Innovative Technology
Summary Report

DOE/EM-0447

AEA FluidicPulse Jet Mixer

Tanks Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

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INNOVATIVE TECHNOLOGY
Summary Report

AEA Fluidic Pulse Jet Mixer

OST Reference #1511

Tanks Focus Area

Demonstrated at
Oak Ridge National Laboratory
Oak Ridge, Tennessee

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available onthe OST Web site at http://ost.em.doe.gov under "Publications."

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SECTION 1

SUMMARY

Technology Summary

Hundreds of U.S. Department of Energy (DOE) underground storage tanks contain radioactive waste requiring remediation. After many years of storage, the wastes have separated into layers of liquid and sludge. Remediation of these tanks involves waste removal and processing to stabilize the radioactive and hazardous components for long-term disposal. The heavy layer of sludge must be mobilized to remove it from a tank. A preferred method involves mixing the sludge with existing tank liquids rather than adding more liquids and increasing the waste volume. This approach produces slurry that can be easily removed from a tank.

The AEA Fluidic Pulse Jet Mixer addresses the need for an efficient, cost-effective system to mix and mobilize bulk quantities of sludge in underground tanks with limited access and internal obstructions. Using a small amount of added water or supernatant, submerged jets stir and mix sludge waste. If necessary, the waste can be pumped out of a tank when the desired consistency is achieved. This process is repeated until the bulk of the sludge is removed. Figure 1 displays the installation of the retrieval system at Oak Ridge National Laboratory (ORNL) on the Oak Ridge Reservation (ORR).

Fluidic pulse jet mixing technologies are operating commercially in various applications in the United Kingdom. These systems have no in-tank moving parts and have a proven history of maintenance-free in-tank performance. This combination makes them particularly suitable for radioactive waste operations.

Figure 1. Installation of the jet pump skid.

Pulse jet mixing has several advantages over alternative technologies:

- Generation of secondary waste is minimized.
- The system can often connect to a tank using the tank's existing infrastructure.
- The system is nearly maintenance free because it has no moving parts inside the tank.
- The life cycle of a pulse jet mixer is 25 years, as opposed to three years for a mechanical pump.
- Rapid installation is possible due to a modular design.
- The system can be used in tanks with interior equipment or flammable gases.
- The system can be used for multiple tanks by being moved from tank to tank.

The AEA Fluidic Pulse Jet Mixer was successfully deployed during FY98 and FY99 at ORR's Bethel Valley Evaporator Service Tanks (BVEST) site. The system was used to mobilize 43,100 gal of sludge in five tanks: W-21, W-22, W-23, C-1, and C-2. The mixer was installed in Tank W-21 over seven weeks during July and August 1997, a month ahead of schedule. In September, it began breaking apart the sludge in Tank W-21. During September and October 1997, a series of six jet mixing campaigns mobilized the sludge. Nitric acid was added to the tank before the final jet mixing to dissolve the remaining sludge. The system operated remotely for 52 days to mobilize and retrieve waste in W-21.

Demonstration Summary

Tank W-22 operations took place in January and February 1998, and W-23 operations occurred in April and May 1998. The C-1 and C-2 removals took place in February and March 1999. After completion of the C tank mixing operations, tank W-23 was mixed for seven days in March 1999 before final waste removal.

- This technology minimized the amount of additional waste created by using existing liquids for most of the additions.
- The system operated in multiple tanks by using existing pipe system cross-connections.
- The rapid installation alone resulted in a 30 percent cost savings over alternative technologies.
- The system achieved at least a 75 percent cost savings and a 50 percent schedule improvement.

The following parties contributed to successful deployment of the AEA Fluidic Pulse Jet Mixer:

- AEA Technology developed and fabricated the system and provided oversight and training.
- Tanks Focus Area supported AEA Technology in adapting the system for the ORNL application.
- DOE–Oak Ridge Office of Waste Management supported system adaptation and implementation.
- DOE–Oak Ridge Transuranic Waste Program Management provided leadership and established goals.
- Bechtel Jacobs Company managed the project and provided engineering support.
- Lockheed Martin Energy Research and Energy Systems designed installation interfaces and provided suppport in the areas of safety, engineering, field operations, and documentation.
- MK-Ferguson installed the system, supported radiation protection, and fabricated and operated a sluicer.
- Solutions to Environmental Problems, Inc. provided photographic and video coverage of operations.

ORR plans to deploy similar equipment at additional tanks. The system will also be used in FY99 to demonstrate mixing of a pump tank at Savannah River Site (SRS). Full deployment is being pursued through the Accelerated Site Technology Deployment Program.

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Other
All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for the AEA Fluidic Pulse Jet Mixer is 1511.

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

Goals for demonstrating AEA's Fluidic Pulse Jet Mixer included the following:

- Evaluate a system for efficiently mixing radioactive waste in underground storage tanks to mobilize the sludge for removal.
- Perform these activities in a cost-effective manner.
- Reduce time required to complete activities.
- Reduce risks.
- Minimize generation of secondary waste.

