until superseded.

UNITED STATES ATOMIC ENERGY COMMISSION
AEC MANUAL

IMMEDIATE ACTION DIRECTIVE

IAD NO. 0511-21

DATE: March 20, 1970

SUBJECT: POLICY STATEMENT REGARDING SOLID WASTE BURIAL

This Immediate Action Directive (IAD) implements the recommendations of the Task Force on AEC Operational Radioactive Waste Management on costing, segregation, and retrievability of waste. (Reference AECDO December 2, 1969, memorandum to Managers of AL, ID, OR, RL, and SR) This IAD applies to burials of all solid waste after April 30, 1970, and reflects the field comments, which are summarized below, on the Task Force report:

1. There are no objections to the apparent intent of the policies; and at present they are being followed, or could be followed.
2. Clear definitions and clarifications as to intent are required for a number of the terms used.
3. More time is needed to put the policies into effect fully.
4. In some cases the costs may be considerable.

It is recognized that specific definitions would be helpful in these areas, and they will be forthcoming after additional review and evaluation are completed by the Task Force and particularly its Working Group on Sorting.

Heads of Headquarters Divisions and Offices and Managers of Field Offices are responsible for assuring that:

1. For AEC operational situations, intersite burial charges include full cost, exclusive of land, depreciation, added factor, and perpetual care costs. For purposes

March 20, 1970

of comparative cost evaluations of solid waste burial (or interim storage) versus additional processing for volume reductions etc., all costs are included; e.g., depreciation of facilities, cost of land, and present worth of perpetual care costs.

2. Wastes with known or detectable contamination of transuranium nuclides are segregated from other types of wastes by the waste generator and kept segregated in the solid waste burial ground. The most sensitive and reliable methods available for detection are used for segregation.

NOTE: Detection limits of equipment now being used for routine checking of plutonium-containing waste packages is approximately 500 milligrams per cubic foot for a 5-cubic foot package. New instrumentation now being tested is expected to reduce this detection limit by at least one order of magnitude. The application of this policy will be refined by the Working Group on Sorting as more information is obtained.

3. Wastes with known or detectable contamination of transuranium nuclides are packaged and buried in such a fashion that they can be readily retrievable as contamination-free packages within an interim period of 20 years; beyond that period retrievability should continue to be possible. Wastes received by a burial ground operator, which are not suitably packaged for retrievability, will be so packaged by that operator with such packaging and handling costs charged to the shipper.

Those offices which cannot comply with the above policies shall request an exception, in writing, which states the reasons for noncompliance and indicating the date on which compliance can be effected. Requests for exceptions shall be directed to the AGMO.

General Manager

APPENDIX B
AEC MANUAL CHAPTER 0511

U.S. ATOMIC ENERGY COMMISSION
AEC MANUAL

Volume: 0000 General Administration
Part : 0500 Health and Safety

AEC 0511-01
WMT

Chapter 0511 RADIOACTIVE WASTE MANAGEMENT

0511-01 POLICY

It is the policy of the AEC to manage radioactive waste in such a manner as to minimize the radiation exposure and associated risk to man and his environment over the lifetime of the radionuclides.

0511-02 OBJECTIVE

To assure safe long-term management of all radioactive waste generated by AEC operations and of that radioactive waste which is delivered to the AEC by licensed operations as required by regulations.

0511-03 RESPONSIBILITIES AND AUTHORITIES

031 The General Manager approves the AEC radioactive waste management plan submitted by the Division of Waste Management and Transportation (WMT) and determines compatibility of field office waste management plans with the AEC plan if questions as to compatibility raised by WMT are not resolved by the Assistant General Managers concerned.

032 The Director, Division of Waste Management and Transportation:

- a. is responsible for program direction and fiscal control of the long-term management of high-level radioactive wastes at AEC facilities.
- b. is responsible for program direction and fiscal control of all near-surface radioactive solid waste burial grounds at AEC facilities, and of engineered storage vaults at AEC facilities for interim storage of solid radioactive wastes from licensed activities.
- c. is responsible for program direction and fiscal control of operations of Federal repositories for the disposal or long-term storage of radioactive wastes, to include: developing, performing studies for, designing, constructing, demonstrating, and obtaining necessary external reviews and approvals.

- d. coordinates the development and annual updating of an overall plan for the management of radioactive waste from AEC operations.
- e. calls for field office waste management plans, reviews them with advice of program divisions, and determines their compatibility with the overall plan.
- f. exercises overall cognizance, coordination, and review of waste management activities, including the degree of progress in meeting schedules and objectives, to assure compliance with AEC policies and requirements; coordinates with appropriate program divisions to assure that field office waste management planning and budgeting are consistent with the AEC overall plan.
- g. develops, recommends, and promulgates policies, guides, and requirements for treatment and storage of liquid, solid, and gaseous wastes at AEC facilities, including the definition of categories of waste; assists the Division of Operational Safety in the development of safety policies, guides, standards, and requirements for the release of radioactive effluents to the environment.
- h. determines or approves criteria and specifications, including those relating to packaging and transport, for wastes which are to be stored in near-surface land burial grounds or engineered storage vaults at AEC facilities, or are to be stored in Federal radioactive waste repositories.
- i. prepares in cooperation with appropriate field offices and contractor staff, environmental assessments and statements for major AEC waste management facilities, in accordance with IAD-0510-29.
- j. maintains: (1) central records of the capabilities and capacities of AEC facilities and Federal repositories for accepting, processing, storing, burying, and disposing of radioactive waste; and (2) central inventories of radioactive waste being stored, buried, or disposed of at AEC facilities and Federal repositories.
- k. provides program direction and fiscal control of a research and development program for

Approved: September 19, 1973

(1) techniques for long-term storage or disposal of commercial and AEC high-level waste; (2) compaction, incineration, or other improvements in handling practices for contaminated solid waste; and (3) improvements in air cleaning or liquid effluent treatment.

