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7. Abstract

Various methods were evaluated for decontaminating the Light Duty Utility Arm (LDUA). Physical capabilities of each method were compared with the constraints and requirements for the LDUA Decontamination System. Costs were compared and a preferred alternative was chosen.

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DECONTAMINATION TRADE STUDY FOR THE LIGHT DUTY UTILITY ARM

1.0 INTRODUCTION

1.1 PURPOSE

This trade study has been commissioned by the Westinghouse Hanford Company (WHC) to evaluate alternatives and recommend a preferred candidate for the decontamination of the Light Duty Utility Arm (LDUA), which is to be deployed in the Hanford Site tank farms.

1.2 SCOPE AND APPLICABILITY

The LDUA project is a joint effort involving WHC, Idaho National Engineering Laboratory (INEL), Oak Ridge National Laboratory, Pacific Northwest Laboratory, Sandia National Laboratory, and Westinghouse Savannah River Company. The scope of this study is limited to the selection of the LDUA decontamination method to be deployed in the Hanford Site tank farms. This report does not address the needs of project participants at the other sites, which may operate under different constraints and with different interfaces.

1.3 BACKGROUND

The Tank Waste Remediation System (TWRS) mission to store, treat, and ultimately dispose of Hanford Site tank waste in an environmentally sound, safe, and cost-effective manner encompasses the 149 single-shell tanks (SST) in the 200 Area tank farms. These tanks contain various quantities and mixtures of hazardous and radiological wastes in liquid, solid, and sludge form. Because of the hostile environment in the tanks, manned entry is impractical. This has led to the recognition of robotics as a possible method of performing required operations in the tanks.

Westinghouse Hanford Company, under sponsorship by the U.S. Department of Energy's Office of Technology Development (EM-50), has been studying available robotics technology that may prove instrumental in accomplishing the TWRS mission. A formal value engineering (VE) study has been conducted (Harrington 1994) to consider the operational aspects of the LDUA at its preliminary level of design at the Hanford Site. The LDUA is an articulated robotic arm system that is capable of deploying a variety of end effectors within the tanks using existing tank risers. The LDUA is being developed by a vendor.

Carbon dioxide (CO_2) pellet blasting was the proposed method of decontaminating the LDUA at this preliminary level based on the assumption that no water can be added to the SSTs during LDUA decontamination. However, the VE study recommended alternate

LDUA decontamination methods be considered for use at the Site due to the high costs anticipated with the acquisition and operation of the CO_2 system and the fact that the "zero water addition" constraint does not apply to all SSTs at the Hanford Site. Thus, this trade study has been initiated to identify alternate decontamination methods for the LDUA to be used at the Site, and to compare the costs of these methods to the preliminary CO_2 system. The objective of this trade study is to recommend the decontamination method to be utilized with the LDUA deployed in the tank farms.

2.0 SUMMARY OF RESULTS

The strategy in performing this trade study was to first identify the constraints and requirements for the decontamination system. Constraints are restrictions or limitations imposed by physical, programmatic, or regulatory interfaces. Constraints are not tradable; they are fixed conditions that dictate certain design specifications. Examples of constraints include physical limitations of interfacing equipment or structures, such as load limits on the tank dome. Requirements, in comparison, describe how well the system needs to perform a function. These may be tradable. Examples of requirements may include cost, availability, or specialized functions. These are typically traded in any given design selection, i.e., specialized functions are sometimes added at additional cost and/or reduced maintainability.

Various decontamination alternatives currently available are identified in Section 3.0 of this trade study. The capability of each alternative to satisfy the constraints and requirements are evaluated and ranked. This report differs from previous work (Capps 1993 and Manhardt 1993) in the following ways.

- This report evaluates decontamination systems specifically according to the needs of the LDUA to be deployed in the Hanford Site tank farms.

- Earlier reports ruled out methods that resulted in water addition to underground storage tanks. Recent information from Hanford Site tank farm operations indicates that water additions up to 1,892.5 L (500 gal) to a tank during a single entry are allowable. For certain activities, such additions have not posed permitting difficulties. As an example, water decontamination of the drill string is performed during push-mode core sampling.

