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RECOMMENDED APPLICATIONS OF NUCLEAR SAFEGUARDS TO THE STORAGE OF MATERIALS
IN THE PROPOSED NATIONAL NUCLEAR WASTE REPOSITORY, LYONS, KANSAS

by

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The Atomic Energy Commission has selected the approximately 1000 foot deep abandoned Carey salt mine site in the Lyons, Kansas area for evaluation as a long term storage facility for both low level plutonium contaminated wastes and power reactor generated high level fission product wastes. By action of the Kansas Governor's Nuclear Energy Council, the 1000 acre Lyons site was named the Kansas Nuclear Park (June 17, 1970). This action was originally suggested by the Governor's Nuclear Energy Advisory Council in 1968 following completion of the ORNL conducted study, Salt Vault.¹

Sources of Radioactive Materials to be Stored

in the Lyons Site

Two types of radioactive materials are to be stored in the proposed Lyons facility: a) low level alpha contaminated waste (chiefly plutonium contaminated waste but other transuranium elements will also be present) and b) high level fission product wastes. The low level wastes have been accumulating for some time in federally operated plants in connection with the production of nuclear weapons as well as plowshare type nuclear explosives. A large quantity of such material was amassed during the cleanup operation at the Rocky Flats, Colorado Nuclear Weapons Arsenal fire.² Public anxiety, created by allegations that significant plutonium contamination of the environment had resulted from the fire and the subsequent discovery that plutonium contaminated oil had leaked into the soil from cans in areas where low level wastes were stored, led to public pressure for storage of low level wastes in safe, remote areas.

¹Bradshaw, R. L. and McClain, W. C., "Project Salt Vault: A Demonstration of the Disposal of High Activity Solidified Wastes in Underground Salt Mines," Oak Ridge National Laboratory, ORNL-4555.

²Shepherd, J., "The Nuclear Threat Inside America," Look Magazine, 12-15-70 (pp. 21-27).

In the future it is expected that small volumes of low level contaminated wastes will continue to be produced in federally operated facilities in connection with weapons and plowshare device production. However, it is also expected that increasing amounts of such low level alpha contaminated wastes will result from production of plutonium fueled nuclear power reactor fuel elements. Presently it is difficult to estimate the year by year production of low level waste from plutonium fuel fabrication. This difficulty arises from the lack of a decision on the part of nuclear-electric utilities to begin either recycling plutonium being produced in their present light water reactors (LWR) to fuel these same reactors or to hold the plutonium until such time that it can be burned in the more efficient liquid metal fast breeder reactor expected to appear in commercial use about 1980-85. [In the face of this present lack of definitive information the AEC³ has projected that the volume rate of low level waste handling will be one million cu. ft./year (before reduction in volume by compaction or incineration) beginning in 1975 and continuing through 2000. If utilities should decide to make extensive use of recycle plutonium in present LWR's the rate of production of plutonium contaminated low level wastes could be greater than the above noted AEC base figure.]

The source of high level wastes to be stored in the Lyons facility will be the civilian nuclear powered electric utility industry. The high level wastes are the fission products resulting today from the use of uranium-235 fuels but in the future also from the use of uranium-233 and plutonium based fuels. To be sure, such fission product high level wastes have been accumulating since about 1944 in connection with the federal

³Telephone communication, W. Meyer with C. B. Bartlett, Division of Waste and Scrap Management, US/AEC, Washington, D. C. (November 16 and 17, 1970).

nuclear weapons program. These wastes, stored in the main at Hanford, Washington and Aiken, South Carolina and amounting to some eighty million gallons of liquid wastes will not be moved to the Lyons facility but if present studies prove the feasibility will be stored in perpetuity at their present sites.³

Development of the Lyons, Kansas site as a perpetual storage repository for high level wastes represents an effort by the AEC working in concert with the National Academy of Sciences to prevent the accumulation of significant quantities of high level liquid radioactive wastes resulting from the reprocessing of nuclear power reactor fuels at many separated sites. Preliminary studies by the National Academy of Sciences completed in 1957 indicated that burial of wastes in salt beds or domes seemed to offer the best possibilities for protecting the public and the environment from the potential hazards of high level wastes.⁴ Based on these studies as well as Project Salt Vault¹ and additional evaluations by the National Academy of Sciences,⁵ the Atomic Energy Commission has amended its licensing regulations to establish a policy governing the disposal of high level radioactive liquid wastes. Effective ninety days after its publication on November 14, 1970, the revised AEC policy states that a civilian fuel reprocessing plant's inventory of high level liquid waste shall be limited to that produced in the prior five years.⁶ Shipment of waste in an AEC-approved solid form shall be made to a federal repository no later than ten years after separation of the fission products from the burned fuel.

