ENVIRONMENTALLY RESPONSIVE ALTERNATIVE TO SHALLOW LAND BURIAL OF LLRW

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ABSTRACT

The authors consider both the need for, and the demand for, alternatives to traditional shallow land burial (SLB) of low-level radioactive wastes (LLRW). They conclude that engineered alternatives will be employed at future LLRW disposal facilities. They also conclude that such enhanced facilities must have the capability of detecting the migration of radioactive materials prior to such materials entering the environment. An enhanced alternative which provides such a capability, called S/M/R, is proposed and described. The cost of implementing their alternative is presented in comparison to continuation of SLB for a specific case. Based on their computations, the S/M/R alternative is shown to be less costly than shallow land burial over the twenty year operational life of a regional LLRW disposal facility.

INTRODUCTION AND BACKGROUND

The purpose of this paper is to describe an enhanced low-level radioactive waste (LLRW) disposal unit technology. Because the technology is designed with the ability to store, monitor, and retrieve radioactive waste prior to final disposal, we refer to it as the S/M/R (Store/Monitor/Retreive) Technology. The S/M/R Technology was specifically developed to be environmentally responsive in that it provides a means of detecting leakage from LLRW packages without radioactive materials entering the environment — earthen, aquatic, or atmospheric. The S/M/R Technology provides for continuous performance assurance through the use of active monitoring for as long as is desired. And, the S/M/R Technology can be employed at reasonable costs. The combination of these attributes is believed to provide an alternative for the disposal of LLRW which is sociopolitically acceptable while exceeding technical adequacy requirements.

The Need for an Alternative

Many respected and learned people have defended, and continue to defend, the technical adequacy of shallow land burial (SLB) for the safe disposal of LLRW. Independent of any particular opinion concerning the technical adequacy of SLB, the fact remains that the performance record of certain shallow land burial sites has not met the expectations of the general public. Those of us associated with the industry cannot escape that fact.

The performance record of shallow land burial facilities has given birth to an increasing demand for alternative technology. We believe the relevant question is not whether an alternative is required, rather what alternative will be employed.

The nuclear industry finds itself in a position of having lost credibility. Regulatory agencies are not trusted; disposal site operators are not trusted; and, waste generators are not trusted.

Members of the environmental community are insisting that LLRW disposal practices change to assure the protection of the environment. In this regard, protection of the environment is viewed as a prerequisite for assurance of the public health and safety.

It is our opinion that the time has come when sociopolitical acceptability must be given a higher priority than technical adequacy. We believe that any technology which is acceptable to the people will be, of necessity, technically adequate. The converse we do not believe to be inevitable.

The importance of sociopolitical acceptability is highlighted by the incorporation into statute of conditions for the disposal of LLRW. Conditions which both specifically prohibit shallow land burial and call for the employment of alternatives to shallow land burial are now contained within both state and federal laws[1,2]. The adoption of such legislation continues to gain momentum throughout the United States.

The Benefits of the S/M/R Alternative

For an alternative disposal technology to be sociopolitically acceptable, all involved parties must win. In this regard, the involved parties are: the public at large (and their elected representatives); the environmental community; the regulatory agencies; the nuclear industry in general (the waste generators); and, the disposal site operators.

The public at large wins if LLRW disposal is conducted in a manner which assures public health and safety. We believe the general public will only conclude that LLRW disposal is safe if no radioactive materials enter the environment — earthen, aquatic, or atmospheric.

At the same time, the disposal must not be so overwhelmingly costly that increases in either taxes or electric power rates become intolerable. This aspect of the overall concern will probably be most actively defended by both the elected representatives of the public and the independently established consumer advocate groups.

The environmental community wins if LLRW disposal is conducted in a manner which assures that no radioactive materials enter the environment because their demands will have been met.

The regulatory agencies win if they have placed into law the necessary regulatory controls which will assure that no radioactive materials enter the environment. They will be viewed as the strong protectors of the public health and safety which the people and the environmental community expect them to be.

The nuclear industry in general wins if LLRW are disposed of in a manner which assures that no radioactive materials enter the environment. Waste disposal operations can be reduced to a confident routine which no longer consumes resources far beyond anticipated commitments.

