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7. Abstract <p>This plan supersedes, but does not replace, the previous Waste Receiving and Processing/Solid Waste Engineering Development Program Plan. In doing this, it does not repeat the basic definitions of the various types or classes of development activities nor provide the rigorous written description of each facility and assign the equipment to development classes. The methodology described in the previous document is still valid and was used to determine the types of verification efforts required. This Engineering Verification Program Plan will be updated on a yearly basis.</p> <p>This EVPP provides programmatic definition of all engineering verification activities for the following SWOC projects:</p> <ul style="list-style-type: none"> • Project W-026 - Waste Receiving and Processing Facility Module 1; • Project W-100 - Waste Receiving and Processing Facility Module 2A; • Project W-112 - Phase V Storage Facility; and • Project W-113 - Solid Waste Retrieval. <p>No engineering verification activities are defined for Project W-112 as no verification work was identified.</p> <p>The Acceptance Test Procedures/Operational Test Procedures will be part of each project's Title III operation test efforts. The ATPs/OTPs are not covered by this EVPP.</p>		
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**SOLID WASTE OPERATIONS COMPLEX
ENGINEERING VERIFICATION PROGRAM PLAN**

September 27, 1994

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LIST OF ACRONYMS

ATP	Acceptance Test Procedure
BNFL	British Nuclear Fuels, Ltd.
BNL	Brookhaven National Laboratory
CVS	container venting system
DOE	U.S. Department of Energy
DMS	Data Management System
EVPP	Engineering Verification Program Plan
FDC	Functional Design Criteria
FY	fiscal year
GEA	gamma energy assay
I-PAN	Imaging Passive and Active Neutron
IQI	image quality indicator
LEL	lower explosive limit
LLMW	low-level mixed waste
LLW	low-level waste
NDA	nondestructive assay
NDE	nondestructive examination
OTP	Operational Test Procedure
PCS	Plant Control System
PE	polyethylene
REC	Raytheon Engineers & Constructors
ROM	reliability, operability, and maintainability
RFP	request for proposal
RTR	real-time radiography
RTV	room temperature vulcanizing
SWITS	Solid Waste Information and Tracking System
SWOC	Solid Waste Operations Complex
TRU	transuranic
VOC	volatile organic compound
WHC	Westinghouse Hanford Company
WRAP 1	Waste Receiving and Processing Module 1
WRAP 2A	Waste Receiving and Processing Module 2A

UNITS OF MEASURE

cm	centimeters
ft	foot
ft ³	cubic foot
gal	gallon
Kg	kilogram
kV	kilovolts
L	liter
lb	pound
m	meter
m ³	cubic meter
mm	millimeter
ppm	parts per million

1.0 INTRODUCTION

1.1 PURPOSE {CL Bergeson}

This Solid Waste Operations Complex (SWOC) Engineering Verification Program Plan (EVPP) will:

- Identify all engineering verification activities required to support the SWOC technical basis and design efforts.
- Identify schedule and associated budget outlay to support all the SWOC projects engineering verification work.
- Establish the basis for statement of work instructions to the performing organizations.
- Track progress of the engineering verification activities; engineering verification activities will be reported in subsequent revisions of this EVPP.

1.2 SCOPE {CL Bergeson}

This plan supersedes, but does not replace, the previous Waste Receiving and Processing/Solid Waste (WRAP/SW) Engineering Development Program Plan (LeClair 1993). In doing this, it does not repeat the basic definitions of the various types or classes of development activities nor provide the rigorous written description of each facility and assign the equipment to development classes. The methodology described in the previous document is still valid and was used to determine the types of verification efforts required. This EVPP will be updated on a yearly basis.

This EVPP provides programmatic definition of all engineering verification activities for the following SWOC projects:

- Project W-026 - Waste Receiving and Processing Facility Module 1 (WRAP 1);
- Project W-100 - Waste Receiving and Processing Facility Module 2A (WRAP 2A);
- Project W-112 - Phase V Storage Facility; and
- Project W-113 - Solid Waste Retrieval.

No engineering verification activities are defined for Project W-112 as no verification work was identified.