⁴"Disposal of Radioactive Wastes on Land," Publ. 519 National Academy of Sciences - National Research Council, Washington, D. C. (1957).

⁵"Disposal of Solid Radioactive Wastes in Bedded Salt Deposits," Report by the Committee on Radioactive Waste Management - National Academy of Sciences - National Research Council, Washington, D. C. (November 1970).

⁶AEC News Release No. N-197 (November 11, 1970).

The revised AEC policy also states that disposal of high-level fission product wastes will be permitted only on land owned and controlled by the federal government.⁶ By the AEC announcement on June 17, 1970 the planned development of a proposed federal waste demonstration repository on the site of an abandoned Carey Company salt mine near Lyons, Kansas was made known.⁷ It is expected that construction of the waste repository will begin in 1972 with initiation of high level waste deposition in 1975. It is expected that the one thousand acres proposed for initial acquisition at the Lyons site will accept up to a million cubic feet of solidified waste and that the initial site will be filled about the year 2010.

Public Concern and the Proposed

Lyons Federal Waste Repository

Concern expressed by the public regarding the proposed Federal Repository center on 1) possible accidents during transportation of high level waste materials to the site and 2) the long term integrity of the site. AEC requirements regarding waste shipping cask design would seem to be very conservative, thus making the release of any significant amount of radioactive material through a transportation accident highly improbable.⁸ With respect to site integrity however, several questions remain.

The basic concept underlying the perpetual storage of high level radioactive wastes in the proposed National Nuclear Waste Repository is the inviolability of the salt bed that will act as the ultimate storage container for the wastes. Examination of documents relating to the Project Salt Vault¹ shows that a light walled stainless steel canister was used to

⁷ AEC News Release No. N-102 (June 17, 1970).

⁸ AEC News Release, "Transportation of Radioactive Waste," (July 29, 1970).

load the ETR fuel elements (used to simulate high level wastes during Project Salt Vault) into test holes in the floor of the Carey salt mine in Lyons. Presently, it appears that a similar container will be used in handling actual high level wastes. Such a light walled container would be rapidly corroded away by the salt environment (surface temperatures of containers will be approximately 200°C in a 100% salt environment). Stainless steel in particular is subject to rapid corrosive attack in a chloride ion environment.⁹ Thus a light walled canister would lose its integrity and the high level waste would be in contact with the salt bed within 10 years or less after burial in the floor of the salt mine. This situation is expected under present design concepts and is acceptable as long as the salt bed remains inviolate. However, three questions exist regarding the long term stability of the salt bed in the Lyons vicinity. All of these questions involve problems of water invasion of the storage site. One possible mode of invasion would be via an unplugged or improperly plugged drill hole (numerous producing and abandoned oil wells are present in the Lyons area) or naturally produced fissure through the salt bed.¹⁰ Water from the aquifer above the salt bed could enter and erode the salt bed via the drill hole or fissure. The water could subsequently contact the buried exposed radioactive waste material and dissolve minute portions of the waste. Even though the wastes are generally considered to be in an insoluble form, they may be expected to dissolve to the extent of a few

⁹ Clark, W. E., et al., "Laboratory Development of Processes for Fixation of High-Level Radioactive Wastes in Glassy Solids. (4) Corrosion Studies on Candidate Materials of Construction," Oak Ridge National Laboratory, ORNL-3816 (1967).

¹⁰ Hambleton, W. W., "Interim Report of the Kansas Geological Survey on Storage of Radioactive Waste in Salt at Lyons, Kansas," Kansas State Geological Survey, Lawrence, Kansas, July 8 (1970).

parts per billion to a few parts per million; because of the high level of radioactivity of these wastes even this amount of dissolution could constitute a health hazard if the contaminated water should gain access to the aquifer or surface water.

