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RETRIEVABLE SURFACE STORAGE OF HIGH-LEVEL RADIOACTIVE WASTES

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INTRODUCTION

The policy of the Atomic Energy Commission is to take custody of all high-level nuclear wastes and dispose of them permanently. This policy (Code of Federal Regulations, Title 10, Part 50) requires that these wastes be solidified at fuel reprocessing plants and shipped to the Federal repository within ten years after separation. Ultimate disposal methods have not yet been selected and are not expected to be available when waste deliveries begin about 1983. The AEC therefore plans to build an interim storage facility to serve until the permanent repository has been established. This interim facility is called the Retrievable Surface Storage Facility (RSSF).

SUMMARY

The Atlantic Richfield Hanford Company was selected by the AEC Division of Waste Management and Transportation to perform engineering and site studies for the RSSF, with Kaiser Engineers providing design support. Alternative storage concepts are currently being evaluated, with plans to select the preferred concept early in 1974 and then do further conceptual design so that design and construction funds can be requested in the AEC's fiscal year 1976 budget.

DISCUSSION

Principal design criteria, which must be met by any storage concept, have been established for the RSSF. These criteria are:

- Store all high-level wastes generated by the nuclear power economy through the year 2000 A.D.
- Store the waste for at least 100 years.
- Design, construct, and operate in accordance with AEC, Federal, State, and local regulations.
- Limit radioactive material released to less than guideline values in applicable regulations.
- Limit maximum waste temperature by continuous heat removal.
- Assure retrievability of stored waste at all times.
- Use existing technology.
- Construct on a modular basis to optimize expenditures, safety, and operability.

The waste to be stored will be a dry, stable solid contained in metal canisters. The criteria for canister size, material, and features have not been established but, for conceptual design, a typical canister as indicated in Figure 1 has been assumed.

Assuming the typical waste canister and 10-year reprocessor storage prior to shipment, the load buildup for the RSSF is as shown in Figure 2. In 1990, about 20 canisters per week would be received; in 2010, the rate would be about 20 per day. The radioactive decay heat load associated with the waste reaches a maximum of 195 megawatts in the year 2010 and, if no additional waste is added to the RSSF, would decrease to about 30 megawatts in 100 years.

Three basic alternative storage concepts are currently being studied and evaluated for the RSSF. These are:

- Storage in cooled water basins (Water Basin Concept).
- Storage in air-cooled concrete vaults (Air-Cooled Vault Concept).
- Storage in air-cooled steel casks (Sealed Storage Cask Concept).

In the WBC the waste canisters are stored in a series of water-filled, stainless steel-lined concrete basins. Radioactive decay heat is transferred from the waste to the basin water and then rejected to the atmosphere via primary and secondary cooling loops, a heat exchanger, and a cooling tower as shown in Figure 3. Each basin would contain 500 typical canisters each generating up to 5 kilowatts of decay heat. The demineralized basin water would be maintained at less than 120° F under normal operating conditions. Since the basins have no water interconnections, cross-contamination is prevented in case of canister failure. Consideration is also being given to placing each canister in a secondary container (overpack) upon receipt to further reduce the potential for waste to enter the basin water. The water in the storage basin is a good heat sink, a transparent, flexible radiation shield, and provides an additional radioactive material confinement barrier. Storage of highly radioactive, heat-emitting materials in water basins has been successfully accomplished for three decades.

Storage of high-level wastes in air-cooled concrete vaults is attractive because air is normally less corrosive than water and it is possible to remove the heat by natural draft air flow, thus eliminating reliance on mechanical systems. As currently conceived in the ACVC, the waste canisters would be placed in sealed overpacks which would be stored in a concrete vault, as shown in Figure 4. The heat would be removed by the air entering at the bottom of the vault, flowing up past the overpacked waste canister, and then out a short stack. The air temperature would be about 200° F at the exit and velocities low, less than 10 feet per second. In the current concept, high efficiency particulate air filters would not be utilized for confinement but, rather, reliance would be placed on the overpack to contain any leakage of radioactive material from the waste canister. Each vault would contain 500 canisters and canister overpack temperatures would be maintained at less than 500° F. As the waste storage load increased, additional vaults would be built until the year 2010 when 150 vaults would be in service.

