10CFR61 WASTE FORM CONFORMANCE PROGRAM

FOR ASPHALTED RADWASTE

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ABSTRACT

With the enactment of Title 10, Code of Federal Regulations, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste" came the imposition of new requirements on licensees who dispose of radioactive waste via shallow land burial. Specifically, 10CFR61 both imposed a waste classification system requiring segregation of waste according to hazard and established waste performance characteristics required to enhance stability of the burial site. In order to provide licensees with guidance regarding implementation of applicable requirements of 10CFR61, the NRC Low Level Waste Licensing Branch issued two Technical Positions.

To demonstrate compliance of asphalted radwaste produced with oxidized asphalt with 10CFR61 criteria and the NRC's Technical Position, five utilities combined resources. The five utilities sponsoring the program were Public Service Electric and Gas Company, Niagara Mohawk Power Company, Detroit Edison Company, New Hampshire Yankee, and Consumers Power Company.

HISTORY

When enacted, in January, 1983, Title 10, Code of Federal Regulations, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," revised Federal regulations governing land disposal of low-level radioactive waste. These changes included the imposition of new requirements on licensees who dispose of radioactive waste via near-surface disposal. Specifically, 10CFR61 imposed a classification system requiring segregation of waste according to hazard. The hazardous conditions were defined by concentration of specific long-lived radionuclides for which institutional controls, waste form, and disposal methods are effective. Also, 10CFR61 established waste performance characteristics required to provide stability of the burial site. These waste characteristics include structure stability, water content, void spaces within the waste, between the waste and its package.

In order to provide licensees with guidance regarding implementation of applicable requirements of 10CFR61, the NRC Low Level Waste Licensing Branch issued two Branch Technical Positions (BTPs). The BTP pertaining to Radioactive Waste Classification describes the overall procedure acceptable to determine the presence and concentration of the radionuclides listed in 10CFR61 and thereby classifying and manifesting of wastes for shallow land burial. This BTP defines the following waste characteristics as the minimum shipping manifesting waste information requirements.

1. Physical description of the waste
2. Volume
3. Radionuclide identity
4. Radionuclide quantity
5. Total radioactivity
6. Principal chemical form
7. Solidification agent (if any)
8. Waste class
9. Total quantity of radionuclides

Acceptable methods for determining the concentration of radionuclides are defined as:

1. Materials accountability
2. Classification by source
3. Gross radioactivity measurements
4. Direct measurement of individual radionuclides

The BTP on Waste Form provides recommended waste form performance standards which the NRC staff would recognize as satisfying the intent of 10CFR61. Specifically, this BTP delineates acceptable criteria for the following waste form characteristics:

1. Compressive strength
2. Radiation stability
3. Leach resistance
4. Moisture resistance
5. Absence of free standing water or corrosive liquids
6. Resistance to biodegradation
7. Thermal stability.

The Waste Form Conformance Program described below delineates the means by which generic asphalt-encapsulated waste forms produced by the VRStm System were tested and evaluated to demonstrate compliance with the performance requirements recommended in the BTP on Waste Form.

THE PROGRAM

The Generic Waste Forms examined were derived from Brookhaven National Laboratory's (BNL's) NRC sponsored report, "Properties of Radioactive Waste and Waste Containers (NUREG-30957). Deviations from the BNL generic waste types included:

1. An evaporator concentrate waste stream for BWRs which process floor drain wastes by concentration rather than by filtration and ion exchange.

2. A mixed resin and filter cake waste for BWRs which do not segregate and solidify independently the various precoat and ion exchange materials uses in liquid waste process systems.

Together with these new additions, the test program resulted with eight waste formulations representing PWR and BWR uniqueties:

1. Bead Resins (BWR/PWR)
2. Precoat Filter Cake with Powdered Resins (BWR)
3. Precoat Filter Cake with Diatromaceous Earth (BWR)
4. Evaporator Concentrates - Neutralization Waste (BWR)
5. Evaporator Concentrates - Floor Drain Waste (BWR)
6. Evaporator Concentrates (PWR)
7. Decontamination Waste (BWR/PWR)
8. Mixed Resin and Filter Cake Waste (BWR)

Five utilities, as owners of VRS equipment, combined resources to share the costs of the program. They are:

- Public Service Electric and Gas Company
- Niagara Mohawk Power Company
- Detroit Edison Company
- New Hampshire Yankee
- Consumers Power Company

Of course, Consumers Power, at their Palisades station has operated their equipment since January 1984 and Public Service, at Hope Creek, is currently using their VRS equipment. The balance are due for 1987 start-ups.