A second mode of water invasion would be by progressive natural erosion of the salt bed. Such erosion of the bed is occurring and has occurred at its eastern edge.¹⁰ The rate of this erosion may be slow enough that it will never be a threat to the proposed site, but because the high level wastes must be contained safely for a period on the order of a thousand years, the erosion rate must be carefully and conservatively measured. Even if such measurements indicate that the site should be safe from erosion for the necessary time span, the possibility of drastic alteration of the rate of erosion by some future natural calamity cannot be ruled out.¹⁰

The third mode of water invasion would be by migration of brine filled cavities into the canister storage holes. Such migration has been noted and the migration rate measured by ORNL.¹¹ These measurements involved the migration of small, naturally occurring brine filled voids or negative crystals in the rock salt toward regions of high temperature. The voids move at a rate proportional to the temperature gradient produced by the stored radioactive waste. In general, ORNL measurements during Salt Vault showed that very small amounts of water were involved (1 to 2 liters per stored ETR element).¹ However, it should be noted that even these small amounts would enhance the rate of corrosion of the waste canister material.

The Salt Vault study could not demonstrate void migration effects when a very large volume of salt is heated as would be the case when the initial

¹¹ Bradshaw, R. L. and Sanchez, F. "Migration of Brine Cavities in Rock Salt," Geophysical Res., Vol. 74, No. 17, Aug. 15, 1969.

one thousand acre Lyons facility is filled about the year 2010. It is possible that a more general migration of water into the site than noted during the Salt Vault experiment may occur. If this water should enter after some of the waste canisters have been breached by corrosion, initial dissolution of some of the waste could be expected. This contaminated water would constitute no hazard to man or the environment unless a fissure, natural or man-made, provided a means for the radioactive solute to escape from the salt bed and then by processes of convection or displacement enter the aquifer or ground water.

Extensive efforts are being made to locate all holes drilled into and through the salt bed. Also bedded salt has been chosen because of the low frequency of fissure producing earth quakes in geographical areas where bedded salt is found. However, earthquakes do occur in all areas of the United States to some extent. If a combination of events should occur that would permit (1) water to invade the high level waste storage site and (2) provide an exit for the radioactive waste contaminated water to escape from the salt, obviously a very hazardous situation would exist. Once the presence or the imminent presence of water in the site were noted, the prudent action would be to remove the high level waste to a more stable storage site. The AEC has now adopted the concept of retrievability, the detailing of which should contribute to a reduction in opposition to the national nuclear waste repository.

Safeguards & Accountability at the Lyons Repository

In view of the concern for the public's health and safety relative to the proposed disposal operation at the Lyons facility and considering the

significance of the facility to the overall national commitment to nuclear material safeguards, it is recommended that an increased emphasis be placed upon the nuclear material controls applied to waste containers intended for disposal at the Lyons repository. Specifically, it is suggested that all material, without qualification, intended for the storage facility must undergo an authentication and evaluation procedure before it is considered acceptable for disposal.

The need for and the techniques required for such authentication and evaluation procedures depend upon whether the waste is of the high level fission product or the low level alpha contaminated type. For example, one of the remaining questions relative to the safety of the Lyons repository concerns the geological consequences to the salt formation and the ecological consequences to the surface area in the vicinity of the repository resulting from the temperature rise due to fission product heating. Therefore, a time dependent dose rate limitation should be established for high level waste canisters, with the dose rate for each canister determined on-site at disposal time to verify that the rate is below the established limit.

High level waste does not involve the accountability requirements of special nuclear materials, is of questionable value on the black market, and is inherently tamper resistant. High level waste thus has negligible diversion potential, so that only moderate safeguards precautions need be applied to this material at the disposal site. From the point of view of nuclear material safeguards the problems associated with low level waste disposal are more complex than those for high level waste, since in the former case 1) the possibility of diversion is significant, 2) there is a

possibility of tampering with the intent of sabotage, and 3) the fissionable material content of a scrap container is difficult to determine experimentally.

The problem of the diversion of low level waste during transportation is a distinct problem which will not be considered here. It might be commented, however, that since a few grams of fissile material have a large potential black market value, good physical security and accounting practices are essential at the disposal site.

The possibility of an individual or group disrupting the disposal operation, for example, by introducing conventional explosives into low level waste containers, though improbable, should not be neglected. Considering the sensitive national position of the AEC and the nuclear industry, it is not necessary to elaborate on the physical and political consequences of an explosion and fire in a plutonium-containing environment. Here again good physical security is an important consideration.

Concerning the fissionable material content of low level waste, it is strongly recommended that upper limits be established for the total fissile material content and total plutonium content of the waste. Such limitations are essential 1) for a national nuclear safeguards program 2) to eliminate criticality considerations in the salt formation, and 3) to reduce and control potential danger to public health and safety resulting from a containment failure in the salt repository.