The Acceptance Test Procedures/Operational Test Procedures (ATP/OTP) will be part of each project's Title III operation test efforts. The ATPs/OTPs are not covered by this EVPP.

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2.0 VERIFICATION TASK SUMMARY

2.1 WASTE RECEIVING AND PACKAGING MODULE 1 {KJ Leist}

The WRAP 1 facility will be the first facility of its kind in the United States to repackage drums of low-level waste (LLW) and transuranic (TRU) waste for permanent disposal on a production scale. Because of the drum source terms anticipated, all operations must be performed within gloveboxes. Repackaging activities are potentially dangerous, not only from a radiological standpoint, but also because the equipment is large, awkward and the potential for operator injury exist if sorting and repackaging were done by hand. Therefore, many of the sorting and repackaging functions are being designed to operate remotely or with minimal manual assistance to increase worker safety.

In support of WRAP 1 definitive design, testing was done to verify that the equipment designed could operate effectively and consistently within the confines of a glovebox environment. This testing included:

- Waste characterization;
- Entry and exit ports;
- Drum handling; and
- Waste handling.

2.2 WASTE RECEIVING AND PACKAGING MODULE 2A {KE Weingardt}

The WRAP 2A (Project W-100) is being designed to treat low-level mixed waste (LLMW) at the Hanford Site. As part of the engineering effort for this project several systems will require verification testing work to ensure workability and effectiveness for the facility. This work has been broken down into four major elements: (1) debris process, (2) cement stabilization process, (3) polyethylene process, and (4) general facility mechanical equipment. These elements have been further divided into distinct testing phases as seen in Figure 1. The schedule and associated budgetary requirements for these elements are shown in Figure 2. This report and the test plans for the various systems contain detailed descriptions of the verification testing. This verification testing will support the design, equipment procurement, and start-up of the facility.

07/26/94 BLT

Figure 1. WRAP 2A Work Breakdown Structure.

WRAP 2A ENGINEERING VERIFICATION -- (BY FISCAL YEAR)

9/12/94

Figure 2. WRAP 2A Schedule and Budget.

2.3 SOLID WASTE RETRIEVAL FACILITY {VP Ocampo}

The Solid Waste Retrieval Facility Phase 1, Project W-113, is a full-scale retrieval project to address retrieval of a portion of the waste that is expected to be intact with no significant risk of containers having the potential for questionable structural integrity or contamination release to the environment. The waste targeted for this project is located in the 200 West Area Burial Ground 218-W-4C Trench 04 and contains 105 Kg of Plutonium.

In support of the Solid Waste Retrieval Facility design, testing is required to verify that the equipment can operate effectively and consistently. This testing included:

- Vent and Sample Drums;
- Nondestructive Drum Assay; and
- Nondestructive Drum Examination.

The nondestructive examination (NDE) and nondestructive assay (NDA) equipment are similar to the equipment being provided for the WRAP 1 project, except that the Project W-113 equipment is transportable. Variations that require development work include the potential improvement to detect corrosion. The equipment is commercially available and has been developed for use in standard industrial applications; however, some evaluation of subsystem components for specific Project W-113 needs will be required.

The Project W-113 work breakdown structure is shown in Figure 3. The accompanying schedule and budget are shown in Figure 4.

Figure 3. Project W-113 Retrieval Work Breakdown Structure.

09/21/94 BLT

SOLID WASTE RETRIEVAL FACILITY (W-113) - VERIFICATION PLAN SCHEDULE (BY FISCAL YEAR)

9/21/94

Activities	1993	1994	1995	1996	1997
W-113 Facility Design / Construction	ACDR	▽	Title I ▽ Title II ▽	Construction	▽
CVS HEADSPACE GAS SAMPLING / ANALYSIS VERIFICATION:		▽			
		(45)	(20)		
NDE VERIFICATION:					
DRUM INTERIOR CORROSION (RADIOGRAPHIC) VERIFICATION			▽		
Prepare Demonstration Plan					
• Evaluate Oblique x-ray Technique					
• Evaluate New Technology					
ADVANCED NDE TECHNOLOGY AND EQUIPMENT VERIFICATION			▽		
Prepare Demonstration Plan					
• Large Field Image Intensifier					
• Tilt and Subtract Technique					
• High Energy 36" Linear Array					
IMPLEMENT PLAN			▽		
		(0)	(0)		
Budget (\$ in 000's):		45	20		

Figure 4. Project W-113 Retrieval Schedule and Budget.

