TANK WASTE PRETREATMENT ISSUES, ALTERNATIVES AND STRATEGIES FOR RESOLUTION

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ABSTRACT

The U.S. Department of Energy (DOE) has established the Tank Waste Remediation System (TWRS) to safely manage and dispose of the Hanford Site tank waste. The overall strategy for disposing of tank waste is evolving and initial recommendations on a course of action are expected in March, 1993. Pretreatment of these wastes may be required for one or both of the following reasons: 1) resolution of tank safety issues, and 2) preparation of low level and high level waste fractions for disposal. Pretreatment is faced with several issues that must be addressed by the deployment strategies that are being formulated. These issues are identified. There is also a discussion of several pretreatment deployment strategies and how these strategies address the issues. Finally, the technology alternatives that are being considered for the pretreatment function are briefly discussed.

INTRODUCTION

At the Hanford Site there are 28 double-shell tanks and 149 single-shell tanks containing the radioactive byproducts from 48 years of spent fuel and waste processing. A variety of processes have been used over the years, resulting in several distinct categories of waste. The waste is in the form of sludge, hard salt cake, and supernatant. Initially, sludges from the various processes were segregated. Over the years, sludges have been intermixed to a large extent; the salts and supernatants have been intermixed to an even greater extent in an effort to conserve tank space and stabilize tanks. Of the total 177 tanks, 57 have been classified as "watch list" tanks because there are potential safety issues associated with the storage of the waste. (See two other papers in this session - "A STRATEGY for RESOLVING WASTE TANK SAFETY ISSUES" and "RESOLVING the SAFETY ISSUE for RADIOACTIVE ACTIVE WASTE TANKS with HIGH ORGANIC CONTENT.")

The U.S. Department of Energy (DOE) has established the Tank Waste Remediation System (TWRS) to safely manage and dispose of the Hanford Site tank waste. An overview of the TWRS is depicted in Fig. 1. Pretreatment is one of the major program elements of the TWRS (Other program elements of the TWRS are discussed in other papers in this session). The purpose of the Pretreatment program element is to 1) resolve tank safety issues by eliminating the cause of the issue through treatment or other appropriate means, and 2) prepare acceptable feed for immobilization by separating the tank waste into high level and low level waste fractions. The high level waste (HLW) will be converted to glass for disposal in a deep geological repository, while the low level waste (LLW) will be converted to a form suitable for near surface disposal on the Hanford site.

The strategy for implementing the TWRS is still emerging. Reference technical strategies are being identified for each program element. In addition, enhancements and alternatives to these reference technical strategies are also being identified. The overall strategy for implementing TWRS will use combinations of these technical strategies. Not all of the technologies that make up the references, enhancements, or alternatives within a given program element are fully developed. Consequently, the timing for implementation of any particular technical strategy will depend on how rapidly the technologies can be brought to maturity.

This paper will focus on the Pretreatment program element. Specifically, it will address the issues facing pretreatment, a discussion of the pretreatment strategic alternatives to address these issues, and a discussion of technologies being considered to implement these strategic alternatives. It is important that the pretreatment strategies selected be compatible with strategies selected for the other program elements.

ISSUES

Any pretreatment strategy that is selected needs to address a number of critical issues. The issues that will be discussed include:

1. The composition and chemistry of existing tank waste
2. The degree of pretreatment required
3. The timing for deployment of pretreatment
4. The cost of pretreatment
5. The maturity of candidate processes.

Waste Composition and Chemistry

The first critical issue deals with the limited knowledge of the composition of existing tank waste. Although some information is known for each of the 177 tanks based on historical records, confirmation of the tank compositions through core sampling and analysis will not be completed until at least 1998 according to the current schedule. Twelve tanks have been core sampled and the analysis of many of these cores is still in progress. Most of the quantitative analytical methods currently available are limited to providing information on elemental constituents. These analyses provide little information about the molecular species that are present. For example, there is not an acceptable nickel ferrocyanide analytical method available to determine how much nickel ferrocyanide is in each tank. The behavior of waste (the chemistry of waste solids in particular) during treatment must be determined empirically.