This operation is illustrated by the suction, drive, and vent phases represented in Figure 2.

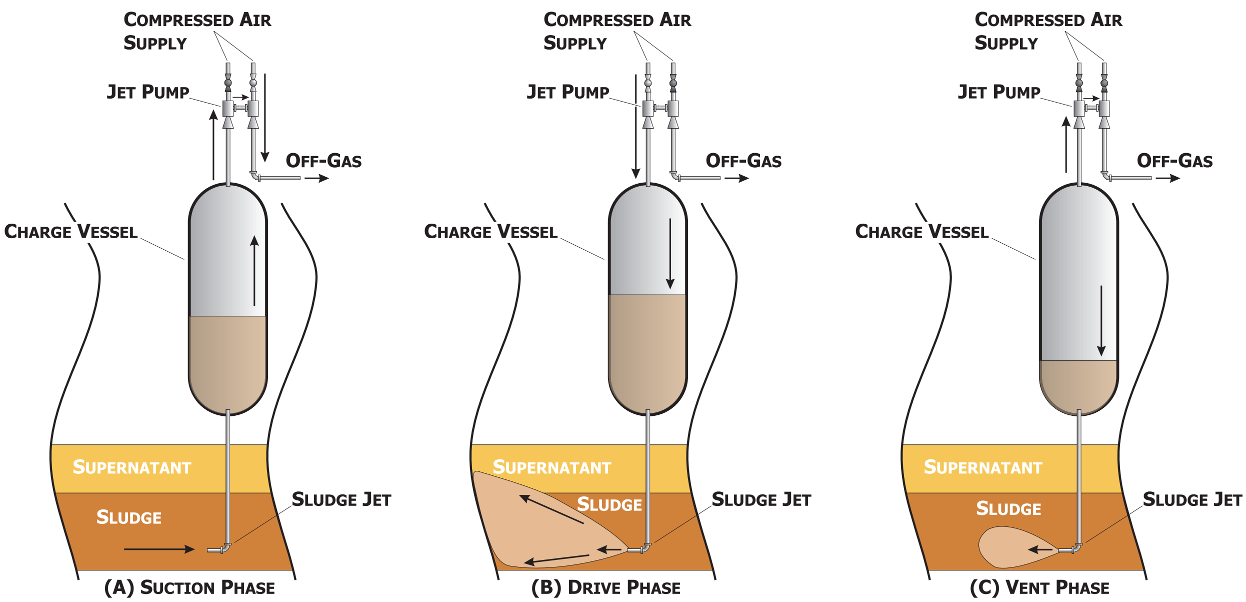

Figure 2. Operating principles of Fluidic Pulse Jet Mixer.

Modified Fluidic Pulse Jet Mixing Process for BVEST Deployment

At the BVEST deployment, the AEA Fluidic Pulse Jet Mixer was slightly modified to make use of six existing pipes in each tank. The 3-inch-diameter pipes hang vertically from the top of the tank in opposing pairs along the tank's length. The pipes extend to approximately 8 inches above the tank bottom, with 90^o elbows at the bottom. These pipes were originally installed for mixing purposes but were never used and were left in a blanked-off condition within the pump and valve vault (PVV) of the tank system. The process as applied to the BVEST deployment follows.

- The AEA Fluidic Pulse Jet Mixer was designed to use existing tank pipes by connecting each pipe to a charge vessel instead of a pulse tube.
- A small amount of water is added to the tank if necessary.
- The jet pump is first used to pull a vacuum on the charge vessel and draw material from the tank.
- When the mixture reaches a predetermined level in the charge vessel, the jet pump is switched from vacuum to pressure mode.
- Air pressure is applied to the charge vessel to force fluid back into the tank, mixing the waste.
- The system is vented to depressurize the charge vessel.
- Pressure, frequency, and sequence of pulsing for the six jets are adjusted to achieve optimum mixing.

The general process operates using only the suction and vent phases shown in Figure 2, while the modified process for the BVEST deployment uses all three phases: suction, drive, and vent.

Key Elements of the Technology and Support Equipment/Systems

The AEA Fluidic Pulse Jet Mixer deployed at ORR consists of the following seven equipment modules:

- Two charge vessel skids
- Jet pump skid
- Valve skid
- Off-gas skid
- Pipe bridge skid
- Control cubicle

Other notable aspects of the technology include:

- The valve skid, jet pump skid, and charge vessel skids were constructed of 304L stainless steel for corrosion resistance to the waste and compatibility with acidic cleaning solutions.

- Charge vessel skids were installed within the PVV at the ORR site, while the other skids were located on top of and adjacent to the BVEST vault cover. A separate trailer was used to house controls that are used to operate and monitor the system.

- The ORR deployment used existing submerged nozzles for mixing the settled sludges with existing supernatant in the tank. This setup is illustrated in Figure 3. Existing piping and progressive cavity pumps were also used for retrieval and transfer of waste mixtures.

