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ENGINEERED STORAGE OF RADIOACTIVE WASTE

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**U. S. ATOMIC ENERGY COMMISSION
AND
ATLANTIC RICHFIELD HANFORD COMPANY**

MASTER

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ENGINEERED STORAGE OF RADIOACTIVE WASTE

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ABSTRACT

Radioactive waste materials must be stored or disposed of in such a manner that isolation from the biosphere is assured until they have decayed to innocuous levels. An alternative to an ultimate disposal which depends upon the surveillance and administration of man, is an engineered storage. An Engineered Storage Facility is being studied. Storage concepts involving air, water and conduction cooling were considered and storage in cooled water basins was selected for further development.

A modular construction schedule is proposed to minimize investment and to utilize technological advancements.

The Atlantic Richfield Hanford Company, at the direction of the United States Atomic Energy Commission, has undertaken work to perform conceptual designs and engineering studies on equipment and structures for the interim storage of commercially generated high-level radioactive wastes. Such a facility has been designated an ENGINEERED STORAGE FACILITY.

"ENGINEERED" in the term ENGINEERED STORAGE means that, utilizing existing technology, the facility will be a structure above ground or just below ground designed to:

- Provide required cooling system and isolation,
- Meet applicable local, Federal and U. S. AEC codes and regulations,
- Cope with normal and postulated abnormal conditions, and
- Cost a minimum, consistent with functional requirements.

The general criteria or design bases for the proposed Engineered Storage Facility are that:

- The facility will be designed to receive high-level waste in solid form resulting from the nuclear power economy through about the year 2000 AD.
- A modular construction schedule will be planned to allow flexibility in integrated waste management plans.
- High-level waste is defined as in the U. S. Code of Federal Regulations: "...high-level liquid radioactive wastes means those aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels."

- Waste in solid form, is received contained--stored for about 100 years, and shipped contained.
- The waste will be monitored and can integrity will be maintained.
- The heat will be dissipated to the atmosphere.

The objective of the ARHCO studies is to supply designs and data to support a fiscal year 1975 budget request for an Engineered Storage Facility.

Designating the site for the Engineered Storage Facility depends upon:

- Facility Requirements
- Environmental Requirements
- Economics
- Public Acceptance

Basically, the Engineered Storage Facility should be located where the public safety requirements, under both normal operating conditions and under maximum hypothetical accident conditions, can be satisfied at minimum cost considering both construction and operating costs during the life of the facility.

The Engineered Storage Facility could be located at a single central repository, or at facilities located at each reprocessing site. Alternatively, particularly as the nuclear economy grows, regionally located repositories may be desirable.

Consideration of waste storage at reprocessing plants compared to the Engineered Storage Facility, as indicated by inventories of radioactive materials is as follows:

	Fission Product <u>Megacuries</u>	<u>Megawatts</u>
Reprocessing Plant - 5 metric tons per day (10-year storage)	12, 000 - 20, 000	50-75
Engineered Storage (at 2010 AD)	52, 000	195

A significant difference between an operating reactor and high-level waste storage is that the heat evolution from a reactor drops to relatively low levels shortly after "shutdown". There is no difference between a "shutdown" or an "operating" status for waste storage. The operating conditions, i. e., heat flux and unit heat rates, are substantially less for waste storage.

The significant difference between storage at the reprocessing plants and at the Engineered Storage Repository is in the time frame, i. e., currently the reprocessing plant must ship within ten years of separation (storage of canned waste will be five to ten years) whereas storage at the Engineered Storage Facility will be in the order of 100 years.

Both reactors and reprocessing plants may be expected to have low-level radioactive effluents during normal operation. In the normal operating condition for the Engineered Storage Facility, the radioactive waste is contained and the facility is operated "clean". The only radioactivity that is handled in a processing sense is that which might be received as contamination on can and cask surfaces, or that which might be in the system due to can failures. This material will be processed by conventional techniques, and routine radioactive effluents should be essentially nonexistent.

A waste can, typically as in the illustration (Figure 1), can be cooled or maintained at tolerable temperatures in

water, air or conductive systems. Currently, to assure compatibility with salt mine disposal, it is expected that the maximum heat evolution per can will be five kilowatts.

Concepts for a cooling system which have been studied in some detail are as follow:

- Container in direct contact with water
 - Non-boiling cooled recirculating water
 - Boiling water
- Container in an air environment
 - Container exposed to cooling air
 - Once through
 - Recirculated cooled air
 - Container isolated from cooling medium
 - Heat removed by water
 - Non-boiling cooled water
 - Boiling water condensed steam
 - Heat removed by air
 - Once through
 - Recirculated cooled air
 - Heat removed by conduction

These general concepts were converted into engineering concepts and studied with sufficient detail to obtain comparative costs and an appraisal of design problems and of operating conditions and hazards.

The study of these concepts resulted in the conclusions that:

- Cooling with air by natural convection appears attractive by potentially achieving a safe "unattended" plant. However, the low volumetric heat dissipation capacity leads to a high cost facility and can failure problems are formidable to cope with.

