BORED TUNNEL STORAGE OF NUCLEAR WASTE

Larry Penberthy
Penberthy Electromelt Int'l, Inc.
631 South 96th Street
Seattle, Washington 98108

ABSTRACT

Contrary to the current emphasis on deep geologic disposal of high-level nuclear waste, simple bored tunnels offer many advantages. Much lower cost is important in this period of severe budget crisis. Recoverability is feasible from a tunnel in a mountain, but dubious from a flooded mine 3000 ft deep. It is quite possible that the world will need the breeder energy cycle urgently 200 years from now. In the writer's opinion, it would be a sin for our generation to make so much fertile and fissile uranium fuel unavailable for future generations. Storage conditions in a near-surface repository are much better than deep because the temperature can be kept down, pressure will be atmospheric instead of potentially 1200 psi, and flooding will not occur. The so-called "hydrothermal" conditions are thus completely avoided. Accordingly, endless studies of hydrogeology, water pathway times, waste-host rock interactions and the like are unnecessary, and the time for action is much shorter.

BACKGROUND

High level radioactive waste is currently in these forms:

- "Spent" fuel removed from commercial power reactors
- Separated fission products in liquid + sludge forms, alkaline or acid
- Separated Cs-Sr salts in powder form

The public perception is that these wastes in their present forms and locations are not secure (disposed of) and that something more needs to be done.

"Spent" Fuel can be: stored; or disposed of as is; or can be reprocessed to recover metal values and the separated fission products can then be disposed of.

Separated fission products and salts can be: dried and stored in tanks; or can be made into glass to make them insoluble, followed by storage or disposal.

Separated Cs-Sr powders are now being stored in shielded vaults, waiting for: a commercial use; or a decision to leave them in the vaults; or a decision to glassify them and place the glass in a repository.

In this paper, "storage" implies retrievable, and "repository" implies practically non-retrievable. A considered decision has to be made whether the radwaste is to go into storage or a repository.[1] In the writer's opinion, all should go into storage.

The AEC (Pittman 1972-74) proposed a Retrievable Surface Storage Facility.[1,2] Response to the draft EIS was negative and the draft was withdrawn in 1975 by ERDA, in favor of deep geologic repositories.

Interest in Monitored Retrievable Storage was revived by Congress in 1981.[3] The DOE contracted with General Atomic to prepare a review and status of MRS.[4] Philip Hammond[5] was the guiding consultant. The resulting conceptual drawing is shown in Fig. 1.

The proposals of this paper are therefore not novel basically.[6,7] They are intended to be a contribution due to simplified design using modern tunnel boring capability for sharply lower cost.

THINKING OF THE PRESENT CONCEPT

1. It is well known in mining that every corner turned costs a lot of money overall. Going down is even worse, as in deep mined repositories. Therefore the present design has the tunnel going straight in horizontally.

2. Uranium fuel removed from a power reactor is misnamed "spent fuel" and certainly is not waste. Natural uranium is 0.7% fissile. It is enriched to 3% fissile going in. Coming out, it is still 1.4% fissile.

Heavy water reactors use 0.7% fissile fuel. A heavy water reactor can be designed to run on "spent" fuel after minimal reprocessing.

There is almost as much potential non-breeder energy left for the second pass as was obtained in the first pass. The potential energy of the fertile uranium left, used in a breeder cycle, is <u>sixty</u> times as much as the single pass energy.

Accordingly, "spent" fuel will be called onward in this paper "Reusable Uranium Fuel." (RUF) It would be a sin for our generation to make such valuable material unavailable for future generations.

3. "Keeping the waste dry solves (avoids) a lot of problems." Therefore this RUF Storage is above the flood plain. There are no sealing or pumping challenges. Water leakage if any runs out by gravity, underneath the concrete pedestals in the tunnel.

4. Staying near the surface also avoids any possibility of high hydrostatic pressure. This avoids any possibility of "hydro*thermal conditions*" which can disintegrate most waste forms.