- Sluicing tools may be used to aid in moving sludge toward a tank's suction nozzle.

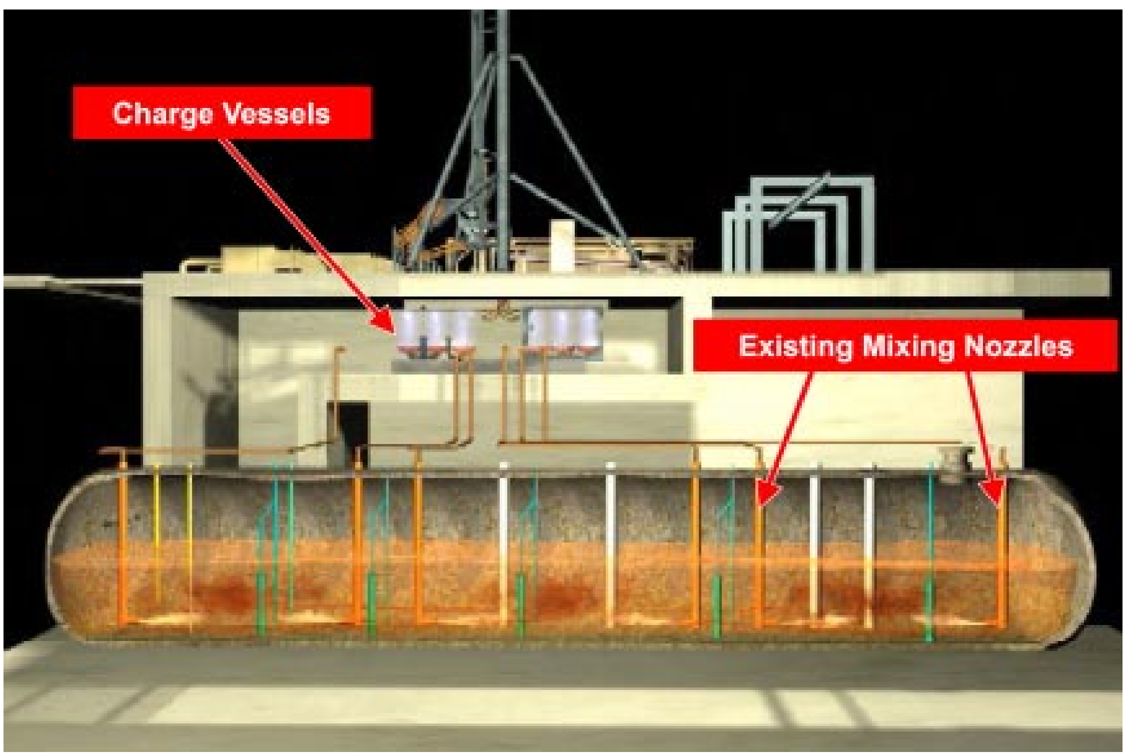

Figure 3. AEA Fluidic Pulse Jet Mixer in operation using existing mixing nozzles in Bethel Valley Evaporator Storage Tank W-21.

System Operation

Table 1 summarizes system operational requirements. Figure 4 shows a model identifying the system parts where they were installed at the BVEST site, and Figure 5 shows completed installation of the actual system.

Table 1. System operational requirements

Operational area	Requirement
Operating parameters and conditions	Modifications may be necessary to operate the system using a tank's existing infrastructure The tank mixture must be sampled prior to transfer out of the tank to determine the solids content of the mixture
Materials	Process waste, supernatant, and/or nitric acid may be added to a tank as needed to dissolve the sludge
Technical skills/training	General construction Process, instrumentation, and mechanical engineering Quality assurance and quality control Waste sampling techniques and tools Waste characterization Heel retrieval technology Regulatory requirements Montoring and inspection of systems operations
Secondary waste considerations	Addition of process water must be minimized Existing or recycled supernatant should be used to the extent possible
Concerns/risks	Worker exposure must be minimized during equipment installation and system operations

