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Status Assessment of Readiness to Deploy Permanganate Treatment for Removal of Strontium and Actinides from Savannah River Site High Level Waste

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SUMMARY

This report assesses the merits of the process using sodium permanganate, instead of monosodium titanate (MST), to remove soluble strontium and actinides from Savannah River Site high-level waste. The assessment considered deployment in both the Salt Waste Processing Facility and within Building 512-S for the Actinide Removal Process. Finished development efforts demonstrate notable gains available in cycle time for the permanganate treatment option. In addition, the process will result in substantial reductions in equipment and facility size for the Salt Waste Processing Facility. Deployment of the technology within the Actinide Removal Process appears certain to result in substantial increases in facility throughput for the same equipment. Nevertheless, the technology lacks sufficient maturity to deploy in either project. The program needs to continue investigations of several aspects of the technology before adopting the process. The report describes the major elements of the recommended research and engineering including the following:

- Development of material balances and glass recipes for integration with the Defense Waste Processing Facility (DWPF),
- Additional demonstrations with simulated and actual waste including tests with concentrated wastes and experiments to confirm the optimal recipe for the process, and
- Initial demonstration of the DWPF operations and glass synthesis using waste treated by the permanganate process.

BACKGROUND

The current plan to dispose of high-level waste at the Savannah River Site uses MST to remove soluble strontium and alpha-emitting radionuclides to levels acceptable for disposal in the Saltstone Production Facility.[1] Both the planned facilities – the Actinide Removal Process in Building 512-S and the Salt Waste Processing Facility scheduled for later construction – assume use of this inorganic sorbent. However, plutonium and neptunium removal by MST proves relatively slow in these alkaline wastes with the kinetics for plutonium ultimately defining the equipment size or process cycle times (i.e., batch contact times of 24 – 30 hours). Furthermore, the current designs assume separation of the solids from the slurries by cross-flow filtration. The filtration rate (of 0.02-0.04 gpm/ft^2 for up to 5 wt % slurries) further defines the size of equipment, such as pumps, filters and tanks. For wastes with lower concentrations of plutonium, the filtration rates become process limiting for the overall facility.

Realizing these limitations, the Salt Processing Project initiated extensive research and development efforts to identify alternate process options with much work scheduled in fiscal year 2002.[2] One process alternative uses the addition of sodium permanganate and non-radioactive strontium nitrate to replace MST. Prior research proves this process effective in the treatment of waste from the Hanford, Washington, site.

This report discusses recent advancements aimed at deploying the permanganate treatment for Savannah River Site wastes. The authors summarize the assessment of the technology readiness for these applications as judged by a team composed of personnel from High Level Waste

Division, Tanks Focus Area, the Department of Energy, and the Savannah River Technology Center. Finally, the report provides recommendations for additional research necessary to mature the technology.

TECHNICAL BASES

The use of permanganate for removal of actinides and strontium from high level waste most recently gained favor in the River Protection Program dedicated to treatment of stored waste at the Hanford, Washington, site. Development started using Russian studies of the "method of appearing reagents" by Peretrukin et al.[3] This approach takes advantage of the onset of homogeneous crystallization of sorbents that show an affinity for actinides in alkaline solutions. Reduction of permanganate in the Hanford waste, through reaction with the included organic components, produces just such manganese oxides. In this application, addition of strontium nitrate also helps to reduce the concentration of radioactive strontium in solution. Numerous studies continue to complete development of this process technology for the Hanford program.[4,5,6]

The process requirements for treatment of the Savannah River Site waste differ from those at Hanford, most notably with the lower allowed concentrations for soluble strontium and alpha emitting radionuclides in the treated waste at Savannah River Site.[7] Further, current plans include treatment of most of the stored liquid and saltcake waste at Savannah River Site to remove actinides and strontium.[1] At Hanford, only two of the tanks contain sufficient strontium and actinide to require treatment.[8] The tighter restrictions on the treated waste and greater volume needing treatment at this location favor sorbents with relatively high efficiencies for sorption of the radionuclides. Hence, sorption with MST followed by filtration evolved as the preferred technology. Prior work demonstrated that glass made after treating waste with 0.4 g MST per liter of waste (at 5.6 M sodium content) would meet performance requirements. Unfortunately, current waste-characterization data suggests that as much as 7.5% of the waste will still contain excessive amounts of dissolved actinides after such treatment.[9] A more recent report defines the projected feeds to the 20% scale Salt Waste Processing Facility accounting for the revised operations.[10] That reference suggests that current plans to process waste with lower actinide content either directly through the Saltstone Production Facility or through the Actinide Removal Process in Building 512-S will increase the fraction of waste exceeding the limits. The program can address this deficiency by adding greater amounts of MST. (Other mitigation strategies also exist such as dilution of the waste and alternate blending scenarios.) The additional titanium content of the solids poses a concern for the glass ultimately made from the solids, as the titanium content exceeds the bounds of current testing. Consequently, personnel continue to seek alternate technologies to provide superior performance to MST.