- The burial concept, with heat conduction to the ground, achieves the objective of a potentially unattended plant; however, burial in any medium with a thermal conductivity less than that of salt leads to severe restriction in can loading and to a high cost facility.
- The water in the water storage concepts is a large heat sink that is somewhat forgiving during accident or "acts of God" conditions.

Water also provides a hold up point for escaped waste material since the waste will tend to be held in the water instead of being swept in an air stream. Water provides low cost shielding.

- Container corrosion problems are expected to be worse where the container is in contact with water, but this problem can be overcome by proper container design, adequate surveillance, and repackaging. The impact of container failures can also be reduced significantly if the waste form has low solubility.

On the basis of these considerations, major emphasis was placed on the simple water basin and the radiant-to-water concepts. The water basin is preferable if the can failure rate is low during the storage period. The radiant-to-water (or thimble concept) provides some additional protection to the can but results in design and operational features which increase costs. Typical engineering artist's conceptual layouts for these concepts are illustrated in Figures 2 through 4.

Potentially, the integrity of the waste container may be breached by nonstandard operating or accident conditions. Typically, container failures could occur in incidents involving:

- Partial loss of coolant

- Loss of coolant support system
- Accidental impact
- Defective can
- Corrosion

Complete loss of coolant will likely not be considered a credible accident since it should be possible to design the structures and operational systems such that complete loss of coolant cannot reasonably occur. Loss of coolant support systems, i. e., pumps, fans, instruments, power, etc., is considered credible. With forced air cooling, loss of air velocity due to power loss or flow blockage will result in potentially dangerous temperatures within a few hours. Natural convection air cooling would overcome this objection but present concepts indicate large capital cost for this type of facility. With water cooling, the higher capacity of water for absorbing heat will delay the development of high temperature conditions for days, and emergency procedures can be incorporated into the design and operational plans which could alleviate a dangerous situation.

Cooled water basin storage was selected as the initial concept for storage.

The operational features and safety considerations that might be associated with this concept in an operating facility are being studied by Atlantic Richfield Hanford Company operating staffs in a "Safety Analysis". These analyses will contribute to the design of the facility, which is just now getting under way.

A functional diagram of the facility is illustrated in Figure 5. Although the design is in its very early stages, a preliminary description of the facility can be made.

The waste cans will be received in casks of about 100 tons. At the head end the waste cans will be prepared for storage. Tentatively, facilities will be available for:

- Cooling
- Inventory control
- Examination
- Canning
- Recleaning

The waste cans will be transported to the water basins. Likely, this will be accomplished in a shielded transporter cask. The waste cans will be unloaded into the storage basin and loaded into racks. Water will be circulated through the storage basin and through heat exchangers. If necessary, a secondary loop will be used between the primary heat exchanger and the atmospheric heat exchangers located outside of the building.

In the event that the cooling water becomes contaminated due to a waste container rupture, the water will be processed by ion exchange or by evaporation. The recovered water will be recycled and the recovered radioactive materials will be fixed and placed in storage. Routine radioactive effluents are expected to approach zero.

The waste containers will be under continuous surveillance and evaluation. If it is determined that can failure is probable for any given type or lot, the suspected containers will be recanned in available facilities. Randomly failed containers will also be located and recanned as required.

The nuclear economy used for a design basis is illustrated in Figure 6. Optimally, the repository would be constructed in increments to minimize the present worth. Construction in increments also provides for potential changes in direction of the Waste Management Program with minimum impact on cost. A further advantage is that it allows for the design of future increments to be based on advances in technology and to be based on the actual waste can requirements that might exist at the time of construction.

A tentative construction schedule is illustrated. Currently, the design is being categorized into storage "modules" of 24 cells of 500 containers each (excluding spares). Basically,

the schedule would require construction every five years, following an initial period of 10 years. The first construction would be eight cells (a part of a module). Ten years later in 1990, the remainder of the module (16 cells) would be put in operation. Following this, an additional full module would be put in operation in 1995, two modules during 2000, and three during 2005.

An artist's early conceptual view of the Engineered Storage Facility is illustrated in Figure 7.

In conclusion, the concept of Engineered Storage of a high-level radioactive waste is technically a viable concept that can be implemented with well established technology. The design of the facility should present no new problems, and the only unique considerations will be those associated with the extended storage period.

FIGURE 1
"TYPICAL" CONTAINER

RANGE
TYPICAL

DIAMETER
15 cm TO 60 cm
30 cm

LENGTH
.6 m TO 3 m
3 m

FIGURE 2

NATURAL CONVECTION

FIGURE 3
WATER BASIN

FIGURE 4
RADIANT TO WATER

FIGURE 5

FUNCTIONAL DIAGRAM ENGINEERED STORAGE FACILITY

FIGURE 6
ENGINEERED STORAGE FACILITY
BUILDING PROGRAM

FIGURE 7 - ARTIST'S CONCEPT OF ENGINEERED STORAGE FACILITY