

ALTERNATIVE METHOD OF SOLIDIFICATION FOR LOW-LEVEL CLASS A RADIOACTIVE WASTE

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ABSTRACT

New solidification media have been developed that exhibit excellent spatial efficiency over the entire range of virtually all Class A liquid wastes. These new media are being used to incorporate from 41 to 48 gallons of liquid radioactive waste in a 55-gallon drum. To date, wastes processing at nuclear power plants and facilities include oils, evaporator bottoms, sludges, and ion-exchange resins as well as combinations of these waste streams. This paper comparatively discusses the performance of solidification agents known as AQUASET™* and PETROSET™** with other currently available agents. It presents key advantages of using the AQUASET and PETROSET media over other media. These advantages include improvements in packaging efficiency, leachability, and repeatability.

INTRODUCTION

The management and disposal of Class A low-level radioactive waste continues to be a problem for radioactive waste generators. Increasing costs, public pressures, mandated volume reduction, and more stringent disposal requirements have caused waste generators to seek alternative methods for treating low-level waste prior to disposal. Due to a lack of alternative treatment processes, a large portion of the Class A waste has been disposed of using the Class B final waste form stabilization criteria. Some of the Class A liquid waste streams, most notably radioactive waste oils, are treated with solidification media that produce volume increases of up to 100% of the original waste volume. Also, for some of the smaller waste generators, the current method of absorbing liquids and shipping the waste for burial in overpacks can increase the burial volume by 600%. The use of these practices increases burial costs and depletes burial allocations. Additionally, the use of media such as cement or asphalt for solidification of Class A wastes may produce an acceptable waste form, but these media may initiate undesirable chemical reactions for some waste streams.

New solidification media, AQUASET and PETROSET, have been introduced and are being used successfully at many U.S. nuclear facilities as an alternative to stabilization media for Class A liquid waste solidification. These products, when used in accordance with the supplied process control procedure, will produce a final waste form

that meets the requirements of the NRC Branch Technical Position (BTP) (1) for Class A unstable waste.

AQUASET and PETROSET, developed for the efficient disposal of liquid wastes, are slightly alkaline, inert, non-corrosive, non-biodegradable, non-hazardous, versatile, and simple to use. The AQUASET/PETROSET solidification agents immobilize wastes via complex bonding mechanisms and result in a homogeneous free-standing monolith with excellent leach characteristics. The waste fluid and any suspended and dissolved solids are fixed in a non-pourable flexible matrix that will not undergo brittle fragmentation under accidental spill conditions.

Figure 1 presents the solidification media, comprising four solidification agents. The figure outlines these solidification agents and briefly describes the waste material that can be solidified with each of the individual media types. Dotted lines are used to indicate where a combination of media would be required. These agents are:

- AQUASET is a water-activated granular solidification agent used for aqueous liquids containing small amounts of dissolved and suspended solids, detergents, chelating agents and up to 5% oil. AQUASET is simply added to the liquid and does not require stirring.
- AQUASET II is a powdered solidification agent used either alone or in combination with

* AQUASET™ - Fluid Tech, Inc., Las Vegas, Nevada

** PETROSET™ - Fluid Tech, Inc., Las Vegas, Nevada

PETROSET or PETROSET II. AQUASET II is most useful in solidifying aqueous solutions extremely high in dissolved solids such as neutralized acids and bases and those organic liquids that are water miscible.

- PETROSET is a powdered, water-activated solidification agent that exhibits properties similar to AQUASET. PETROSET requires stirring and is used primarily in conjunction with PETROSET II and AQUASET II when combinations of water and oil are present and the oils exceed 5% of the waste volume.
- PETROSET II is a finely ground solidification agent used for liquids that are essentially 100% oils, solvents and/or water immiscible organics. Petroset II will not solidify aqueous wastes. Therefore, when aqueous wastes are present with the organics, combinations of PETROSET or AQUASET II should be mixed with the PETROSET II.