Hobbs conducted the initial experimental investigation using permanganate to treat Savannah River Site waste.[11] That work proved the feasibility of applying the permanganate process through demonstrations with simulated waste. The work also suggested lines of inquiry for further development of the technology. Since that time, a number of efforts examined the removal efficiency with simulated waste,[12] demonstrated the process option with actual waste samples,[13] and examined the impact on the filtration process.[14,15,16] Additional studies examined the fundamental surface chemistry that occurs during the permanganate process.[17] Using this collected data set, Hobbs developed predictions of the amount of sodium permanganate and strontium nitrate required to successfully treat the waste.[18] Table I contains those estimated decontamination factors for treatment of average waste with varying amounts of radionuclides assuming no added strontium nitrate. Hobbs recommends assuming a minimum decontamination factor of 30 for strontium when adding strontium nitrate. Subosits and Campbell used those estimates, and assumed optimum concentrations of 0.03 M sodium permanganate with 0.01 M strontium nitrate, to provide comparative material balances for the Salt Waste Processing Facility using either MST or permanganate to treat the waste.[19] Additional work in progress includes an experimental demonstration that directly compares the performance of MST and permanganate treatment of waste in equipment that emulates that located in Building 512-S for the Actinide Removal Process.[20]

Table I. Estimated decontamination factor as function of added permanganate.

[NaMnO4]	**Initial [Sr] 191 nCi/g**	**Initial [Sr] 1130 nCi/g**	**Initial [Pu] 200 μg/L**	**Initial [Pu] 1100 μg/L**	**Initial [U] 10000 μg/L**	**Initial [U] 59000 μg/L**	**Initial [Np] 1900 μg/L**
0.005	1.61	1.069	1.26	1.038	1.022	1.0037	1.002
0.01	4.18	1.147	1.69	1.08	1.045	1.0074	1.004
0.02	>100	1.345	5.37	1.17	1.094	1.0148	1.008
0.03	>100	1.625	>100	1.29	1.148	1.0224	1.012
0.04	>100	2.053	>100	1.42	1.208	1.0301	1.015
0.05	>100	2.786	>100	1.59	1.275	1.0379	1.019

The solids formed during the permanganate treatment of waste prove easier to filter than the MST under comparable conditions (i.e., equal solids content), providing on average three times the flux rate.[19,14,15,16] Table II contains a comparison of filter performance for the permanganate and MST process options from data collected at "pilot scale". The permanganate data derives for demonstrations using lesser amounts of reagents than proposed as optimum. However, the current plans for facility operation will limit the concentration of solids transferred to the DWPF to a constant concentration of ~5 wt %. Hence, the relative performance shown in Table II remains approximately valid. Subosits and Campbell estimated that the higher available filtration and decontamination rate for permanganate allows use of (64%) smaller filters and a (33%) smaller hold tank for the waste.

Table II. Average Filter Flux and Permeance

Permanganate Addition[16]			MST Addition[21]			MST Addition[22]		
TIS (wt %)	Flux (gpm/ft^2)	Permeance (gpm/ft^2-psi)	TIS (wt %)	Flux (gpm/ft^2)	Permeance (gpm/ft^2-psi)	TIS (wt %)	Flux (gpm/ft^2)	Permeance (gpm/ft^2-psi)
0.076	0.19	0.0063	0.03	0.086	0.0021	0.04	0.079	0.0022
0.41	0.16	0.0052	0.25	0.068	0.0017	0.19	0.041	0.0012
1.46	0.13	0.0043	1.13	0.040	0.0010	N/A	N/A	N/A
2.66	0.10	0.0034	4.19	0.022	0.0006	N/A	N/A	N/A