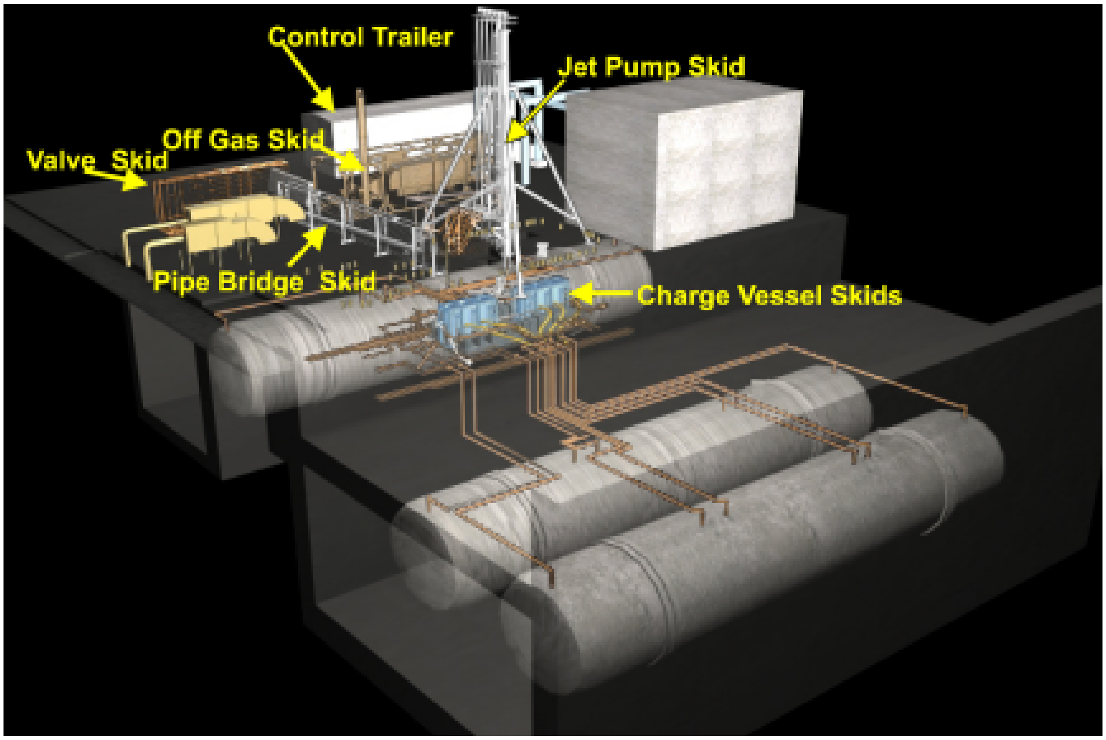

Figure 4. Three-dimensional model detailing the AEA Fluidic Pulse Jet Mixer installed at the Oak Ridge site.

Figure 5. AEA Fluidic Pulse Jet Mixer deployed at the Bethel Valley Evaporator Storage Tanks site in Oak Ridge.

SECTION 3

PERFORMANCE

Demonstration Plan

In FY97, AEA Technology modified the mixer to meet ORNL's specifications and completed a cold test in April 1997. The equipment was installed at the BVEST site in July 1997. Following commissioning, W-21 mixing operations were started in September 1997. Operations (including the tanks W-21, W-22, W-23, C-1, and C-2) continued into FY99. The BVEST site is located in the center of ORNL's main plant area and contains five horizontal, stainless steel storage tanks in underground, concrete vaults. These tanks are 12 ft in diameter and 61.5 ft long, with a capacity of 50,000 gal. They store evaporator concentrate and dilute radioactive liquid low-level waste. Radiation levels up to 27 rad/h have been detected in and around the tanks. Precipitants from the cooled evaporator waste formed a sludge layer 3–5 ft deep in the tanks.

DOE's major objective for deploying the AEA Fluidic Pulse Jet Mixer was to improve upon existing technology used to mobilize sludge to advance and refine the overall cleanup effort. Desired improvements included

- reducing time required for operations, leading to accelerated cleanup schedules, and
- reducing waste volumes in the tanks.

Table 2 lists the major elements evaluated during the deployment.

Table 2. Major elements evaluated during deployment of the AEA Fluidic Pulse Jet Mixer

Element	Success criteria
Installation	The system's modular design shall enable faster, easier installation
Maintenance	Maintenance shall be minimal
Mixing	The system shall effectively mobilize sludge in a timely manner
Risks/hazards/safety	Risk management shall include appropriate procedures, actions, and protective measures to mitigate potential risks and hazards and provide a safe environment for workers and the public
Cost	The system shall generate costs savings over baseline technologies
Schedule	Process completion time shall be less than that of alternative technologies

System Performance

All success criteria listed in Table 2 were achieved. Notable details follow.

- The system was installed in Tank W-21 and commissioned in approximately seven weeks.
- Installation was completed a month ahead of schedule, yielding a 30 percent cost savings.
- A tank inspection after the first waste transfer showed that jet mixing was able to mobilize the sludge in W-21, W-22, and W-23 for transfer out of the tank.
- Manual sluicing in Tank W-21 was successful in moving sludge from the nozzle areas and tank ends toward the tank's suction nozzle, where the fixed pulse jets were less effective.
- Tanks W-21, W-22, and W-23 were emptied in months, as opposed to an estimated three years to empty only one tank using alternative technology.

• Instead of relying on erratic cold-test data, visual observation and tank sampling at several depths during each campaign were necessary to judge uniformity of the mixture prior to transfer to the Melton Valley Storage Tanks. After the transfer, the in-tank video camera was used to inspect the tank and estimate the amount of sludge remaining. The estimated sludge quantity was used to determine the amount of liquid to add to the tank for the next mixing campaign.