A third concept, called the Sealed Storage Cask Concept (SSCC), is an air-cooled concept which is intriguing because of its simplicity. This storage concept utilizes thick-walled steel cylinders (casks) in which the waste canisters are sealed by welding and then stored outdoors. The cask provides radiation shielding, containment, and structural strength, while the decay heat is transferred to the atmosphere by radiation and natural convection. The concept is shown in Figure 5. Advantages of the SSCC are:

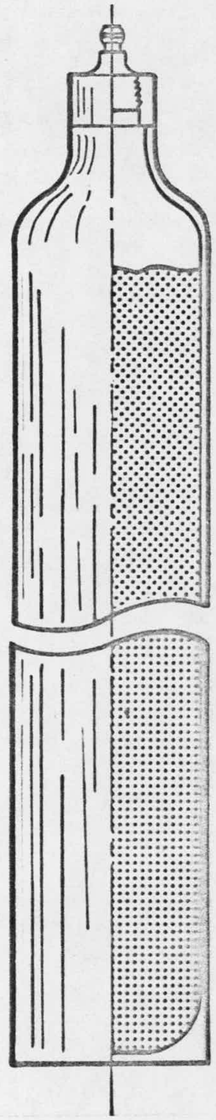
- Natural convection cooling.
- High integrity containment.
- "Walk away" capability.
- Service life more than 100 years.
- Cask investment timing matches load buildup.

Two problem areas which have been defined are: (1) neutron radiation from certain types of wastes, and (2) assurance of cask quality at reasonable cost. Radiation dose rates for the 10-year-old waste, using just steel for shielding, are shown in Figure 6. The high dose rate from plutonium recycle fuel waste is primarily a neutron dose from ^{244}Cm; the neutron dose from uranium fuel waste is much lower. Figure 7 shows a storage cask arrangement which overcomes this neutron radiation problem by utilizing a concrete neutron shield around the steel cask.

A key factor to the feasibility of the SSCC is the cost of the steel cask. The concept utilizes the massive steel thickness required for shielding to provide a large safety factor to the containment thickness requirement. Secondary containment around the waste canister is considered necessary since the canister will not be monitored for leakage. However, as the waste form is to be a dry, stable material, this secondary barrier should not have to withstand significant pressure or corrosion. By making the closure weld several inches thick in conjunction with the thick walls of the cask, it is thought that the steel casting and weld closure will not require expensive steel or costly quality assurance inspections and certifications. If the steel casting quality assurance requirements can be satisfied with low-level inspection, this concept is economically competitive with the other storage concepts being studied. The concept is also amenable to optimization to improve the waste-to-steel ratio. This could be done by increasing the capacity of the casks to store larger waste canisters or by storing more than one canister per cask. The key to increasing the amount of waste in a cask is removal of the decay heat. With improved thermal conductivity within the waste product itself and in the air gap between the canister and the cask, it should be possible to accommodate a heat load of 10 to 20 kw. Such optimization could significantly reduce the waste storage cost or offset a higher quality assurance cost.

The 75,000 typical steel casks needed to store all of the waste through the year 2010 would require 2.2 million tons of steel or less than one week's current steel production in the United States and would occupy about 1,000 acres of storage area. An artist's concept of such a storage yard is shown in Figure 8.

All of the storage concepts being studied meet the RSSF principal design criteria and would provide safe storage of the high-level waste. Whichever concept is selected, the RSSF will play an important role in the development of nuclear power so that we, and our children, will have an ample supply of electrical energy.



