ALTERNATIVE ENHANCED LOW-LEVEL RADIOACTIVE WASTE BURIAL

H. Lawroski
H. Lawroski & Associates, P.A.
Idaho Falls, ID 83401

ABSTRACT

The author presents background information on low-level radioactive waste disposal. An alternative enhanced low-level radioactive waste burial concept utilizing engineered concrete entombment is presented. Costs of the concrete entombment are estimated as well as costs of the presently NRC required waste form testing and process control programs. The yearly costs for the alternative enhanced low-level radioactive waste burial concept are $500,000 for all United States Class B and C wastes. The present yearly costs for waste form testing, process control programs and other expenses are estimated to be at least $6,000,000. The relative long-term characteristics indicate that the engineered concrete entombment is superior to the dependence on individual waste package buried at the disposal site.

BACKGROUND

Low-level radioactive wastes types can be categorized by generators such as utilities, academia, medical, and industrial. Although there are variations from year to year, the volumes of wastes by category for the past several years have been 55 to 60 percent-utilities, 35 to 40 percent-industrial, 1 to 2 percent-academia, and 1 to 2 percent-medical. A breakdown by radioactivity is 75 to 80 percent-utilities, 20 to 25 percent-industrial, less than 1 percent-academia, and less than 1 percent-medical. The vast majority of the volumes of waste is in low concentrations. These large volumes for the past five to seven years have been buried in separate areas in the burial sites. Further, regulations have been imposed to eliminate free liquids from disposal sites. The higher activity concentrated wastes have been solidified or disposed of by dewatering in special containers.

In 1979, the existing major low-level radioactive waste burial sites were closed because of improper waste shipments. These events along with the askewed geographical locations of disposal sites led to an overall reassessment of disposal of low-level radioactive waste with states wanting a more significant role in disposal activities. In response pressure was put on the United States Congress by the states governors.

Congress enacted the Low-Level Radioactive Waste Policy Act (Public Law 96-573) in December, 1980 (1) which designated the individual states as the responsible government level of low-level waste management. The concepts were that each State was responsible for disposal of low-level radioactive wastes generated within its borders and that these wastes could be most safely and efficiently managed on a regional basis. As a result compacts could be formed and facilities for disposal could be built and restricted for use within the compact region. By 1984, it was evident that no new disposal facilities would be operating by the deadline date of January, 1986. As a result, Congress passed the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240) (2) which extended out-of-region access to the existing disposal sites through 1992. However, during this interim access period, states are required to meet specific milestones leading to operation of new regional disposal sites. Further there will be assessments for disposal of low-level wastes from states in compacts which do not have existing disposal sites. If insufficient progress is made in developing new disposal facilities, states may be denied access to existing disposal sites.

The final rulemaking on land disposal of low-level radioactive waste (10CFR Part 61) (3) was published by the Nuclear Regulatory Commission in the Federal Register on December 27, 1982. Although Part 61 applied primarily to disposal site operators, it had provisions for waste generators which included classifying wastes, preparing manifests, and record keeping. The bases for 10CFR Part 61 were published in the Draft Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Wastes," NUREG-0782, September, 1981 (4), and in the Final Environmental Impact Statement on 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Materials," NUREG-0945, November, 1982 (5). The major conclusion of 10 CFR Part 61 was that with a properly selected site shallow land burial disposal of low-level radioactive wastes could be performed with adequate safety to the public. The two major considerations for public safety were stability and protection from inadvertent intrusion.

In discussions with state personnel, Department of Energy contractor staff, and the public, the perception by those state regulators wanting to establish new disposal facilities is that the public is somewhat unwilling to accept shallow land disposal with soil backfill, i.e., something more is required. The observed stance of the Nuclear Regulatory Commission (NRC) is that, with proper waste classification and stability, shallow land disposal is acceptable for public health and safety.

Waste Classification and Stability

The capability of the disposal site to retain the radionuclides in their as-disposed-of location determines the performance of the site. Both NUREG-0782 (4) and NUREG-0945 (5) provide insight on important characteristics of the burial sites and waste streams. The present functioning burial sites in the States of Nevada (1962), Washington (1968) and South Carolina (1971) have been operating for some 15 to 24 years. Both the Nevada and Washington disposal facilities are considered arid sites and, therefore, water intrusion and transport of radionuclides are minimal. The South Carolina site at Barnwell is considered a humid site. The Nuclear Regulatory Commission published a report "Environmental Assessment for the Barnwell Low-Level Waste Disposal Facility", NUREG-0879, January, 1982 (6). The important conclusion of NUREG-0879 was that the staff recommend that present (note that 1981 time frame) operation of the Barnwell disposal site continue. Further the NRC staff's modeling indicated that the effects (environmental) would be well within the limits of the proposed 10 CFR Part 61. The NRC assessment included the fact that specific waste streams were adequately being solidified and that the then approved waste solidification agents were acceptable. In the report's conclusion, the public's health and safety were being properly addressed by waste generators shipping waste to this burial site.