3.0 WRAP MODULE 1

3.1 WASTE CHARACTERIZATION

3.1.1 Nondestructive Examination {JR Weber}

The Wrap Module 1 NDE systems specifications are based on evaluations of the test results from the demonstrations using the same test standards and 450 kV X-ray source for each type of imaging system. The WRAP 1 drum NDE system provides real-time imaging using a 9 inch (23 cm), high-contrast, high-resolution, image intensifier. This provides minimal test object distortion and can image through approximately 8 cm of steel. The drum NDE system also uses a 36 inch (91 cm) linear diode array, which provides a large field-of-view of the entire drum. The digital image distortion is minimal, and the examination time is 20 to 30 seconds per view. The image contrast is adjustable from the 12-bit data revealing up to 4,096 shades of grey or density levels. The linear diode array images are not dynamic or real time and are limited to a steel equivalent thickness of approximately 1.5 inch (3.8 cm). The imaging system is capable of examining both 55- and 83-gal (208- and 314-L) drums.

The demonstration and performance testing activities associated with developing the specifications for the WRAP 1 NDE and NDA equipment are detailed in the following documents.

- *Evaluation of Alternatives for Nondestructive Assay and Examination of Drummed and Boxed Waste in WRAP 1* (Weber 1991a)
- *Nondestructive Examination Development and Demonstration Plan* (Weber 1991b)
- *Test Plan for Nondestructive Examination of Boxes* (Weber 1992a)
- *Boxed Waste Assay System Test Plan* (Gilles 1991)
- *Drum Waste Non-Destructive Examination Interim Status Report* (Weber and Keve 1992b)
- *Mailscope V Packet X-Ray System Development Test Report* (Weber 1994a).

The WRAP 1 facility also includes a box NDE system using a 12 inch (31 cm), high-contrast, high-resolution, image intensifier (Lucas, 1992). A linear diode array is not provided in the box NDE system.

Ongoing efforts for the WRAP 1 NDE systems include review of design media and preliminary performance testing. A contract for both systems was placed with V. J. Technologies of Bohemia, New York, in May 1994.

3.1.2 Core Sampling {KJ Leist}

A basic function of WRAP 1 is to characterize all solid waste as part of the waste disposal certification process. Because approximately 50% of the waste was retrieved from the waste burial grounds and was stored with poor records, reviewing the original packing dockets does not provide adequate characterization. Issues concerning the characterization process are addressed in Sexton (1992).

Originally, the WRAP 1 waste sampling plan was to core sample waste drums immediately after the supercompaction process. This technique, although attractive from a process standpoint, had not been attempted with heterogenous waste. Therefore, a verification effort was implemented to better understand the technology, define its operating parameters, and fabricate a function core sample system. These efforts are documented in Hull (1992).

The testing effort was discontinued because it was determined that the technology was not well suited for heterogenous waste sampling. Three important barriers were determined. These barriers are listed below.

- High wear rate. The core sample bits are very expensive and wore very quickly during testing. The high wear rate was attributed to the core sampling tool colliding with the edges of hard metal fragments within the drum, thus causing high impact loads.
- High temperatures. Because of the combustible nature of the paper, plastic, and other solid waste within the drums, generated temperatures were of concern. Although temperature mitigation methods (e.g., compressed air injection) were employed, these temperatures remained a concern.
- Housekeeping. The core sampling function was a messy operation, particularly after compressed air injection was added to cool the core sample process.

3.2 ENTRY/EXIT PORTS {KJ Leist}

The entry/exit system was designed and extensively tested specifically for the WRAP-1 facility. This system is different from other double-lid bagless transfer systems because it uses air flow rather than a high-precision mating surface to maintain confinement. This feature permits standard drums to be used without the addition of a flange and inner lid assembly and allows the full opening to be exposed to the glovebox confinement. As its name implies, this system can be used for removing items from LLW enclosures, as well as inserting items into them.