SIZE

6 TO 24 INCH DIAMETER

2 TO 10 FEET LENGTH

12 INCH DIAMETER × 10 FEET LENGTH TYPICAL

MATERIAL

300 SERIES STAINLESS STEEL

HEAT

<1 TO 20 KW

5 KW TYPICAL

FIGURE 1

HIGH-LEVEL WASTE CANISTER

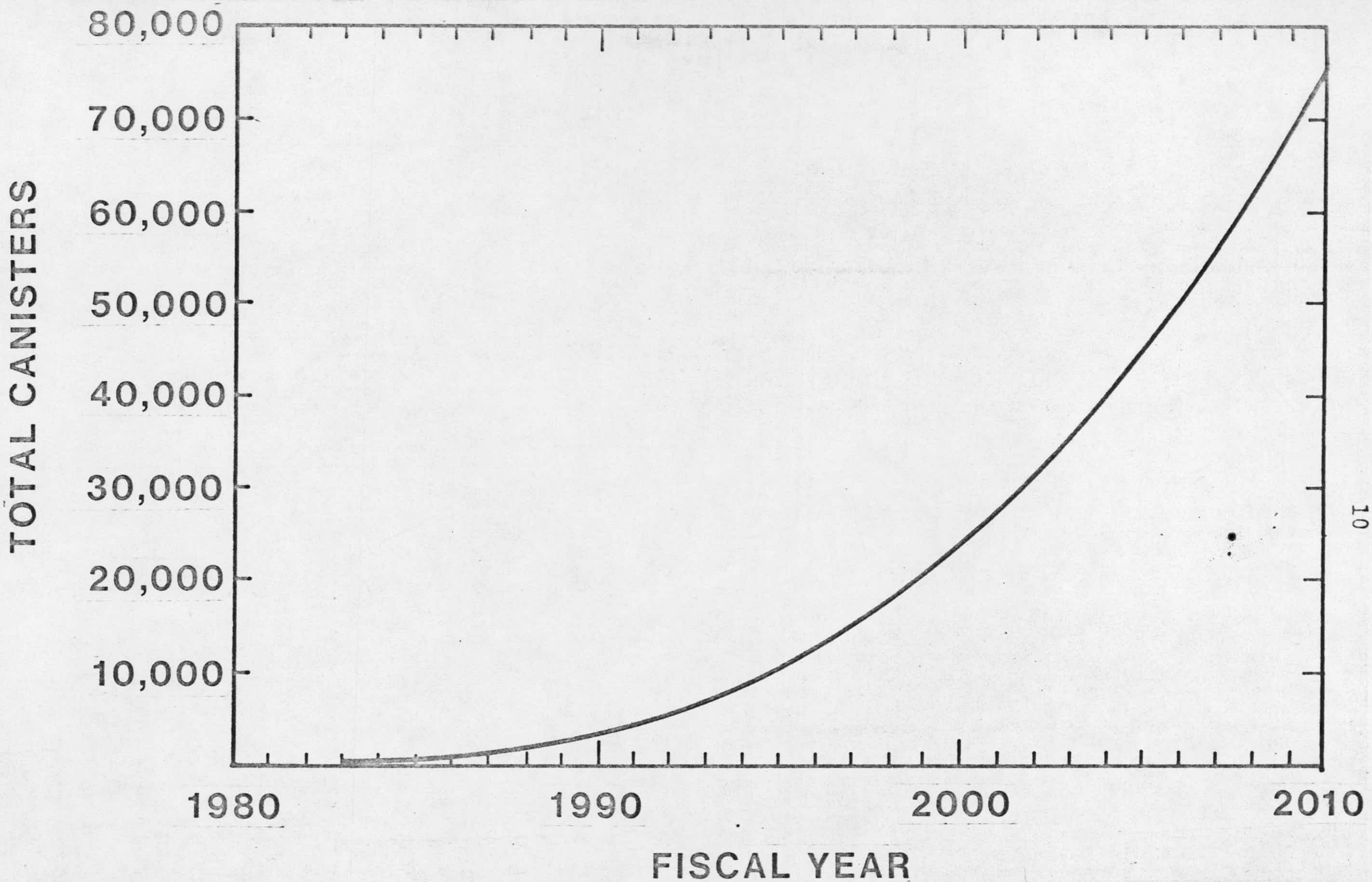


FIGURE 2

CANISTERS IN STORAGE

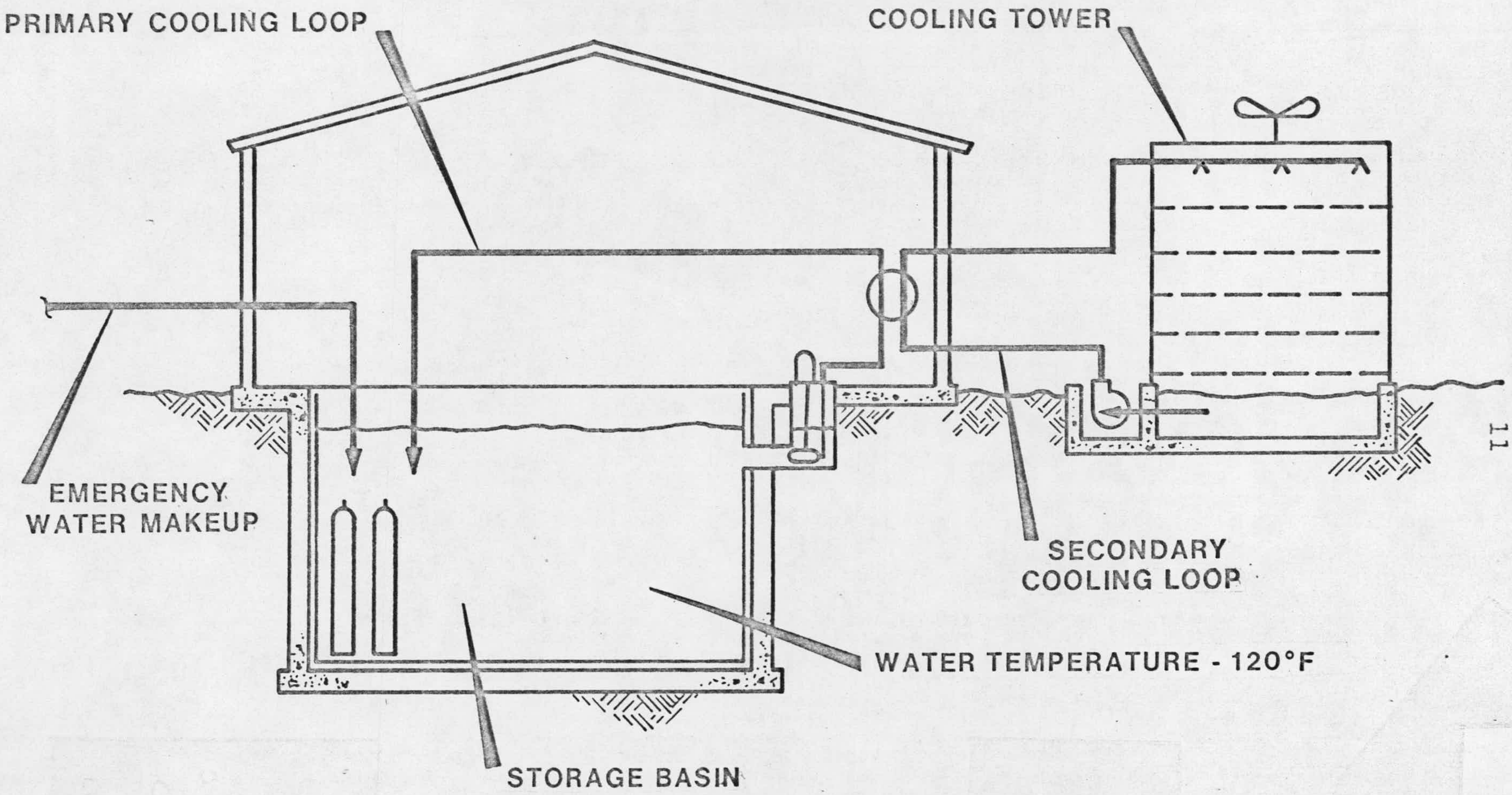


FIGURE 3

WATER BASIN CONCEPT

