A SURVEY OF LOW-LEVEL RADIOACTIVE WASTE TREATMENT METHODS AND PROBLEM AREAS ASSOCIATED WITH COMMERCIAL NUCLEAR POWER PLANTS*

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ABSTRACT

A survey was made (June 1985) of technologies that were currently being used, those that had been discontinued, and those that were under consideration for treatment of low-level radioactive waste from the commerical nuclear power plants in the United States. The survey results included information concerning problems areas, areas needing research and development, and the use of mobile treatment facilities.

INTRODUCTION

A major objective of nuclear waste management is to reduce the hazards associated with radioactive wastes to the lowest practicable level consistent both with economic and social requirements. Historically, this result has been accomplished by dispersion into the environment, principally as low-activity wastes that are liquids or gases, or by containment until decay has reduced the radioactivity to nonhazardous levels (1). Treatment of the wastes using several of a variety of treatment methodologies is generally required before disposal by either environmental dispersal or containment and confinement.

Nuclear power plants in the United States generate many types of radioactive wastes including dry combustible and noncombustible waste, resins and sludges from treatment of liquid streams, and oils (2). Waste generators are seeking to find the most cost-effective combination of treatment, transportation, and disposal systems to apply to these wastes, within the regulatory constraints, of the local, state, tribal, and federal governments (3).

As part of a larger task (4) of providing an assessment of currently available technology for treating commercial low-level radioactive waste (LLRW), the nuclear power plant operators in the United States were surveyed in June 1985 concerning treatment methods being used, those that had been discontinued, or those still being considered. In addition, information concerning problem areas, areas needing research and development, and the use of mobile treatment facilities was requested.

SURVEY

Because LLRW supervisors generally have heavy work schedules, the two-page survey was designed to faciliate answering and had sufficient space for additional comments (Fig. 1). The survey was sent to 76 nuclear power plants, including 55 in operation and 21 under construction.

Forty-one nuclear power plant operators (i.e., 54% response) responded. The results were current as of mid-1985.

In the survey, treatment methods were classified into the following categories:

1. dewatering methods including technologies for isolating or concentrating waste constituents;
2. thermal and physicochemical methods;
3. biological methods;
4. sorting/segregation methods;
5. decontamination methods;
6. mechanical treatment methods [e.g., volume reduction (VR)];
7. solidification methods; and
8. other treatment methods.

Information concerning the number of treatment methodologies (including mobile facilities) currently used, discontinued, and being considered, was requested. In addition, the survey solicited identification of problem areas and research and development (R&D) needs.

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LOW-LEVEL RADIOACTIVE WASTE (LLW) FROM COMMERCIAL NUCLEAR REACTORS: ASSESSMENT OF TREATMENT METHODOLOGIES

[Please mark table with: D - for discontinued; U - for presently using (if a mobile unit indicate by adding M, i.e., UM); C - for considering]

*Mark only the treatment/waste combinations that are applicable. For simplicity of organization parallel construction was used, although it is obvious that certain methodologies are not applicable to all wastes.

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TREATMENT METHODOLOGIES	AQUEOUS LIQUIDS	NONAQUEOUS LIQUIDS	WET RESIDUES					DRY WASTES				OTHER
			FILTERS	RESINS	SLUDGES	CONCENTRATES	OTHER	COMBUSTIBLE	NONCOMBUSTIBLE	COMPACTIBLE	NONCOMPACTIBLE	
Removal of water (dewatering)												
Evaporation												
Drying												
Centrifugation												
Filtration												
Reverse osmosis												
Ultrafiltration												
Electrodialysis												
Precipitation												
Coagulation/floc/ sedimentation												
Freeze-thawing												
Other												
Thermal and physicochemical												
Ion exchange												
Distillation												
Incineration												
Wet-air oxidation												
Oxidation/reduction												
Acid-digestion												
Electrolytic processes												
Smelting												
Other												
Biological												
Sorting/Segregation												

Fig. 1. Survey Form.

TREATMENT METHODOLOGIES	AQUEOUS LIQUIDS	NONAQUEOUS LIQUIDS	WET RESIDUES					DRY WASTES				OTHER
			FILTERS	RESINS	SLUDGES	CONCENTRATES	OTHER	COMBUSTIBLE	NONCOMBUSTIBLE	COMPACTIBLE	NONCOMPACTIBLE	
Decontamination												
Mechanical												
Chemical												
Electrolytic polishing												
Ultrasonic cleaning												
Other												
Mechanical treatment (VR)												
Dismantlement												
Cutting, sawing, and shearing												
Shredding and grinding												
Baling												
Crushing												
Compaction												
Supercompaction												
Other												
Solidification												
Cement												
Asphalt												
Sorbents												
Glass												
Organic polymers												
Slagging												
Other												
Other Treatment Methods												

PROBLEM AREAS:

RESEARCH AND DEVELOPMENT NEEDS:

Name: _____ Phone Number: _____

Address: _____

_____

Fig. 1. Survey Form, Cont'd.