- l. develops and defends budget estimates for its waste management responsibilities and activities, including facility requirements, and exercises fiscal control over such activities; provides staff assistance to other divisions in the budget submissions of waste management items for which they are responsible.
- m. provides advice on applicability or interpretation of the provisions of this chapter and approves exceptions, where warranted, coordinating these actions with appropriate Headquarters divisions.
- n. sponsors and coordinates testing and development of improved products and systems (such as High Efficiency Particulate Air Filters) for reducing to the lowest economically and technically practical¹ level radioactive material releases to the environment.
- o. with regard to the above assigned responsibilities, acts as the General Manager's staff liaison and point of contact with the Office of Regulation and with other Federal, state, or local groups with regard to activities concerning (1) AEC-generated wastes and (2) commercially generated wastes to be delivered to the AEC as required by regulations.

033 The Director, Division of Operational Safety:

- a. develops, recommends, and promulgates policy, standards, and requirements relevant to (1) the protection of man and the environment from radiation or contamination, and (2) safety of systems and system components used for controlling radioactive material discharge to the environment.
- b. exercises overall surveillance, evaluation, and appraisal of AEC site effluent and environmental monitoring programs to assure compliance with AEC safety standards and policy relating to protection of man and his environment in accordance with AECM 0513, and coordinates such monitoring programs with comparable programs of other agencies.

- c. in cooperation with WMT, evaluates radioactive waste management programs to assure that the AEC policy of controlling the release of radioactive materials to the lowest levels² technically and economically practical is being implemented.
- d. appraises the safety aspects of field office waste management programs and activities.
- e. reviews waste management plans in relation to their impact on man and the environment and recommends any appropriate modifications to the Director, Division of Waste Management and Transportation.
- f. coordinates with appropriate directors of program divisions prior to establishing policy standards which may have a programmatic impact.

034 Directors of Program Divisions, Headquarters:³

- a. consistent with programmatic responsibilities and the provisions of sections 032 above and 044 below, provide direction of operations involving radioactive waste generated in their programs.
- b. within programmatic responsibilities, may provide direction and guidance consistent with appendix part II for the preparation of waste management plans to be submitted by field office managers under 038(c).
- c. review waste management plans submitted by field office managers relative to each site at which they have programmatic responsibilities, including related comments of other program divisions which have activities at those same sites, and consult with the Director, WMT, concerning his review function described in 032(e).
- d. as requested by the Director, WMT, review inquiries on the applicability or interpretation of the provisions of this chapter and requests for exemptions.
- e. consult with the Director, OS, in matters relating to policy, standards, and requirements relevant to the protection of man and the environment from radiation or contamination.

035 The Director, Division of Naval Reactors, assumes the same responsibilities as managers of field offices for its respective program activities.

036 The Director, Office of Information Services, assumes responsibilities for waste generated in connection with nuclear exhibits not under direction of any field office manager.

Approved: September 19, 1973

037 The Director, Division of Construction:

- a. develops or approves in conjunction with WMT, and other concerned Headquarters divisions, design criteria for facilities to be constructed or modified for the purpose of processing or storing radioactive wastes or of controlling the release of radioactive wastes to the environment.
- b. reviews waste management plans relative to their planned construction activities and advises the Director, Division of Waste Management and Transportation, on the estimated costs and schedules and conformance with design criteria.

038 Managers of Field Offices:

- a. assure that the relevant criteria in 044, below, are followed in developing practices for routine and emergency operations at AEC installations under their jurisdictions and that current practices, where differing, are revised to comply with the criteria.
- b. refer questions as to applicability, interpretation, or exemption from the criteria (see 044, below) to the Director, Division of Waste Management and Transportation, through the appropriate program divisions.
- c. prepare and submit to WMT, with copies to the appropriate program divisions, annually updated waste management plans for their sites, following the general guidance in appendix 0511, part II.
- d. maintain suitable approval control over key waste management decisions of operating contractors, such as the establishment or major modification of:
 - (1) operating limits for quantities or concentrations of radioactive materials released to the environment.
 - (2) release locations and timing of releases.
 - (3) methods of treatment of effluents to minimize release of radioactive materials.
 - (4) methods of conversion of high-level liquid waste for interim storage or disposal.
 - (5) process flowsheets, to the extent that they determine the quality or quantity of wastes.
 - (6) methods of interim storage of solid wastes.
- e. assure that for AEC operational situations, calculations related to burial/storage

operations include full cost, exclusive of land, depreciation, added factor, and perpetual care costs. For purposes of comparative cost evaluations of solid waste burial or storage with and without additional processing for volume reduction, all costs are included, e.g., depreciation of facilities, cost of land, and present worth of perpetual care costs.

- f. maintain records of radioactive waste stored or buried at their sites.
- g. conduct a program of annual appraisals of contractor radioactive waste management activities.

0511-04 BASIC REQUIREMENTS

041 Applicability. This chapter applies to divisions and offices, Headquarters, field offices, and contractors who operate AEC-owned or -controlled facilities and whose contracts contain the Standard Safety, Health, and Fire Protection Clause (see AECPR 9-7.5006-47).

042 Coverage. This chapter and its appendix specify the responsibilities, requirements, and procedures which shall govern the management of radioactive waste.

043 Appendix 0511. Appendix 0511 contains definitions (part I) and guidance (part II) for use in implementing the policies and responsibilities of this chapter. The detail of the appendix is not to be taken as all-inclusive nor should it preempt the use of good judgment by knowledgeable field office and contractor staff in the development of safe practices and controls in the management of radioactive waste.