APPLICATIONS

The AQUASET and PETROSET media can be used effectively to solidify a wide variety of liquid wastes. Table

I summarizes applications of the various media in this family of products and indicates the typical waste streams and the agent or combination of agents required to solidify these individual wastes. The combinations of wastes identified in Table I represent normal waste combinations, but are not the only combinations that can be effectively solidified. Due to the nature of the solidification process, virtually any combination of waste can be mixed.

The AQUASET and PETROSET media have been used to solidify a variety of waste streams at nuclear facilities. These waste streams have included oil, sludge, ion exchange resins, evaporator bottoms, and solvents. Results of these solidification campaigns revealed that the media can solidify these wastes with great efficiency. Results further showed that problem waste streams, such as oil, were successfully solidified with up to 48 gallons of actual waste in a 55-gallon drum. In comparison, solidification of the oil waste with more widely used media such as Envirostone^R resulted in a volume increase of over 100% (25 gallons in a 55-gallon drum). The PETROSET solidification media, therefore, provided a means to reduce the burial volume by 50%.

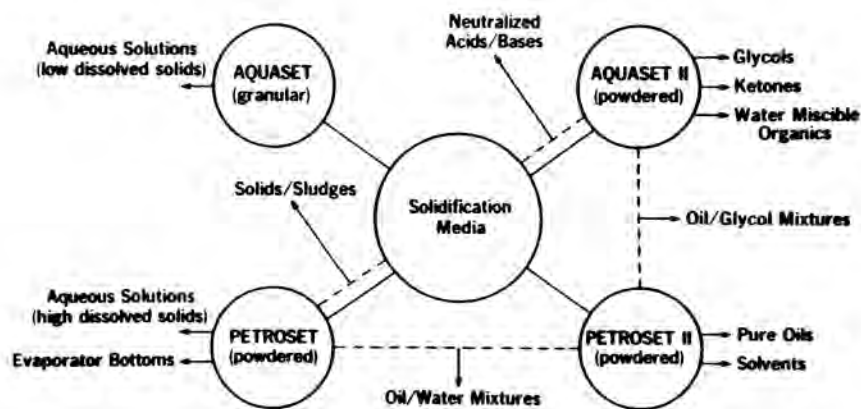


Fig. 1. AQUASET and PETROSET Family of Waste Solidification Media.

**Typical Waste/Fluid Tech Solidifier Combination
(per 55-gallon drum)**

<u>Waste Type</u>	<u>Waste Volume</u>	<u>Fluid Tech Product</u>
Aqueous, Low Ionic Concentration	45-48 gallons	Aquaset
Aqueous, Medium Ionic Concentration	43-47 gallons	Petroset
Glycols, Ketones, Water Miscible Organics	42-46 gallons	Aquaset II
Pure Oils, Solvents, Chlorinated Hydrocarbons	40-47 gallons	Petroset II
Acids and Bases, Neutralized, pH 5-10	42-47 gallons	Petroset and Aquaset II
Waste Lubricating Oil and Water	41-48 gallons	Petroset and Petroset II
Waste Lubricating Oil and Glycols	40-44 gallons	Aquaset II and Petroset II
Ion-Exchange Resins	41-45 gallons	Aquaset II and Petroset

Solidification of other waste streams such as bead and powdered ion exchange resins with the media have also demonstrated high efficiency. These wastes, when solidified with AQUASET/PETROSET media, produced a waste form that was acceptable for burial at both the Hanford, Washington, and Beatty, Nevada, disposal sites. The minimal volume increase associated with the solidification process, (15% to 20%), indicates that this form of solidification could provide a cost-effective disposal alternative to the current method of dewatering of resins and burial in high-integrity containers.

TESTING

Waste samples solidified with AQUASET and PETROSET were extensively tested prior to formal acceptance of the media at the burial sites. Some of the tests included leach testing, radiation testing, and testing to assure that the solidified waste would meet the freestanding solid requirement with less than .5% free liquid. The media have been tested on samples of oil, sludge, water and ion exchange resins. Although most of the tests were not required for Class A wastes, the additional evaluation was performed to assure that the solidification process provides an environmentally safe and consistent final product. One of the most significant tests was to assess the rate at which the radionuclides would leach from the waste form. This test is discussed below.