The cost of the program was based on which of the eight waste forms each utility wished to sponsor. A simple matrix using sum of the parts, was used to calculate a particular utility's share of the total program cost.

Necessary to the success of the program was a presentation to the NRC.

In April of 1985, utility representatives and WasteChem Corporation met with representatives of the NRC's Low Level Waste Licensing Branch, to present the program. The meeting resulting in four changes to the program:

- Elimination of citric acid from the Decontamination Waste Form
- Raising the depletion rate of the bead resin waste form
- Complete testing of the floor drain concentrates waste form
- Change in ASTM D1074 temperature from 70° to 55°

CONDUCT OF TESTING

The simulated waste forms were prepared on an electrically heated Werner-Pfleiderer 53 mm extruder-evaporator (Figure 1 shows the test equipment arrangement). This extruder-evaporator is a small scale version of the standard commercial radwaste extruder used in Wastechem's Volume Reduction and Solidification (VRS) System. The small scale extruder produces waste products which are equivalent in all respects to those produced by a 120 mm extruder. The simulated waste feed streams are shown in Table 1. The three Evaporator Concentrates feed streams and the Decontamination Waste Feed stream were fed to the extruder-evaporator as liquids containing suspended and dissolved solids. The remainder of the waste streams were processed in a dewatered state, even though the extruder-evaporator is capable of accepting them in either a slurried or dewatered state. Since the volume reduced product from the process is a dehydrated waste residue dispersed in asphalt, the feed condition, whether slurried or dewatered, has no effect on the properties of the product and the products from both feed types are equivalent in all respects.

Since the pilot plant facility was not licensed to handle radioactive waste, the simulated waste feed streams were "doped" with non-radioactive tracers, salts of cesium, strontium, and cobalt, for leach test purposes.

SAMPLE PREPARATION

The various asphalt encapsulated waste forms were cast in cylindrical, thin-wall aluminum sample molds nominally two inches in diameter by five and one-half inches long. This type of mold was used because it can be stripped from the waste forms without the use of lubricants or parting compounds which could interfere with test results, particularly the leach test.

In addition to the small scale waste forms, a full size 55 gallon drum waste form was generated from a bead resin feed with a nominal 50% waste loading. The waste sample was made for destructive examination to demonstrate that the properties of a typical waste are independent of size.

For the small samples, the waste loadings were prepared from 0% waste - 100% asphalt to the maximum achievable waste loading and corresponding asphalt percent, for each feed stream, in increments of 10 wt% up to 40 wt% and increments of 5 wt% were used on the waste stream until the maximum achievable was attained. Samples at 0% loading and the maximum loading were subject to the tests listed in Table II. By testing samples for both the maximum and minimum waste loadings, the complete range of loadings have been characterized (bracketed), thereby eliminating the need to test products at intermediate loading.

All samples were prepared using high-viscosity, oxidized asphalt conforming to ASTM-D-312, Type III requirements.

METHODOLOGY AND RESULTS

The methodology for each test is summarized below. In all cases duplicate samples of each waste form were tested.

COMPRESSIVE STRENGTH

After the samples were removed from the sample mold, they were cut to length by a high speed saw to yield a length to diameter ratio of approximately 2. The samples were then conditioned in an environmental chamber to 55°F ± 2.5°F. Samples were then placed in a testing machine conforming to the requirements of ASTM D1074. The compressive force at 10% sample deformation was measured. The acceptance criterion is a compressive strength of 50 psi at 10% deformation.

RADIATION STABILITY

For the Radiation Stability testing the test samples were irradiated to a nominal exposure of 10^8 rads. Two batches of samples were tested. The first batch was exposed in a Cobalt-60 irradiator to a gamma field average 0.96 megarads per hour for 184.3 hours. The second batch to an average field of 0.93 megarads per hour for 107.9 hours. Following irradiation, the samples were tested for compressive strength as described above. The acceptance criterion is a compressive strength of 50 psi at 100% deformation.