- Overall costs of the alternatives are compared quantitatively. Additionally, cost is given a higher relative weight factor than was the case in earlier reports.

Various decontamination technologies are identified and evaluated in terms of constraints imposed by waste tank and LDUA configuration; and requirements concerning secondary waste, as low as reasonably achievable (ALARA), cost, design simplicity, decontamination effectiveness, and schedule support. Water decontamination (i.e., hydrolasing) proved to be the alternative that best satisfies the combination of these constraints and requirements. It is recommended that hydrolasing be used as the baseline LDUA decontamination method in Hanford Site tank farms.

3.0 TRADE STUDY

3.1 CONSTRAINT LISTING

The following constraints are imposed by the tank farm configuration and operating requirements, and by the design and operation of the LDUA:

C1 Tank dome loading: Loads imposed on the 22.86-m (75-ft) diameter tanks are limited to 889.6 kN (100 tons) (Boyles 1994).

C2 Tank waste containment: Tank waste, including any airborne particulate or vapors generated by in-tank operations, must remain contained during and after decontamination.

C3 Damage to equipment: The decontamination method must not damage the LDUA mast, arm, or end effectors.

C4 Compatibility: The decontamination method must be physically and chemically compatible with the LDUA, end effectors, deployment mast, and tank riser interface and confinement (TRIC) subsystem, and with the waste tank and its contents.

C5 In-place decontamination: The LDUA decontamination method must provide in-place decontamination while deployed in the tank rather than removal of the LDUA to a separate decontamination facility.

3.2 REQUIREMENT LISTING

Any decontamination system chosen *should* satisfy the following requirements:

R1 Minimize the secondary waste generated.

R2 Minimize the radiation and hazard exposure of operating personnel ALARA.

R3 Minimize capital and operating costs.

R4 Maximize the simplicity of the system and peripheral support equipment.

R5 Be capable of decontaminating the LDUA mast, arm, and end effectors to $<1{,}000$ dpm/100 cm^2 $\beta\gamma$ and 20 dpm α (<200 counts per minute smearable) contamination.

R6 Be capable of supporting timely completion of the LDUA campaign.

3.3 ALTERNATIVES LISTING

The decontamination alternatives considered in this study are listed in Subsections 3.3.1 through 3.3.17. Additionally, the "no action" alternative that implements no decontamination method into the LDUA system is investigated. The following paragraphs briefly describe each decontamination method investigated. For a more detailed description of the methods, see *Decontamination Investigation Report* (Capps 1993) and *Preliminary Recommendations and Design Package for a Decontamination System* (Manhardt 1993).

3.3.1 Hydrolasing

Hydrolasing involves directing a pressurized water spray at the target for cleaning. The pressurized water impacts the target and loosens the contamination, which is washed away by the water stream. This technology has been proven for equipment and facility decontamination.

3.3.2 Steam Jet

High-pressure steam is directed at a target for cleaning. Like hydrolasing, the pressurized stream impacts the target and loosens contamination, which is washed away by the steam. The elevated temperature of the steam also aids decontamination by effecting a thermal shock on the surface being cleaned, assisting the release of contamination.

3.3.3 Ice Blasting

Compressed air (1.38 MPa [<200 psig]) is used to direct a stream of ice chips at the target. Decontamination is achieved by surface crack formation and propagation. The melting ice and air stream sweep away the loosened contamination.

3.3.4 CO_2 Blasting

This method decontaminates a target surface by directing a stream of high-velocity CO_2 pellets at the surface. The pellets sublimate on impact, expanding as they return to the gaseous state. This cleans the target by flushing the surface with the expanding gas. The method is nondestructive due to the sublimation of the pellets, and it has been used to clean highly contaminated tools and facilities.

3.3.5 Abrasion

Two variations of this technology exist: (1) dry blasting propels fine abrasive particles toward a target using compressed air, while (2) liquid abrasive cleaning consists of forming a slurry of the abrasive particles and water, and directing the slurry spray toward the target material. Surface contamination is removed along with a layer of the target's surface.

3.3.6 Electropolishing

This method can only be employed with conductive materials because the object to be cleaned is the anode in an electrolytic cell. The anode is immersed in an electrolyte and electric current is passed through the cell. This results in dissolution of the anode's surface, releasing contamination from the surface. The anode is rinsed to remove any remaining electrolyte after the electropolishing process.