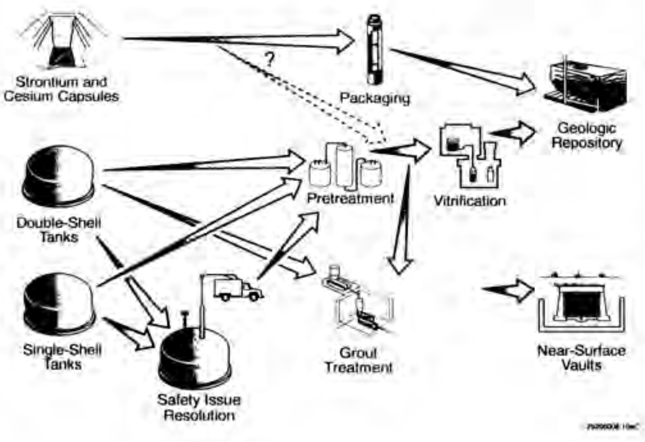

Fig. 1. Hanford site tank waste remediation system.

Degree of Pretreatment Required

The second critical issue derives from uncertainty in the degree of pretreatment required. This uncertainty is in four major areas:

1. The degree of pretreatment required to resolve the tank safety issues
2. The degree of pretreatment required by the reference LLW form--grout
3. The degree of pretreatment required for alternative LLW forms
4. The cost of disposing of HLW in the national geologic repository.

These requirements are still evolving; political considerations can also drive requirements where no technical basis for pretreatment can be identified.

Currently there is not a universally accepted criteria for judging if the existing or pretreated waste is being stored safely. For the time being, many tanks are conservatively classified as safety "watch list" tanks even though an analyses to prove the existence of significant safety issues is not available. The potential safety issues for almost all of the 57 "watch list" tanks could be put to rest by the destruction of either organics or nickel ferrocyanide compounds in a pretreatment process. Eight tanks containing organic complexants (and their degradation products) and 24 tanks containing nickel ferrocyanide are considered potentially unsafe from the standpoint of chemical reactivity. Twenty five tanks also have the potential to accumulate an unsafe concentration of hydrogen gas. The definite number of tanks that will require safety pretreatment and the acceptable residual concentration level of organic and nickel ferrocyanide are not currently known.

The U.S. Nuclear Regulatory Commission (NRC) reviewed Hanford plans to dispose of existing LLW (Class C waste or better) and ruled that waste intended for disposal in grout is classified as incidental waste. Thus, the disposal site is not subject to NRC licensing. Subsequent to this ruling, various parties both inside and outside of the DOE have questioned the acceptability of disposing of significant inventories of radionuclides in shallow land burial on the Hanford Site. The Washington Department of Ecology, the State of Oregon and others have petitioned the NRC to reconsider its ruling by requiring that all technically feasible means be used to extract radionuclides from the waste before disposal. The NRC has not taken action to supersede its initial ruling, thus leaving the question of acceptable radionuclide concentration in grout unresolved at this point in time.

LLW forms other than grout are also being considered for use in implementing the TWRS strategy. Testing of these other forms with Hanford tank waste has not yet occurred and therefore acceptable levels of waste constituents (including radionuclides, hazardous chemicals, and other chemical constituents) is not yet known.

One of the key drivers for separating the tank waste into high level and low level fractions is the anticipated high cost of disposing of defense waste in the national geological repository. However, development of the repository is taking substantially longer than originally planned. The latest projected date for availability of the repository is 2010. The availability of the repository and the cost for disposing of Hanford waste in the repository remains highly uncertain.

Timing of Pretreatment

The third critical issue that the pretreatment strategy must address is the need for relatively near term deployment of pretreatment. LLW immobilization and disposal in the Hanford grout vaults must proceed in the very near future to free tank space for mitigation of tank safety issues, other pretreatment operations, and mobilization/storage of the pretreated high level waste sludges. If decisions are made to impose more stringent radionuclide standards on grout feeds (e.g., NRC Class A concentration limits), then near term pretreatment will be needed to reduce the level of radionuclides in all existing LLW on a highly accelerated schedule. For some of the nuclides that might require removal, process technology has yet to be identified. The available technology for cesium removal requires either deployment of a fairly substantial facility for resin regeneration or the interim storage of a large volume of cesium loaded ion exchanger. Cesium ion exchangers with much higher capacities are in development, but their commercial availability is uncertain at this time.

In addition to the potential need for deployment of near term low level waste and safety related pretreatment, there is also a potential need to deploy more sophisticated pretreatment processes for high level and TRU waste sludges. In view of the delivery dates for those processes and the extended time required to bring new facilities on line in today's regulated environment, the time available to develop the more sophisticated separation technologies is already relatively short. In most cases, more sophisticated pretreatment processes are only now in the laboratory stage of development, although some are ready for bench scale demonstration.