N/A = not available

Experimental work to date indicates that manganese oxide solids formed by addition of sodium permanganate and strontium nitrate to high level waste trap less soluble plutonium per gram of resulting solids than MST particles under identical processing conditions. This difference implies that a permanganate treatment process will send greater amounts of solids to the DWPF than for the baseline MST process. The added manganese can result in a lower liquidus temperature and separate phases (e.g., spinels) in the glass. Researchers at Pacific Northwest National Laboratory and Savannah River Technology Center are exploring glass formulations to understand the range of composition acceptable for processing including concentrations of manganese that exceed those required by this process option.[23,24]

Recently, personnel successfully demonstrated the vitrification of an actual waste sample from Hanford after treatment with an analogous permanganate process.[25,26] The manganese content of this waste reached as high as 3.53 wt % (expressed as MnO) in these experiments, compared to an expected maximum value of 2.6 wt % for Savannah River Site wastes. (The maximum-expected value comes from unpublished work by H. H. Elder.) That glass met all product requirements, containing single-phase glass with leaching performance exceeding that measured for the Environmental Assessment standard glass. Experiments with simulated waste examined the behavior of glasses with even greater manganese, reaching 6.6 wt % MnO.[27] These glasses did show formation of spinels.

ASSESSMENT VERSUS PROJECT CRITERIA

The original High Level Waste systems evaluation to select the current configuration assessed each unit operation and the entire process against a set of criteria.[28] Adoption of new process technology should first consider the impact of the decision along these lines of inquiry. To perform this assessment the management team identified representatives for the Department of Energy, the Tanks Focus Area management, High Level Waste Engineering, and the Savannah River Technology Center. ATTACHMENT I contains the charter statement and the list of team members.

Table III lists the selection criterion used for the assessment and a short definition. ATTACHMENT II contains additional clarification on the definition for selected criterion. The Team altered the original definitions to reflect advancements in the project since the earlier work. Originally, the Team rated the process option for deployment within the Salt Waste Processing Facility. In the final assessment, the Team extended the scope to include deployment of the process option in the Actinide Removal Process within Building 512-S.

Assessment for Deploying in Salt Waste Processing Facility

During January 2002, the Team conducted the first assessment for deploying the permanganate process in the Salt Waste Processing Facility. ATTACHMENT III contains the results from that initial comparison. Table IV contains the updated ratings from the most recent scoring exercise conducted by the team. Changes in the ratings reflect the perceived gains made from the research that occurred since the previous assessment. Overall, the Team judged the permanganate process as lacking sufficient technical maturity and development to warrant replacing the MST process. A latter section of the report will describe the major development activities needed. The paragraphs following the table describe the bases for the scores.

Table III. Selection Criteria for Process Options.

CRITERION	DEFINITION
1. Schedule Risk	Salt Waste Processing Facility: the risk to providing sufficient data to allow the Engineering, Procurement, and Construction Contractor to meet the milestone for a conceptual design. The rating will assess the adequacy of data available at the anticipated award of the contract. Actinide Removal Process: The team evaluated the risk impact on life-cycle operations rather than radioactive commissioning.
2. Reduction in Life Cycle Costs	Potential to identify additional cost savings in the total project cost. Salt Waste Processing Facility: The team will evaluate this potential as a "delta" case from current estimates (contained in WSRC-RP-99-00006, Rev. 3 and WSRC-RP-2001-00410, Rev. 1) based on changes in footprint, equipment, raw chemical costs, and total canisters of glass produced.
3. Technical Maturity	The overall maturity of the process flowsheets (including the required strontium and actinide removal steps). The EM-50 stages of maturity are applied to each unit operation and the results are averaged – see ATTACHMENT II.
4. Implementation Confidence	Amount of relevant process experience (large-scale demonstration or deployment) in the DOE complex and industry for the key equipment used for each Strontium and Alpha removal process – see ATTACHMENT II. This criterion includes commercial availability of essential components and chemicals.
5. Environmental Impacts	Comparative assessment of environmental impacts from secondary waste streams, airborne emissions, and liquid effluents.
6. Impacts of Interface to Cesium Removal Process, DWPF, Saltstone, and Tank Farms including Pipeline Transfers	Changes in chemistry or operations of the Cesium Removal Process, DWPF, Saltstone, and Tank Farms including impacts of transfers, suspension, and required flush volumes.
7. Complexity of Safety Control	Listing of safety-related impacts and group consensus of severity of these impacts.
8. Maximize Process Flexibility	Capability to operate the process at a higher throughput based on the equipment in the current pre-conceptual design as well as any restrictions implied on varying the waste composition.
9. Maximize Process Simplicity (Operability)	Simplicity of the process as indicated by the number and difficulty of process steps.