3.2.1 Entry/Exit System

The entry/exit system was designed by United Engineers & Constructors, specifically for WRAP 1. It is a partial confinement system that uses standard drums as the container.

Initial testing was performed in accordance with the test plan (Winkleman 1993) and the results were reported in Winkleman (1993). During testing, the entry/exit system exhibited the following weaknesses.

- Drum "puffing". As the port closes, the confinement air flow decreases. At the same time, the recessed drum lid expels air from the waste drum. The result is a "puff" of air from the waste drum that is not swept into the confines of the glovebox.
- Ring of contamination. A ring of contamination is defined as a small portion of the port door and container lid that is both exposed to the glovebox interior and, when closed, to the exterior. Although characteristic of bagless transfer systems, the tested system exhibited a very large ring of contamination.
- Operating interferences. During operation, interferences were noted as the port door removed and replaced the container lid.

To alleviate these weaknesses, further testing was initiated on a modified entry/exit system. In this series of tests, the "puffing" problems were alleviated as well as the operating interferences; however, efforts to reduce the ring of contamination were unsuccessful. The results of these tests are documented in Ruff (1993a).

Consequently, a third testing phase was conducted to minimize the ring of contamination. The test scope was defined in Ruff (1993b). As a result of testing, the ring of contamination was successfully minimized and the system's confinement capability demonstrated. The results of this third testing phase are documented in Ruff (1993c).

3.2.2 Sphincter Seal System

The sphincter seal system testing scope was defined in Ruff (1992a). The primary focus was to assess system housekeeping requirements, seal endurance, and confinement. As a result of testing, the sphincter seal was found to operate with high flexibility, requiring little housekeeping. The seal was tested through 1,200 cycles and exhibited minimal wear. The results of the tests are documented in Ruff (1993d).

3.2.3 British Nuclear Fuels, Ltd. One Trip System

The British Nuclear Fuels, Ltd. (BNFL) one trip system is a total confinement style bagless transfer system based on a modified 55-gal (208-L) drum. The one trip system was initially designed and tested by BNFL but has never been used in a contaminated environment.

This system was identified for use in the WRAP 1 TRU gloveboxes as a means to repackage sorted waste and remove it from confinement for permanent disposal. A modification to the system's port diameter was made to enlarge it for use in WRAP 1.

The one trip system required testing to demonstrate the system operation and the modifications. The system was also to be used to determine methods of inner lid attachment for the one trip system 55-gal (208-L) drum. The testing scope is defined in Ruff (1993e).

During testing, a number of fabrication and reliability issues were identified:

- Sensitivity to fabrication and alignment tolerances;
- Cost, manufacturing difficulty, and expected life of port seals; and
- Hydraulic cylinder leakage and binding.

These issues were further defined and resolved through testing. Modifications to the baseline system were tested and proven. These activities are documented in Ruff (1994).

Waste packaged by the BNFL One Trip System, the drums would be certified in the WRAP-1 facility and transported to the WIPP site for disposal. To be accepted by WIPP, all packages must meet DOT Specification 7A packaging performance requirements. For this reason, a performance evaluation of the one trip system drums was initiated to assure adherence to WIPP waste package criteria.

Docket "94-35-7A, WRAP-1, One Trip 55-gallon Drum" was opened, through DOE headquarters, Transportation Packaging Safety Division (EH-332), in order to initiate performance testing. This docket number also identifies a packaging Qualification Checklist which describes the container and its packaging limitations.

Drop testing was initiated at Los Alamos, New Mexico in mid-July, 1994. Testing was unsuccessful, however, as a slight dusting of powder was noted on the 1000 lb drum lid after the 450 drop from a 4 foot elevation. This finding led to the addition of a rubber ring between the containers inner and outer lid.

A second series of drop tests was performed at Hanford under supervision of the Los Alamos test engineer. These tests were deemed successful after maintaining confinement throughout the drop test sequence. The results of these tests are expected to be issued once the review cycle is complete. Once complete, this package will be added to WHC-EP-0558, known as the "Blue Book" which is a catalog of Type A packages approved for use within the DOE.