The disposal site operators win if disposal operations are conducted to the satisfaction of all other concerned parties and if a reasonable profit is realized.

In general, all involved parties win if a single element is incorporated, at a reasonable cost, into the alternative technology for the disposal of LLRW. That element is the ability to assure that no radioactive materials enter the environment -- earthen, aquatic, or atmospheric.

How can such assurance be provided when dealing with the extreme sensitivity of modern measurements of radioactive materials combined with the high mobility of certain common radioactive species, such as tritium? It is precisely this apparent dilemma which is addressed by the proposed alternative described in the following section.

DESCRIPTION OF PROPOSED ALTERNATIVE

As previously stated, the primary requirement is that radioactive materials be prevented from entering the environment. With such a premise in mind, we have been led to the rather straightforward conclusion that the alternative technology must include the capability to detect the migration of radioactive materials without the radioactive materials entering the environment. Conversely, we consider as sociopolitically unacceptable those technologies which depend upon the detection of migrated radioactive materials only after such materials have entered the environment.

Furthermore, we consider it unacceptable to incorporate experimental or unproven technology. The noted essential feature must be incorporated by means of simple and easily maintainable technology. At the same time, such a feature must be capable of incorporation without an overwhelming cost penalty.

Overview of Proposed Alternative

We are proposing an alternative which incorporates the patented[3] S/M/R Technology of Nuclear Monitoring Systems & Management Corporation. The unique element of the S/M/R Technology is a specially designed, multijacketed canister, as illustrated in Fig. 1. The inner core of the canister contains, in a dry, corrosion-free environment, the shipping containers of packaged LLRW. The sealed inner core is contained within a second container -- the shell of the S/M/R canister.

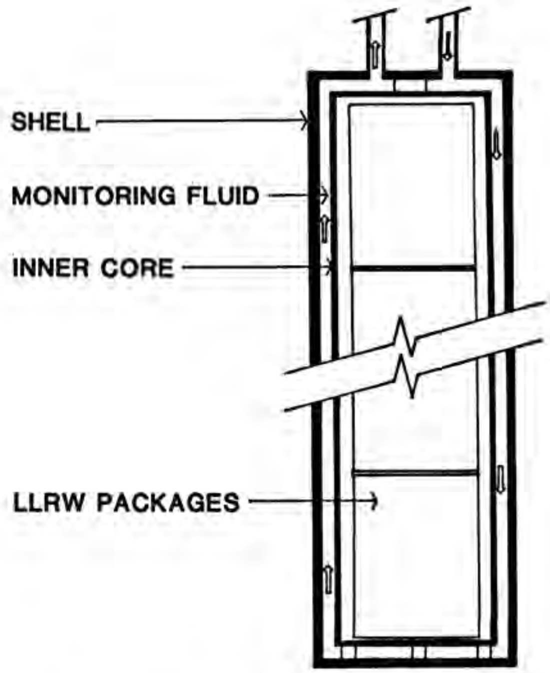

Fig. 1. The S/M/R Technology Multijacketed Low-Level Radioactive Waste Disposal Canister

A space is provided, between the inner core and the outer shell, at the top, bottom, and along the lateral surfaces. A special monitoring fluid is circulated through the space and to monitoring stations in an instrument bay. Any materials which leak out of the inner core are transported by the monitoring fluid to the monitoring stations. The volume of the monitoring fluid is also monitored so that a leak of monitoring fluid through either the outer shell or the inner core can be detected.

Thus, the S/M/R Technology provides a means for detecting the migration of radioactive materials without contamination of the environment. This enhanced early warning system makes it possible to take corrective action while assuring isolation of wastes from the environment.

As presently designed, four canisters would be placed into a reinforced concrete compartment, as illustrated in Fig. 2. After the four canisters are placed within the compartment, a reinforced concrete cover is placed on the compartment. The compartment, and everything contained within it, constitutes the smallest repeatable unit of the S/M/R alternative. The concrete compartments can be located above ground, below ground, or partially above ground and partially below ground. Thus, this alternative is suitable for employment within a variety of vault or bunker configurations.