Table IV. Team Assessment Ratings for Deployment in Salt Waste Processing Facility.

	Team Consensus Score (1-5)		
CRITERION	**MST**	**Permanganate**	**COMMENTS**
1. Schedule Risk	4	2	MST: 5 of 67 macrobatches not covered by nominal flowsheet. Permanganate: data only provides an operating point and does not fully explore compositional effects. We currently lack a firm estimate of the number of glass canisters and a definition of the glass formulation. The permanganate testing with actual waste remains sparse. Filtration data does not exist at the proposed recipe. In addition, the Nuclear Criticality Safety Assessment (NCSE) will not be available for EPC Contractor by September 2002.
2. Reduction in Life Cycle Costs	3	4	Permanganate offers shorter cycle time and smaller footprint for Sr/Alpha portion of flowsheet (due to faster kinetics and improved filtration). In contrast, permanganate may result in higher number of glass canisters with these costs offset the savings suggested by facility size. Full realization of the savings in process cycle time requires simultaneous improvements in analytical response time.
3. Technical Maturity	4	3	MST: Pilot-scale filtration tests. Prior ITP experience demonstrates chemistry if not kinetics. Permanganate reached Advanced Development (score = 3) with successful actual waste tests.
4. Implementation Confidence	4	3	MST: lacks actual waste demonstration at appreciable scale. Actinide Removal Process will provide that data. Prior ITP data gives some confidence although kinetics not demonstrated and filter flux declines without sodium tetraphenylborate. Permanganate: Oxalate precipitation in FB-Line represents a comparable process deployed in DOE complex but at smaller scale. Pilot scale testing at USC FRED showed no foaming concerns and confirmed rapid reaction – without verification of actinide removal.
5. Environmental Impacts	3	3	MST: alcohol content (already covered and only a trace component)

Table IV. Team Assessment Ratings for Deployment in Salt Waste Processing Facility. (continued)

	Team Consensus Score (1-5)		
CRITERION	**MST**	**Permanganate**	**COMMENTS**
6. Impacts of Interface to Cesium Removal Process, DWPF, Saltstone, and Tank Farms including Pipeline Transfers	3	2	MST: Titanium limit in glass restricts operating envelope. ORNL test at elevated temperature shows hardening of the slurry, as does operational experience with MST supplied by vendor. Permanganate: Process produces additional solids influencing the glass formulation (i.e., frit change) and may increase the number of glass canisters. Potential impact on redox behavior in DWPF needs assessed. Rheology of material not well known and may pose transfer risk although Hanford testing at ~20 wt % mitigates this concerns. Actual waste test shows no or minimal impact on CSSX process.
7. Complexity of Safety Control	3	3	Permanganate: No NCSE available but believed technically simple. Nominal flowsheet provide [Mn]/[fissile] ratio exceeding the fail-safe value. Process adds concerns on off-gas and operator handling issue. (No foaming observed in pilot-scale test at USC.) Accidental spill for permanganate or peroxide will need evaluated. All these concerns judged as relatively minor safety issues.
8. Maximize Process Flexibility	3	4	MST: Additional glass studies may allow increase concentrations of MST (Ti). Permanganate: decontamination efficiency shows less variance with ionic strength and may allow processing less diluted solutions. Potentially easier to accommodate additional Mn, rather than additional Ti, in glass. Improved filtration gives greater capacity for same equipment.
9. Maximize Process Simplicity (Operability)	4	3	Permanganate: chemicals – both permanganate and peroxide – have more pronounced shelf life issues than MST. Added chemicals increase training burden. Process control slightly more complicated as the reaction requires blending two reagents with the waste.
Totals	31	27	

Schedule Risk

Data for the permanganate option only provides definition of the operating point and does not fully explore compositional effects. Furthermore, the demonstrations with actual waste remain sparse. No demonstration exists at the defined optimum operational condition. In addition, we currently lack a firm estimate of the number of glass canisters and a definition of the glass formulation. Filtration data does not exist for the proposed recipe. In addition, the Nuclear Criticality Safety Evaluation (NCSE) will not be available for EPC Contractor by September 2002. The Team believes these represent the minimal additional data needed before accepting this technology as reliable for replacing the MST chemistry.