Figure 6 illustrates the suction times versus mixing time that recorded after the first 120 h of campaign 3 of Tank W-21.

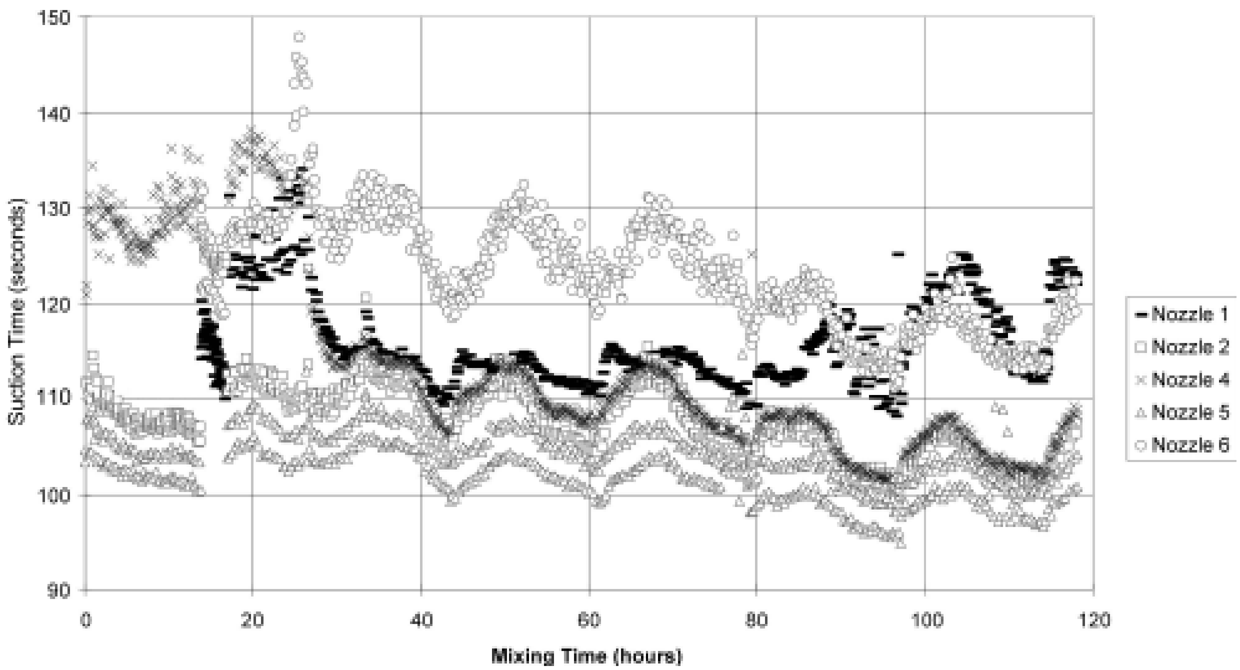

Figure 6. Charge vessel suction times versus mixing time for Tank W-21 campaign 3.

Table 3 provides detailed performance results for Tanks W-21, W-22, and W-23. Additional detailed performance data on each mixing campaign for Tanks W-21, W-22, and W-23, as well as sludge characteristics, are contained in Bechtel Jacobs 1998.

Similar performance was observed during C tank mixing and mobilization. Total reduction in sludge for the C tanks was as follows:

- Tank C-1 (95.5%, or 3,100 gal of sludge removed)
- Tank C-2 (98.9%, or 8,100 gal of sludge removed)

Table 3. Individual performance results for Tanks W-21, W-22, and W-23

Performance area	Tank W-21	Tank W-22	Tank W-23
Sludge removed	98% (7,100 gal)	>97% (6,800 gal)	96% (18,000 gal) Additional sludge removal at the time was possible, but operations were stopped because W-23 will be used to receive sludges from other retrieval activities Mixing following the C tank mobilization removed ~525 gal of sludge, yielding a total removal of 18,775 gal (>98%)
Liquid required to mix and transfer sludge	64,000 gal liquid for 7,100 gal sludge	52,000 gal liquid for 7,000 gal sludge	45,000 gal liquid for 19,000 gal sludge
Percentage of liquid used that was existing or recycled supernatant	88%	95%	96%
Process water and/or acid added	7,770 gal water	2,840 gal water or acid	1,780 gal water and acid
Sluicing activities	6,000 gal of process water was added to remove an additional 550 gal of sludge Dilute nitric acid was added to dissolve 350 gal of remaining sludge ~100 gal of sludge remained in all three tanks at completion	Not required	Not required
Total mixing and transfer campaigns completed	9	5	3 (plus 1 more following C tank mobilization activities)
Time required for system operation to remove waste	52 days, including a short amount of downtime and manual sluicer operations	19 days, with essentially no downtime	25 days (plus 13 following the C tanks), with essentially no downtime

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Cost, maintenance requirements, extensive system modifications, and additional water usage limited the alternative mixing systems considered. Table 4 provides a summary comparison of the Fluidic Pulse Jet Mixer to other competing technologies.