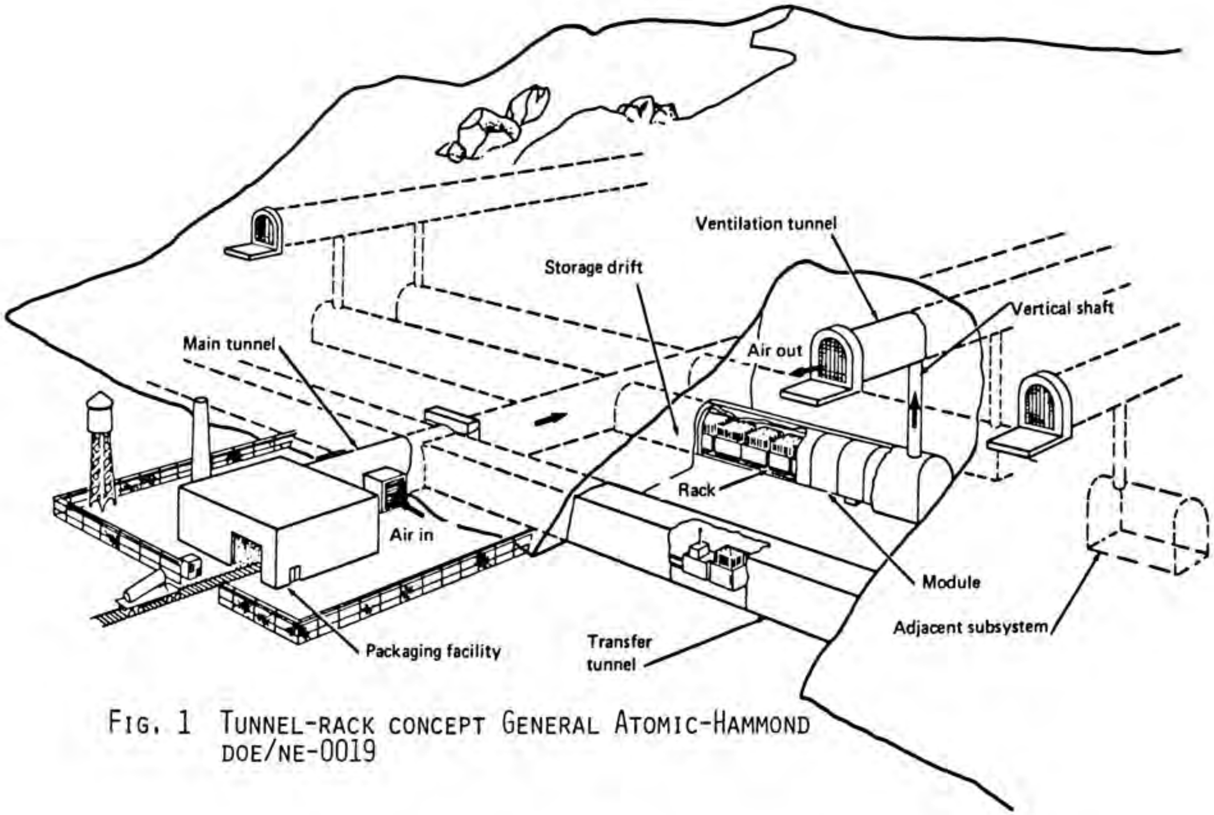

FIG. 1 TUNNEL-RACK CONCEPT GENERAL ATOMIC-HAMMOND DOE/NE-0019