3.3.7 Light Ablation

Light pulses from a laser or xenon flash unit heat the surface film of the target area to 1000 to 2000 °C (1800 to 3600 °F) in microseconds, leaving the remaining substrate of the target material unaffected. Decontamination is achieved via three mechanisms: vaporization of the contamination, thermal shock of the surface film, and scouring of the surface by the vaporized material. The application of this technology to radiological decontamination is relatively new.

3.3.8 Scabbling and Spalling

This is a destructive technique used primarily on concrete. Mechanical impacting tools are used to remove a layer of the target material thereby removing any surface contamination as well.

3.3.9 Strippable Coatings

A coating is applied to the desired surface in liquid form (e.g., latex paint), fixing the contamination to the coating as it dries. When the dried coating is removed, the contamination is removed with it. Coatings also can be applied before contact with the contamination source in order to prevent contamination of the surface.

3.3.10 Wiping/Hand Scrubbing

This method is widely used, especially for low-level decontamination. The contaminated surface is wiped or scrubbed by hand using cloths, mops, power brushes, spray washers, or other equipment. Water or other chemicals can be used to enhance cleaning.

3.3.11 Biological Treatment

Biological treatment processes utilize either aerobic or anaerobic organisms. The anaerobic process is not considered to be practical for the LDUA as it would require an oxygen-free atmosphere. The aerobic process involves the addition of citric acid to the solution for decontamination to extract metal in the form of metal citrates. Next, the biological culture is introduced and incubated. The bacteria degrade the metal citrates except for uranium and chromium citrates. The precipitated metal citrates are removed while the supernate is subjected to heat or ultraviolet light to decompose the remaining citrates.

3.3.12 Kelly Decon

This method is similar to hydrolasing except that superheated water is used as the cleaning agent. A cleaning head is manually moved about the surface to be cleaned spraying superheated water that is then removed by a vacuum uptake system, which is similar to a commercial carpet cleaning machine.

3.3.13 Supercritical CO_2

Carbon dioxide above its critical temperature of 31 °C (87.8 °F) and at high pressure ($\approx$ 379 MPa [$\approx$ 55 ksi]) is forced through nozzles to generate CO_2 speeds up to 914 m/s (3,000 ft/s). This high speed CO_2 stream is directed at a target for cleaning. The CO_2 thoroughly penetrates the surface layer, flushing away contaminants along with some of the target's surface layer.

3.3.14 Gas Phase Flushing

This method is applicable only to uranium contamination. A strong fluorinating gas is used to charge a vessel containing the item requiring decontamination. The item is then left charged for a certain time period to allow complete diffusion of the gas throughout the material. The gas is then removed, and the uranium hexafluoride formed is recovered.

3.3.15 Ultrasonic Treatment

This method utilizes the scrubbing action of a liquid excited by ultrasonic frequencies to remove surface deposits. The object requiring decontamination is placed in a bath containing liquid, which is then excited. This process works best for relatively small, delicate parts that can fit into the ultrasonic bath and that cannot be subjected to some of the harsher methods discussed.

3.3.16 Microwave Scabbling

Like the scabbling/spalling technique discussed in Subsection 3.3.8, this method is used primarily as a destructive process to remove contamination from concrete. Microwave energy is directed at the surface to be decontaminated, heating the surface and any water present. Continued heating causes the water to vaporize, causing stress due to steam pressure and thermal expansion of the material. The surface bursts because of this stress, removing any contamination on the surface as well.

3.3.17 Chemical Washing

This method is similar to other washing techniques previously discussed, such as abrasive water jets (Subsection 3.3.5) and hand washing (Subsection 3.3.10). Instead of water or an abrasive water slurry, various chemical agents are applied to the surface requiring decontamination. The chemical solution can be applied either manually or by a spray jet.

3.3.18 No Action

This alternative examines the consequence of not using any decontamination method in conjunction with the LDUA. The LDUA would be repeatedly inserted and withdrawn from the tank without any part being decontaminated.