Cost of Pretreatment

The fourth critical issue that the pretreatment strategy must address is the cost of pretreatment. The primary driver behind pretreatment when it was conceived several years ago was to reduce the overall cost of disposal; pretreatment had to pay for itself or it couldn't be justified. Over the last few years, pretreatment drivers related to safety and other less quantifiable objectives have been imposed. For example, the health and environmental impacts from disposing of cesium in grout may be quite limited, yet removing the cesium from grout feed could be driven by As Low As Reasonably

Achievable (ALARA) considerations. The costs and benefits of each pretreatment process must be carefully weighed to assure that limited resources are allocated wisely. Preliminary alternative studies for the TWRS suggest that both the capital and operating cost of pretreatment could be substantial. Thus it becomes imperative to implement the pretreatment strategy in a cost effective manner. This represents an enormous challenge considering the state of knowledge of the requirements for pretreatment.

Process Maturity

The fifth critical issue that the pretreatment strategy must take into consideration is process maturity. The TWRS has conducted workshops to identify technologies with potential for application to pretreatment. For a required function, there are usually several technologies that have the potential to provide that function. Closer scrutiny often reveals that those processes deployed full scale in other situations may not be compatible with pretreatment objectives, or that the processes will require substantial development and modification to adapt them to treat Hanford waste streams. Frequently, the amount of information available about process concepts that have not seen full scale application will be limited to a few references, and the effort and time to bring them to maturity can be significant.

DESCRIPTION OF PRETREATMENT STRATEGIES

There are five pretreatment strategies currently being considered. These strategies represent alternatives to meet the dual goals of timely deployment of pretreatment on the one hand, and achieving the highest possible degree of separation (radioactive constituents from inert constituents) on the other hand. The strategies that will be discussed include:

1. Minimum pretreatment
2. Phased pretreatment--minimum pretreatment to advanced separations
3. Phased pretreatment--minimum to maximum pretreatment
4. Maximum pretreatment
5. Pretreatment to an intermediate form, hold the intermediate form, pretreat further and then immobilize
6. Delay pretreatment until technologies are mature

Common to all these pretreatment strategies is the need to resolve tank safety issues by destroying organics and nickel ferrocyanide as quickly as possible. A project to provide facilities for resolution of safety issues is currently in the engineering study phase. Several facility concepts for the Initial Pretreatment Module (IPM) have been considered, and candidate technologies are being evaluated. Expedited development programs are underway to bring the candidate technologies to a similar level of maturity before final process selection. Conceptual Design of the IPM is scheduled to begin in May, 1993.

Minimum Pretreatment

In addition to organic and nickel ferrocyanide destruction to resolve tank safety issues, the minimum pretreatment strategy involves the decantation of supernatant, sludge washing with water to remove soluble salts from the sludges, and cesium removal from the supernatant/wash water using a regenerable organic ion exchange resin. This is considered minimum pretreatment since it requires minimal facilities to implement (tank farms for decantation and sludge washing, and a facility for the ion exchange process), and the degree of separation (radionuclides from inert constituents) is the least of the five strategies. Other than the organic and ferrocyanide destruction processes, the processes used for minimum pretreatment are generally proven technology. Since the washed sludge consists primarily of insoluble inert compounds, the amount of pretreated HLW resulting from minimum pretreatment is large relative to some of the other strategies that perform further treatment of the washed sludges. The amount of HLW resulting from this strategy is incompatible with the current sizing of the Hanford Waste Vitrification Project (HWVP). In addition, the amount of radionuclides left in the LLW is higher than that left in the LLW from some of the other strategies because only cesium is removed from the supernate and wash water.

Phased Pretreatment - Minimum Pretreatment to Advanced Separations

This strategy entails starting with minimum pretreatment and storage of the washed sludges, while simultaneously developing the technology and facilities to do advanced separations on washed sludges. The underlying assumption of this strategy is that the facility requirements for sludge washing and some alkaline fission product processes are low to moderate, and the processes themselves sufficiently developed to be deployable in the near term. The advanced separations to be phased in consist of further aggressive treatment of the washed sludges to separate transuranics and strontium from the inert constituents. The inert constituents thus separated can be disposed of with the low level waste rather than in glass. The cost of advanced separations must, of course, be more than offset by reductions in the cost of waste immobilization and disposal to be justified. The sooner the advanced separations are phased in, the more cost effective they will be. This strategy has the advantage of providing early feed to the HWVP, although the early feed will not have had the benefit of advanced separations.