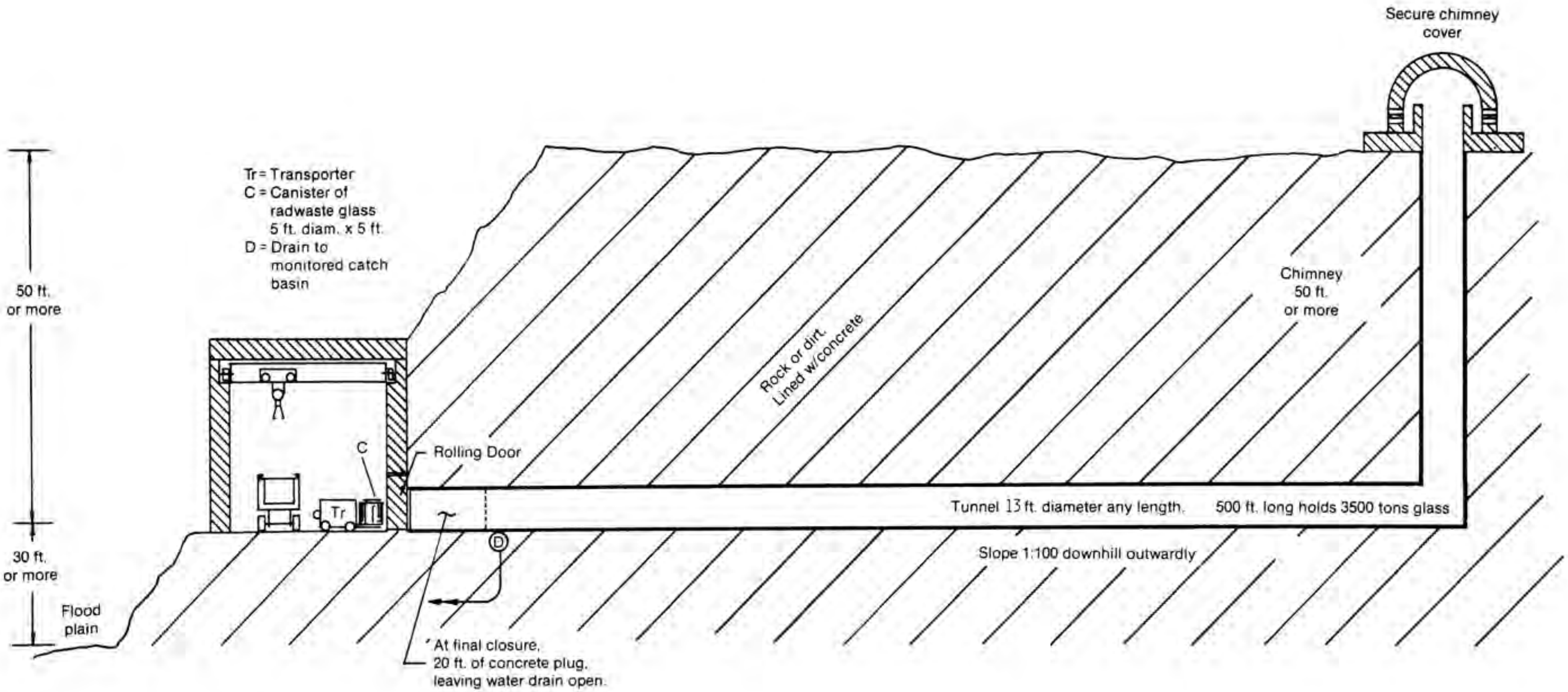

Fig. 2. Vertical Section, RUF Storage Unit.