Reduction in Life Cycle Cost

The permanganate process offers savings in equipment size due to the faster cycle time and improved filter performance. This process does require additional reagents, adding a chemical storage tank and altering the operational costs. The cost savings estimates derive from a comparison of the conceptual design.[29,30]

Table V provides a rough approximation of the impact on reagent costs. (These costs do not include any bulk procurement discounts.) For the permanganate process, the cost information reflects the small quantity order value. Substantial reductions will occur when ordering in bulk.

Table V. Comparative Reagent Cost

Chemical	**Mass Needed (g/(L waste))**	**Unit Cost (\$/g)**	**Batch Cost (\$/(L waste))**
MST Process			
MST	0.4	\$124.60/gal [*] 130±13 g MST/L	0.103
Permanganate Process			
Sodium Permanganate	4.26	\$204/kg ABCR-Gelest (UK) Ltd.	0.869
Hydrogen Peroxide	1.53	\$42.50/L (30 wt %) Alfa Aesar	0.217
Strontium Nitrate	2.12	\$49.92/kg ABCR-Gelest (UK) Ltd.	0.106
Sum			\$1.192

[*] The MST cost data comes from the most recent procurement in 1995. Value shown without adjustment for inflation.

Table VI provides an initial description of the savings in equipment dimensions. The smaller tanks shrink the length of the shielded section of the building by about 4 ft. The smaller area results in direct savings in capital cost. The project will also realize a reduction in life-cycle costs with items such as the ultimate decommissioning costs for the facility.

We lack a revised formulation for glass based on the permanganate recipe and hence can not assess the potential change in number of glass canisters produced.

Technical Maturity and Implementation Confidence

The baseline process maintains a distinct edge in technical maturity with numerous demonstrations using actual waste. Research during this period extended the available data for MST to include the most restrictive waste whereas only limited data exist for the permanganate treatment. Similarly, vitrification demonstrations exist for the MST treated waste.

Table VI. Relative Equipment Sizes

Item	MST Process	Permanganate Process
Filters (filter area for concentration)	1,060 ft^2	380 ft^2
Tanks (working volume)		
Alpha Sorption Tank	88,900 gal	69,000 gal
Filter Feed Tank	112,200 gal	59,000 gal
Sludge Solids Receipt Tank	10,000 gal	15,000 gal
Wash Water Hold Tank	25,000 gal	30,000 gal
Facility Space		
Shielded cell space	12,360 ft^2	12,120 ft^2

Similarly, prior experience with MST during the commissioning of the In-Tank Precipitation facility and more extensive studies at pilot scale provide an edge for implementation of the technology. The criterion definition requires demonstration of the permanganate process with actual waste at pilot scale to achieve equal implementation confidence. Hence, without a change in SRS plans, the permanganate process can not close this gap until commissioning of the process at Hanford.

Impacts on Interfacing Facilities

Wilmarth et al. recently demonstrated that the product from the permanganate process causes no detrimental impacts on downstream solvent extraction operations.[31] The permanganate process does require a change in glass formulation and hence in DWPF operations.

Process Flexibility and Simplicity

The permanganate treatment shows negligible variance in efficiency with changes in solution concentration between 4.0 and 5.6 M sodium.[12] A good potential exists that the permanganate reduction reaction will effectively strip actinides from solution for more concentrated waste allowing an increased processing rate for the equipment. In contrast, the rate of plutonium sorption by MST drops rapidly as the solution concentration increases.[32,33]

Glass can only accommodate a limited amount to titanium, from MST treatment of waste, before forming a second phase. The currently demonstrated concentration proves inadequate to treat the entire waste inventory. Additional investigations of glass formulation might increase the allowable amount of MST.