Phased Pretreatment - Minimum to Maximum Pretreatment

This strategy entails starting with minimum pretreatment, while simultaneously developing the technology and facilities to 1) reduce the inventory of radionuclides left on site and 2) concentrate the radioactivity into a smaller volume of HLW that would be compatible with the capacity of the HWVP. In addition to separating cesium from LLW, this strategy ensures that strontium, technetium, iodine and uranium are also recovered. This strategy also addresses potential hazardous waste considerations in those wastes disposed of on site by converting nitrites, nitrates and organics to non-hazardous forms, and the reduction of chromium(VI) to a less hazardous valence. The cost of implementing such extensive pretreatment is expected to be high, but could be offset by significant reductions in the overall cost of disposal. The sooner that these processes are phased in, the more significant will be the impact on the volume radionuclides and hazardous materials disposed of on site, and on the volume of HLW.

Maximum Pretreatment

Otherwise known as the "Clean Option", maximum pretreatment is similar to the previous strategy with the exceptions that pretreatment would not start until an alkaline liquid process line had been deployed to remove all water-soluble radionuclides of importance from grout feeds. Pretreatment of supernatants and salt cakes would proceed first. A sludge wash process would then be deployed and all washed sludges would be stored until advanced separations processes were available to treat the washed sludges. The objective of the "Clean Option" is to 1) minimize the inventory of radionuclides left at Hanford in near surface disposal, and 2) minimize the volume of the HLW (approximately 1,000 canisters of glass has been targeted).

Pretreat to an Intermediate Form

The final strategy is to pretreat all of the waste to some intermediate stable waste form to resolve safety and environmental concerns with continued storage in Hanford tanks, hold it indefinitely in that form, and then conduct final pretreatment prior to immobilization. This strategy basically postpones decisions on disposal to address the concerns of certain stakeholders who don't want to see any waste permanently disposed of at Hanford. The intermediate waste form would resolve the tank safety and hazardous waste issues that need to be resolved as soon as possible, while leaving open numerous options for further pretreatment and disposal.

Delay Pretreatment Until Requirements and Technology are Mature

In view of the current lack of definition with respect to pretreatment requirements and the development status of many technology alternatives, one strategy is to delay pretreatment while working toward a consensus on how much and what kind of pretreatment is required, with simultaneous development of pretreatment technology. Deployment would occur after a systematic decision process had arrived at definitive objectives for pretreatment and preferred technologies had been totally demonstrated.

HOW THE STRATEGIES RESOLVE THE ISSUES

Each strategy must provide processes to resolve waste tank safety concerns. The IPM project resolves those concerns and is integral to each of the following strategies. The IPM project itself faces the same deployment issues of composition and chemistry, degree of pretreatment required, timing and cost that must be addressed in the balance of each strategy.

Minimum Pretreatment

Minimum pretreatment is not nearly as sensitive to the lack of complete characterization and chemistry data as the more advanced processing strategies. The chemistry of the constituents that dissolve in water is fairly predictable. The washed solids are not subjected to advanced processes so their dissolution chemistry is not significant. The timing of deployment for minimum pretreatment is favorable from the standpoint of sludge washing because existing facilities can be modified to support relatively simple processes, and the technology is generally available. Recovery of Cs from alkaline solutions, on the other hand, will require a new, albeit modest facility. Some sort of temporary arrangement might suffice until the IPM facility starts up, since the IPM will provide permanent ion exchange capability. Cs technology is also available; it is primarily a matter of selecting the most appropriate technology and then optimizing the process for a specific set of conditions. The startup costs are also favorable because existing facilities can be modified in preference to building new facilities.

Minimum pretreatment, however, cannot be responsive to changing pretreatment requirements because of its limited objectives.

Phased Pretreatment - Minimum Pretreatment to Advanced Separations

Starting with minimum pretreatment and phasing in advanced sludge treatment processes allows additional time for developing characterization and chemistry data on the sludges while proceeding with the pretreatment of supernatants, wash waters and salt solutions. It may not be responsive to the imposition of additional pretreatment requirements, however, since this strategy is focused more on reducing glass feed volume than on producing very clean grout feed. A phased in approach can be deployed in such as way as to have minimal impact on the operation of the grout plant and HWVP.