Details of Proposed Alternative

The proposed alternative employs a defense-in-depth philosophy of multiple engineered barriers between the waste and the environment. Emplacement

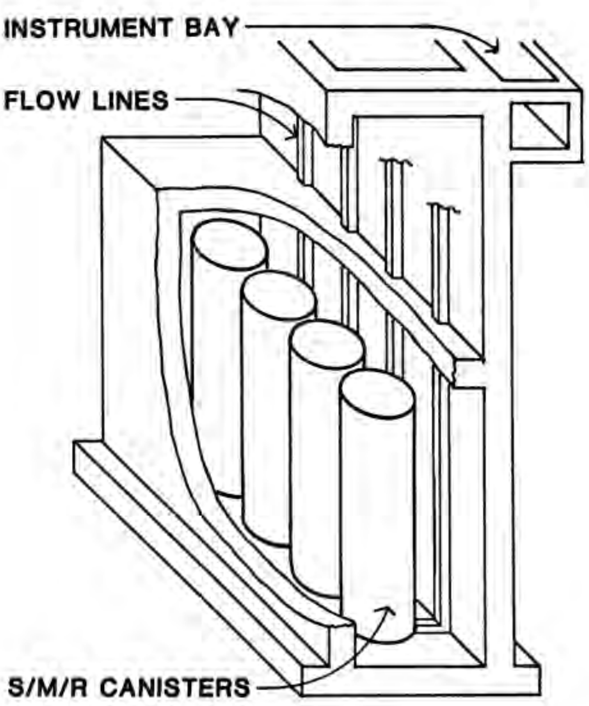

Fig. 2. Disposal Vault for Low-Level Radioactive Wastes Using the S/M/R Technology Canisters

of waste packages within a sealed, dry, corrosion-free environment should ensure indefinite stability of the waste containers. Nevertheless, experience indicates that provision for the unexpected must be provided. An example of the unexpected would be an improperly prepared waste container, such as one which contains excess moisture or corrosive liquid.

If a waste container fails, followed by failure of the inner core, radioactive materials could leak from the inner core of the canister. Such a leak would be detected by means of the monitoring fluid bringing contaminants to the monitoring stations. At the monitoring stations, the monitoring fluid is continuously analyzed for the presence of contaminants.

The system has also been designed to continuously monitor the fluid levels. A loss of monitoring fluid as small as 20 cubic centimeters is detectable. The purpose of this capability is to detect an unexpected occurrence of fluid leak in any part of the monitoring system. Such leaks could be caused by failure of either the inner core or the outer shell of the canister.

When it has been established that a particular canister has a problem, the operating staff can immediately isolate the canister and transfer it to a shielded room for repair. The retrieval procedure involves the following steps: removing the reinforced concrete compartment cover; lowering a radiation shield over the canister (if necessary); locking the radiation shield to the canister; removing the canister-shield assembly from the compartment; transporting the assembly to a shielded repair room; and, removing the radiation shield from the canister.

During canister repair or decontamination (as required), the waste packages can be examined for integrity. Depending on the source of the problem and the nature of the waste packages, alternative actions would be taken. The alternatives include repackaging of the wastes, loading the waste packages into a new canister, or setting the waste packages aside for reloading into the repaired or decontaminated canister. Following remedial action, the S/M/R canister would be returned to the disposal compartment.

The key point here is that the S/M/R Technology provides a capability of fault detection and remedial action at a point when an unbreached engineered barrier (the outer shell of the canister) exists between radioactive materials and the environment.

The position of regulatory agencies[4] seems to be in favor of so-called passive monitoring. One interpretation of such a position is that of minimum effort monitoring. In other words, certain groups have interpreted an emphasis on passive monitoring as an attitude which implies favoring the least amount of work. The emphasis appears, to some, to be upon minimizing resource commitments rather than upon maximizing public health and safety.

The proposed S/M/R alternative provides for continuous monitoring for as long as desired. The present design can provide reliable operation in the continuous monitoring mode for a minimum of 100 years. We believe that the environmental community desires an alternative which provides for continuous monitoring as long as necessary to establish the integrity of the system. The S/M/R alternative provides such a capability with the option of terminating continuous monitoring at any desired time.

When sufficient data have been collected to establish the desired confidence level (that is, when all interested parties are convinced that the long term isolation of wastes has been achieved) continuous monitoring of the disposal unit can be discontinued. The monitoring lines can then be disconnected and sealed. The disposal unit can be further sealed by any of a number of methods acceptable to the interested parties.