The program has yet to develop and demonstrate a recipe for making glass from waste treated by the permanganate process. To reliably assess the degree of process flexibility, one needs a defined recipe and the understanding of the manganese concentration in the operations.

The permanganate process requires mixing of three regents into the waste. Since each of the three react with the waste, the process must control addition rates and timings to achieve the optimal homogeneous reaction in solution. This adds process complexity relative to use of MST.

Assessment for Deploying in Actinide Removal Process (Building 512-S)

During the most recent rating exercise, the Team decided to also examine the merits of deploying the permanganate process within Building 512-S as part of the Actinide Removal Project. Table VII contains the Team ratings for deployment within the Actinide Removal Project. The Team performed its assessment in a comparative manner, contrasting the features of the Actinide Removal Project with those of the Salt Waste Removal Project. The paragraphs following the table elaborate on the bases for the numerical scores.

Table VII. Team Assessment Ratings for Deployment in Actinide Removal Process.

	Team Consensus Score (1-5)		
CRITERION	**MST**	**Permanganate**	**COMMENTS**
1. Schedule Risk	3	3	Permanganate process, in simplest form, will require additional storage tanks (unless design authority elects to use drums). Will require development of additional procedures and training. Neither modification implies an interruption to the current schedule. Will require Authorization Basis revision.
2. Reduction in Life Cycle Costs	3	3	Permanganate offers the potential for faster process cycle times. Added capital costs for cold feed tanks will offset the savings. Currently, the Team lacks material balances and canister counts needed to make a comparison.
3. Technical Maturity	4	3	Same as SWPF
4. Implementation Confidence	4	3	Same as SWPF
5. Environmental Impacts	3	3	Same as SWPF
6. Impacts of Interface to Cesium Removal Process, DWPF, Saltstone, and Tank Farms including Pipeline Transfers	3	2	Permanganate: Impacts in DWPF on redox control and glass formulation require evaluation.
7. Complexity of Safety Control	3	3	Same as SWPF.
8. Maximize Process Flexibility	3	4	Same as SWPF.
9. Maximize Process Simplicity (Operability)	4	3	Same as SWPF.
Totals	30	27	

<u>Schedule Risk</u>

In considering the schedule risk for deploying the permanganate treatment in Building 512-S, the Team assessed impact on long-term radioactive operations. One option for deploying the technology involves adding the three reagents (i.e., sodium permanganate, strontium nitrate, and hydrogen peroxide) instead of MST. This option requires no change in equipment within the biologically shielded cells. The deployment may require the addition of an additional chemical storage tank. However, installation of that tank may occur with minimal impact on operations. Hence, the Team agreed that the two options carry equal schedule risk.

Reduction in Life Cycle Cost

The simplest deployment of the permanganate treatment process – using existing equipment – will have minimal impact on capital costs. Deployment may require one to two additional storage tanks for chemical supplies plus other piping changes. The Team believes the deployment would not need any additional penetrations of the cells as preliminary discussions suggest the design could route all the chemicals through existing lines. Assuming jacketed tanks of 500-gal capacity, we assumed an installed cost of about $100,000 (based on prior estimates for a 1000-gal jacketed tank for the solvent-extraction pilot facility within this facility). The cost does not include any additional piping from the "cold" chemical feed area to the cells of Building 512-S. If the process can not adapt to use of existing piping, the cost will increase considerably.

Impacts on Interfacing Facilities

Deployment of the permanganate treatment process in Building 512-S substantially increases the frequency of transfers to DWPF. Transfers will occur every 1-2 weeks versus every 6 weeks for the MST process. Integration with DWPF operations may require the addition of a new blend tank to allow batch treatment of the solids.

RECOMMENDED ADDITIONAL RESEARCH

Finished development efforts demonstrate notable gains available in cycle time for the permanganate treatment option. In addition, the process will result in substantial reductions in equipment and facility size for the Salt Waste Processing Facility. Deployment of the technology within the Actinide Removal Process appears certain to result in substantial increases in facility throughput for the same equipment. However, the program needs to continue investigations of several aspects of the technology before adopting the process. The following paragraphs describe the major elements of the recommended research.

The program needs to complete initial material-balance calculations that include DWPF operations and determination of the number of canisters produced. The calculations should also provide an initial recommendation of the recipe for vitrification based in part on prior studies conducted for Hanford wastes. The lack of this information represents the most critical weakness in the current evaluation. Personnel did begin this work in FY02 although the results remain unavailable at this time.