Table 4. Comparison of competing technologies

Technology	Advantages	Disadvantages
Fluidic Pulse Jet Mixers	Have few or no in-tank moving parts Effectively mobilize waste in storage vessels Require minimal or no maintenance Modular design simplifies installation Lower risk Generates significant cost savings over some alternative technologies	A number of tubes may need to be installed, depending on design Significant modifications may be required for aboveground transfer of pressurized waste since this is problematic in unshielded pipes
Jet mixer pumps	Successfully deployed at Savannah River and West Valley sites Fit through 42-inch risers Can be used for slurry mobilization, slurry mixing, and in-tank solids-liquid separation	High capital costs High installation costs Add heat to waste Limited operating lifetime May require frequent maintenance
Agitator-based systems	The most commonly used mixing technique in the chemical processing industry For tanks without a layer of settled sludge, Flygt mixers provide an alternative to jet mixers due to small size and low cost	Metallic measuring tape or other materials in the tank can get wound around the impeller, decreasing mixer performance

Table 4. Comparison of competing technologies (continued)

Technology	Advantages	Disadvantages
Pulsed-air mixing	Requires no in-tank moving parts Maintenance costs lower than for alternatives Mixes tank waste simulant slurries adequately in tests Potentially applicable to smaller (50,000-gal) horizontal tanks	Requires an excessive number of plates (~64) to mobilize sludge in large-diameter vertical tanks Installation of multiple air spargers would require additional access ports or a complex and expensive deployment system Additional design work and modifications would be required to control aerosols Heavy sludge settles out of the mixing plate range
Sluicing	As effective as jet pump mixers at mobilizing sludge Used for several campaigns at the Hanford Site	Single-point sluicing equipment would require significant design changes for use in horizontal tanks Requires large amounts of water and provides little control over the solids content of the slurry being transferred Expensive to install
Air-lift circulators	Already located in several Savannah River and Hanford double-shell tanks According to numerical models, flow rates are high enough to resuspend solids after being briefly shut off	Generally not effective at suspending heavy sludge, judging from Hanford experience
Arm- or crawler-based retrieval methods	Arm-based systems can be outfitted with end effectors for retrieving waste Arm-based systems such as the Borehole Miner extendable nozzle can be extended into a tank, positioned to avoid internal obstructions, and have a greater impact on remote areas in the tank	Better at hard heel removal than at continuous sludge suspension and mixing Require greater access to tank, additional equipment, and more maintenance Umbilical systems can limit a crawler's mobility
Chemical retrieval	Sludge can be retrieved more easily if the pH of a tank is altered, the temperature is raised, or other chemicals are added	Adding chemicals can increase tank waste problems Altering waste can increase volume and complicate downstream processing

Technology Applicability

The AEA Fluidic Pulse Jet Mixer has a proven track record of operation. The system has been tested, demonstrated, and deployed in the United Kingdom, where it is used today in commercial operations. As a result of an international agreement between DOE and AEA Technology, the system was deployed at ORNL and proven successful as a tool for mobilization of radioactive sludge.

The AEA Fluidic Pulse Jet Mixer has many applications, including the recently completed C tank mixing project, as well as additional deployments planned for ORR. A demonstration is also planned for FY99 to demonstrate mixing of a pump tank at SRS. Full deployment for additional tanks is being pursued through the Accelerated Site Technology Deployment Program. Other potential sites for deployment include the Hanford Reservation and Idaho National Engineering and Environmental Laboratory.

Considerations that favor selecting this technology for future application are as follows:

- The system has a proven track record for mobilization of sludge for retrieval.
- The technology can be applied to both horizontal and vertical tanks.
- The system was used on multiple tanks using existing cross-connections.
- The life span of a fluidic pulse jet pump is 25 years.
- Other cost savings can be realized through rapid installation, faster operations, and elimination/reduction of maintenance.

Patents/Commercialization/Sponsors

The AEA Fluidic Pulse Jet Mixer is commercially available from AEA Technology. Patent status is unclear at this time and is being researched by AEA Technology.

DOE sponsored the ORR deployment. Key parties involved with development and implementation of this technology are listed in Section 1 under Demonstration Summary.

SECTION 5

COST

Methodology

The AEA Fluidic Pulse Jet Mixer is part of the current baseline. The mixer is inserted through one small access port and can reach all locations in the 50,000-gal tanks. It is needed to meet the regulatory schedule of retrieval operations. Mechanical mixer pumps are considered the alternative for this analysis. Mixing the sludge inside BVEST tanks is very difficult, and the geometry of the tanks makes the effectiveness of a large, mechanical mixer pump questionable. Capital costs and operation and maintenance (O&M) costs for the AEA Fluidic Pulse Jet Mixer are compared to those for mechanical mixer pumps in the Cost Analysis section. This comparison is for a single pump and does not include the cost of supporting equipment modules for the AEA Fluidic Pulse Jet Mixer. Actual costs for deployment of the AEA Fluidic Pulse Jet Mixer at ORNL are detailed in the Cost Conclusions section.