Phased Pretreatment - Minimum to Maximum Pretreatment

The phased in approach deals with the current status of tank waste composition and chemistry by assuming that both will improve with time as core sample characterization progresses. The general approach is to deploy pretreatment capability as it develops to minimize the radioactivity and hazardous components disposed of on the Hanford Site through treatment of the hazardous components and a battery of radionuclide separation processes, while simultaneously minimizing the volume of high-level waste. This strategy partially addresses the perception that too much radioactivity and hazardous material is being disposed of on site, and in the absence of firm pretreatment requirements anticipates what those requirements will be. Unlike the Clean Option, this strategy does not defer the vitrification of washed solids until appropriate advanced separations processes are deployed. How quickly the solids processing can be brought online will ultimately determine the extent to which high level waste can be minimized. The phased in approach is facilitated by the compact processing concept, which also reduces the risk of committing large amounts of capital funding to a major processing facility.

Maximum Pretreatment

The maximum pretreatment approach deals with the major pretreatment issues by postponing any pretreatment action until composition and chemistry are fully understood, requirements have been fully defined, and technology has been developed to maturity. The Clean Option incorporates the concept of "decoupling" or deferring the treatment of solids while proceeding with the treatment of supernates and salt cake. Whether the high cost of such an elaborate processing scheme can be justified will depend to a great extent on the debate over how much radioactivity can be disposed of at Hanford.

Pretreat to an Intermediate Form

Pretreating waste to an intermediate, stabilized form and holding it is likely to require less detailed composition and chemistry information in the near term than some of the preceding strategies because the treatment objectives are more limited. This strategy only deals with the resolution of safety and hazardous waste issues and postpones decisions on separating waste to a future time when the objectives of pretreatment have been firmly defined. Consequently, additional time for determining final pretreatment requirements is made available. Because this strategy defers the pretreatment of stabilized waste, it is likely to require a considerable investment in facilities to hold the waste that is retrieved from single-shell tanks, pretreated and held. This strategy will defer conversion of high level waste to glass while decisions are made on furthering processing of the stabilized waste.

Delay Pretreatment Until Requirements and Technology are Mature

Delaying processing until all of the tank sludges have been thoroughly characterized and the pretreatment processes are fully developed resolves the issues arising from currently limited knowledge of tank sludge composition and chemistry. Delaying would also resolve the uncertainties with respect to how much pretreatment is required, provided the time is used to identify firm pretreatment requirements. Delaying until pretreatment is fully defined would be cost effective since processing facilities would not be equipped with processes that turn out to be unnecessary, and the cost of adding newly identified requirements to projects in progress would be avoided.

Unfortunately, delaying pretreatment does not contribute to the timely resolution of tank safety issues, nor to expediting disposal of tank waste.

ALTERNATE TECHNOLOGIES

For tanks having safety issues, minimum pretreatment will include the resolution of those issues. The Initial Pretreatment Module (IPM) project is currently in the engineering study phase. The purpose of IPM is to remediate waste safety concerns (potential for reaction between oxidants and organics, nickel ferrocyanides or hydrogen generated in the tanks) and satisfy grout feed acceptance criteria with respect to organic content and fission products. An initial large list of organic destruction technologies has been pared down to a few. Ozonation, wet oxidation, calcining (molten salt), hydrothermal (high temperature-high pressure), steam reforming and electrochemical processes are being carried by the IPM project as alternatives. For application to tank waste, these processes are in the early stages of development.

Minimum Pretreatment

For non-safety issue waste, minimum pretreatment consists of sludge washing and cesium removal. A functional diagram for minimum pretreatment is shown in Fig. 2. Preparation of flowsheets and mass balances for in-tank sludge washing is in progress. A batch washing approach and an alternative continuous clarifier approach are being considered. Laboratory scale sludge washing studies are in progress to characterize waste component washing efficiencies and product stream properties. Such studies are limited by the availability of actual core sample material.

The primary candidate for removal of dissolved cesium from the supernates and wash waters is *ion exchange*. Screening tests of candidate ion exchangers identified three media for further testing. CS-100 (a phenol-formaldehyde resin) and IE-96 (a zeolite) are commercially available from Rohm and Haas and UOP, respectively. A second resin (a resorcinol-formaldehyde polymer) developed at the Savannah River Technology Center (SRTC) is currently available in small quantities from Boulder Scientific. Extensive batch equilibrium testing with simulated Hanford waste solutions have been completed to determine the effect of temperature, Na concentration, equilibrium Na/Cs ratio, and initial Na/K ratio on the capacity of these exchangers. Development of engineering for loading, elution and regeneration* is in the early stages, and will include continued laboratory studies. The need for pilot testing of ion exchange is being evaluated.

