foresight in waste management

In a lecture to members of the Agency staff, C. M. Slansky of the Division of Health, Safety and Waste Management, outlined the ways in which wastes from the nuclear industry are handled.
He also put forward suggestions for making use of developing technology and knowledge to remove all possibility of harmful effects to the environment.
A shortened version of his address is given here.

Never has an industry shown such a preventive approach to the disposal of waste and the elimination of hazards as has the nuclear industry. From the beginning it has been under tight governmental regulations, safety has been a major concern, each operation has been under careful inspection and control, and much research and development has been performed to ensure safe waste management practices.

Perhaps even more striking is the manner in which the industry has approached the moral implications of an operation which could affect generations hundreds of years in the future. Most of man's past considerations in the use of natural resources such as arable land, minerals, water supplies, forests, etc. have been very shortsighted. For the first time man has faced the consequences of a release of a hazardous material to the environs which could affect posterity at some time hundreds and even thousands of years hence.

My intention is to describe the magnitude of waste which will be generated in the nuclear industry, existing methods of control of these wastes, possible approaches to "ultimate disposal", and the role of the Agency in waste management.

Radioactive waste arises at the stages of ore mining, milling and refinement; fabrication of nuclear fuel; reactor operation; reprocessing of spent fuel; the use of radioactive by-products; research and development; and in peaceful nuclear explosions.

The majority of waste in terms of radioactivity measured in curies is released from the reprocessing of spent fuel and amount to approximately 99% of the total. This does not imply that the cost of waste management is proportional to the quantity handled or that the other 1% is insignificant. In 20 years it is estimated that six thousand tonnes of pure fission products will have accumulated which would be present in 155 000 cubic metres of liquid and would be generating nearly 1280 million Btu/hr of heat by radioactive decay. This is rather like the problem of storing six thousand tonnes of permanently rotting potatoes, except that the pure fission products must be contained with permissible losses to the human environment of well under a millionth of one per cent. By the year 2000 the anticipated weight of accumulated fission product wast increases to 16 000 tonnes.

A summary of the types of waste produced by the nuclear industry is shown in Table I.

Table I. Types of radioactive waste

I. Natural activity
- A. Mining operations
  U-238, Th-234, Ra-226, Th-230, Rn-222
- B. Fuel Fabrication Plants
  U-235 and U-238 (Th-234)

II. Fission-product activity
- Reactor Operation (0.1%); Reprocessing (99.9%)
  Cs-137, Sr-90, Tc-99, Ru-103, Ce-144, I-131, Kr-85, Tritium, Transuranic elements — Np, Pu, Am, Cm

III. Activation-product activity
- A. Reactor Waste
  Al-28, Mn-56, Co-58, N-16, C-14
- B. Isotope Production and Use
  Co-60, P-32

Three methods are followed in waste management policy. The delay and decay approach is reasonable for short-lived isotopes in which only a short period is needed to allow the material to decay to an undetectable level. Dilute and disperse is used where vast quantities of diluent, such as air, can be used to disperse moderate quantities of waste at levels far below those considered hazardous for man. The great majority of longlived waste, primarily the high-level fission product waste from fuel reprocessing, is being concentrated and contained. Without further treatment the tank storage would be needed presumably for a period extending into centuries.

Table II shows how the three policies of waste management apply to fission products accumulated in the fuel at discharge of the core of a 1000 MW(e) nuclear reactor after one year of operation. The quantities of those wastes that require "dilute and disperse" and "concentrate and contain" were calculated at six months following discharge, i.e. when reprocessing takes place.

Table II. Waste management of fission products from the core of a 100 MW(e) nuclear reactor whose inventory at discharge is 13,520 megacuries total fission products

	Megacuries	% Total
Delay and Decay	13,257	98.02
Dilute and Disperse (Kr-85)	0.4	0.003
Concentrate and Contain (Cs, Sr, long-lived)	262.5	1.98
		100.00

The policy of "concentrate and contain" of long-lived wastes carries with it the requirement of surveillance. A stored waste which might escape into man's food cycle, will require surveillance. However, some persons claim that few, if any, nations, societies or responsible governments have been found in which surveillance of a stored waste for five to ten centuries would be possible. Therefore, methods of waste disposal in which the waste will not require surveillance would be attractive; that is, the waste is eliminated and can never come back to man's environment. Such a process we will call ultimate disposal.