3.3 DRUM CUTTING, DELIDDING, AND RELIDDING (*KJ Leist*)

While defining process operations, the seemingly simple function of opening and relidding a drum within the confines of a glovebox was identified as a formidable task.

3.3.1 Drum Delidding

Routine operations required that both the LLW and the TRU sorting glovebox be capable of opening drums. The following design requirements had to be considered.

- The method of drum opening had to permit relidding the drum after sorting was complete.
- The method of opening could not be halted by credible drum conditions, such as rusted clamp bolts.
- The method of opening had to be remote and not require significant operator effort.

Initial efforts centered on identifying viable methods of opening drums (Kanjilal 1991). This test plan also included a review of cutting tools for drum dismantling in the event a drum was in such poor condition that it could not be used as a waste container for supercompaction.

The results of the drum cutting testing are reported in Kanjilal and Leist (1991). In summary, a reciprocating saw was determined to be the most appropriate drum cutting tool. The saw was able to sever a drum clamp band without distortion and without significant container strength loss.

Following completion of the initial testing, Raytheon Engineers & Constructors (REC) requested further drum delidding testing to demonstrate that the drum lids could be removed using a vacuum cup assembly. The tests were performed and the results are documented in Ruff (1992b). The test results were considered successful, demonstrating that the vacuum cup system recommended by REC could, under a variety of conditions, remove and retain drum lids. Test conditions included smooth lids, rusted lids, dirty lids, and lids glued to the waste drum with room temperature vulcanizing (RTV) silicone rubber. The lids glued with RTV silicone rubber were the most difficult obstacle, although the test sequence demonstrated that delidding could be achieved by gently prying on one side of the drum lid with a screwdriver.

3.3.2 Drum Relidding

A second testing effort was identified to review methods of relidding drums (Griffin 1992). The primary requirements of this testing effort follow.

- The drum opening had to be performed remotely and could not require significant operator effort.
- The drum relidding had to be of adequate integrity to withstand supercompaction and subsequent springback.

One method of reattaching the drum lid by hydraulically crimping it in place was tested and the results are documented in Ruff (1992c). Other methods of relidding included using C-shaped clips, P-shaped clips, and standard clamp bands. During the supercompaction process, only drums relidded with standard clamp bands and with C-shaped clips remained intact. Further testing was then performed on drums relidded with the C-shaped clips to assess the reliability of the clips. The results are documented in Ruff (1992d).

A final relidding verification effort focused on ensuring that the relidding/delidding device, as designed for glovebox installation, would actually perform as desired. The planned verification effort is described in Weber (1993a). The actual verification effort only tested crimping assembly following feedback to design. The results are documented in Burgess (1994).

3.4 WASTE HANDLING {KJ Leist}

3.4.1 Aerosol Can Puncture System

Sorted waste may contain aerosol cans. Disposal waste acceptance criteria require that these cans be depressurized and that any internal liquids be immobilized. This function is performed in the WRAP 1 Restricted Waste Management gloveboxes.

As part of process definitive design, a custom device was designed to depressurize aerosol cans. Can draining and liquid immobilization were then to be performed as separate activities. Through review of its design, however, concerns were raised by WHC Fire Protection as to the system's fire or explosion potential. An engineering study, WHC-SD-W026-ES-011, titled "Aerosol Can Puncturing Device Evaluation", was issued to address these concerns. While the engineering study found that all features in the design had been proven in commercially available puncture devices, it was WHC's decision to require that the system be tested by an independent laboratory or modified to use a commercially available puncture device.

A new system was then proposed as a substitute for the baseline design. The new aerosol can puncturing system is based on a commercially available puncture device mounted on a frame that integrates a disposable liquid collection bottle and a propellant filter. In one step this system punctures and drains an aerosol can, containerizes expressed liquid, and filters released organic vapors. Absorbent contained in the liquid collection bottle also immobilizes liquids as they drain from the aerosol can.