044 Operating Criteria. To assure an effective program for the management of radioactive waste, the following criteria shall be observed:

a. General

- (1) Field offices and their contractors shall conduct their operations and dispose of and store radioactive waste in such a manner as to assure that present and future radiation exposures to individuals and population groups will be at the lowest levels technically and economically practical not exceeding limits established in AECM 0524 appendix parts I and II.
- (2) Continuing efforts shall be made to develop and use improved technology for reducing the radioactivity releases to

Approved: September 19, 1973

- the lowest technically and economically practical level.
- (3) High-level liquid radioactive waste shall not be transported offsite.
 - (4) The extent and degree of radioactive contamination of land by AEC waste management activities shall be minimized.
- b. **High-Level Radioactive Waste**
- (1) High-level liquid wastes shall be converted to suitable physical and chemical forms and confined in a manner which shall provide high assurance of isolation from man's environment with minimal reliance on perpetual maintenance and surveillance by man under conditions of credible geologic, seismic, and other naturally occurring events.
 - (2) High-level liquid radioactive wastes may be initially stored in carefully engineered systems equipped with adequate provision for leak detection and control. Tanks and transfer systems shall be designed to resist credible internal and external forces. Technology shall be developed and employed as soon as practical to reduce the volume and mobility of the high-level liquid wastes placed in initial storage facilities.
 - (3) High-level liquid wastes in initial storage and high-level wastes in long-term storage, or in pilot plant facilities shall, in each case, be contained and emplaced so as to be retrievable for removal and transfer elsewhere. The method of storage and the physical and chemical forms of the stored waste shall be predicated on safety and not on possible retrieval for recovery of fission products for beneficial uses.
 - (4) The radioactivity and the chemical and physical characteristics of all high-level wastes in initial, long-term, or pilot plant storage shall be determined for each condition of storage.
 - (5) Spare tanks shall be maintained providing volume in excess of initial storage requirements for high-level liquid wastes. Each tank farm holding high-heat liquid waste shall have available, in tanks empty except for a residual heel, space equivalent to the largest volume of such wastes stored in any one tank. Each tank farm holding low-heat liquid waste shall have available reserve storage capacity to accommodate the contents of the largest tank in the system. Where interconnected tank farms are sufficiently close that the times required to transfer tank contents between farms are similar to the times required to transfer tank contents within a farm, such interconnected tank farms may be considered as a single tank farm for purposes of the above requirements.
- c. **Other Liquid Radioactive Waste**
- (1) Liquid radioactive waste not meeting the definition of "high-level waste" shall be converted into two fractions, one consisting of liquids which can be discharged to the environment pursuant to AECM 0524 (i.e., persons in uncontrolled areas will not be exposed to concentrations in excess of those prescribed in table II, annex A, appendix 0524) and the other consisting of either: (a) high-level liquid waste, which would be handled in accordance with the policies of b., above; or (b) solid waste which would be handled in accordance with the policies in d., below.
 - (2) As soon as technically and economically practical, the use of natural-soil columns (such as cribs, seepage ponds, and similar facilities) for liquid streams that exceed established standards for release of radioactivity to uncontrolled areas shall be replaced with other treatment systems. It should be recognized that liquid which meets established standards and is released to soil columns still may result in a buildup (at a slower rate) of radioactivity in the soil column. Thus, it would be advantageous to design soil column structures so either the soil can be retrieved and relocated or the points of release are separated to the extent that the buildup of radioactivity in the soil column will not exceed an acceptable level.
 - (3) Adequate diversion systems shall be provided to assure that normally releasable streams, which, as a consequence of accident or operational upset, exceed established standards (cited in AECM 0524) for releases to uncontrolled areas, are automatically

Approved: September 19, 1973

detected and diverted to controlled holding areas and are recycled or processed to yield a releasable stream.

d. Radioactive Solid Waste Other Than That Generated by Solidification of High-Level Liquid Waste

- (1) Technical and administrative efforts shall be directed toward a marked reduction of (a) the gross volume of solid waste generated in AEC operations and (b) the amount of radioactivity in such waste.
- (2) Volume-reduction technology, such as compaction and incineration, shall be adapted for use with radioactive solid waste and placed in operation wherever practical.
- (3) Except as dictated by (4), below, solid radioactive waste may be stored in conventional burial grounds approved by the AEC.
- (4) Solid waste generated at AEC sites and containing significant U-233 or transuranium nuclide contamination shall be stored at AEC sites, segregated from other radioactively contaminated solid waste and with combustible and noncombustible transuranium-contaminated waste packaged separately. The packaging and storage conditions shall be such that the packages can be readily retrieved in an intact, contamination-free condition for 20 years. The packages shall be suitably labeled so the waste they contain can be identified by cross-reference to permanent records.

e. Airborne Radioactive Effluents. Gaseous and other airborne radioactive effluents shall be controlled at the lowest level below the limits of AECM 0524 consistent with the state of the technology and good economic practices.

f. Other. Radioactive waste generated by underground nuclear tests, and remaining underground shall be considered as a special case.

045 References

- a. AECM 2401, "Physical Protection of Classified Matter and Information," for additional protection required for classified radioactive waste.
- b. AECM 0510, "Prevention, Control, and Abatement of Air and Water Pollution."
- c. AECM 0513, "Effluent and Environmental Monitoring and Reporting."
- d. AECM 0524, "Standards for Radiation Protection."
- e. AECM 0529, "Safety Standards for the Packaging of Fissile and Other Radioactive Materials."
- f. AECM 0530, "Nuclear Criticality Safety."
- g. AECM 0544, "Planning for Emergencies in AEC Operations."
- h. AECM 6301, "General Design Criteria."
- i. AECM 7401, "Safeguards Control and Management of Nuclear Materials."
- j. WASH-1202, "Plan for the Management of AEC-Generated Radioactive Wastes."
- k. AEC Property Management Instructions Subpart 109-45.50, "Excess and Surplus Radioactively Contaminated Personal Property."

0511-05 NATIONAL EMERGENCY APPLICATION

In the event of a national emergency, as defined in AECM 0601-04, the provisions of this chapter and its appendix shall continue in effect.

¹In the context of the policy statement in AECM 0524-012.

²In the context of the policy statement in AECM 0524-012.

³For purposes of this chapter, program divisions are those Headquarters divisions that provide functional direction of activities which generate radioactive waste.