3.4 INITIAL SCREENING OF ALTERNATIVES VERSUS CONSTRAINTS

Because the constraints are not tradable, failure of a decontamination method to satisfy a single constraint results in the rejection of that method as an alternative for LDUA decontamination. Table 1 shows each alternative's ability to satisfy each constraint identified in Section 3.1. The ability of an alternative to meet each constraint was determined from discussions with vendors, tank farm operations personnel, and members of the LDUA project team. Satisfaction of the constraints was determined as follows:

C1 Tank dome loading: Each alternative is expected to result in a tank dome area loading <889.6 kN (<100 tons).

C2 Tank waste containment: Each alternative is expected to be capable of containing the waste that is removed during decontamination.

C3 Damage to equipment: The alternative failed if use of the method is expected to damage the LDUA equipment. Any method that involves the removal of substrate material from the item being decontaminated or that is expected to employ temperatures, pressures, or processes that could be detrimental to any of the LDUA components has the potential to damage the equipment.

Table 1. Alternatives Versus Constraints.

Alternative	Constraint satisfaction (yes/no)				
	C1	C2	C3	C4	C5
Hydrolasing	yes	yes	yes	yes	yes
Steam jet	yes	yes	no	no	yes
Ice blasting	yes	yes	no	yes	yes
CO_2 blasting	yes	yes	yes	yes	yes
Abrasion	yes	yes	no	yes	yes
Electropolishing	yes	yes	yes	no	no
Light ablation	yes	yes	yes	yes	yes
Scabbling and spalling	yes	yes	no	no	yes
Strippable coatings	yes	yes	yes	yes	yes
Wiping/hand scrubbing	yes	yes	yes	yes	yes
Biological treatment	yes	yes	no	no	?*
Kelly Decon	yes	yes	yes	yes	yes
Supercritical CO_2	yes	yes	no	yes	yes
Gas phase flushing	yes	yes	yes	no	no
Ultrasonic treatment	yes	?	yes	no	no
Microwave scabbling	yes	yes	no	no	yes
Chemical washing	yes	yes	?	no	yes
No action	yes	yes	yes	yes	no

*A question mark (?) is used when an alternative's ability to satisfy a given constraint is not readily known.

CO_2 = Carbon dioxide

C4 <u>Compatibility</u>: The alternative failed if the method was not considered to be compatible with the size, chemical makeup, or material properties of the LDUA components or tank waste because it is expected that the decontamination media could leak into the tank to some degree.

C5 <u>In-place decontamination</u>: The alternative failed this constraint if use of the method could not reasonably be performed as the LDUA is withdrawn from the tank.

The following methods have the potential to damage the LDUA components and thus violate the third constraint: steam jet, ice blasting, abrasion, scabbling/spalling, biological treatment, supercritical CO_2, and microwave scabbling.

The following methods are incompatible with the LDUA, end effectors, deployment mast, TRIC, or waste tank and thus violate the fourth constraint: steam jet, electro-polishing, scabbling/spalling, biological treatment, gas phase flushing, ultrasonic treatment, microwave scabbling, and chemical washing.

The in-place decontamination constraint (C5) is crucial to minimize risk, exposure, and schedule delays associated with the removal and transport of the LDUA to a decontamination facility in the event the LDUA or end effector directly contacts the waste. The following alternatives violate the fifth constraint: electropolishing, gas phase flushing, ultrasonic treatment, and no action.

3.5 SCREENING OF REMAINING ALTERNATIVES VERSUS REQUIREMENTS

The remaining alternatives are hydrolasing, CO_2 blasting, light ablation, strippable coating, wiping/hand scrubbing, and Kelly Decon. The following sections describe the process of selecting an option from these remaining alternatives.

3.5.1 Weighting of the Requirements

The weights assigned to the criteria reflect the relative importance associated with satisfying each of the performance requirements described in Section 3.2. This assessment of relative importance is based on the most current information available on operating procedures, regulatory requirements, and new technology. This is subject to change as information, experience, and interpretation of regulations change.

Weighting factors were determined by review of previous studies and by discussions and workshops with the LDUA project team. Equipment cost and simplicity were identified as higher-priority requirements (R3 and R4) as were minimizing personnel hazards and schedule support (R2 and R6). Each was assigned a weight factor of 2. The generation of secondary waste and expected relative decontamination factors are considered lower-priority requirements and were assigned a weight factor of 1.