The aerosol can puncturing system is based on a commercially available puncture device mounted on a frame that integrates a disposable liquid collection bottle and a propellant filter. In one step this system punctures and drains an aerosol can, containerizes expressed liquid, and filters released organic vapors. Absorbent contained in the liquid collection bottle also immobilizes liquids as they drain from the aerosol can.

The test plan for the aerosol can puncture device is documented in Leist (1994a). Before the system could be implemented into the glovebox design, several operating concerns were raised and are listed below.

- The puncturing device internals may overpressurize, causing the liquid collection bottle to rupture.
- The propellant filter must be operated remotely and should not require significant operator effort.

The following observations were made during testing.

- Because of rapid depressurization, liquid expressed from a pressurized aerosol can tended to foam as liquified propellant quickly vaporized. When full aerosol cans were punctured, the foam tended to overflow the liquid collection bottle.
- Expressed liquid tended to pool on top of absorbent located within the liquid collection bottle. This reduced the available volume, and allowed expressed liquid and foam to overflow the liquid collection bottle.

As a result of testing, the prototype was modified to enhance the system's operating characteristics as follows.

- The can puncture needle was reduced. This extended the drain duration, allowing foam to subside. This also reduced the discharge pressure.
- A secondary liquid collection bottle was added. This was added to collect liquid or foam that might overflow the primary liquid collection bottle.
- A corn cob-based absorbent was identified. This absorbent possessed rapid absorbing properties.

Complete test results are documented in Leist (1994b).

3.4.2 Manipulator System Definition

Sorting waste within process gloveboxes is seen as a hazardous operation because it involves opening waste packages and sorting through drummed solid waste. This drummed solid waste contains a variety of failed equipment; consumables; and construction, or demolition, debris. Although NDE efforts help identify items that may be present in a package, sharp or pointed items may still wound a worker. Robotic manipulators were added to the process glovebox design to alleviate this risk.

Although robotic manipulators are commercially available, they have not yet been applied to glovebox operations. Therefore, a verification effort was initiated to ensure successful application in the WRAP 1 gloveboxes. The verification effort focused on the following specific areas.

- Evaluate the manipulator coverage within the confines of a glovebox.
- Evaluate jaw control system requirements to handle, but not break, jars and bottles.
- Evaluate operator viewing requirements.
- Evaluate the manipulator's package opening abilities.
- Evaluate the system mounting and operating rigidity.

The results of the tests are documented in Weber (1993b).

3.5 DATA MANAGEMENT SYSTEM *{LL Lang}*

Each of the facilities (WRAP 1, WRAP 2A, and the Solid Waste Retrieval Facility [Project W-113]) will require a solid waste data base. This data base will be referred to as a Data Management System (DMS). Each DMS will store, retrieve, and manage data describing the solid waste within its facility. Ideally, the DMSs will only be responsible for solid waste data; however, if a future need were to be identified, other kinds of data might be serviced by the DMS.

The Hanford Site Solid Waste Information and Tracking System (SWITS) data base already tracks solid waste. At one time a centralized approach was considered, in which SWITS would be used to provide all of the DMS functions. However, because of the high volume of data generated at each facility, and because of each facility's special requirements, it was decided that a distributed approach was more appropriate. SWITS will continue to be used as a central repository of waste data. The DMS data bases at each facility will transfer data to and from SWITS as the waste is moved into and out of the different facilities.

Because the primary product of each facility will be certified solid waste, the DMSs will be critical to the success of the SWOC, which depends on the waste data for certification. Each DMS will typically (1) provide historical data to the operators; (2) store new data as the waste packages are moved, characterized, and treated; and (3) provide reporting, especially as the waste is certified and prepared for shipping.

3.5.1 Data Management System Verification Needs

The requirements for the WRAP 1 DMS must be identified; the system must be coded, built, integrated with other systems; and the DMS must be tested.

The WRAP 1 DMS will be developed with the help of Boeing Computer Services, Richland. The group providing support is responsible for the development and maintenance of SWITS, which will allow the DMS developers to benefit from their experience with SWITS. This collaboration will also improve the communication between SWITS and DMS since both systems will be developed and maintained by the same group.