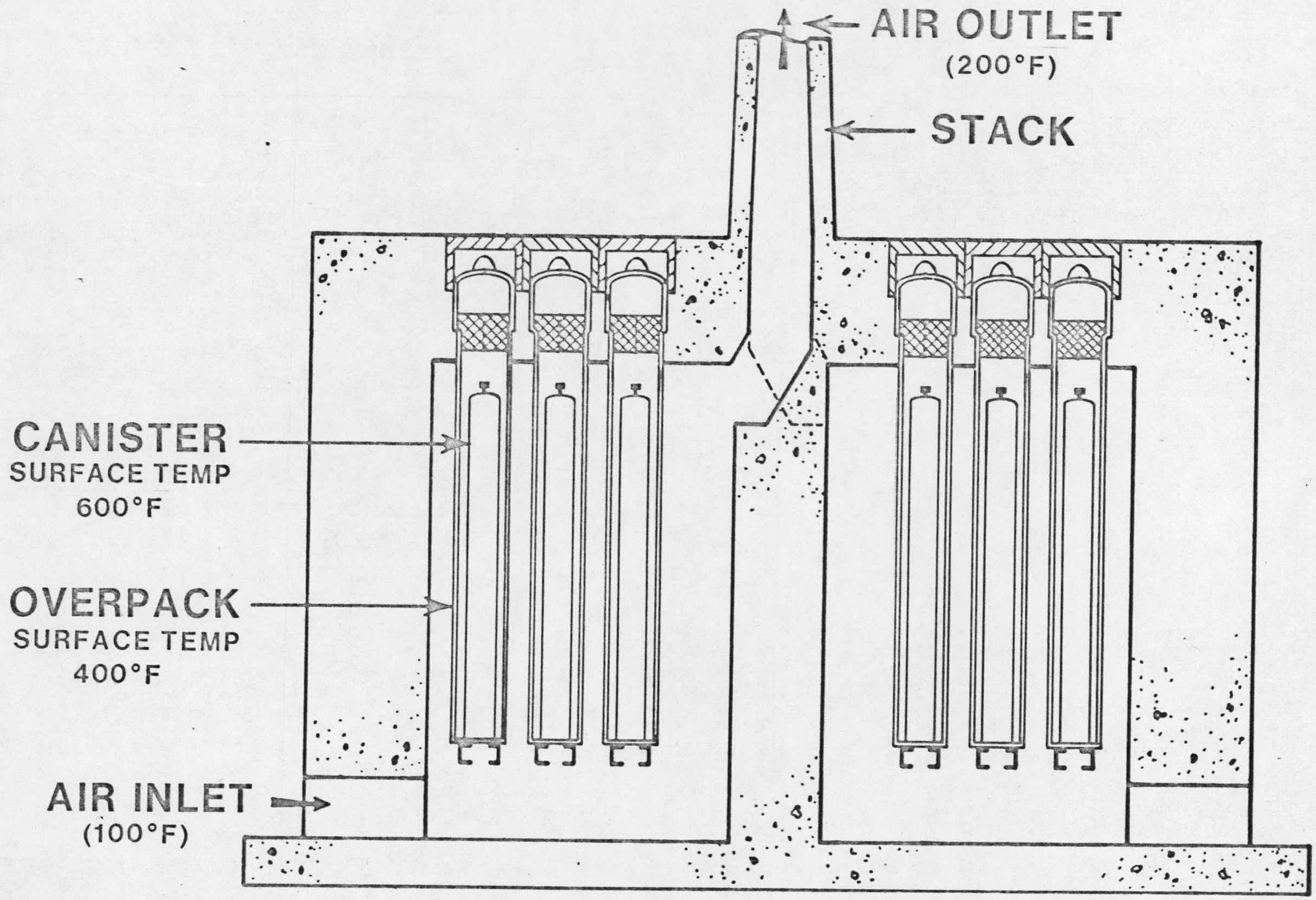


FIGURE 4

AIR-COOLED VAULT CONCEPT

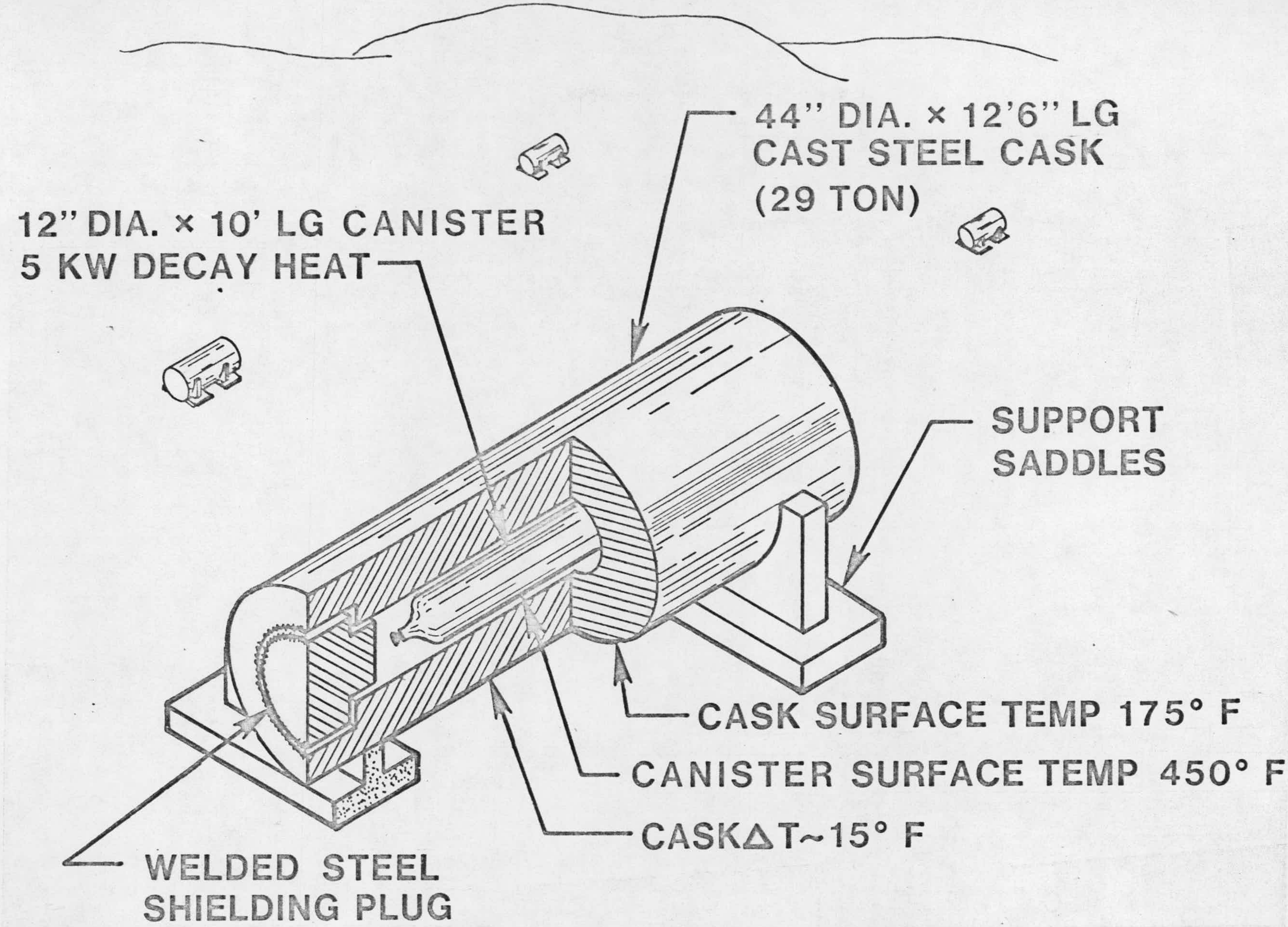


FIGURE 5

SEALED STORAGE CASK CONCEPT

	PWR-PU	PWR-U
PRIMARY GAMMA	1	2
SECONDARY GAMMA	5	0.3
NEUTRONS	3000	200
TOTAL	~3000	~200

FIGURE 6

SEALED STORAGE CASK CONCEPT
RADIATION LEVEL AT CASK SURFACE (MREM/HR)