3.5.2 Evaluating Satisfaction of Requirements for Each Alternative

Before applying any weight factors to the requirements, the degree to which each alternative satisfies each requirement must be determined. Numerical assignments are made to reflect the extent to which the alternative satisfies the requirement, with "10" corresponding to high satisfaction and "1" corresponding to low satisfaction. A value of "0" reflects a failure to satisfy the requirement. The criteria used to evaluate the alternatives and assign numerical scores are described below.

R1 Minimize the secondary waste generated: Alternatives that are expected to result in the addition of no secondary waste requiring treatment are ranked highest. Alternatives that are expected to result in the addition of low-level waste that can be treated separately from the tank waste are ranked lower. Alternatives that are expected to result in the addition of secondary waste to the tank itself are assigned the lowest numerical scores.

R2 Minimize the radiation and hazard exposure of operating personnel ALARA: Alternatives that are expected to be performed remotely, without the need for personnel stationed at the tank dome area, are ranked higher. Additionally, methods that do not require the use of high-fluid pressures or temperatures, high voltage, or materials that may be hazardous to operating personnel are ranked higher. Alternatives that are expected to require personnel to work directly in the tank riser area during decontamination are ranked lower.

R3 Minimize capital and operating costs: Alternatives that are expected to have high acquisition or operating costs are ranked lower than those for which the costs are expected to be lower.

R4 Maximize the simplicity of the system and peripheral support equipment: Alternatives that are expected to employ fewer and smaller-sized components are ranked higher, as these alternatives will require less maintenance, a lower spare parts inventory, and less space in the tank farm (thereby reducing congestion and equipment siting difficulties). Lighter equipment also reduces the tank dome load and enhances the overall system portability.

R5 Be capable of decontaminating the LDUA mast, arm, and end effectors to $\leq$1000 dpm/100 cm^2 $\beta\ \gamma$ and 20 dpm α ($<$200 counts per minute smearable) contamination: Alternatives that are expected to have the highest decontamination factors are assigned higher numerical values. Alternatives for which the decontamination factor is lower or not well established by operational experience are ranked lower.

R6 Be capable of supporting timely completion of the LDUA campaign: Alternatives that are expected to have the fastest setup and takedown times, and which are able to adequately decontaminate the LDUA in less time than the other alternatives, are ranked higher. Alternatives that require more time to deploy and disassemble, or which require time or labor-intensive steps (such as hand wiping), are ranked lower.

3.5.3 Ranking of the Alternatives

Table 2 qualitatively shows the degree to which each of the remaining alternatives satisfies the requirements identified in Section 3.2. A number between 0 and 10 is assigned to each alternative for each requirement using the criteria described in Section 3.5.2. The numerical value is then multiplied by the weight factor defined in Subsection 3.5.1 to adjust for the relative importance of meeting the requirement. Raw and weighted totals are shown to indicate how the weight factors affect the scores.

Table 2. Remaining Alternatives Versus Requirements.

Alternative	Requirement satisfaction scores/weight factor						
	R1/1.0	R2/2.0	R3/2.0	R4/2.0	R5/1.0	R6/2.0	Total
Hydrolasing, raw	3	10	10	9	7	9	48
Hydrolasing, weighted	3	20	20	18	7	18	86
CO_2 blasting, raw	10	9	3	2	9	6	39
CO_2 blasting, weighted	10	18	6	4	9	12	59
Light ablation, raw	10	7	1	1	9	4	32
Light ablation, weighted	10	14	2	2	9	8	45
Strippable coatings, raw	2	2	8	8	8	1	29
Strippable coatings, weighted	2	4	16	16	8	2	48
Wiping/hand scrubbing, raw	1	1	10	10	10	2	34
Wiping/hand scrubbing, weighted	1	2	20	20	10	4	57
Kelly Decon, raw	2	1	7	7	7	2	26
Kelly Decon, weighted	2	2	14	14	7	4	43

CO_2 = Carbon dioxide

The fact that the hydrolasing and CO_2 blasting alternatives received the highest scores (both weighted and raw) indicates that even without applying weight factors these alternatives lead the ranking.