SURVEY RESULTS ON USE OF TREATMENT METHODS

Summary data on the use of LLRW treatment methods by technology category as reported by the responding commercial nuclear power plants are presented in Table I.

The most frequently used techonologies in mid-1985 were mechanical VR, dewatering, decontamination, and solicification processes. Compaction was the principal mechanical VR treatment used for solid wastes, followed by dismantlement and cutting, sawing, and shearing. Evaporation and filtration were the principal dewatering methods used for relatively high concentration aqueous wastes, and drying was the principal dewatering method for wet residues. Ion exchange was the principal physicochemical method for treatment of dilute aqueous streams. Mechanical, ultrasonic, and chemical methods were most commonly used for decontamination. Cement was the principal solidification agent, although adsorption methods were also significantly used.

Treatment methodologies being considered for future use involved wider use of ultrafiltration, reverse osmosis, and evaporation as dewatering methods. Incineration was the principal thermal and physicochemical VR method under consideration. Electrolytic polishing was the principal decontamination method being considered. Of several other VR methods, most consideration was being given to supercompaction. Shredding and grinding methods were also being considered. Cement and asphalt were the principal solidification methods under consideration.

Forty-seven instances were reported in which a treatment method was discontinued. Included in the discontinued uses were: drying, evaporation, centrifugation, distillation, chemical and electrolytic polishing decontamination, and cement solidification. Reasons for discontinuation were not solicited nor given.

Mobile facilities were being used or under consideration principally for filtration, ion exchange, and solidification using cement.

Dewatering Methods

The treatment (in mid-1985) of aqueous liquid LLRW is summarized in Table II. Processes most used were drying, evaporation, and filtration. Ultrafiltration, filtration, and evaporation techniques were being considered most for new application in the future.

Thermal, Physicochemical, and Biological Methods

Ion exchange was the most used physicochemical technique for LLRW treatment (Table III); however, incineration was receiving the most consideration as a potentially very important VR method. No biological methods were used or contemplated for use at U.S. nuclear power plants.

TABLE I

Summary of the use of LLRW treatment technologies in mid-1985 by U.S. commercial nuclear power plants

Category	Current uses	Uses being considered	Discontinued uses
Dewatering	172(a)	27(b)	19
Thermal, physicochemical	56(c)	29	3
Biological	0	0	0
Sorting/segregation	89	16	0
Decontamination	142	27	13
Mechanical treatment (VR)	181	72	0
Solidification	121(d)	48(e)	12
TOTAL	761(f)	219(c)	47

(a) Including 12 mobile facilities.
(b) Including 2 mobile facilities.
(c) Including 7 mobile facilities.
(d) Including 36 mobile facilities.
(e) Including 5 mobile facilities.
(f) Including 55 mobile facilties.

TABLE II

Distribution and frequency of the use (in mid-1985) of dewatering methods for LLRW reported by U.S. commercial nuclear power plants

Treatment	Current uses	Uses being considered	Discontinued uses
Evaporation	38	6	5
Drying	49(a)	1	6
Centrifugation	5	1	4
Filtration	38(b)	6(c)	0
Reverse osmosis	2	3	2
Ultrafiltration	4	8	0
Electrodialysis	2	0	0
Solids Handling(d)	7	1	0
Other	27(e)	1	2
TOTAL	172(f)	27(c)	19

(a) Including 1 mobile facility.
(b) Including 8 mobile facilities.
(c) Including 2 mobile facilities.
(d) Precipitation,coagulation,flocculation, and/or sedimentation.
(e) Including 3 mobile facilities.
(f) Including 12 mobile facilities.

TABLE III

Distribution and frequency of the use in mid-1985 of thermal, physicochemical, and biological methods for LLRW treatment

Treatment	Current uses	Uses being considered	Discontinued uses
Ion exchange	41(a)	2	0
Distillation	11(b)	3	3
Incineration	2	24	0
Electrolytic processes	1	0	0
Other thermal or physicochemical	1	0	0
Biological	0	0	0
TOTAL	56(c)	29	3

(a) Including 6 mobile facilities.
(b) Including 1 mobile facility.
(c) Including 7 mobile facilities.

Sorting/segregation and Decontamination Methods

Most plant operators use several types of sorting/segregation methods for LLRW (Table IV). The most-used decontamination techniques are mechanical, ultrasonic cleaning, and chemical.