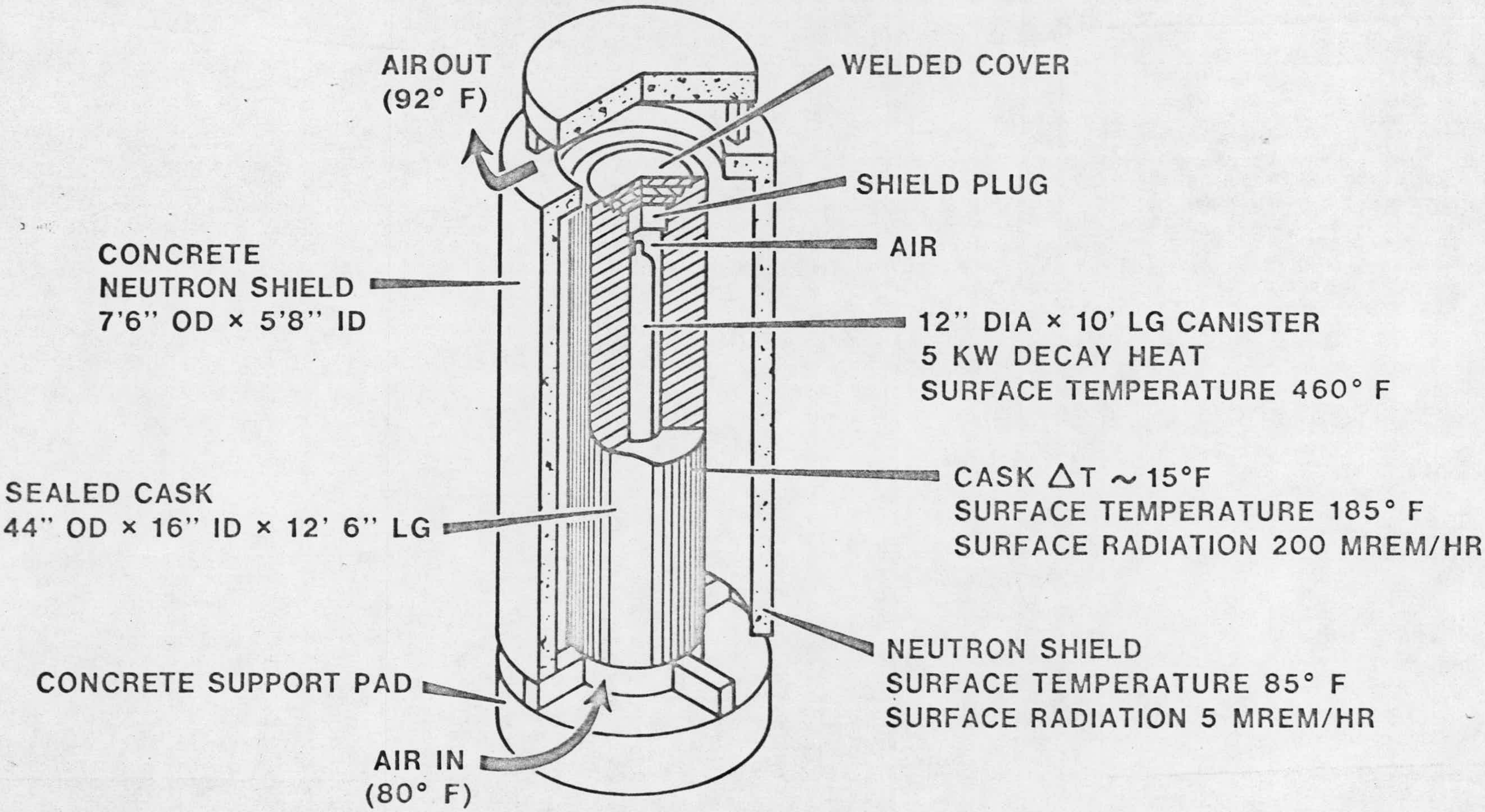


FIGURE 7

SEALED STORAGE CASK CONCEPT
WITH NEUTRON SHIELD