Approved: September 19, 1973

PART I

TERMINOLOGY

A. PURPOSE

This part provides terminology to be used in interpreting and implementing this chapter. For consistency, its use is recommended in other communications concerning radioactive waste management.

B. USAGES

1. **Airborne Radioactive Effluents**—Radioactive particulates, mists, vapors, fumes, and/or gases, contained or entrained in air effluents. (Note: The special case of materials such as Kr-85 removed from effluents and packaged for retention, should be described as "Compressed radioactive gases" or "Adsorbed radioactive gases.")
2. **Combustible** (for purposes of AECM 0511-044 d.(4))—Organic material capable of being burned, except that if the only combustible content of a package is plastic lining or wrapping used for contamination control purposes around incombustible objects or materials, the contents of the package as a whole may be considered noncombustible.
3. **Contamination-Free** (for purposes of AECM 0511-044 d.(4))—A condition of the outer surfaces of stored containers, as determined by appropriate swipe surveys or direct radiation instrument surveys, sufficiently free of contamination so that under standard radiation work procedures for the site in question respiratory protection will not be required during container handling.
4. **Crib**—An underground framework or structure into which liquid wastes are discharged, located so that the radioactivity (other than tritium) is sorbed on the soil before the liquid reaches groundwater.
5. **Disposal**—The planned release of radioactive waste in a manner that precludes recovery, or its placement in a manner which is considered permanent so that recovery is not provided for. (Note: If recovery is planned, or could be provided for easily as in the case of conventional surface burial grounds, the term "storage" should be used.)
6. **Diversion**—As applied to nominally uncontaminated fluid streams, the capability of automatically detecting excessive radioactivity and diverting the stream to a retention system for treatment.
7. **Effluents—Airborne and liquid streams discharged from a facility after all engineered process waste treatment and effluent controls have been effected. Releases offsite or into groundwater and surface streams which leave the site or go to the atmosphere from engineered systems such as stacks, lagoons, retention ponds, or injection wells are to be considered as effluents. The term does not include solid waste or other waste which is contained (e.g., underground nuclear test debris), stored (e.g., in lagoons, retention ponds, trenches, tanks), or shipped offsite.**
8. **Storage**—Retention of radioactive waste in some type of man-made device, such as a tank or vault, in a manner permitting retrieval.
9. **Long-Term Storage**—The status of radioactive waste under control and surveillance, and readily retrievable, but in such a form and location that no further processing or manipulation is considered necessary for a period of time which is very long compared to other periods of time in the nuclear fuel cycle; an example would be storage in a high-quality near-surface storage vault with an expected durability of many decades.
10. **Federal Repository**—A Federally owned and operated facility for storage or disposal of specific types of radioactive waste from AEC sites and/or licensees.
11. **Federal Reservation**—An AEC site requiring long-term control and restrictions because of stored or buried waste or decommissioned facilities.

RADIOACTIVE WASTE MANAGEMENT

12. **High-Heat Liquid Waste**—Liquid waste containing sufficient thermal energy to require some supplemental means of cooling, such as cooling coils.
13. **High-Level Liquid Waste**—The aqueous waste resulting from the operation of the first-cycle extraction system, or equivalent concentrated wastes from subsequent extraction cycles, or equivalent wastes from a process not using solvent extraction, in a facility for processing irradiated reactor fuels.
14. **High-Level Waste**—(a) high-level liquid waste, or (b) the products from solidification of high-level liquid waste, or (c) irradiated fuel elements if discarded without processing.
15. **Other Liquid Waste**—Liquid waste, not within the definitions of high-level liquid waste.
16. **Liquid Radioactive Waste**—Solutions, suspensions, and mobile sludges, contaminated with radioactive materials.
17. **Management (Waste)**—The planning (including design and process improvement), execution, and surveillance of essential functions related to control of radioactive waste, including treatment, solidification, initial or long-term storage, and disposal.
18. **Radioactive Waste**—Materials of no value consisting of, including, or contaminated with radioactive material in excess of the levels or concentrations permitted in AEC Property Management Instructions for unconditional release of excess property. This includes (a) stored liquid, solid, or gaseous residues from chemical or metallurgical processing of radioactive materials; (b) discarded items such as defective equipment and building rubble, not radioactive in themselves but contaminated with radioactive materials; and (c) discarded items containing induced radioactivity. Treated as a separate category are: (1) irradiated fuels stored for possible processing; (2) radioactive scrap stored for possible recovery of useful values; and (3) materials and equipment stored for possible future use following decontamination.
19. **Retention Basin**—A watertight basin in which liquid waste is held for any one or more of the following reasons: (a) the decay of short-lived radioactivity; (b) analysis to verify activity levels permitting release; (c) recycle for treatment; (d) evaporation.
20. **Seepage Basin**—A basin in permeable earth through which liquid percolates and in which radioactivity, except for tritium, is sorbed.
21. **Settling Basin**—A watertight basin designed for separating sludges and sediments as a layer on the bottom. The water is disposed of by overflow or solar evaporation.
22. **Solid Radioactive Waste**—Material that is essentially dry but may contain sorbed radioactive fluids in sufficiently small amounts to be immobile when buried in dry soil.
23. **Transuranium-Contaminated Solid Waste**—Those contaminated with certain alpha-emitting radionuclides of long half-life and high specific radiotoxicity to greater than 10 nanocuries/gram (10 microcuries/kilogram), subject to the following conditions and understandings:
 - a. The radionuclides included are U-233 (with its daughter products), plutonium, and transplutonium nuclides except Pu-238 and Pu-241. (Note that Pu-238 and Pu-241 waste should be handled as transuranium-contaminated waste when so indicated by Pu-239 impurities or when required by local burial criteria.)
 - b. The value of 10 nCi/g is derived from the upper range of concentrations of radium-226 in the earth and is subject to modification based on long-term studies of nuclide migration in soil.
 - c. The activity density may be averaged over the contents of individual shipping containers, such as 55-gallon drums, including materials added for shielding or sorption of liquids. Late discovery (for example, on recalculation of data) that an individual container is above this level will not be considered as necessitating its retrieval provided there is reasonable assurance that the average of the container and the balance of the associated containers is below the level.