The following are some thoughts on how one might apply safeguards procedures and measurements to the nuclear waste repository facility.

High level waste should be packaged such that each container has a unique serial number as an integral portion of the container. A routine collimated gamma scan under specified geometric and shielding conditions

along the entire length of a high level container would be sufficient to determine whether or not the waste radiation was "normal" for the particular product under measurement and fell below the maximum dose rate limit. These results would be compared to those obtained from similar measurements taken at the packaging site. These measurements on high level wastes involve relatively little instrumentation and could be performed, e.g., while the high level waste canister is being lowered through the repository entrance shaft. These procedures for high level wastes would serve as a simple, fast, and inexpensive safeguards precaution and also serve to eliminate accounting errors.

The problems of diversion and tampering encountered during low level waste handling must be met by physical security. It is important, however, to know when diversion or tampering has occurred. It is recommended, therefore, that low level waste at its source of origin should be sealed in its container in a tamper-indicating fashion and given a unique serial number integrally mounted on the container. To further guarantee authenticity waste containers could be appropriately and inconspicuously tagged in a manner the knowledge of which would be restricted information. At the disposal site the serial number and tag should be verified and the seal checked.

Of particular importance and difficulty is the determination that the amount of fissile material and plutonium residing in a particular waste container does not exceed the established maximum values. During the past several years the technology for nondestructively assaying waste packages containing fissionable materials has undergone considerable development. Nevertheless, the problems of assay at the national nuclear waste repository could be formidable, depending on the containers used, accuracies required, etc.

It should be noted here that the recommended waste assay at the repository does not in any way replace the accountability requirements at the source, where, since the nature of the waste should be well known, a more accurate assay is to be expected and required. Since the disposal site assay need only determine upper limits for the content of certain materials, the measurement problems in this respect are reduced; on the other hand, the measurements must be applicable to unknown amounts of unknown materials, i.e., to pure black box conditions, and therefore assay problems in this respect are more difficult.

Four topics of particular importance for on-site waste assay are 1) the limits imposed on the fissile material and plutonium content, 2) the volume of waste to be assayed, 3) the nature of the waste containers, and 4) the cost.

The limits to be imposed on specific materials must be determined as a compromise between excessive recycling costs and accountability demands. These limits are to be met at the source of the waste material and are to be checked at the disposal site.

The volume of waste is estimated to be such that the time available for assay per cubic foot is on the order of seconds. This implies not only that substantial automation will be required, but also that the assay techniques must be quite rapid and must be of universal nature; time will not permit the contemplation of individual containers.

Waste container geometry should be standardized to one or at most two designs. The 55-gallon drum is a well-studied, easily manipulated container of convenient size, and should permit reliable assay if further experimentation is directed toward problems specific to 55-gallon drums. If there are significant reasons why containers larger than 55-gallon drums should be

used, then a program should be initiated immediately to investigate the assay possibilities for the proposed geometry. Such a program would require at least one or two years' effort, and time is running short.

Finally, the cost of operating an assay station at the nuclear waste repository is expected to be nominal, a rough estimate being on the order of a few cents per cubic foot of low level waste.

The materials accounting processing of low level waste at the disposal site is thus visualized to proceed on a largely automated, assembly-line basis as follows. Incoming containers undergo serial number, tag, and tamper-indication verification. Additional checks, which are easily automated, such as a measurement of total container weight, could be imposed at this point. The waste containers then proceed through several physically separate assay stages for the determination or estimation of, e.g., 1) the possibility of massive fissile material content, 2) total fissile material content, and 3) total plutonium content. Containers passing all inspections are forwarded directly to a burial location. Containers failing an inspection are recycled for a detailed assay and possibly repackaging or return to shipper. All data collected at the disposal site is permanently stored and, of course, compared with corresponding shipper's data. The final decision on whether to accept or not to accept a particular container for disposal rests with a supervisor of safeguards and materials management, i.e., an accountability officer, who answers directly to the project director and is independent of the operations and storage administration.

To summarize, the authentication and evaluation of radioactive waste prior to disposal in the Lyons repository is of immediate practical importance, is technologically possible with current knowledge, and is of small expected cost relative to the overall disposal expenses. Since the disposal

operations are intended to proceed on a large scale over an indefinite period of time, adequate safeguards procedures such as outlined above for purposes of safety and accountability should be fully defined, researched, and implemented before disposal operations begin.