We believe, however, that the option for ongoing continuous monitoring of the disposal unit should be available to future generations. Because of this belief, we have included in the cost projections the option for ongoing continuous monitoring of the disposal units for an indefinite period of time.

A test unit has been constructed and monitoring sensitivity determined. Test results indicated a capability of detecting 10 microcuries of technetium-99m (0.2% of a common diagnostic dose) within thirty seconds. Although further testing is planned, the test results demonstrated a successful reduction to practice of the S/M/R concept.

All monitoring tests are automated and computer controlled. Results of each test are stored by the computer and displayed on video terminals in a state-of-the-art computer control room. Members of the operational staff are warned by the computer if any anomalous condition exists. The computer system will regularly validate the original source data and the operating condition of the system.

If a computer component failure should occur, the monitoring function will be automatically switched to a correctly operating backup unit. The operator will be notified of the failed unit's status.

A LLRW disposal facility utilizing the S/M/R disposal unit alternative can be constructed in a modular fashion. Land requirements, although somewhat dependent upon the chosen vault or bunker configuration, are approximately 30 acres for the first 8500 cubic meters (300,000 cubic feet) of waste volume (on an as-shipped basis). Land requirements increase to approximately 70 acres for a facility capable of handling a total of 85,000 cubic meters (3,000,000 cubic feet) of wastes.

The required number of operating personnel would vary, depending upon the site capacity, between approximately 35 and 75. Complete details related to both land and personnel requirements have been determined for a number of facility options[5,6,7,8,9].

COST OF PROPOSED ALTERNATIVE

Nuclear Monitoring Systems & Management Corporation has designed, developed, and tested the S/M/R Technology over a period of five years. While discussing the technology with various interested parties, we have received many comments. One general reaction to such presentations has been a concern that the employment of such a technology would be extremely costly. Having obtained professional engineering cost projections for all required equipment, we are in the position of firmly stating that such technology can be placed in service at competitive rates.

The following cost projections include all revenue requirements for a fully staffed, operational facility. All required revenues, such as that for closure and maintenance funds, are fully funded. Our level of confidence in the financial data is demonstrated by our willingness to openly share complete financial projections, including itemized employee payroll and corporate profit, for the entire lifetime of the facility.

Cost Comparison to Shallow Land Burial (SLB)

With any financial projections of this type, we must keep two points in mind. First, the annual volumes of LLRW projected for regional facilities are generally much smaller than the annual volumes processed at either the Barnwell, SC site or the Richland, WA site during 1985 and prior years. Thus, even traditional shallow land burial at a regional facility would be more costly per unit volume because of the loss of economies of scale. Second, disposal costs per unit volume for any enhanced alternative to traditional shallow land burial must be higher for a given volume of LLRW than the corresponding costs per unit volume using shallow land burial.

For our comparison example, we have chosen the Central Midwest Interstate Low-Level Radioactive Waste Compact region. Collectively, all LLRW generators in the Central Midwest Compact region spent approximately eleven million dollars for the transportation and disposal (by shallow land burial) of LLRW in calendar year 1984. This estimate is based on the $47 per cubic foot average reported by Commonwealth Edison Company[10] and the total volume for the compact of approximately 229,000 cubic feet reported by EG&G Idaho[11].

Approximately two-thirds of the $47 per cubic foot expenditure was associated with disposal costs; the remaining third was associated with transportation costs. Thus, the LLRW generators of the Central Midwest Interstate Low-Level Radioactive Waste Compact spent approximately seven million dollars for LLRW disposal (by shallow land burial) in 1984. This corresponds to a unit cost of about $30 per cubic foot. We will use that $30 per cubic foot cost for shallow land burial of LLRW as a starting point for the financial projections and comparisons which follow.

It is a well known fact that the cost of shallow land burial has escalated over the last several years at a rate of about 40% per year. In contrast, recently released rates for 1986 included disposal cost increases of the order of 10%. If we take an optimistic point of view, one could conclude that future rate increases for shallow land burial will be less than the 40% per year increase of the last several years. However, for the next seven years we must conlude that the presently recommended maximum surcharges contained within the Low-Level Radioactive Waste Policy Amendments Act of 1985[12] will be imposed.