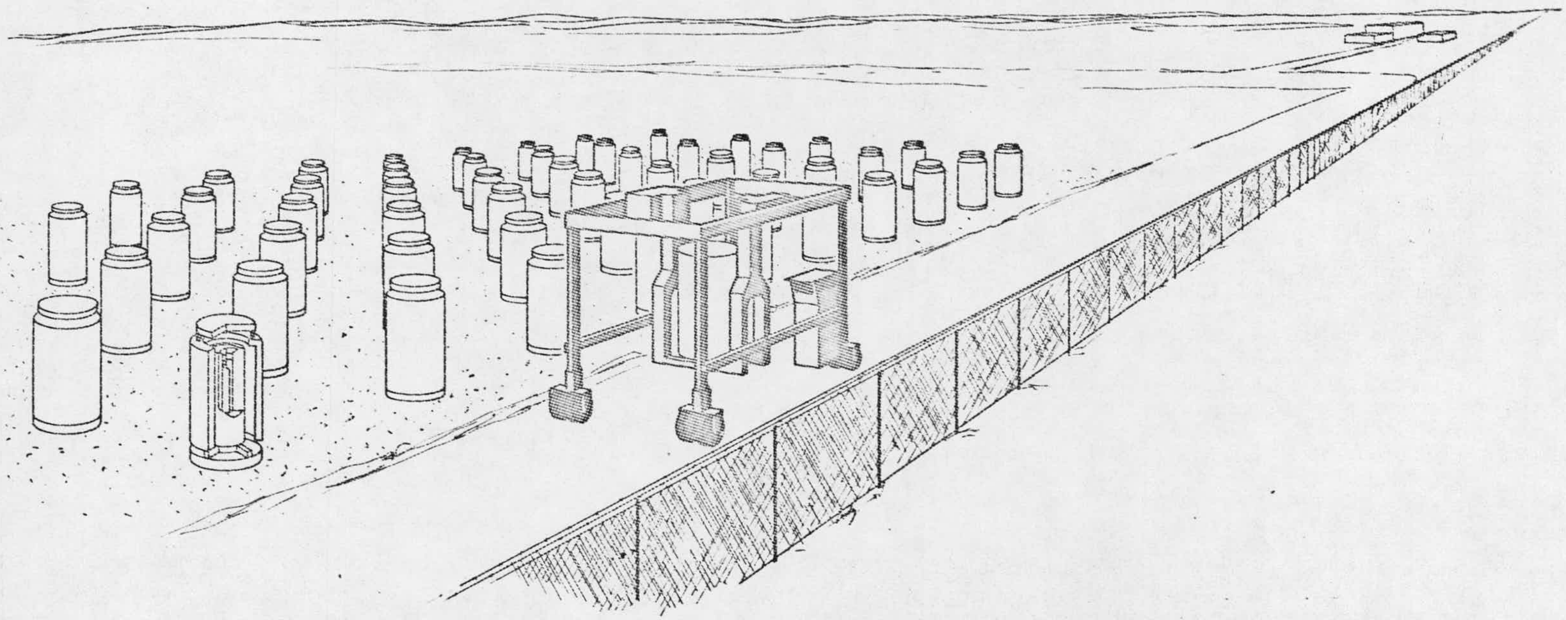


FIGURE 8

SEALED STORAGE CASK CONCEPT
STORAGE AREA