TABLE IV

Distribution and frequency of the use in mid-1985 of sorting/segregation and decontamination methods

Treatment	Current uses	Uses being considered	Discontinued uses
Sorting/segregation	89	16	0
Decontamination			
Mechanical	45	4	0
Chemical	24	6	7
Electrolytic polishing	11	10	4
Ultrasonic cleaning	38	6	2
Other	24	1	0
TOTAL	231	43	13

Mechanical Treatment Methods

In mid-1985 compaction, dismantlement, and cutting and sawing were the most used mechanical treatments for LLRW (Table V). Shredding and supercompaction were under most consideration as VR techniques for dry solid LLRW.

TABLE V

Distribution and frequency of the use in mid-1985 of mechanical treatment methods for LLRW reported by U.S. commercial nuclear power plants

Treatment	Current uses	Uses being considered	Discontinued uses
Dismantlement	40	1	0
Cutting, sawing, etc.	36	3	0
Shredding, grinding	16	29	0
Baling	8	2	0
Crushing	3	0	0
Compaction	74	6	0
Supercompaction	3	30	0
Other	1	1	0
TOTAL	181	72	0

Solidification Methods

In the area of LLRW solidification/stabilization as of mid-1985, cement technologies were the most-used, as well as the most-considered, for use in the future (Table VI). Much consideration was also being given asphalt and organic polymer solidification methods.

TABLE VI

Distribution and frequency of the use (in mid-1985) of solidification methods for LLRW reported by U.S. commercial nuclear power plants

Treatment	Current uses	Uses being considered	Discontinued uses
Cement	83(a)	24(b)	10
Asphalt	9	14	0
Sorbents	19	5	0
Glass	0	0	0
Organic polymers	4	5	1
Slagging	0	0	0
Other	6	0	1
Total	121(a)	48(b)	12

(a) Including 36 mobile facilities.
(b) Including 5 mobile facilities.

SURVEY RESULTS ON SPECIFIC PROBLEM AREAS

Twenty-two of the 41 responding nuclear power plant operators indicated several problem areas. Problems with oily waste including solidification/stabilization were mentioned 8 times (25% of the responses). Major problem areas (with the number of responses presented in brackets) were: solidification/stabilization [5, including 2 specifically for oil]; resins, including activity measurement, sampling, and solidification [5]; filters including disposal [4]; sludge [2]; and scintillation cocktails [2]. Other problem areas reported were: VR, evaporators, storage, sand/rubble, personnel exposure during cleanup when using solidification, mercury, organics, liquid scintillation vials (bottles), aerosol cans, waste burial (disposal), and stability requirements.

SURVEY RESULTS ON SPECIFIC R&D RECOMMENDATIONS

Seventeen of the responding nuclear power plant operators indicated several R&D needs in LLRW treatment. Additional R&D on incineration of LLRW waste including dry active waste, and mobile facilities was mentioned 5 times (17% of the responses). The R&D recommendations (with the number of responses presented in brackets) were: develop a de minimus or below regulatory concern level for all nuclides including wastes such as oil, rubble, sand, and low-level resin [3]; treatment of oily waste [3]; resin processing including regeneration, VR, and developing resins with greater capacity [3]; and sludge treatment [2]. Other areas recommended for R&D were: methods for destroying chelates; gamma scan for spent resin tanks; filtration (fines removal from liquid waste); mercury processing; scintillation cocktail processing; analyzing non-LSA waste; packaging mechanical filter cartridges that exceed NRC (10 CFR 61) class C waste criteria or that exceed transuranium isotope (TRU) concentrations of 100 nCi/g; low-level TRU analysis; drying; VR for resins; economical VR technologies; reliable in-plant solidification systems that are uncomplicated and require low maintenance; and chemical decontamination methods for the full reactor coolant system including fuel.

SUMMARY

A survey of U.S. commercial nuclear power plant LLRW treatment methodologies which were currently (June 1985) used, being considered, or discontinued, showed that evaporation, filtration, and ion exchange were the most highly developed and widely used methods for treatment of liquid LLRW. Some limited uses of distillation, coagulation/flocculation/sedimentation, reverse osmosis, and ultrafiltration were reported with possible future expansions of their applications. The principal method for treating dry radioactive waste, in addition to sorting/segregation, was compaction. Some limited applications of cutting-sawing-shearing, shredding-grinding, baling, and supercompaction were used. The preferred solidification method was cementation, with lesser use of sorbents, and only limited use of asphalt and organic polymers. Incineration had only limited application, principally to nonaqueous liquid LLRW (e.g., oils). Incineration, shredding, and supercompaction were the VR techniques most considered for addition in the future. Greater use of cement and asphalt solidification systems was also under consideration. Principal problem areas and recommended R&D needs included incineration; solidification/stabilization; treatment of oily waste, resins, filters, and sludges; and the establishment of de minimus or below regulatory concern levels for LLRW.

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