Short of obtaining ultimate disposal, we will settle for ultimate storage. In this case the waste remains on earth, slowly decaying, but stored in a form and manner which is considered safe.

The present practice of using tanks is termed interim storage, in the sense that the waste is awaiting the development and application of the ultimate storage or ultimate disposal process. The interim waste storage policy provides a process which assures no release to the environs. However, surveillance is necessary. The waste should be retrievable so that it can be reprocessed by the ultimate process, and probably the quantity of additives to the raw waste should be kept to a minimum.

Waste Treatment Methods

Existing waste treatment methods are listed in Table III. Waste processes for gases and solids are generally well developed and require little comment. Low-level and intermediate-level liquid waste processes also have been satisfactorily developed. The only method in common use now for high-level waste is interim storage in tanks.

The general subject of ultimate waste disposal requires much development before a final analysis can be made. Unfortunately, a single solution to the ultimate management of high-level waste probably will not be applicable to all countries.

Table III. Methods in use for handling radioactive waste

I. Radioactive gases
1. Air cleaning techniques such as high efficiency filters, air washers (scrubbers), particle separators and adsorbers.
2. Dispersion from tall stacks.
3. Storage in compressed cylinders or tanks.

II. Solids (low- and intermediate-level)
1. Mixing in a matrix such as concrete or bitumen and burying or dumping in the sea.
2. Storage in piles.
3. Burial directly in waterproof pits.

III. Liquids

Low Level
1. Removal of radioactivity on ion exchangers.
2. Concentration by evaporation and treat as high level waste.
3. Pumping to isolated strata between impervious strata.

High Level
1. Interim tank storage as liquid.
2. Calcination of liquid and storage for interim period.

By necessity this management of waste becomes a national, if not an international, problem, because the economic incentive occurs only at the time when power is produced and there is no profit from long-term management and surveillance.

Ultimate Disposal or Storage

In the long term aspect of waste management it may be possible to establish an ultimate disposal process which completely eliminates the waste from man's environment. In fact, entirely new technology may be discovered and applied to the subject in the next twenty years. One idea in the conceptual stage is a transmutation process in which the long-lived waste is bombarded in a spallation (or fragmentation) reactor by high energy particles to produce short-lived fragments which decay to harmless waste. However, any alternate ultimate process would require considerable international co-operation since only a limited number of large spallation reactors could be justified or only a few countries will have developed any other technology.

The alternative to ultimate disposal is ultimate storage; i.e. storage on earth until the more hazardous radioisotopes decay away, using a storage environment which will retain all of the waste for the necessary decay time. Most approaches involve initial solidification of high-level liquid waste. The solid can be in the form of a calcined oxide, a glass, or other immobile form. Serious consideration has been given to storing the solid in abandoned salt mines and in underground mines in stable crystalline rocks. Another possible depository which is being investigated is the ocean, particularly the deep trenches which are about 33 000 feet (10 000 metres) deep.

Role of the Agency

The Agency has a fundamental role in waste management. It offers a common ground on which problems common to all Member States can be discussed. Developing nations are in constant contact with developed nations in their effort to apply nuclear power to peaceful uses. In particular, the management of radioactive waste takes on an international aspect comparable in many respects to the safeguarding of nuclear materials.

A strong, well-controlled waste management programme is essential for each country engaged in nuclear development. However, since there is the element of international spread of waste, it is important to each nation to be active in the dissemination of technology and experience and in lending assistance to others. Thus, Agency activities take on greater significance. Close co-operation with other international organizations, particularly members of the United Nations, becomes important.

Certain long-range aspects of waste management are becoming more apparent. The ultimate disposal or storage of high-level waste will not be met in the same manner by all countries. International effort is probably necessary to assist less endowed countries. All countries are concerned to ensure safe disposal practices throughout the nuclear industry.