The Division of Waste Management, however, promulgated "Final Waste Classification and Waste Form Technical Papers" on May 11, 1983 in an NRC Letter to Commission Licensees. The Waste Form Technical Paper prescribed seven (7) waste form stability tests: 1) Compressive Strength, 2) Irradiation, 3) Biodegradation, 4) Leachability, 5) Immersion, 6) Thermal Degradiation, and 7) Free Standing Water. Criteria were also prescribed for the qualification of High Integrity Containers (HICs). The requirements for waste forms and HICs were related to 10 CFR Part 61, paragraph 61.56 (b)(1) "Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal." The NRC has contracted with Brookhaven National Laboratory to develop waste forms and testing of these waste forms since 1976.

There are appropriate reasons for operating burial facilities to provide stability over a period of time (up to 500 years). Stability would prevent or minimize subsidence of the trench cap and subsequent consequences such as the ingress of water to provide a transport mechanism for radionuclides. Some means should also be provided to assure that an inadvertent intruder should recognize the existance of the disposal site so that the impact to man would be minimized.

The Nuclear Regulatory Commission's Division of Waste Management has just recently distributed for comment a Draft Regulatory Guide on Low-Level Waste Form Stability, October 1986, Rev. 4. (8) To the present and apparently to the near future, the NRC's position is that the only method acceptable is that the waste form must be stable to provide overall stability of the site. The NRC assumes that this will avoid slumping, collapse or other failures of the cap or cover over the disposal trench and thereby prevent or minimize water infiltration. The NRC also allows use of qualified HICs to contain dewatered wastes. The above criteria apply only to Class B and C wastes as described in 10 CFR Part 61 Section 61.55.

This paper describes a method which the author believes is superior for waste disposal stability and inadvertent intruder avoidance and is more cost effective.

Alternative Enhanced Stability Concept

The alternative enhanced stability concept utilizes a controlled backfill of engineered concrete composition and an intruder cap. Stability is provided by the encapsulation of all of the Class B and C wastes in a concrete composition designed for chemical stability (9) in the soil of the disposal site. A substantial concrete cap with the top two (2) inches composed of color coded concrete is placed on top of the encapsulated wastes to alert and to inhibit any inadvertent intruder. A cross section of a disposal trench is shown in Fig. 1.

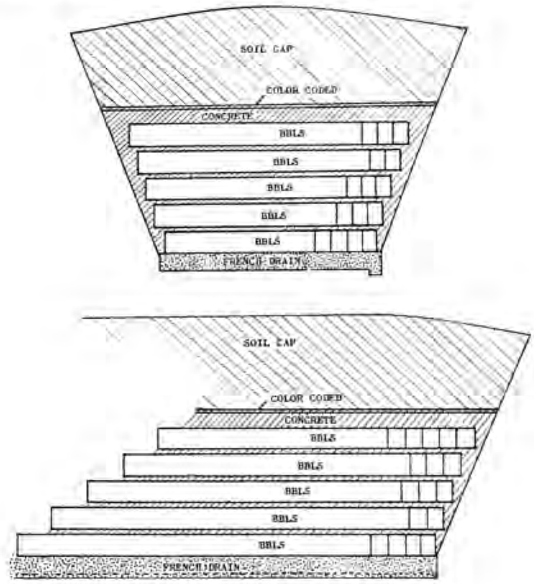

Fig. 1. Conceptual Trench Design.

A review of low level waste disposal volumes for the years 1983 through 1986 indicates that about five (5) percent of the approximately 2,000,000 cubic feet of low-level radioactive wastes are Class B and C. The 100,000 cubic feet of Class B and C wastes can be accommodated in two disposal trenches and can be translated into 7,000 barrels in each trench. A typical trench sized to dispose of 50,000 cubic feet or 7,000 barrels of wastes would be about 250 feet long, 25 feet wide at the bottom, 45 feet wide at the top and 25 feet deep. A French drain is provided at the bottom of the trench. Monitoring wells are provided as required.