- d. For typical Pu-239 waste at this activity density, it is recognized that indirect measurements or estimates and administrative controls must be used instead of direct external measurements. An example of such administrative controls is the establishment of specific in-plant working areas from which typical wastes have been established by suitable studies as being either above or below the control value.
- e. It is recognized that under present technology certain waste, primarily bulky discarded process equipment, with transuranium content above this value may not lend themselves to practical storage in full compliance with AECM 0511-044 d(4). However, these items should be recorded as transuranium wastes.
- f. Requests for exception for applying the 10 nCi/g value on a package-by-package basis, with substitution of an equivalent quantity limit applicable to a burial facility, or requests for exemption for specific short half-lived transplutonium wastes, will be considered on a case-by-case basis, as per AECM 0511-032(m).
- g. The 10 nCi/g value is a criterion for choosing different methods of handling different kinds of radioactive waste; it should not be confused with a value below which excess materials may be unconditionally released, as per AEC Property Management Instructions 109-45.50.

PART II

WASTE MANAGEMENT PLANS

A. PURPOSE

This part provides guidance on the development of a radioactive waste management plan for each site, as required by AECM 0511-038c.

B. DISCUSSION

Existing conditions at the various facilities will require different types and degrees of effort to meet the operating criteria of AECM 0511-044. Accordingly, the plans submitted under AECM 0511-038c need not be identical in degree of detail. Appropriate references to supplement or substantiate the information or conclusions stated in the plan should be provided. The outline of a waste management plan in C, below, is to be followed.

C. FORMAT FOR THE SITE WASTE MANAGEMENT PLANS

1. Program Administration

- 1.1 Site
- 1.2 Office Responsible
- 1.3 Contractors
- 1.4 Lead Responsibility for Site Plans
- 1.5 Source of FY 1972 Funds for Waste Management

2. Description of Waste Generating Processes

2.1 Process Flowcharts

3. Description of Waste Management Facilities

3.1 Identification and Location of Facilities

3.2 Description of Waste Treatment Facilities

3.3 Description of Waste Storage Facilities

3.4 Description of Effluent Control Systems

3.5 Site Administrative Limits on Effluents

4. Radioactive Waste Stored

4.1 High-Level Waste From Chemical Processing Operations

4.2 Solid Radioactive Waste Other Than Solidified High-Level Waste

4.3 Other Radioactive Materials

5. Plans and Budget Projections

5.1 Interim Storage of High-Level Liquid Waste

5.1.1 Milestone Charts

5.1.2 Expected Accomplishments in FY 1972

5.1.3 Proposed Program for FY 1973

5.1.4 Proposed Program for FY 1974 and Beyond

5.1.5 Five-Year Budget Projections for FY 1974 and Beyond

5.2 Long-Term Storage of High-Level Waste

5.3 Management of Low- and Intermediate-Level Liquid Waste

5.4 Management of Solid Waste Contaminated With Radioactivity

5.5 Management of Airborne Radioactive Waste

5.6 Recapitulation of Budget Projection

Detailed instructions for site waste management plans will be forwarded periodically to field office managers.

APPENDIX C
IMMEDIATE ACTION DIRECTIVE 7401-19

Form AEC-333
(7-61)

Published in advance of incorporation in AEC Manual <u>Appendix 7401-B</u> , Part III File and retain in Manual until superseded.

UNITED STATES ATOMIC ENERGY COMMISSION
AEC MANUAL

IMMEDIATE ACTION DIRECTIVE

IAD NO. 7401-19

DATE: May 26, 1971

SUBJECT: SCRAP MANAGEMENT PROGRAM

A. Background

The recently submitted reports on plutonium handling and processing and on the management of oralloy inventories indicate that excessive quantities of scrap or otherwise inactive nuclear material exist in inventories throughout the AEC complex. In some cases, there are inadequacies in the manner in which this material is stored and handled.

Pursuant to AEC 132/168, the Division of Waste and Scrap Management (WSM) was established by Announcement No. 84, dated July 10, 1970. The responsibilities of this Division include providing for consistent policy determinations and coordinated management of scrap nuclear materials at AEC facilities as well as establishing more effective control over the storage and reprocessing of scrap containing special nuclear material.

B. Scope and Purpose

1. This Directive establishes a system of management for unirradiated scrap plutonium-239, plutonium-238, enriched uranium and U-233 generated under AEC contracts or subcontracts. Additional scrap materials may be incorporated into the system in the future. Responsibilities of the scrap generator are identified and a Central Scrap Management Office (CSMO) is designated to provide uniform disposition of Pu-239, Pu-238 and enriched uranium in scrap form. A CSMO to service U-233 is not established at this time pending a definition of the requirements and policies which should be instituted for this material.

May 26, 1971

The Director, Division of Production, the Assistant General Manager for Military Application, and the Director, Division of Space Nuclear Systems, will institute criteria and procedures for the management of scrap in recovery facilities under their control comparable to those exercised by the CSMO's. This will include, where appropriate, the measurement and treatment of scrap for safe handling and storage, adoption of consistent discard criteria and recovery priorities and, in consultation with WSM, seeking appropriate alternatives to local processing when scrap nuclear material cannot be recovered locally on a current basis.

2. In general, the purpose of this scrap management system will be to provide uniform management disposition of scrap nuclear materials regardless of their programmatic origin in consonance with the responsibility for the safe handling and safeguarding of the material and provide for the timely recovery of scrap.
3. This system supplements and implements the management responsibility and policies and procedures contained in AECM Chapter 7401 and AECM Appendix 7401, B., Part III. Appropriate amendments will be issued later.