BIODEGRATION TEST

Based on procedure qualification tests performed by Brookhaven National Laboratory, it is anticipated that most bitumenized waste forms will support some degree of fungal and bacterial growth. Therefore, in accordance with the options defined in the BTP, Bartha-Pramer biodegradation rate tests were performed on specimens in place of the ASTM G21 and G22 general susceptibility tests. The test was performed by an independent laboratory using duplicate samples of each waste form and two soil types, Richland soil and simulated Barnwell soil (see Ref. 5 for soil composition). Test duration was six months.

The acceptance criterion is a projected loss of carbon in the waste form amounting to less than 10% of the total initial content.

LEACH RESISTANCE

Non-radioactive tracers (salts of cesium, strontium, and cobalt) were added to the simulated waste feed materials to produce known concentrations of these materials in the solidified waste forms.

The samples were cut to a nominal 4 inch length and were leach tested in accordance with ANS 16.1 - Draft "Measurement Wastes." The test procedure was modified to include three extra data points (days 19, 47 and 90).

All samples destined for leach testing were sealed after cooling and remained sealed until the test. Two different leachants were used, demineralized water and simulated seawater. Leachant solutions were analyzed by an independent laboratory for tracer content by means of atomic absorption spectrophotometry. Sample acceptance is a leachability index greater than 6.

IMMERSION TEST

For immersion testing, samples were removed from their molds and cut to a nominal 4 inch length using the method described for preparation of samples for compressive strength testing. Each sample was then placed in a one quarter plastic container filled with demineralized water and was left immersed and undisturbed for a 90 day period. Weekly observations were made to note any visible changes.

At the conclusion of the test period water was drained and the samples removed. Sample dimensions were recorded and the samples compression tested as described earlier. The acceptance criterion is a compressive strength of 50 psi at 10% deformation.

THERMAL DEGRADATION

The waste samples, in their sample molds, were subject to 30 thermal cycles between 60° and -40°C in an environmental chamber conforming to the requirements of ASTM B553, Section 3, "Thermal Cycling of Electroplated Plastics." The test apparatus containing the waste samples was cycled in the following manner:

1. Heated from ambient (20°C) to 80°C and maintained for a period of one hour
2. Cooled to ambient (20°C) and maintained there for one hour
3. Further cooled to -40°C and maintained for one hour
4. Heated to ambient (20°C) and maintained for one hour

This sequence constituted a single thermal cycle which was repeated 30 times. Following this sequence, the samples were prepared for compressive strength testing and tested in accordance with the procedure described earlier. The acceptance criterion is a compressive strength of 50 psi at 10% deformation.

FREE LIQUIDS

A 55 gallon drum bead resin waste form was generated. During destructive examination of this sample, the free liquids content was determined in accordance with the method prescribed by ANS 55.1 "solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants." Furthermore, each small scale waste form was visually examined for free water after removal from the sample mold. The acceptance criterion is less than 1% (by volume) free-water in the sample.

RESULTS AND PRESENTATION TO THE NRC

The program data was correlated and summarized into a Waste Form Topical report submitted to the NRC in May of 1986. In August, 1986 WasteChem issued the first supplement which provided the Bartha Pramer Biodegradation Test Results which previously were not available.

Noted in the Topical Report, the Neutralization Waste Form swelled during the immersion testing. A detailed review of all procedures realized that the instantaneous high radiation dosage which the samples were subject jeopardized their ability to hold their form through immersion testing. Since the original tests, WasteChem has reconstructed this section of the program and has demonstrated the Neutralization Waste Forms to have nearly twice the required compressibility strength. The results of this additional testing are expected to be finished in April of this year, after which a second supplement to the Topical Report will be issued.

SUMMARY

Having a approved Class A Process Control Program, Public Service incorporated the test program description and data and has submitted a complete PCP for all waste classes in November of 1986.

This 10CFR61 Program has provided the industry a sound system, backed by an extensive test program and corresponding data evidence, for burial site acceptance of oxidized asphalt products.