Two alternate technologies for separating cesium-free waste fractions from waste solutions entail producing cesium free waste fractions by carefully controlled phase changes. A study is under way to determine if aluminum can be selectively precipitated from waste solutions by a carefully controlled pH adjustment, thereby producing an early feed for grout. Freeze crystallization may also be capable of separating a cesium-free salt solution for disposal in grout because of cesium's extremely high solubility. Alternate approaches to providing low cesium grout feed include selective in-tank precipitation and washing of bulk non-radioactive waste component. Carefully controlled aluminum precipitation by pH adjustment may produce a "better behaved" aluminum solid that is more amenable to settling and clarification. The cesium-bearing aluminum-depleted liquids could be concentrated to conserve tank space, and the separated aluminum solids could be redissolved to provide a low-cesium grout feed.

For several waste tanks containing liquid wastes with no sludges, minimum pretreatment may be limited to cesium removal in an effort to keep the Grout Treatment Facility (GTF) supplied with feed that has minimum environmental and public health impacts. Typical grout feed solutions contain ^{137}Cs ranging from 4 to 600 Ci/m^3. By comparison, waste classified by the NRC as Class A, B, and C may contain no more ^{137}Cs than 1, 44, and 4,600 Ci/m^3, respectively.

At this point in time, single-pass ion exchange with an inorganic exchanger or regenerative ion exchange with an organic exchanger are considered to be the most advanced technologies that can be implemented within the constraints of short-term deployment. Even then, the low capacity and instability of commercially available inorganic exchangers is unattractive. Since early in 1992, Sandia National Laboratory has made and continues to improve crystalline titanate exchangers with very high capacity for Cs even in highly alkaline simulated waste solutions. Production of crystalline titanate materials in a form suitable for single-pass ion exchange and in useable quantities is a high priority activity for 1993.

In tank "getters" (tetraphenyl boron and nickel ferrocyanides) that have been used in the past are not acceptable in today's regulatory and safety conscious environment. Powdered crystalline titanates with relatively high cesium capacity have been produced in the laboratory, and may find acceptance with further improvements in capacity and availability.

Other studies related to minimum pretreatment that are in progress include corrosion during sludge washing,

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* IE-96 (zeolite) is not being considered for regeneration because of its low physical stability in high pH solutions.