Whatever future increases are imposed, we believe it is enlightening to look at projected future costs for continued use of shallow land burial. Table I contains one such projection based on an optimistic assumption that future increases in costs will be lower than the average increase of the last several years. For illustration purposes, the assumed starting cost and rate of increase were $30 per cubic foot and 30% per year, respectively. The projection of Table I also includes the expected imposition of the surcharges contained within the Low-Level Radioactive Waste Policy Amendments Act of 1985[12].

TABLE I

Escalation in Shallow Land Burial Costs Assuming Annual Increases of 30% Combined with the Surcharges of the LLRW Policy Amendments Act

A.D.	Cost per cubic foot	Annual increase
1985	$30.00	
1986	$49.00	63%
1987	$60.70	24%
1988	$85.91	42%
1989	$105.68	23%
1990	$151.39	43%
1991	$184.80	22%
1992	$228.25	24%
Seven year average:		34%

As indicated in Table I, even using the optimistic assumption that future rate increases will be lower than those of the last several years, the expected escalation rate for traditional shallow land burial would average 34% over the next seven years. We think it very unrealistic to assume that disposal site operators will not impose additional cost increases attributable to increases in operational costs. In any case, we must conclude that the cost increases of Table I represent reasonable forecasts. In the following, we will use a 30% annual escalation for shallow land burial.

Sample Facility

To facilitate comparison of our cost projections with costs for traditional shallow land burial, we have calculated financial data for two hypothetical facilities which began operations in 1985. For our sample facilities illustration, we have chosen a location in the Central Midwest Interstate Low-Level Radioactive Waste Compact region. The current LLRW generation rate for this region is about 7000 cubic meters (250,000 cubic feet) per year. Conditions of the compact legislation[2] require placement of the facility within the State of Illinois.

The Illinois Low-Level Radioactive Waste Management Act[1] requires the promotion of LLRW volume reduction technologies. Considering both this requirement and the current plans of the major volume generators in the region, we believe it prudent to anticipate a volume reduction of about a factor of three or four. As previously indicated, this anticipated volume reduction will result in higher costs per cubic foot of disposal volume. To maximize the negative impact (price increases) of the expected volume reduction, we have assumed that the hypothetical facilities will only receive an annual volume of about 2000 cubic meters (69770 cubic feet).

For shallow land burial we have optimistically assumed that disposal costs at the hypothetical facility designed to handle the current regional generation rate of about 7000 cubic meters (250,000 cubic feet) per year would not be higher than the present rates at Barnwell or Richland. We have assumed, however, that volume reduction beyond that point would result in increased disposal costs to maintain the equivalent revenue stream to the facility.

In order to make a fair comparison, we have excluded the costs associated with the transportation of LLRW to the disposal site. Transportation costs are expected to be lower for generators in the Central Midwest Interstate Low-Level Radioactive Waste Compact when a regional facility becomes available. The reduction in transportation costs, however, is not dependent upon the type of disposal facility.

As with any financial projection, we had to make certain economic assumptions. The assumptions which we made are summarized in Table II.

TABLE II

Economic Assumptions Used in Financial Projections

Annual inflation rate	6.00%
Annual interest rate for borrowed money	12.00%
Annual rate of return on invested money	9.79%

We have also assumed that a disposal facility will operate at one site for twenty years. In Table III, we have tabulated our financial projections for the hypothetical midwestern disposal facility using the proposed S/M/R alternative technology. Included in the table are the projected costs for utilization of traditional shallow land burial at the same location. The projections for the shallow land burial facility are based on the values of Table I followed by a 30% annual escalation beginning in 1993.