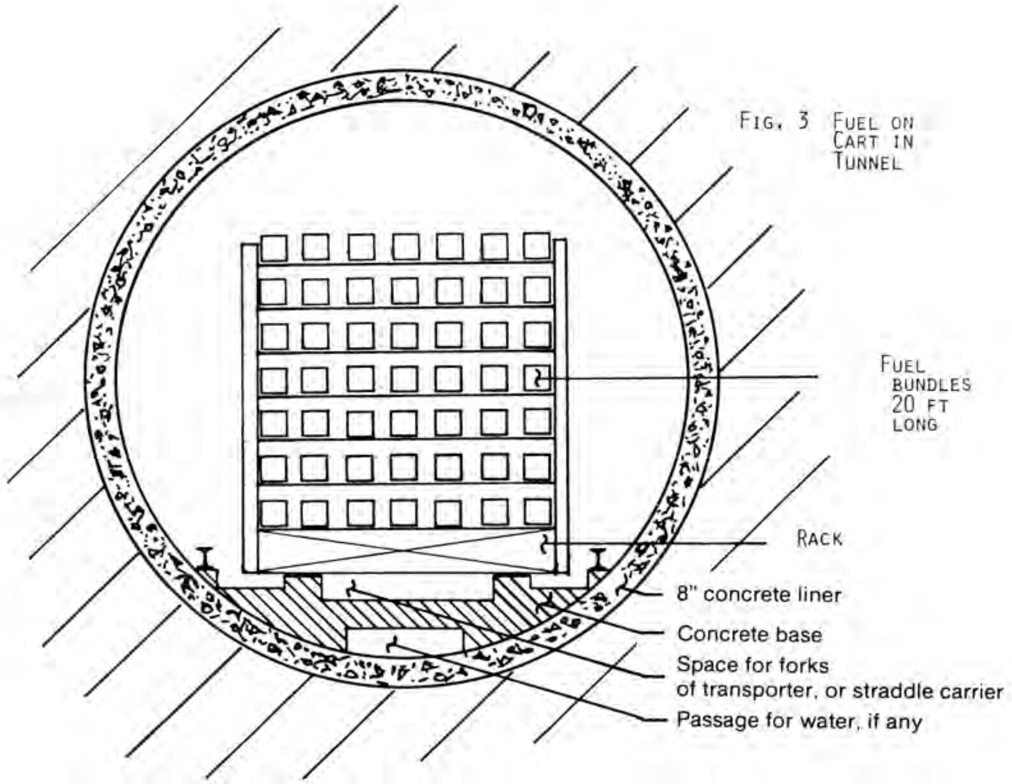

Fig. 3. Fuel on Cart in Tunnel.