C. Definitions as Used in This IAD

1. Scrap Nuclear Material

Scrap is defined as unirradiated nuclear material that is not usable in its existing form, is mixed with other material necessitating purification to be rendered useful and which can be recovered in an economical and safe manner. Excluded, for the purpose of this IAD, are scrap nuclear materials that are considered a feed or are reclaimed on-site on a current basis as part of a production or fabrication process. Current basis means without the buildup of an excessive backlog of scrap in storage pending recovery, or the inactive storage of the material for a period greater than six months.

2. Scrap Generator is defined as the contractor which performs work under an AEC contract which generates scrap nuclear material in the course of that work.

May 26, 1961

3. Central Scrap Management Office (CSMO) is defined as an AEC field office that has been designated to implement the scrap management system for a specific material. The CSMO will receive declarations of scrap from scrap generators, make determinations of recoverability as outlined in this IAD and issue instructions for disposition accordingly. The following offices are designated as CSMO's:

For enriched uranium, Oak Ridge Operations Office.

For plutonium, excluding Pu-238, Richland Operations Office.

For plutonium-238, Savannah River Operations Office.

For U-233, the Division of Waste and Scrap Management will assist in arranging disposition of scrap in consultation with the U-233 inventory management conducted at Oak Ridge National Laboratory.

Additional designations of CSMO's will be made as required.

D. Organization and Implementation of Scrap Management System

1. General

The scrap management system herein established is based upon the provisions of AECM Chapter 7401 and Appendix 7401, B., Part III, with certain local responsibilities assigned to the scrap generator as well as the implementation, by a CSMO, of a uniform and centralized scrap management program for each type of material.

2. Role of Scrap Generators

- a. Each scrap generator will be responsible for local scrap handling and storage operations. These operations include the determination of nuclear material content for safeguards and assay purposes by the best approved means, making the material safe for shipment, storage and handling by placing it in a stable form, sorting into reasonably homogeneous lots and packaging and labeling the material to permit proper shipping, storage and handling. The material shall be packaged in

May 26, 1971

noncombustible primary containers suitable for storage and, for those sites not having processing capability for the scrap, in primary containers suitable for subsequent shipment without repackaging. Labeling of the material shall permit a positive identification of the contained material, its composition and origin (ref. 7401, B., III, I.). The scrap generator will also be responsible for interim storage and for transporting the scrap nuclear materials which it generates to the recovery site designated by the CSNO or, if the material is adjudged waste, disposing of the material through approved waste management procedures.

The cost of the local scrap management operations will be funded within the budgets for the programs which generate scrap. It is the responsibility of the Director of each program division to assure that adequate funds are budgeted and remain available for the timely preparation and removal of scrap generated within his programs to the recovery site designated by the CSNO. The amounts of such funding will be disclosed within the Commission at all levels of budget review.

- b. The scrap generating sites shall issue declarations of scrap material available for recovery elsewhere through the cognizant AEC field office to the CSNO assigned responsibility for the particular material with copies to WSM and the program division involved. These declarations will be issued as soon as the material is identified as scrap but in no case will material be stored for a period greater than six months at the generating site without arrangements being made for its disposition within the scrap management system. In order to assure that material is declared on a current basis and that scrap generators follow through with disposition instructions, each AEC field office will report semiannually the inventory and status of such materials under its cognizance. The report will summarize the total scrap inventory, the material declared to the CSNO for disposition, the material shipped for recovery and the material disposed of as waste during the period. These reports should be provided within four weeks of the periods closing December 31 and June 30 of each year and should be directed to the Division of Waste and Scrap Management, Headquarters, the Office of Safeguards and Materials Management, Headquarters, and the Headquarters program division or divisions having programmatic authority for the nuclear material in question. The detailed format of these reports will be prescribed following a review of the submissions made in response to the memorandum of January 12, 1971, requesting a report of the current inventory of scrap and inactive material.

May 26, 1971

- c. The scrap generator will include in each declaration such information as will permit the CSMO to determine the proper disposition of the material in accordance with AEC policies. These are detailed in the attachment to this IAD. Ref. paragraph 2.

3. Role of Office of Safeguards and Materials Management

The Office of Safeguards and Materials Management (OSMM), in keeping with its assigned functions, will appraise field office management of nuclear materials and audit and report quantitative data on materials including scrap.

4. Consideration of Scrap in Forecasts of Nuclear Material Requirements

Divisions participating in production planning and the preparation of supply schedules shall incorporate the availability of such materials from scrap sources.

5. Role of AEC Field Offices

AEC field offices will continue to audit and appraise contractor performance including compliance with this IAD for management of scrap nuclear materials. Ref. Appendix 7401, D.

6. Role of Central Scrap Management Offices

- a. The CSMO for each nuclear material will evaluate the recoverability of scrap materials declared to them by the scrap generating site and will issue appropriate instructions for the disposition of the material as recoverable scrap.
- b. The assignment of this "clearinghouse" function to designated AEC field offices and instructions on the procedures to be followed for evaluation of scrap materials under this system will be made by WSM. Initial designation of the CSMO's is indicated in paragraph C.3. Basic procedures for the activities of the CSMO's are included in the attachment to this IAD.

7. Role of the Divisions of Production and Military Application

These organizations will institute the procedures and adopt criteria for the management of scrap nuclear material generated in their respective programs which are approved by WSM and are consistent with the scope and purpose outlined in B. above. In addition, the Divisions of Production and Military Application

May 26, 1971

will provide operational management of scrap processing facilities at sites under their cognizance and, in consultation with WSM, develop programs to apply the capabilities of these facilities to the program of scrap recovery.

