STRATEGY ANALYSIS F R KRYPTON-85 WASTE MANAGEMENT[a]

by

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SUMMARY

Krypton-85 is a chemically inert, radioactive gas produced by fission of uranium or plutonium isotopes. Depending on the fuel cycle, krypton-85 production in nuclear reactors may range from ~200 to ~600 kC_i/GW_e-year. However, the EPA has published a standard restricting krypton-85 release to 50 kC_i/GW_e-year for fuel irradiated after January 1, 1983.[1] To conform with the federal standard, recovery and storage of krypton-85 will be required in some nuclear fuel cycle processes.

The long-term waste management of krypton-85 poses unique judgemental problems. Release, recovery, immobilization, and storage (individually, and in combinations), involve a wide range of environmental, economic, and social commitments. The choice of applicable technologies, if such technologies are to be used at all, imposes another set of boundary conditions.

This strategy analysis describes the use of a general framework for decision-making in evaluating krypton-85 waste management systems. Such a framework can be further used to provide technical assessment and dose-probability calculations for individual technologies,[2,3] and to show the interactions among technological options required for the overall waste management scheme.

The major options in krypton-85 waste management, shown in Figure 1, include spent fuel storage (1.0), fuel processing (2.0), release of krypton-85 (3.0) or recovery (4.0), further krypton-85 separation (5.0) and purification (6.0), krypton-85 immobilization or bottling (7.0), packaging and shipping (8.0), and storage or disposal (9.0).

Krypton concentrations and inventories vary a great deal. Typical concentrations for a 2000 MTHM reprocessing plant scale range from 10-0.01 Ci/m^3 during the dissolution and release options and become $\leq$40 MCi/m^3 during the recovery/separation/purification steps. During immobilization/storage the concentration ranges from $\sim$0.1 to $\sim$10 MCi/m^3. Inventories range from 10^4 to 10^6 curies per day for recovery and immobilization processes. Storage inventories will approach several hundred megacuries from the lifetime production of a 2000 MTHM per year reprocessing plant.

Major Decision Points in Krypton-85 Waste Management

(a) Process or Store Spent Fuel

If krypton is recovered from fuel processing, it can be stored safely by several methods. Containment of krypton in spent fuel may not be as certain during fuel disposal, and unplanned releases may result.

(b) Release to the Environment or Recover and/or Purify Krypton From the Processed Fuel

Release of dilute krypton is considered only as a global hazard. When krypton is recovered, however, several hundred megacuries can accumulate at one site, leading to potential local and global hazards. If a decision to recover krypton is made, immobilization and storage technologies must be on hand which will give very low probabilities for release.

(c) Engineered or Environmental Storage

Disposal options which don't mechanically immobilize krypton include filling of underground caverns, trapping during grout injection, or ocean disposal. Reduced costs are offset by potentially larger probability for release during storage/disposal. Similar tradeoffs occur with krypton in pressurized cylinders. Engineered storage could provide better secondary containment than that of geological disposal.

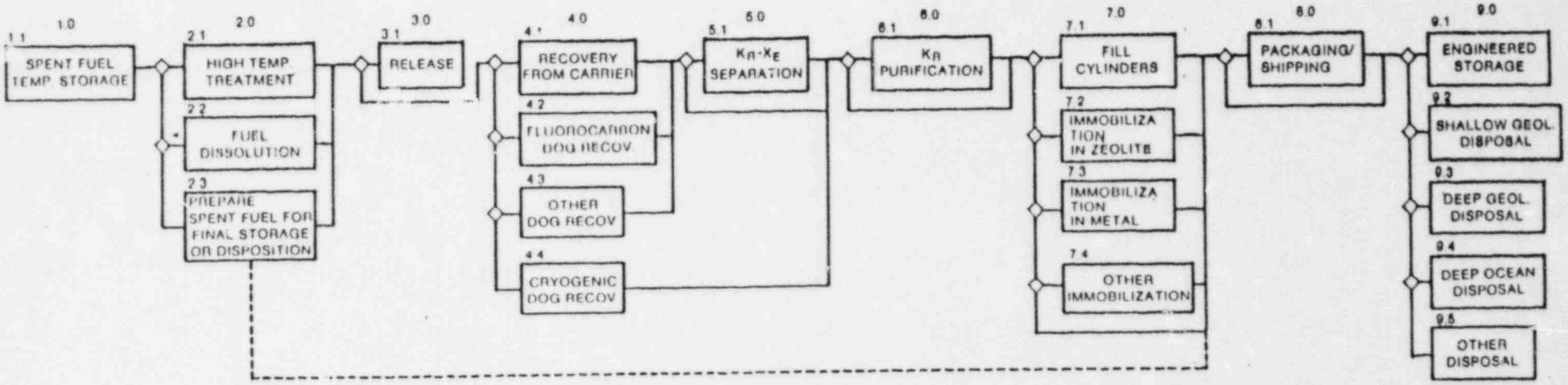

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Figure 1. Major Technological Options and Decision Points in Krypton-85 Waste Management

Possible Constraints in Krypton-85 Waste Management

If one technological option is fixed, constraints may be imposed on other options in Figure 1, for example:

(a) Disposed fuel may not provide krypton storage integrity comparable with geological disposal.

(b) If the physical characteristics of a geological disposal site limit removal of radioactive decay heat, the amount of krypton which can be immobilized in a zeolite or metal may be limited.

(c) A Kr-Xe separation step may be required for metal immobilization processing or for economical engineered storage of pressurized cylinders.

(d) Concentrations of O_2 or N_2 in the krypton may have to be reduced to ~ppm levels to avoid serious corrosion of pressurized cylinders by the decay product Rb.

This strategy analysis provides a framework for evaluating the options for krypton-85 waste management. Major decision points are identified and illustrated, as are constraints imposed by the choice of one element of the waste management system on the remaining serial options. This type of analysis may be used as a basis for the systematic resolution of a set of linked process decisions. While standard technology assessment methods are used for individual technological options, this analysis defines interactions with other technological options.

References

1. Federal Register 42, 40CFR190 (1977)

2. J. Cohen, "Suggested Nuclear Waste Management Radiological Performance Objectives", NUREG/CR-0579-URCL-52626, USNRC (1978)

3. L. E. Trevorrow and M. J. Steindler, Chemtech 9, 88 (1979)