The Class B and C wastes will arrive at the burial site at a rate of approximately 30 barrels a day or 150 per week. After preparation of the trench, the first 300 or two weeks of barrels or containers are placed on the bottom of the trench. On the Saturday of the second week, the first concrete pour is made to about the half height of the barrels. This is to lock in the barrels and avoid levitation during the second concrete pour. The second concrete pour can be made on Sunday and will include a six (6) inch layer of concrete over the tops of the barrels. The process is repeated up to the fifth (5th) layer of barrels. An additional fifteen (15) inches of concrete are placed on the encapsulated barrels. A three (3) inch layer of colored concrete is poured as the top layer of concrete to alert inadvertent intruders. The top eight (8) feet of the trench is backfilled with soil and contoured for water run off. This top layer of earth is stabilized to minimize erosion.

Containers other than barrels can be integrated in with the barrels.

Since it has been shown (4)(5) that Class A wastes contribute only a small part to potential dose to the public, there appears to be no good reason to deviate from the present practice of disposal of Class A wastes in separate burial trenches at the disposal sites.

Costs

The costs of using engineered concrete for encapsulation of Class B and C wastes were estimated. Consultations with Burns Brothers Concrete Company in Idaho Falls, Idaho, indicated that acceptable concrete can be delivered fifty miles away for \$65 per cubic yard. Assuming five levels of barrels encapsulated as shown in Fig. 1, each cubic foot of waste would require 0.8 cubic foot of concrete. This includes the two (2) feet thick concrete cap. At \$65 per yard, the cost of delivered concrete would be \$1.95 per cubic foot of disposed waste; at \$75 per yard the cost would be \$2.25 and at \$100 per yard the cost would be \$3.00.

Since the required placement of concrete is well within the present technology of delivery, no difficulties are anticipated. The openings between the barrels are large and easily accessible for the concrete pour. No forms are required. Quality control of concretes are well known practices.

Placing of the wastes for each level would be enhanced by having a level plane for each layer.

Dose levels to workers should be within the present practices at disposal sites. Manipulations of the concrete equipment would be remote from nearness to the wastes.

To compensate for uncertainties, profit margins, quality assurance, and any delays, additional costs are estimated to be \$2.50 per cubic foot of waste.

The cost for concrete entombment of the Class B and C wastes would therefore be \$4.50 to \$5.00 per cubic foot. This compares favorably with the present costs of placing the concrete cover over Class C wastes presently at Barnwell (7).

For the 100,000 cubic feet per year of Class B and C wastes the incremental cost to the generators for using concrete instead of soil would be \$450,000 to \$500,000 per year.

Discussion

The performance of the low-level radioactive waste disposal site is the major important aspect facing the present operating facilities and the future burial sites. The criteria for selecting a site is well presented and appropriate in 10 CFR Part 61. The burial system performance has been approached, however, is a disjointed fashion. The Nuclear Regulatory Commission's Division of Waste Management has imposed detailed prescriptive requirements on waste generators. In the utilities alone, there are some 68 nuclear stations which have different waste streams. Each of these waste streams which result in Class B and C wastes requrie extensive process control programs. Since these utilities are licensed by the NRC, the NRC can require continual expensive programs to produce qualified waste forms. The requirements are such that at present all of the utilities use vendors for solidification of waste streams or qualified high integrity containers. The tax payers and rate payers are billed for these efforts. Yet the waste form is only one part of the system.

When the waste forms are placed in the burial site, the control of the operation shifts to the states where the disposal sites are located. In the present methods of operation for placement and backfill around the waste, there is no assurance that all voids are filled. Thus settling can occur over time and does. When degradeable containers, which are not completely filled, decompose, additional voids are presented and further settling can occur. In short this is not a well disciplined system.

The long time stability requirements of the burial of Class B and C wastes are purportedly satisfied by testing of mixtures of solidified wastes or HICs as prescribed by the Division of Waste Management on the waste generators. However even the developers of the tests admit that the required tests are short term and no data are available for extrapolation. Also note that there is reliance on hundreds of operations to produce qualified waste forms from generators.

The above is to be contrasted to the operations proposed by the entombment of the Class B and C wastes in a substantial engineered concrete matrix. The formulation of the concrete and the placement around and upon the waste containers are readily observed and verified. The practice of making good concrete is well known and does not depend upon the vagaries of multiple waste streams.