Cost Analysis

Table 5 compares capital and O&M costs for a single pump installation of the mechanical mixer with those for the AEA Fluidic Pulse Jet Mixer system. Total cost savings increase with the life of the project because the AEA Fluidic Pulse Jet Mixer can last 25–30 years, whereas mixer pumps must be replaced and sent to disposal every 2–5 years.

Table 5. Comparison of capital and operating costs for single installation of mechanical mixer and AEA Fluidic Pulse Jet Mixer system

Action	Costs for mechanical mixer	Costs for AEA Fluidic Pulse Jet Mixer
Purchase	$350,000 for each agitator	$550,000 per tank for the duration of processing
Installation	Several hundred thousand dollars (replace after 2 to 5 years)	Less than mechanical mixer due to modular design; 30 percent cost savings was achieved at ORR by completing installation one month ahead of schedule
Disposal	$100,000 (dispose of old pump every 2 to 5 years)	$100,000 (dispose of one pump at the end of processing)
Operation and maintenance[a]	$20,000 per year plus maintenance downtime	$20,000 per year
Upgrades to tank infrastructure	$5 million to $10 million[b]	Supporting equipment can cost several million dollars unless existing facilities are available

[a]O&M costs per year:
Flow costs = 20 gal/min * 60 min/h * 10 h/wk* 52 wk/yr * $.002/gal
Labor costs = 20 h/wk * 50 wk/yr * $20/h

[b]Upgrades include preparing the tank to bear the weight of the mixer pump or building a superstructure to bear the weight external to the tank. Upgrades may not be necessary, depending on the tank.

Operating and maintenance costs

Operating costs are assumed to be similar to those of a mechanical mixer pump. Both require one to three workers to supervise the tank mixing, depending on site requirements. However, maintenance downtime will be greater with a mechanical mixer because the pump must be replaced. Maintenance downtime for pulse jet mixer is negligible.

Technology scale-up

A single AEA Fluidic Pulse Jet Mixer can be used in several tanks with little or no modification to the system. The fluidic mixer pump starts easily regardless of the amount of time between operations. The system can be scaled down for use on smaller tanks. Fabrication and installation of a number of supporting equipment modules will be required unless existing facilities are available. At Oak Ridge, these included the charge vessel skid, jet pump skid, valve skid, off-gas skid, pipe bridge skid, and control cubicle. The cost of these items is included in Table 6 below.

Cost-benefit analysis

Fluidic pulse jet mixing is expected to be applicable to a variety of mixing challenges at the DOE waste sites. The system can be deployed in a single operation for 25–30 years or used in multiple tanks, stored, and used at a later date to mobilize stored wastes. As noted by the ORR deployment, significant cost savings can be realized by using the AEA Fluidic Pulse Jet Mixing system as opposed to alternative technologies.

The amount of cost savings depends on a variety of factors. The following list identifies means by which cost savings are achieved.

- The system has the potential to save several million dollars per installation by using tanks' existing infrastructures.
- The modular design of the system enables rapid installation.
- The system eliminates, or drastically reduces, the need for maintenance and pump replacement.
- Savings can be generated through an accelerated schedule that results from both rapid installation and more efficient operations.
- Greater efficiency enables achieving desired results more quickly, safely, and economically.
- Replacement costs for system pumps are eliminated. (The life cycle of the fluidic pulse jet pump is 25 years versus three years for mechanical mixers.)

Cost Conclusions

Table 6 lists actual costs for deployment of the AEA Fluidic Pulse Jet Mixing System at ORNL. For the ORR deployment, at least a 75 percent cost savings and at least a 50 percent schedule acceleration were reportedly achieved. The previous estimate was to empty one of the W tanks with a three-year schedule for $15 million. The AEA Fluidic Pulse Jet Mixer emptied five BVEST tanks at a cost of $10 million in approximately two years.

Table 6. Total estimated costs for mixing, mobilization, and transfer of Oak Ridge tank sludges from five BVESTs using the AEA Fluidic Pulse Jet Mixer system

BVEST tank	Activities	Cost ($K)
W-21, -22, -23	Design and fabrication of AEA Pulse Jet Mixer System	~$2,500
W-21, -22, -23	Installation and transfer upgrades and operations	~$2,063
C-1 and C-2	Design and fabrication of AEA Pulse Jet Mixer System	~$2,700
C-1 and C-2	Installation and transfer upgrades and operations	~$1,300
C-1 and C-2	Installation of access ports (manholes)	~$1,500
Total		~$10,063

Source: ORO Need ID Number TK-03, September 30, 1998.