To that end, the Hanford site continues to accept oxidized asphalted waste forms and the Barnwell site has recently issued Amendment 43 to the IT license accepting oxidized asphalt waste forms.

The program, despite the normal tribulations commensurate with any analytical undertaking has established a reasonable trail of confidence for the oxidized asphalt waste form and clear conformance to the regulatory guidelines on which the program was based.

TABLE I

WASTE FEED STREAM	CONSTITUENTS
Bead Resin	95 wt% Bead Resin + Cobalt, Strontium, and Cobalt Tracers
Precoat Filter Cake with Powdered Resin (BWR)	74 wt% Powdered Resin, 18 wt% crud, + Cesium, Strontium, and Cobalt Tracers
Precoat Filter Cake with Diatomaceous Earth (BWR)	76% Diatomaceous Earth, 19% Crud, Cobalt, Cesium, and Strontium Tracers
Evaporator Concentrates - Neutralization Waste (BWR)	69% Water, 17% Sodium Sulfate, 13% Evaporator Concentrates + Cesium, Strontium, and Cobalt Tracers
Evaporator Concentrates Floor Draine Waste (BWR)	85% Water, 5 wt% Sodium Bicarbonate, 4 wt% Sodium Phosphate, 3 wt% Calcium Chloride, 2 wt% Magnesium Sulfate + Cesium, Strontium, and Cobalt Tracers
Evaporator Concentrates - (PWR)	90 wt% Water, 9 wt% Sodium Borate + Lubricating Oil, Potassium Chromate and Tracers of Cesium, Strontium, and Cobalt
Decontamination Waste (BWR/PWR)	73 wt% Water, 26 wt% Rad Clean, 1 wt% oils, + Tracers of Cesium, Strontium, and Cobalt
Mixed Resin and Filter Cake Waste (BWR)	45 wt% Bead Resin, 50 wt% Powdered Resin, 5% Diatomaceous Earth

TABLE II

Test	Recommended Acceptance Criterion	Test Results
Compressive Strength	≥50 psi at 10% deformation	>50 psi at 10% deformation for all waste forms
Radiation Stability	≥50 psi at 10% deformation after 10% rad exposure	>50 psi at 10% deformation for all waste forms after 10% rad exposure
Leach Resistance	Leach index 6	Leach index 8 for all waste forms for Co, Sr, Cs
Immersion	≥50 psi at 10% deformation after 90-day water immersion	>50 psi at 10% deformation for all waste forms
Thermal Stability	≥50 psi at 10% deformation after 30 thermal cycles	>50 psi at 10% deformation after 30 thermal cycles for all waste forms
Biodegration for all waste forms in Hanford soil	Less than 10 weight percent degradation in 300 years	Less than 5.49 weight percent degradation in 300 years for all waste forms
Biodegradation for all waste forms in Barnwell soil	Less than 10 weight percent degradation in 300 years	Less than 4.57 weight percent degradation in 300 years for all waste forms

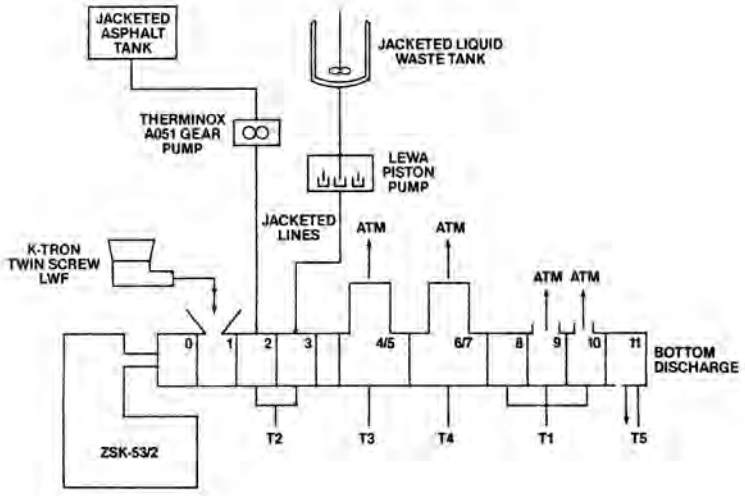

Fig. 1. Test Equipment Arrangement.