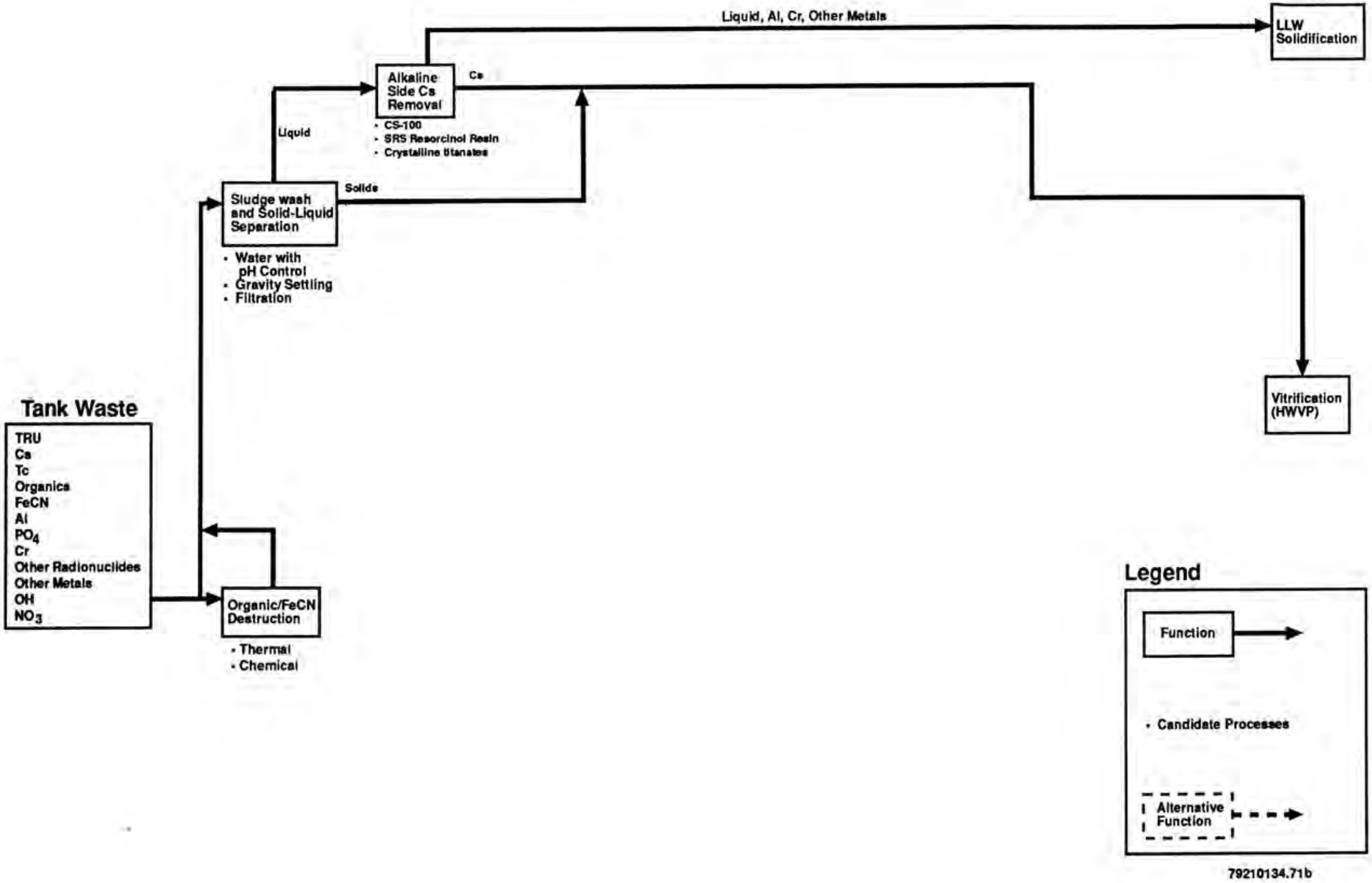

Fig. 2. Technical alternatives for minimum pretreatment strategy.

demonstration of an on-line TRU monitor, testing of solid-liquid interface monitors and corrosion probes, testing of suspended solids and temperature profile monitors, the effect of radioactive heating and mixing pump action on in-tank processing, and computer simulations of in-tank settling.

Advanced Separations

Laboratory scale studies with washed solids are in progress to determine the applicability of processes such as selective leaching of TRU and fission products, leaching chromium and aluminum, and selective precipitation.

More aggressive pretreatment technologies than those discussed above are being evaluated for deployment at a later date. Lab-scale studies with actual waste are proceeding to determine the susceptibility of single-shell tank sludges to dissolution by various chemical agents. Lab-scale studies are being conducted to evaluate solvent extraction for TRU removal as well as alternate processes such as ion exchange, precipitation, and extraction chromatography. Processes for Cs and Sr removal have been identified by national technology working groups and are currently being evaluated and tested.

Laboratory studies are also underway on a process that consolidates TRU, Cs and Sr removal into a single solvent extraction process. The main focus of current work is to find combinations of extractants that do not adversely affect the selectivity and capacity of the others and to identify effective scrubbing and stripping agents.

Various equipment related studies are also in progress including corrosion studies to identify appropriate materials of construction for long-term deployment, filter materials and performance, and solids behavior in centrifugal contactors.

Additional Technologies for Maximum Pretreatment

Hanford personnel are currently reviewing the literature for potential processes that could be further developed for the Clean Option. A functional diagram for the Clean Option is depicted in Fig. 3. The list of operations tentatively include the following alkaline liquid processes:

- Cs cation exchange
- Sr chelating ion exchange
- Tc anion exchange
- Molten salt processing to destroy organics, nitrates and nitrites
- Cr(VI) reduction
- NaOH recycle.

Sludge processing will include regular sludge washing and caustic leaching to remove aluminum. Acidic processing of the washed sludge will include the following:

- Acid dissolution of washed sludges
- U extraction with tri-butyl phosphate
- TRU/rare earth recovery by solvent extraction
- TRU/rare earth separation by ion exchange
- Sr/Ba recovery by solvent extraction
- Sr/Ba separation by ion exchange
- Cs recovery from acidic solutions
- Nitric acid recycle
- Water recycle.