8. Role of Division of Waste and Scrap Management (WSM)

- a. WSM will be responsible for supervising the program for disposition of non-02-03 plutonium and enriched uranium scrap and commercial recovery processing. WSM will also develop operational plans in consultation with the cognizant programs divisions for the recovery of non-02-03 scrap in AEC facilities. WSM will review and approve the scrap management plans within the 02 and 03 Programs to assure that the operation of recovery facilities and management of scrap inventories is consistent with overall AEC policies.
- b. For FY 1973 and beyond, WSM will be responsible for all aspects of the management of non-02-03 plutonium and enriched uranium scrap recovery in both commercial and AEC facilities. For non-02-03 plutonium and enriched uranium scrap that is to be recovered in AEC facilities, WSM will develop recovery plans in consultation with the program divisions having operational responsibility for these facilities. WSM will continue to review and approve the 02-03 Program scrap management plans as noted above.

E. Budgeting and Funding

1. In FY 1971 and FY 1972, funds already budgeted under the 02 Program for scrap processing will be administered by WSM and the Division of Production. WSM and Production will jointly administer funds for non-02-03 scrap processing and Production will administer funds for 02 scrap processing. For FY 1973 and beyond, non-02-03 scrap management operating costs will be budgeted as a separate line item under the "Special Activities" account in the special nuclear materials (02) program. WSM will be responsible for reviewing the budget estimates for scrap storage or recovery operating costs, research and development costs, and equipment, GPP and line item construction costs and for preparing and justifying the non-02-03 estimates in the "Special Activities" account for these operations in AEC facilities and commercial recovery contracts.

May 26, 1971

2. General plant projects and capital equipment will continue to be budgeted by the program division having operational and contracting responsibility for scrap recovery facilities. Specific general plant projects and capital equipment items relating to scrap management will be developed and justified by WSM and will be separately identified in internal AEC budgets and subsequently incorporated into the appropriate program division's CPP and equipment estimates to OMB. Special line item construction projects relating to scrap and waste management may be developed and advanced by WSM in the budget of the appropriate program division having the site responsibility where the project would be located.
3. The cognizant operating divisions will continue to be responsible for contracting and operating AEC scrap recovery facilities now under their jurisdiction. WSM will advise the cognizant operating division as to the amount of non-02-03 scrap recovery which should be considered in the operating plans for AEC facilities under their control.
4. The CSMO will arrange for recovery of scrap in commercial facilities in accordance with AEC policy, WSM program guidance and the best interests of the scrap management program.
5. See D., 2., a., above for budgeting and funding requirements for scrap generators.

F. Other Basic Requirements

1. To the extent feasible, fixed-price contractors of the AEC will continue to be responsible under special terms of their contract for securing commercial recovery of their scrap.
2. The operations of the CSMO's in receiving declarations and arranging the disposition of declared scrap shall be instituted as soon as possible. Scrap generators are to act immediately to comply with their responsibilities as outlined in this IAD and issue declarations for any existing inventories as well as required reports and forecasts by June 30, 1971. This scrap management program shall be fully implemented by FY 1973.

Any questions relating to this IAD or its implementation should be addressed to the Director, WSM, for resolution.

General Manager

Attachment:
Criteria and Procedures

May 26, 1971

CRITERIA AND PROCEDURES - SCRAP MANAGEMENT PROGRAM

The following criteria and procedures describe the activity of the scrap management system established by IAD 7401. The policies of AECM 7401 and its Appendices and other AEC Manual Chapters of the 0500 series relating to the safety of operations remain in effect and are unaltered by the institution of the criteria and procedures outlined herein for implementation of the scrap management program.

1. Criteriaa. Safety

Operations such as sorting, storage, handling, transportation and processing of scrap nuclear materials shall be performed in such a manner that the potential risk of fire, criticality, loss, contamination or injury is minimized. Preliminary treatments such as passivation, incineration, neutralization, decontamination or other processing which is necessary to reduce the hazard of handling operations to acceptable levels shall be performed as part of the initial disposition of scrap materials even though the material may ultimately be determined to be discardable as waste. The material is to be sorted to provide reasonably homogeneous lots with respect to recovery processing and packaged in noncombustible containers suitable for safe storage. If material cannot be processed on-site on a current basis, the containers are to be suitable for use as primary containers in subsequent storage, transportation and handling operations without necessitating repackaging. Packages are to be labeled in accordance with Appendix 7401, B., III, I. The label affixed to the primary container should be sufficiently rugged to remain intact through normal handling and storage operations. In the event labels are lost or destroyed, an index marking should be affixed to each primary container that will maintain the identity of any intact container. Unnecessary combustible items are to be minimized in storage areas or facilities. It is the responsibility of the scrap generator to provide for and carry out these operations as part of the day-to-day management of scrap materials.

b. Evaluation of Nuclear Material Content

The nuclear material content of all scrap will be measured or otherwise determined for safeguards and accountability, to assure its safe handling and for evaluation of recoverability. This determination will be performed as soon as the scrap is identifiable regardless of whether it will be considered for recovery or for disposal as waste. It is the responsibility

May 26, 1971

of the scrap generator to make this determination including such measurements as are technically and economically feasible or necessary and to include such data as part of the labeling of the scrap container and for the declaration of scrap for disposition.

The criteria outlined above for safety and measurement associated with scrap management are prerequisite to the disposition of scrap under the scrap management program and are the responsibility of the generating site. Care should be exercised in the selection of processes and treatments to anticipate these requirements and make adequate provisions for compliance before material is committed to the process or operation.

c. Retention and Recoverability of Scrap Nuclear Material

(1) General

Scrap nuclear material will be considered for recovery if it is of economic advantage to the AEC or is necessary to assure the safe disposition of the material. The option of recovery processing will be selected when it is necessary for the safe disposition of the material and contributes to meeting current requirements or requirements that are forecast for the nuclear material. Retention will be based upon obtaining the maximum benefit from the nuclear material at minimum current cost.

(2) Formula

Material will be adjudged recoverable by the CSMO when there is a requirement for material and the material considered for recovery satisfies the following conceptual formulation:

$$C \leq I+D$$

Where: C equals all incremental costs of recovering the material including the additional costs of packaging in a shipping container for transfer to the recovery site, handling and shipping associated with transportation to the recovery site, processing to the standard feed form, disposal of residues from the reprocessing and packaging, handling and shipping of the recovered material to the production plant or storage facility which distributes or markets the material from AEC programs.