TABLE III

Comparison of SLB and S/M/R Alternative Disposal Cost for LLRW Generated in the Central Midwest Interstate LLRW Compact

Year	A.D.	SLB Cost (millions)	S/M/R Cost (millions)
01	1985	$ 7.50	$ 45.47
02	1986	12.25	54.73
03	1987	15.18	64.78
04	1988	21.48	75.68
05	1989	26.42	87.54
06	1990	37.85	100.45
07	1991	46.20	114.53
08	1992	57.06	129.93
8 year totals:		$ 223.93	$ 673.11
09	1993	61.18	146.80
10	1994	79.53	165.37
11	1995	103.39	185.89
12	1996	134.41	208.69
13	1997	174.74	234.21
14	1998	227.16	263.07
15	1999	295.30	296.16
16	2000	383.89	334.87
17	2001	499.06	381.61
18	2002	648.78	441.09
19	2003	843.42	525.02
20	2004	1,096.44	540.80
20 year totals:		$ 4,771.24	$ 4,396.70

As concerned citizens and electric service rate payers, we must ask ourselves why a commitment of nearly five billion dollars would be made for traditional shallow land burial when an enhanced technology can be employed for approximately the same commitment.

Some people would have us believe, however, that disposal charges for shallow land burial will not increase at the historical rates. That is, after 1992, some would claim that shallow land burial escalation rates will dramatically decline. In response to such claims, Nuclear Monitoring Systems & Management Corporation issues an open invitation to compare their cost projections for the S/M/R Technology alternative with any other proposal. At this time, data for such a comparison are not available.

In contrast to such speculative cost comparisons, one can compare with reasonable confidence the costs over the near term. Such a comparison serves to place in perspective the required financial commitment associated with the selection of an environmentally responsive alternative. For this reason we have included in Table III the subtotals for disposal costs through 1992. As indicated in that table, the costs associated with utilization of the S/M/R Technology at the hypothetical facility would have been only about three times the corresponding expected costs for continued use of shallow land burial through 1992.

Finally, independent of any comparison to any other alternative, the costs for employment of the S/M/R Technology alternative can be evaluated. The overwhelming majority (about 90% by volume) of LLRW generated in the Central Midwest Interstate Low-Level Radioactive Waste Compact region originates at nuclear power facilities. The cost of disposal can be thought of as being due by those who benefit from the industry which produces the wastes -- the electric power rate payers.

Commonwealth Edison Company reported total sales of over sixty-three billion kilowatthours in 1984[13]. Thus, using the rate payer approach, the cost of the S/M/R Technology would be about one mill per kilowatt hour of purchased power over the period from 1985 through 1992. Furthermore, allowing for reasonable growth in electric power demands over the next twenty years, the cost for utilization of the S/M/R Technology alternative over the entire twenty year period would still be approximately one mill per kilowatthour of purchased power.

CONCLUSION

Those of us who have worked with radioactive materials for several years have an understanding and appreciation of the relative hazard associated with, for example, leakage of small quantities of radionuclides such as tritium. Even though we might have an understanding of such a condition, is it reasonable to assume that the general public will accept such a condition? Experience seems to indicate that public acceptance of controlled leakage from a disposal site will not likely be forthcoming.

Do we continue to stand firm in a position which demands that the general public accept a position based on a high level of technical understanding? We think that this approach is doomed to failure and will generate increased animosity.

We in the industry must be open to change. The question is whether or not we are flexible enough to be responsive to the concerns of the people even if such responsiveness is contrary to our technical convictions.

The Credibility Gap Must be Closed

In the past, we in the industry have promised the safe disposal of low-level radioactive wastes. Our performance record, however, has been viewed as not meeting the expectations of such promises. If we are to gain the trust of the environmental community, and the general public, we must be responsive to their concerns. It seems to us that at this time we should be cooperating with the environmental community in the selection of future technology for the disposal of low-level radioactive wastes.

Through our discussions with representatives of the environmental community, we have concluded that no level of leakage of radioactive materials into the environment — earthen, aquatic, or atmospheric -- is acceptable. At the same time, man-made structures cannot be built which will totally contain such mobile materials as tritium. What then is the solution to this apparent dilemma?

We believe the environmental community has provided the answer -- leakage must be immediately detectable, and corrective action possible, without any radioactive materials entering the environment.

Nuclear Monitoring Systems & Management Corporation has designed such an environmentally responsive disposal technology. By including the S/M/R enhanced disposal unit technology within an enhanced disposal facility, such a goal can be achieved.

Furthermore, such a goal can be achieved without continuation of a 40% per year escalation in the cost of disposal. We have shown that disposal cost escalation can be controlled at under 15% per year, while employing an alternative technology which assures protection of the environment.

The question at hand seems to be not whether or not we can do it, rather, whether or not we will do it.

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