Personnel need to complete additional demonstrations of the process chemistry with both simulated and actual wastes to demonstrate predictable performance. Testing needs to include less dilute wastes to assess potential advantages in increasing the processing rate. Use of more concentrated waste also offers the potential to apply the technology in the large storage tanks and perhaps eliminating the need for including the operation in the Salt Waste Processing Facility. The DOE did authorize the start of this work in late FY02.[34]

Following selection of the optimal recipe for the treatment process, the program should initiate laboratory demonstrations of the DWPF operations. These demonstrations should include process simulations for the Slurry Receipt Adjustment Tank and the Slurry Mix Evaporator. The program should also give priority to conducting initial glass formulations. The program should also include demonstrations of the Hydragard™ sampler, although start of this work might await the other studies. (The smaller manganese solids and their degree of agglomeration will influence the tendency for preferential segregation from frit and sludge particles within the sampling loop.)

With less urgency, the program needs to acquire additional information on the physical properties and chemical stability of the solids produced. In selected cases, the program can make use of analogous data developed by the River Protection project for items like rheology[35] and thermal stability[31] to minimize the total program costs. In other instances, such as nuclear criticality safety, the program needs to develop project specific documentation such as a Nuclear Criticality Safety Evaluation for the process and impact on downstream facilities.

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Steve Subosits and Seth Campbell provided the material balances and equipment sizing information using either MST or sodium permanganate treatment options. Hank Elder, David Peeler, and Charles Crawford provided guidance on vitrification of the permanganate treated streams. Richard Hallen (Pacific Northwest National Laboratory) and Chi Leung (Washington Group International) kindly provided cost information and guidance for the chemical reagents used in the permanganate treatment option.

ATTACHMENT I

Charter and Goal for Assessment Team

Charter

The FY02 research tasks for support of the Salt Processing Project includes activities to investigate alternate technologies for both solid-liquid separation as well as for removal of strontium and alpha emitting actinides. The Department of Energy requested that the Tank Focus Area charter a team to develop the evaluation process for comparing and selecting between competing technologies. The team members include the following personnel.

Samuel Fink	Chair, TFA System Lead for Alpha and Strontium Removal
David Hobbs	process chemistry subject matter expert
Mike Poirier	solid-liquid separation technology subject matter expert
Carol Jantzen	glass chemistry and impacts subject matter expert
Rich Edwards	HLW Process Engineering
Steve Subosits	MST Baseline Process subject matter expert
Hank Elder	HLW System Plan subject matter expert
Sam Shah	design authority subject matter expert
Pat Suggs	customer (DOE) subject matter expert,
Bill Clark	customer (DOE) sponsor
Harry Harmon	TFA Technology Development Manager

Goals

The team developed the following list of goals that each technology should achieve. They patterned the goals in large part after those used in the original process selection effort leading to selection of the preferred (or baseline) process.

- Meet or exceed Process Requirements for
  - Strontium removal,
  - Removal of alpha emitters, and
  - Cycle time
- Meet schedule
- Minimize cost
- Minimize technical risk
- Minimize environmental, safety, and health (ES&H) risks
- Minimize impact to interfaces (with the Cesium Removal Process, DWPF, Saltstone, and Tank Farms including pipeline transfers)
- Maximize process flexibility.

Associated with the goals, the team defined the criteria for use in comparing the relative benefits of competing technologies. Again, the team developed this list by considering criteria used in the selection of the preferred technology for the project. However, given the more limited scope of this evaluation effort, the team refined the definitions for each criterion and eliminated some criteria from consideration. For each omitted criterion, the group either believed the feature offered no discrimination or that the team could not obtain reliable data by which to evaluate the technologies.

ATTACHMENT II

Scoring Methodology

The team decided to adopt the EM-50 "Gate" concept as the measure of Technical Maturity for the competing technologies. The following table provides the definition of the scoring metric.

Technology Maturity metric based on EM-50 "Gate" Model.