CONCLUDING REMARKS

A submittal of the new TWRS proposed baseline is scheduled for March 31, 1991. At that time recommendations pertaining to remediation of the Hanford tank wastes will be made to DOE. A recommended pretreatment strategy will be an integral part of this rebaselining effort.

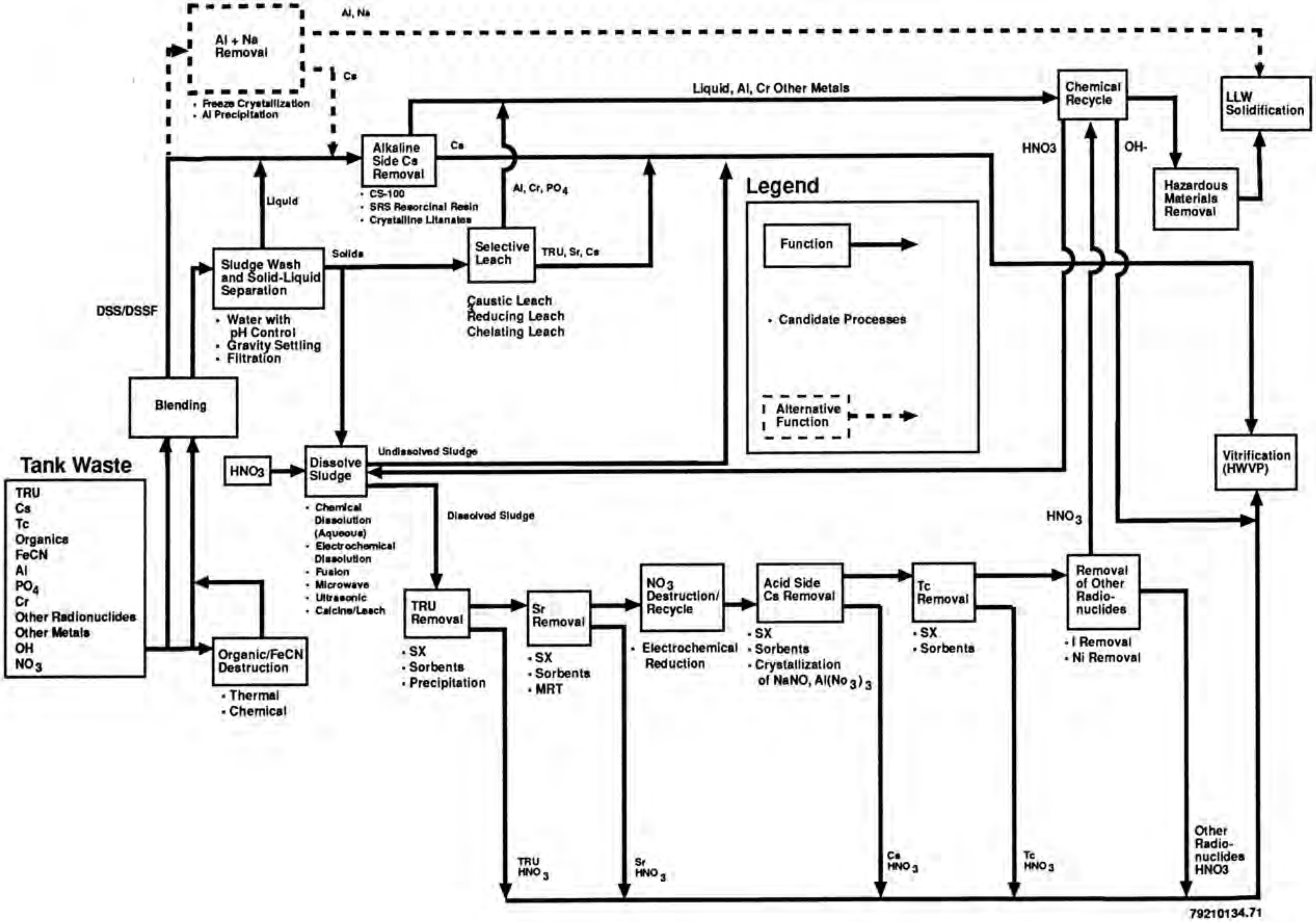

Fig. 3. Technology alternatives for maximum pretreatment strategy.