Both the hydrolasing and CO_2 pellet blasting alternatives are under consideration for decontamination of the LDUA used in the Hanford Site tank farms. These alternatives are presented in greater detail in Section 3.6.

3.6 COMPARISON OF HYDROLASING AND CO_2 ALTERNATIVES

3.6.1 Hydrolasing

A conceptual hydrolasing system for decontaminating the LDUA used in the Hanford Site tank farms includes a 946- to 1,893-L (250- to 500-gal) supply tank, a 1.38- to 3.45-MPa (200- to 500-psig) pump, ≈ 30.48 m (≈ 100 ft) of high-pressure steel-braided hose, and a nozzle ring with four nozzles. A gasoline engine-powered electrical generator will supply power to the pump and controls. All equipment will be skid or trailer mounted for portability. To operate the decontamination system in below-freezing weather conditions, heaters and insulation will be provided to protect the tank, pump, hose, nozzles, and housing from damage.

Commercially available nozzles that have been investigated have a flow rate of 3.37 L/min (0.89 gal/min). Four nozzles are required to achieve complete coverage of the arm with the water spray resulting in a total flow rate of 13.47 L/min (3.56 gal/min). The arm will travel approximately 3.05 m/min (10 ft/min) during withdrawal for decontamination, and the maximum length that could require decontamination is 17.37 m (57 ft). This would then require 5.7 minutes to withdraw into the mast housing. Assuming the decontamination system was spraying continually, the maximum water added during withdrawal would be ≈ 76.8 L (≈ 20.3 gal). This would allow about 14 withdrawal cycles using a 1,135.5 L (300-gal) water supply tank.

The major advantages of this system are the overall simplicity of design resulting in low cost and power requirements (≈ 1.5 kVA). The system components are small and lightweight compared to the CO_2 system minimizing loading of tank dome area and congestion in the tank farm. The system is expected to be set up or taken down in approximately 1 week. The major disadvantage to this system is the generation of secondary waste (used decontamination water).

3.6.2 CO_2 Pellet Blasting

The method currently under development for LDUA decontamination utilizes CO_2 pellet blasting. The equipment used consists of a CO_2 dewar and two 2.4-m by 6.1-m (8-ft by 20-ft) cargo containers housing a pelletizer, support equipment (≈ 74.57 kW [≈ 100 hp] air compressor, ventilation fans, electrical distribution panels) and a separate maintenance unit with a clean room, control room, and glovebox. The CO_2 pellets are propelled through nozzles at the LDUA components using ≈ 0.9 m^3/s (≈ 2,000 ft^3/min) of compressed air (≈ 2.07 MPa [≈ 300 psig]). This requires additional safety features to protect the decontamination module and TRIC from over pressure in the event of a ventilation system failure. Active ventilation is required to exhaust the air, gaseous CO_2, and loose contamination through high-efficiency particulate air filters to the atmosphere.

The major advantages to the system are the nondestructive nature and effectiveness of the CO_2 cleaning, and the minimization of secondary waste. The major disadvantages to this system are the high-power requirements and cost. The system requires approximately 600 A of 480 V, three-phase ac electrical power (≈ 288 kVA). Currently, this is not available in any of the tank farms. The cost of the system is expected to exceed $600,000 for capital equipment. Other disadvantages include the size, number, and complexity of components, which pose additional risks to operating personnel and require additional time to set up and take down (approximately 2 weeks for each). Because of the power rating of the components, air and noise emissions permits for operation of the diesel generator and air compressor are required.

3.6.3 Cost Comparison

The estimated costs associated with the hydrolasing and CO_2 pellet blasting alternatives are shown in Table 3. Column one lists the two alternatives. Column two lists the basic required components of each alternative. The CO_2 system, as supplied by the vendor, already contains many of the components described for the hydrolasing system, such as engineering design and fabrication and miscellaneous controls. Column three lists the estimated costs associated with each component and a total amount. These estimates were obtained from vendors and contractors for the hydrolasing option. The CO_2 system cost estimate was provided by the Underground Storage Tank Integrated Demonstration EM-50 coordinator for CO_2 decontamination at INEL. Individual costs for each component were not available, so only the total cost is shown.