Score	Stage	Title	Activities
1	1	Basic Research	Fundamental scientific research, build knowledge, develop theories and analytical models, laboratory experiments, proof of principle
	2	Applied Research	Laboratory experiments, linked or needs, define materials requirements and design concepts, define cost requirements
2	3	Exploratory Development	Show technical feasibility, laboratory-scale prototyping, estimate costs, identify functional performance requirements
3	4	Advanced Development	Proof of design, full-scale laboratory tests, preliminary field test, develop technical specifications, hot cell tests with real waste
4	5	Engineering Development	Full-scale design, prototype and pilot-scale test, reliability testing
5	5	Demonstration	Full-scale operations with actual waste, prove economic viability
	7	Deployment	Proven technology, in-service treating actual waste cost-effectively

The group opted to judge Implementation Confidence using two measures. First, they agreed upon a score based on the following table. Secondly, the team ranked the relative confidence for uninterrupted vendor supply of the required chemicals or materials for each technology.

Implementation Confidence Metric

Score	Large-Scale Demonstration or Deployment in:
1	None of the below
2	Chemical industry
3	Foreign commercial reprocessing or waste treatment
4	SRS or other DOE reprocessing or waste treatment at different scale or waste disposition
5	Other DOE reprocessing or waste treatment at similar scale or waste composition
5	SRS reprocessing or waste treatment at similar scale or waste composition

ATTACHMENT III

Initial Assessment

The following table summarizes the results of the scoring exercise conducted on January 22, 2002.

	Team Consensus Score (1-5)		
CRITERION	**MST**	**Permanganate**	**COMMENTS**
1. Schedule Risk	4	2	MST: 5 of 67 macrobatches not covered by nominal flowsheet. Permanganate: program will only provide an operating point and does not fully explore compositional effects. Also, Nuclear Criticality Safety Evaluation (NCSE) will not be available for EPC Contractor by May 2002.
2. Reduction in Life Cycle Costs	3	4	Permanganate offers shorter cycle time and smaller footprint for Sr/Alpha portion of flowsheet (due to faster kinetics and improved filtration). Savings in capital cost might reach $200 million in the full-scale SWPF (To Be Confirmed). Permanganate may result in higher number of canisters. Savings in process cycle time require simultaneous improvements in analytical response time.
3. Technical Maturity	4	2	MST: Pilot-scale filtration tests. Prior ITP experience demonstrates chemistry if not kinetics. Permanganate might reach Advanced Development (score = 3) with successful, actual waste tests by May.
4. Implementation Confidence	4	2.5	MST: lacks actual waste demonstration at appreciable scale; Actinide Removal Process will provide that data. Prior ITP data gives some confidence although kinetics not demonstrated and filter flux declines without sodium tetraphenylborate. Permanganate: Oxalate precipitation in FB-Line represents a comparable process deployed in DOE complex but at smaller scale.
5. Environmental Impacts	3	3	MST: alcohol content (already covered and only a trace component)
6. Impacts of Interface to Cesium Removal Process, DWPF, Saltstone, and Tank Farms including Pipeline Transfers	3	2	MST: Titanium limit in glass restricts operating envelope. ORNL test at elevated temperature shows hardening of the slurry as does operational experience with MST supplied by vendor. Permanganate: Process produces additional solids and may result in higher number of glass canisters, more difficult transfers, and sampling issues in DWPF. Potential impact on redox behavior in DWPF needs assessed. Rheology of material not well known and may pose transfer risk. No data currently available to assess impact on Cesium Removal Process.

	Team Consensus Score (1-5)		
CRITERION	**MST**	**Permanganate**	**COMMENTS**
7. Complexity of Safety Control	3	3	Permanganate: No NCSE available but believed technically simple. Nominal flowsheet provide [Mn]/[fissile] ratio of ~28 which nearly equals the fail-safe value. Process adds concerns on foaming, off-gas, and operator handling issue. Accidental spill for permanganate or peroxide will need evaluated. All judged as relatively minor safety issues.
8. Maximize Process Flexibility	2	4	Permanganate: decontamination efficiency shows less variance with ionic strength and may allow processing less diluted solutions. Easier to accommodate additional Mn, rather than additional Ti, in glass. Improved filtration gives greater capacity for same equipment. (Assess whether to credit in LCC evaluation.)
9. Maximize Process Simplicity (Operability)	4	2	Permanganate: chemicals – both permanganate and peroxide -- have more pronounced shelf life issue. Added chemicals increase training burden.
Totals	30	24.5	

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