Consider now the two aspects most important in the long term performance of the burial site, 1) stability and 2) inadvertent intruder.

Concrete is a structural material with a history of use dating back over 2000 years to Greek and Roman civilizations. It is used with confidence, is supported by many scientific studies and has a vast accumulation of practical experience. The British have a 1700 year old sample of Roman concrete recovered during restoration work on Hadrian's wall (11). It has stood the test of time. The waste forms are mixtures which have not stood the test of time.

The Class B and C wastes should be solidified or placed dewatered in high integrity containers. The long term performance of adequate waste forms encased in a concrete matrix should be infinitely better with more certain protection of the public's health and safety. The stability of the trench with the concrete entombment is assured because the solidification of the concrete surrounding the waste forms and the substantial concrete cap. Subsidence due to disintegration of containers is prevented and water ingress is prevented. There is no need for extensive testing of waste forms when the matrix is a well known concrete structure.

The concrete also provides a high pH environment. In this way it influences the chemical conditions inside the disposal site to prevent many radionuclides dissolving in water (9). The concrete matrix provides a well structured barrier to movement of water through the burial trench.

Detailed experimental and theoretical knowledge enables the long-term behavior of concrete to be predicted with considerable confidence.

The presence of the substantial concrete cap with a color coded top layer is certainly more assurance that an inadvertent intruder would be alerted if attempting to penetrate the disposal trench. Further, the concrete and the wastes have little if any nutrients for growth of plants.

In summary, the disposal trench long term performance would be far superior utilizing engineered concrete entombment and capping than dependence on short term testing of waste forms for Class B and C wastes. By this, the concept of encapsulated wastes indeed better serves the health and safety of the public.

Consider now the costs to the consumers. In discussing this concept with utility staffs, the greatest concern was that it would be used to rachet further requirements for low-level waste disposal. This genuine fear is based on past dealings with the Nuclear Regulatory Commission in the nuclear power industry.

At Waste Management '84 (12), the NRC presented a paper on the cost of implementing 10 CFR Part 61. This analysis stated that the costs would be 0.01 mills per kilowatt hour or approximately $4,000,000 per year and there would be a 1 percent increase in occupational exposure or approximately 390 man-rem per year.

Contacts with utilities indicate the cost per station for just implementing the waste form testing and process control programs would be at least $5,100,000 for some 68 nuclear power stations needing at least one staff person to follow waste form testing, process control programs, health physics coverage, procedures, quality assurance, reports, etc., at $75,000 per man year. In additional discussions with vendors, the costs for each cubic foot of waste solidified is estimated to be at least $4. These are only part of the costs-transportation, increased waste volumes, and repeated testing of waste forms when waste streams change due to operations at the nuclear plants. One vendor commented that they had some 50 different waste forms from nuclear plant waste streams that had required testing.

The costs of continual implementing waste form testing at the nuclear power plants are estimated to be at least $6,000,000 per year which are all billed to the public. This is to be compared to $500,000 per year for engineered concrete entombment at the low-level waste burial sites. Further there would be no need for waste form testing. There would be a need for an acceptable solidified waste form (less than 0.5 percent free water and a homogeneous solid) or a dewatered waste (less than 1 percent free water) in a high integrity container.

The estimated savings for consumers would be at least $5,500,000 per year.

Summary and Conclusion

The health and safety of the public is the primary concern for disposal of low-level radioactive wastes. The public perception is that engineered waste disposal is desireable. The use of engineered concrete for entombment of Class B and C wastes appears to be more effective for the protection of the public than the dependence upon waste form testing. The estimated costs for the enhanced entombment utilizing engineered concrete are $500,000 per year for all of the Class B and C wastes. The present system of waste form testing and subsequent soil backfill in the burial trenchs costs the rate payers approximately $6,000,000 per year for waste form testing, process control programs and other aspects of the system.

Selected composition (engineered) concrete enables long-term behavior to be predicted with considerable confidence as contrasted to waste forms with as much as 60 percent waste and 40 percent solidification agent. Subsidence avoidance and disposal site stability are better assured with the concrete emtombment of Class B and C wastes. Inadvertent intruder protection is better served by the concrete entombment than the NRC promulgated individual waste form long--term predicted behavior. Finally, the costs to the rate payers appear to be substantially less with the use of engineered concrete entombment rather than extensive and repeated waste form testing with restrictive process control programs.

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