Column four lists the operating costs associated with a single campaign for each alternative. A campaign is defined as an entry into a tank riser. Each campaign is expected to last approximately 10 days after the LDUA is deployed in the tank. Operating cost estimates are based on two withdrawals of the LDUA from the tank each day. As described earlier, withdrawal speed is approximately 3.05 m/min (10 ft/min) with a total of 17.37 m (57 ft) of the LDUA and mast potentially requiring decontamination. For comparison sake, it is assumed that the decontamination system will be in continuous operation during each withdrawal cycle. This results in approximately 12 min/day of operation or a total of 2 hours per campaign for each alternative.

The capital equipment cost for the CO_2 alternative is more than five times greater than the hydrolasing alternative, and the operating costs are much greater. Costs for operating personnel are assumed to be equal for each alternative and are not included in the comparison.

A copy of an EM-50 cost estimate for a water decontamination system for the LDUA is attached as an Appendix. The EM-50 estimate assumes that tank farms will have to provide radiation detectors at a cost of $85,000. It is assumed in this trade study that the radiation detectors will be provided. Additionally, procurement costs for items such as the

Table 3. Estimated Cost Comparison.

Alternative	System components	Capital equipment cost[a]	Operating costs per campaign[b]	
Hydrolasing	• Engineering design, testing, and fabrication	$ 90,800	Water	29.2 ¢
	• Miscellaneous controls and instruments (TLI, low-level pump shutoff and alarm, nozzle flowmeter, discharge pressure regulator, etc.)	$ 15,000	Gasoline	$ 2.00
	• High-pressure pump	$ 3,500	Electricity	$ 3.11
	• Trailer	$ 3,000		
	• Portable gasoline generator	$ 2,000		
	• 1,136-L (300-gal) stainless steel water tank	$ 2,000		
	• Decon module	$ 1,350		
	• Hose	$ 600		
	• Nozzles and spray ring	$ 300		
	Total	$118,550	Total	$ 5.40
CO_2 pellet blasting	• Vendor-supplied unit includes the following:	$600,000	Diesel	$506.00
	- 6-ton CO_2 dewar		CO_2	$410.00
	- Two 2.4-m x 6.1-m (8-ft x 20-ft) cargo containers			
	- Pelletizer			
	- Ventilation equipment			
	- Decon module			
	- Nozzles and hoses			
	- Miscellaneous controls, alarms, and instruments			
	• Portable diesel generator	$ 40,000		
	Total	$640,000	Total	$916.00

[a]Equipment costs based on quotes from vendors.
[b]Operating costs based on the following rates for services and utilities:

Gasoline	$1.35/gal
Diesel fuel	$1.15/gal
CO_2	75¢/lb
Water	51¢/100 ft^3
Electricity	4¢/kW-h

CO_2 = Carbon dioxide
TLI = Tank-level indication

water pump, tank, and spray ring assembly are higher in the EM-50 estimate. All estimates are based on information considered accurate at the time this study was performed; however, they are subject to change.

3.7 CONCLUSIONS/RECOMMENDATIONS

It is recommended that the hydrolasing decontamination alternative be deployed as the baseline LDUA decontamination method for use in the Hanford Site tank farms. A comparison with several other decontamination alternatives revealed that hydrolasing best satisfies the combination of constraints imposed by waste tank and LDUA configuration, and requirements concerning secondary waste, ALARA, design simplicity, decontamination effectiveness, and schedule support.

The preliminary LDUA system design proposed the use of a CO_2 pellet blast method for decontamination. However, the hydrolasing decontamination method is recommended over the CO_2 alternative because it is expected to have much lower capital and operating costs and to utilize simpler and fewer components thus facilitating setup, takedown, and transportation between and within the tank farms.

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6.0 GLOSSARY

ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
INEL	Idaho National Engineering Laboratory
LDUA	Light Duty Utility Arm
SST	single-shell tank
TLI	tank-level indication
TRIC	tank riser interface and confinement
TWRS	Tank Waste Remediation System
VE	value engineering
WHC	Westinghouse Hanford Company

APPENDIX

TECHNOLOGY AND DEVELOPMENT COST ESTIMATE FOR TRIC WATER DECONTAMINATION SYSTEM

DON'T SAY IT --- Write It!