May 26, 1971

I equals either (1) the incremental production costs of equivalent material in the standard production feed form at the production plant or storage facility which distributes or markets the material from AEC programs or (2) the market price of salable or purchasable material FOB that AEC site, whichever is higher.

D equals the cost of direct disposal of the material as waste including any additional costs of preparation or packaging the material as a waste over and above that required if the material is to be recovered, shipping to the disposal site and final disposal. The initial packaging and labeling operations and the measurement or analysis of the material for the purpose of qualitative or quantitative description shall not be included as part of either the recovery cost (C) or the disposal cost (D). Such packaging and analysis is to be performed for safeguards and safety considerations even though the material may ultimately be determined to be discardable waste.

In applying this formula, an accurate estimate of the quantity of special nuclear material as well as a reliable description of the form and composition of the material relative to recovery processes is extremely important. The content and form will determine, to a large extent, the expense of processing and the efficiency of recovery which are most influential on the economic balance.

(3) Priority for Recovery

Every effort must be made to assure that material is treated for safe handling and storage. However, first priority in recovery processing will be given to the treatment of material which cannot otherwise be rendered safe. In the absence of a safety concern, priority for recovery of various lots of scrap will be determined by the CSMO by ordering the material according to the magnitude by which I+D exceeds C. If I is the incremental cost of new product material and the material is currently being produced and requirements exceed current production, then any material which satisfies the formula with the factor of incremental cost used should be recovered in preference to any other alternative source since the cost of this material will be lower than any other source. If I is the incremental cost of new product material and

May 26, 1971

the material is currently being produced but only for the purpose of stockpiling against forecast requirements, then scrap materials should be processed to the extent that the material contributes to meeting the forecast and current recovery capacity is available to add this material to the stockpile.

(4) Unrequired Material

If new product material is not currently being made and there is no requirement for the material, the management disposition shall be based upon retaining the resource at minimum cost against possible future demands and processing the material when such demands warrant the recovery.

(5) Retention in Storage

The decision to retain material in storage will be based upon the relative economics of storage cost versus the present worth of anticipated future market price which the material can be expected to have under the AEC's long-range forecast. Such inventory optimization will be conducted by the CSMO.

2. Procedures

The following procedure has been prepared to detail the steps used in determining the disposition of scrap nuclear material in the AEC's scrap management program.

- a. Material is identified as scrap by the generating site when: (a) it is not clearly a disposable waste, (b) it arises in a form that is no longer usable in the program to which it is assigned, (c) it has been determined unusable in other programs in its present form (ref. Appendix 7401, B., Part III, E.), and (d) it cannot be restored to a production or other feed form in local scrap recovery or recycle operations on a current basis.
- b. The material should be processed to a form that will assure safe storage and handling in all subsequent operations if not already in such a form. As soon as the material can be consolidated, the generating site will determine the composition and evaluate the nuclear material contained in the material for safeguards accountability purposes and to provide data for the economic determination of retention or recoverability. In addition to evaluation

May 26, 1971

of nuclear material content, the material will also be examined to develop a technical description that will permit suitable recovery or disposal processes to be specified and the material will be sorted to provide reasonably homogeneous lots with respect to reprocessing requirements. Material will be packaged in noncombustible primary containers suitable for subsequent storage, transportation and handling and labeled to provide information on its nuclear material content, composition and origin.

- c. An estimate of the cost of disposal of the material as waste as well as the cost of any additional preparation, packaging, handling and shipping to a site to be designated by the CSMO will be prepared by the generating site for inclusion in a declaration of the scrap material and request for disposition.
- d. The declaration, including the above data, will be forwarded to the CSMO designated for the material as follows: for plutonium-239, Richland Operations Office; for enriched uranium, Oak Ridge Operations Office; for plutonium-238, Savannah River Operations Office; for U-233 and other materials, the Division of Waste and Scrap Management, Headquarters, will determine appropriate disposition of the material in question. Specific designations of CSMO's will be made for other materials if required by WSM.

Copies of all declarations should be forwarded to the Division of Waste and Scrap Management and the cognizant program division at the time they are sent to the CSMO.

- e. Upon receipt of the declaration, the CSMO will develop an estimate of the overall recovery cost for the material to determine the appropriate disposition in accordance with scrap management policies. Using these estimates of cost and the anticipated yield of recovered material, the CSMO will determine if the material is indeed economically recoverable and is to be shipped to the CSMO or other location for recovery or storage or is to be disposed of directly as a waste material by the generating site. The CSMO will obtain information on incremental production cost and market price or other authoritative value for the material from the appropriate Headquarters program or staff division with the concurrence of the Office of the Controller, through WSM. The CSMO will provide a statement of their analysis of recoverability to the scrap generator and the Division of Waste and Scrap Management, Headquarters, along with copies of the instructions it issued to the generating site for disposition of scrap material declared to them.

May 26, 1971

- f. The generating site will prepare and ship the material in accordance with approved shipping regulations and the instructions provided by the CSMO or alternatively will dispose of it as waste. Completion of these actions is confirmed to the Division of Waste and Scrap Management, Headquarters, referenced to the original declaration, and completes the responsibility of the scrap generator for disposition of the particular scrap materials.
- g. Material determined to be recoverable will be assigned an appropriate priority for processing by the CSMO. Recovery operations will be optimized to yield the recovered product at lowest unit cost to meet current and forecasted requirements. Any and all material which is required to meet current demands and which can be recovered at an incremental cost less than the sum of the incremental unit cost of new product plus direct disposal cost should be considered for recovery in current campaigns.
- h. Material in storage will be continually reviewed by WSM and the CSMO to determine if it is still economically justifiable to maintain it in storage for future recovery. If not, the material will be surveyed for disposal as waste. The status of material pending recovery will be reported quarterly by the CSMO to WSM.