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

Site-specific regulatory drivers for remediation of tank wastes at ORR are as follows:

- Oak Ridge Federal Facility Agreement and Consent Order (between the U.S. Environmental Protection Agency [EPA] Region IV, DOE, and Tennessee Department of the Environment and Conservation)

- Tennessee Department of Environment and Conservation Commissioner's Order for the Oak Ridge Reservation Site Treatment Plan

- DOE Order 5820.2A/435.1 requiring treatment of transuranic waste for disposal at the Waste Isolation Pilot Plant

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980

The AEA Fluidic Pulse Jet Mixer was deployed on active tanks. Application of CERCLA criteria is not required at this time but will be when the tanks are closed. Criteria have been met already and are discussed below.

A formal risk management program was applied to this project. Risk management included detailed hazard and risk assessments, studies, and exercises. Potential risks were identified; characterized in terms of their causes, consequences, and likelihood of occurrence; and quantified by significance of their impact. Risk management actions were established, prioritized, and implemented, including quality assurance and control procedures and protection measures to cover all aspects of the project.

CERCLA Evaluation
This section summarizes how the AEA Fluidic Pulse Jet Mixer addresses the nine CERCLA evaluation criteria.

1. Overall Protection of Human Health and the Environment

    - Radiation exposure to workers is minimized during installation due to the system's modular design that allows for quick installation, and use of quick-connect couplings.
    - Exposures are mitigated through the use of personal protective equipment, additional temporary shielding, and personnel training to enable rapid assembly of equipment.
    - Remote-controlled operations and low-maintenance minimize radiation exposure to workers during operations.
    - Increased efficiency reduces exposure risks to human health and the environment.

2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

    - The system was designed and deployed according to applicable regulatory requirements.
    - Project management included monitoring to ensure requirements were met.

3. Long-Term Effectiveness and Permanence

    - The jet pump has an operating life of 25 years, compared to the mechanical pump, which has a life expectancy of only three years.
    - The system significantly reduces, if not eliminates, the need for maintenance due to the absence of moving parts inside a tank.

- Implementation can be accomplished faster than with alternative technologies, thus reducing cost and risks while increasing efficiency and safety.
- This technology can help accelerate tank remediation and closure schedules.

4. Reduction of Toxicity, Mobility, or Volume Through Treatment

   - As tank sludges and liquids are mixed, they enable retrieval of tank wastes, which reduces waste volume.
   - Waste volume is reduced as a result of minimizing secondary waste generation by using existing supernatant/liquids in the tank for mixing as opposed to adding process water/acid.
   - Because the time required to empty tanks is greatly reduced with this technology, empty tanks can be reused, or if necessary, prepared for closure.

5. Short-Term Effectiveness

   - As a result of the lower implementation costs, and tighter schedule, a Pulse Jet Mixer is highly effective in the short term.

6. Implementability

   - The system's modular design simplifies installation and operations.
   - Maintenance is minimal, if required at all.
   - Worker training and qualification programs and procedures are in place.
   - A control system exists for remote operation and monitoring of the system.
   - Safety interlocks and controls are provided.

7. Cost

   - Cost data are provided in Section 5.

8. State (Support Agency) Acceptance

   - Both the state of Tennessee and EPA are parties of the federal facilities agreement that covers regulatory issues and establishes requirements for management of tanks.

9. Community Acceptance

   - DOE-OR holds meetings with the public on a regular basis to discuss and provide a status of the DOE Transuranic Waste Program. Fact sheets providing technology updates are also distributed to the public.

Secondary Waste Stream
The wastes generated from the AEA Fluidic Pulse Jet Mixer consist of personal protective equipment, contaminated equipment and hardware, plastic sheeting and containers, hydraulic fluids, and structural steel support and platforms. These materials must be decontaminated or disposed of as radioactive waste. The disposal site must meet Resource Conservation and Recovery Act Land Disposal Requirements.

Safety, Risks, Benefits, and Community Reaction

Information for this section is covered in the previous section, Regulatory Considerations. Key benefits are discussed in Section 1 of this document under Demonstration Summary.

SECTION 7

LESSONS LEARNED

Implementation Considerations

- The system can be used to mix sludges in multiple tanks when cross-connections to nozzles exist.
- The modular design of the system allows for quick installation and minimizes radiation exposure to workers.
- Using existing or recycled supernatant can minimize generation of secondary waste.
- Use of on-line monitoring instrumentation for continuous measurement of density and solids content of the slurry could possibly shorten mixing times, reduce operating costs, and provide greater assurance of adequate mixing.

Parameters and requirements to be considered for applying this technology include the following:

- site-specific conditions
- system modifications to accommodate each tank's infrastructure
- characteristics of a tank's contents
- operating environment and needs
- protective measures to be implemented for worker safety

Technology Limitations and Need for Future Development

The sludge removal at Oak Ridge was limited by the physical characteristics of the sludge and the tank configuration.

APPENDIX A

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APPENDIX B

ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
BVEST	Bethel Valley Evaporator Service Tanks
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
FY	fiscal year
O&M	operation and maintenance
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OST	Office of Science and Technology
PVV	pump and valve vault
SR	Savannah River
SRS	Savannah River Site