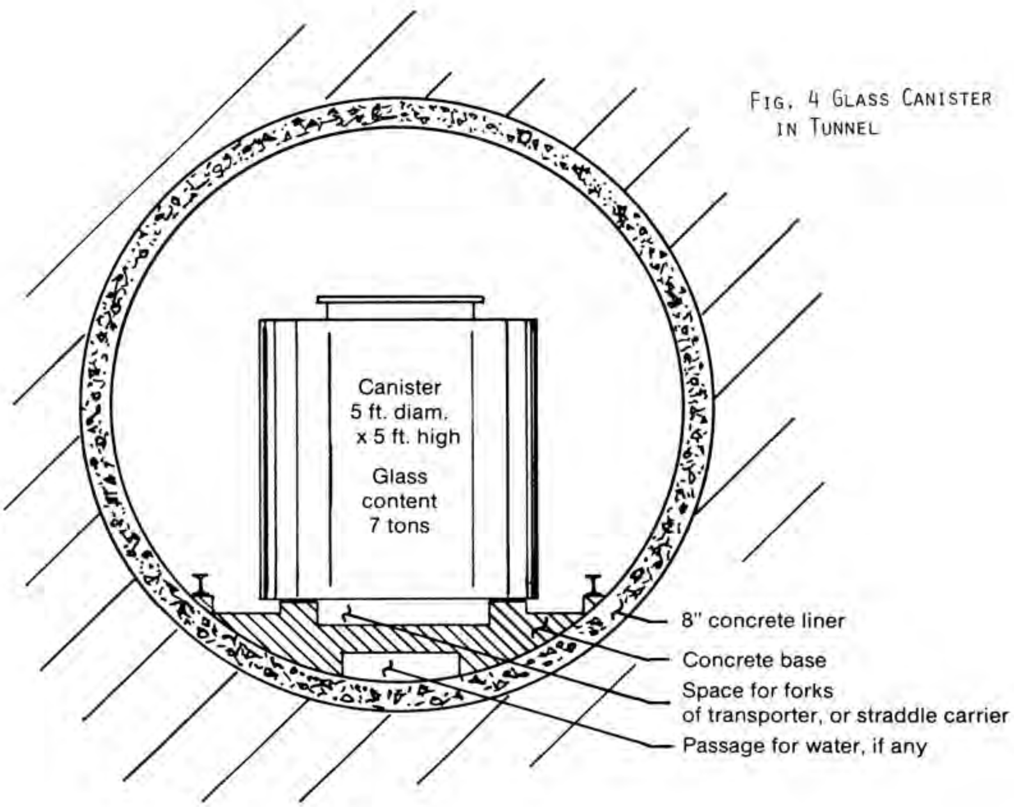

Fig. 4. Glass Canister in Tunnel.

5. Locating the storage near the surface where air and evaporative water cooling are possible permits much higher loading density of the fuel bundles. This greatly reduces the volume of rock to be excavated.

6. Mountains and hills are generally free of the horizontal compressive stresses which are reported to exist in deep basalt layers at Hanford. Such stresses tend to make tunnel roofs unstable.

7. The public perceives mountains as durable and long lived, therefore a reliable place to store materials for 360 years, or 36,000 years if wanted.

LAYOUT OF RUF STORAGE

Figure 2 shows a vertical section through one unit of the RUF Storage. A transfer portal moves along the hillside. Tunnels 135 ft apart center to center are bored as deep as desired into the hill, say 800 ft. At the inner end, a chimney is bored upward to the surface. The opening has a cover with air holes. After filling, the lower end is plugged with concrete having angular holes which allow air to enter, but not radiation to escape.

Figure 3 shows the end and side views of a cart carrying 50 fuel bundles. They are stacked like logs on a truck, except with spacers for cooling air.

The same tunnel system can handle canisters of glassified waste. Figure 4 shows the crossection of a tunnel showing a canister holding 7 tons of glass. Further cost studies may show economy in larger canisters, say 15 tons of glass each, since transportation costs tend to be per canister rather than per ton.

A full scale MRS according to Ref. 4 will hold 48,000 MT Heavy Metal. Each tunnel holds 500 tons, hence 96 tunnels will be required. Spaced 35 ft center-to-center, the distance along the side of the hill will be 3500 ft (1025 m).

COOLING

Passive air cooling by induced draft up the chimney is the preferred system. Added water mist spray along the tunnel can be used to supplement air if desired during the early years.

The fuel bundle canisters and waste glass canisters have no problems if their core temperatures are held below 800°F (427°C).

CONSTRUCTION CAPABILITY

Tunnel boring machines are readily available in diameters to 24 ft. Boring has an advantage over drill-and-blast in causing less fracture of the rock, Fig. 5. The boring speeds are over 100 ft per day.

The chimney is made by first boring a pilot hole followed by raise boring to diameter.

Rock chips are removed at low cost by conveyor.

The concrete lining is precast segmented, to leave an annular expansion gap.

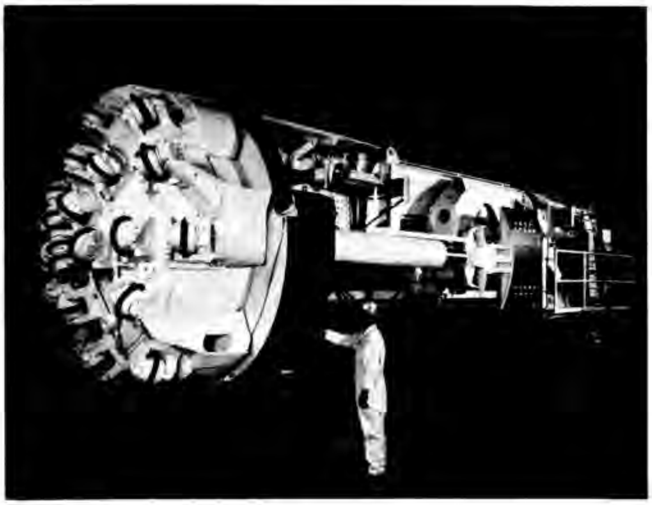

Fig. 5 Tunnel Boring Machine

LOCATION OF RUF STORAGE

There are many locations suitable for RUF storage. Steep hills and bluffs are preferred to reduce excavation costs for the portal platform.