Leach Testing (2)

The leach testing for the AQUASET/PETROSET products was performed in accordance with ANSI/ANS

16.1. The test specified in ANS 16.1 standardizes many of the external factors such as temperature and pressure that bias the results of other tests and defines a method to assure consistent results with each test. This, in turn, assures that when applied to actual conditions, the waste solidification will produce a consistent product.

The 90-day leach testing was performed on samples that were solidified with AQUASET, AQUASET II, PETROSET, and PETROSET II. Testing was accomplished using Cobalt-60, Cesium-137 and Strontium-85 as the radioactive tracers. A 20-specimen matrix of the four products was prepared.

The results of the testing are summarized in Table II. In this table, each whole number reflects one order of magnitude with higher values indicating lower leach rates. These leach indices verify the excellent bonding characteristics of the AQUASET/PETROSET media. The highest overall leachability index (LI) was for Cobalt-60 at 9.4. The lowest was for Strontium-85 at 8.3 with Cesium-137 intermediate at 8.8. The slowest overall leach rate for the three isotopes was from the PETROSET II specimen. The leach testing is continuing with plans to acquire additional data after one year.

Radiation testing of wastes solidified with these media is in process. The samples evaluated have an accumulated dose in excess of 10 million rads, with no breakdown of the waste form. Final test results will be available in the near future.

TABLE II

AQUASET/PETROSET Leach Indices Per ANSI/ANS 16.1

Average leachability indices calculated from 10 leach periods (90 days)

FLUID TECH PRODUCT	LEACHANT	LEACHABILITY INDEX			Average
		Sr-85	Cs-137	Co-60	
Aquaset	#1 Dist. water	8.9	9.0	9.4	9.1
	#2 pH 2.3	7.3	9.7	8.4	8.5
	#3 pH 5.7	8.8	9.7	9.7	9.4
	#4 pH 9.5	9.0	9.5	9.9	9.5
	#5 Seawater	6.5	8.7	9.4	8.2
Aquaset II	#1 Dist. water	7.9	6.3	8.8	7.7
	#2 pH 2.3	7.8	6.5	9.0	7.8
	#3 pH 5.7	8.2	6.7	8.7	7.9
	#4 pH 9.5	8.4	6.3	9.6	8.1
	#5 Seawater	7.6	6.6	9.3	7.8
Petroset	#1 Dist. water	9.4	9.0	9.3	9.2
	#2 pH 2.3	7.3	8.6	8.2	8.0
	#3 pH 5.7	8.7	9.5	9.3	9.2
	#4 pH 9.5	8.3	10.4	9.2	9.3
	#5 Seawater	6.6	9.9	9.8	8.8
Petroset II	#1 Dist. water	8.6	9.5	9.4	9.2
	#2 pH 2.3	9.2	9.6	9.7	9.5
	#3 pH 5.7	8.7	10.0	9.9	9.5
	#4 pH 9.5	9.0	9.8	9.5	9.4
	#5 Seawater	9.7	10.1	9.9	9.9
Overall Avg.		8.3	8.8	9.4	8.8

TABLE III

Oil Leach Indices (Average) (3)

<u>LEACHANT</u>	<u>AQUASET/PETROSET</u>	<u>ENVIROSTONE</u>
Demineralized Water	9.2	7.8
Seawater	9.9	7.6

COMPARISON WITH OTHER MEDIA

Leach Index Comparison

Average leach indices, determined per ANSI/ANS 16.1, for waste oil solidified with ENVIRONSTONE, versus waste oil solidified with PETROSET are presented in Table III. Leach rate indices for the oil solidified with PETROSET exceed those for ENVIROSTONE a more widely used form for oil solidification, by one order of magnitude. The leach index as reported indicates the leach resistance of the test specimen. The higher numbers indicate less leaching.