DATE: May 19, 1994

TO: G.R. Kiebel

FROM: J.D. Potter, H5-70
Telephone: 6-3708

cc:

SUBJECT: COST ESTIMATE FOR THE NEW TRIC WATER DECON SYSTEM

Per your request, I have prepared an unofficial "WAG" for what I think the expected costs may be to WHC for providing a high pressure water decontamination system for use in the TRIC. My findings are attached.

Jerry Potter

attachment:

54-3000-101 (9/59) (EF) GEF014
DSI

J.D. Potter
May 19, 1994

APPROXIMATE COSTS FOR TRIC WATER DECONTAMINATION SYSTEM

1.0 GENERAL ASSUMPTIONS:

The TRIC high pressure water decontamination system has not been designed nor thoroughly conceptualized at the time of this writing. Drawings have been made describing envelope/interfaces for the TRIC Enclosure and for the decon module. The following assumptions apply in general to this estimate:

- Costs are in terms of FY 94 dollars. Cost escalation and contingencies are not included.
- For this estimate, no distinction was made between Capital and Expense dollars, nor were there any schedules applied to when these expenditures would be made.
- Unless otherwise specified all TRIC equipment must comply with WHC-SD-TD-FRD-003, Functions and Requirements for the Integrated Light Duty Utility Arm System, (unreleased at this time).
- My function is only to coordinate/integrate the new water decon system into the TRIC, for which no additional funding is required. George Smith, will oversee the design, development, testing and procurement of the new water decon system. No extra funding is required for George to do this task.
- WHC/KEH will design the water decon module, which will then be fabricated off-site on a build per print contract.
- KEH (Rice/Maiden) will design the new TRIC air inlet, which will then be fabricated off-site on a build per print contract.
- The pump/tank unit required to supply the high pressure water will be procured from a vendor per design & fab contract. WHC will prepare a specification for this equipment.
- Tank farms operations will provide the portable exhauster.
- Radiation detectors to be furnished by INEL.
- INEL to continue to provide the riser adapter module, same as for CO2 system.

2.0 COSTS FOR WATER DECONTAMINATION SYSTEM:

This section deals with those costs associated with design and fabrication of the water decontamination system, consisting of an enclosure, fixed position spray ring, radiation detectors, pump/tank unit, spray isolation barriers, interconnecting hoses, etc.

DESCRIPTION	(Man-Mo) QUANTITY	($K/Mo) RATE	($K) COST
• Design (mechanical)	3.5	8.6	30.0
• Design (electrical)	0.5	8.6	4.3
• Engineering	0.5	10.6	5.3
• Procurement:			
- waterpump/tank unit			30.0
- enclosure			7.0
- rad monitors			85.0
- spray ring assy			7.0
- spray barrier			5.0
- miscellaneous (hoses, etc.)			5.0
MODULE TOTAL:			**178.6**

3.0 COSTS FOR TRIC VENTILATION (i.e. air inlet):

DESCRIPTION	(Man-Mo) QUANTITY	($K/Mo) RATE	($K) COST
• Design (mechanical)	0.5	8.6	4.3
• Engineer (KEH)			24.5
• Procurement:			
- air inlet			5.0
TRIC VENT TOTAL:			**33.8**

4.0 COSTS FOR PORTABLE EXHAUSTER:

No cost. Furnished by tank farms operations as a general, all purpose item of equipment.

5.0 COSTS FOR TESTING:

The scope of testing is TBD at this point. For estimating purposes it is assumed that testing is limited to determining optimum size, quantity, and types of nozzles, verification of cleaning at varied flow rates and pressures, and effect of water on various materials.

DESCRIPTION	(Man-Mo) QUANTITY	($K/Mo) RATE	($K) COST
• Engineer	1.0	10.6	10.6
• Technician	0.8	6.6	5.3
• Test equipment, instrumentation, etc.			5.0
TEST TOTAL:			20.9

GRAND TOTAL.... 178.6 + 33.8 + 20.9 = 233.3K