The national need for MRS facilities for all RUF expected by the year 2000 is 150,000 MTHM, three full-scale facilities.[4]

However, most states having uranium-fueled power plants also have hills, and may wish to store their own RUF. Yes, Congress has set another policy at present, but policies can be changed when costs are considered during a budget crisis.

The same kind of a tunnel facility can be made on small hills (50 ft above the flood plain)[8] using cast concrete construction covered with dirt and rock. The writer considers the worry about intrusion as being overblown.

COSTS FOR DEMONSTRATION FACILITY

The following cost estimates are for a demonstration facility holding 750 each of PWR and BWR spent-fuel assemblies, about 500 MT Heavy Metal.

	$ million (1983)
Portal, including foundations, shielding walls, floats	$ 1.0
Boring costs on contract, horizontal tunnel and chimney 14 ft diameter with 6" rebar concrete liner, 800 ft deep	$ 2.4
Concrete pedestal - runway, chimney cover, door	$ 0.1
Cranes, handling and inspection devices	$ 0.8
Incoming power for boring machine, 1000 hp, 5 miles, and utilities	$ 0.5
Carts for RUF and glass	$ 0.6

	$ million (1983)
Boring machines, purchased	$ 2.0
Access road, 5 miles	$ 3.0
Area and site instrumentation	$ 1.0
Engineering	$ 1.0
Auxiliary buildings	$ 1.0
Total	$13.4

These estimates were developed in discussion with The Robbins Company (tunnel boring), Ederer Engineering (cranes) and James Sekor (concrete consultant). They assure me they cannot spend more.

However, the General Atomic estimate[4] is $341 million. So let's add $13.4 million for contingency and another $13.4 million for luck. Our total now becomes $40 million.

Note that there is no packaging facility. Each fuel bundle should be already enclosed in a sealed canister as a condition of shipment and acceptance.

COSTS FOR ADDITIONAL TUNNELS

The boring machines, access roads, portal, utilities and auxiliary buildings are not recurring costs when more tunnels are made at the same site. Repeat cost per tunnel is only $5 million.

TIME

A Monitored Retrievable Storage demonstration facility according to Fig. 2 can be built on the Hanford Reservation in 12 months under go-ahead policies that applied in the 1950's.

OTHER USES

This facility can be an AFR fuel storage if located just on the west side of the reservation border in Yakima Ridge or Rattlesnake Hills. The State of Washington will have to be consulted. This will take a little longer.

TIME PRESSURE

A good case can be made that the deep mined repository idea should be abandoned for two reasons: excessive cost; wrong thing to do with "spent" reusable fuel.

The Congressional Budget Office projected that two deep mined repositories will cost $14 billion, and fears that the actual cost will be three times that high.

Accordingly, this RUF type of MRS should be built and demonstrated as soon as possible to be used to persuade Congress to change direction on nuclear waste storage/disposal.

REFERENCES

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4. Conference Report (HR No. 96-1366) on HR7590, 198.

5. The Monitored Retrievable Storage Concept DOE/NE-0019, Dec. 1981.

6. Hammond, R.P. 1979. "Nuclear Wastes and Public Acceptance." American Scientist, Vol. 67, pp. 146-150.

7. Acknowledgment also to UKAERE, tunnels in sea cliffs.

8. U.S. Geological Survey, Winograd, I.J., 1974. Radioactive waste storage in the arid zone: EOS (Am. Geophys. Union Trans.), v. 55, no. 10, pp. 884-894.

ABBREVIATIONS

RUF	Reusable Uranium Fuel
MTHM	Metric Ton Heavy Metal
GA	General Atomic
MRS	Monitored Retrievable Storage
AFT	Away From Reactor