Disposal Volume Comparison

Waste oil solidification is of special interest to the plant radwaste operator. An oil solidification process that offers both low costs and low final waste form volumes will have a distinct advantage over other less efficient processes.

A comparison of final waste form volume was made between ENVIROSTONE* and PETROSET II for solidification of radioactive waste oil. This comparison is summarized in Table IV. The solidification of oil with PETROSET II produced 50% less volume for burial than ENVIROSTONE, a commonly used process. This efficiency advantage of PETROSET II over the ENVIROSTONE medium for oil solidification has led to an increased awareness and use of the product at nuclear facilities.

The use of the PETROSET media for solidification of 1,000 gallons of oil resulted in a reduced burial volume of

TABLE IV

Comparison of PETROSET II vs ENVIROSTONE
Oil Solidification
(1000 gallosn)

Medium	Gals/55-gallon Drum	Drums of Solidified Oil
Petroset II	47	21
Envirostone	23	43

approximately 165 cubic feet (Table IV). Based on current Beatty, Nevada, burial rates, the reduced volume would translate into a direct savings on burial costs of \$7,690 for all waste generators outside the Rocky Mountain Compact. This does not include additional potential savings associated with the processing of the waste.

RECENT PLANT EXPERIENCE

One of the greatest advantages in using the AQUASET and PETROSET products is the packaging efficiency. During an actual solidification operation at a U.S. nuclear plant, up to 49 gallons of oil and water waste were solidified in a single 55-gallon drum. Historically, solidification of this type of waste with cement, asphalt, or other more widely used media would yield only approximately 25 gallons of actual waste per drum. Solidification with PETROSET, therefore, reduced the overall volume of solidified waste that required burial by 50%. With the high cost of burial for organic material, this reduction in volume translated into an approximate \$300/drum direct savings on burial cost for the utility.

A second advantage is the versatility of the media. During the solidification campaign discussed above, a mixture of many types of waste were discovered. These wastes, including various combinations of resin, sludge, water and oil, were successfully solidified in the same container. This enabled the solidification process to continue without the need to segregate waste types. If the segregation had been required, the cost associated with the disposal would have been increased and additional personnel radiation exposure would have been incurred.

FUTURE DEVELOPMENT

Although the AQUASET and PETROSET products are extremely beneficial in many areas of waste management, there are some areas that will require additional development. Currently, the final waste form generated by the solidification process does not meet the Class B&C minimum compressive strength criterion specified in the NRC Branch Technical Position. The solidification process, therefore, must be limited to only Class A wastes. Laboratory evaluations are in progress to incorporate specific chemical additives to produce a final waste form that achieves the required compressibility criteria and therefore qualifies the media for use on Class B&C wastes. Another area of development is the use of these media with large burial liners. The equipment currently available for mixing the media limits its application to 55-gallon drums.

* ENVIROSTONE^R - UNITED STATES GYPSUM COMPANY, LIBERTYVILLE, ILL.

The use of the liner could, therefore, contribute to additional cost savings by reducing the processing cost.

SUMMARY

AQUASET/PETROSET are new solidification media that are cost-effective and offer improved packaging efficiency over other agents for solidifying of Class A wet radioactive waste. These media, when used according to the approved process control procedure, produce monolithic, liquid-free waste forms and can solidify a variety of wastes, including waste oils, sludges, evaporator bottoms, and ion-exchange resins. Up to 49 gallons of these types of wastes have been incorporated in a 55-gallon drum. For radioactive oil wastes, PETROSET II minimizes the final solidified

waste form volume and enables the waste generator to dispose of the waste with up to 50% less burial volume.

REFERENCES

1. NRC, United States Nuclear Regulatory Commission, Low Level Waste Licensing Branch Technical Position on Radioactive Waste Classification, May 1983.
2. American Nuclear Society, Measurement of the Leachability of Solidified Low Level Radioactive Waste by a Short Term Test Procedure, ANSI/ANS 16.1, April 1986.
3. Topical Report, Gypsum Cement 10 CFR 61 Compliance Testing, May 1984.