Current plans call for the WRAP 1 DMS to reside on a Hewlett-Packard computer (HP9000 model 800/E35).¹ Another similar computer will be purchased for doing development work. Each computer will cost approximately \$25,000, not counting maintenance expenses. The \$50,000 cost of the computers is small compared to the costs of software development. The DMS software will most likely be Oracle based.

3.5.2 Data Management System Verification Plans

The work plan for developing the WRAP 1 DMS is documented in Weidert (1994a). Table 3-1 identifies the major deliverables for the WRAP 1 development effort.

Table 1. Deliverables for the WRAP 1
Data Management System Development Effort.

Deliverable	Supporting documentation
WRAP 1 process flow diagram	WHC-SD-W026-TI-008 (Mayancsik 1994a)
Operator task description	WHC-SD-W026-SD-001 (Mayancsik 1994b)
DMS/Plant Control System interface document	
Software requirements specification	WHC-SD-W026-CSRS-001 (Brann II, 1994)
Detailed software design	
Software code	
DMS/Plant Control System interface simulator	
Shop tests	
Integration	
Acceptance Test Plan	

¹The HP9000 model 800/E35 is a product of Hewlett-Packard, Company, Palo Alto, California.

The process flow diagrams, operator task description, DMS/Plant Control System (PCS) interface document, and software requirements specification were developed as part of the Requirements Phase; that is, the phase at which the development team determined what the system had to do. The Requirements Phase is scheduled for completion by September 1994.

The detailed software design, software code, and DMS/PCS interface simulator will be delivered as part of the Design and Coding Phase, which is scheduled for completion by July 1995. The DMS/PCS interface simulator will ensure that the DMS can successfully "talk" to the WRAP 1 PCS, which is being developed under a separate contract.

The shop tests, integration, and ATP are included in the final testing effort, which is scheduled for completion by September 1995.

The WRAP 1 DMS is scheduled to be fully installed by Operations by March 1996.

4.0 WRAP MODULE 2A

4.1 DEBRIS PROCESS {KE Weingardt}

Debris consists of solid material that has been contaminated with LLMW and is defined per the *Resource Conservation and Recovery Act of 1976* regulations. Most of the debris in WRAP 2A will consist of paper, plastic, rubber, clothing, and construction debris. A cement-based macroencapsulation process has been selected to treat debris-type waste in WRAP 2A. The objective of this treatment is to entrap the waste and reduce the leachability of the contaminants.

The debris-type material will arrive at WRAP 2A in containers and will be emptied from the containers and loaded into a product container. The product container will be placed on a vibratory table at a cement paste injection station. Premixed cement formulation will be injected into the container to thoroughly coat and infill the preloaded waste with the aid of vibration. Some waste may be shredded in order to better permeate and coat all debris surfaces.

To date, this technique has been used successfully on a drum-scale with hard debris (e.g., rock and metal). However, some difficulty occurred when attempting a similar scale with soft debris (e.g., cloth, plastic, paper). The results of these tests are documented in Hull (1994). No tests have been done on the full-scale box configuration.

4.1.1 Reduced Scale Evaluation

In order to evaluate the box configuration and address the problems with encapsulating soft debris, a reduced scale evaluation has been planned using the expert personnel and test facilities of BNFL. British Nuclear Fuels, Ltd. has developed a similar process for treating similar waste streams at the Sellafield facilities in the United Kingdom. As BNFL is part of the WRAP 2A design team, it was determined that commissioning test work with them would provide a more timely solution to the issues. Westinghouse Hanford Company will perform formulation verification tests as part of this test program.

4.1.1.1 Reduced Scale Verification Needs. This test program will validate the process selected for treating the debris waste in WRAP 2A. The decision to initially perform small-scale work is based on economic considerations and the fact that existing equipment at BNFL would not accommodate full-scale work. This test program will also verify the workability of the box configuration, determine workable cement paste formulations, and verify the performance of the waste form. The information will be used to evaluate the type of equipment selected for WRAP 2A, including shredder and filling parameters. A key result of this test program will be the box internals needed to achieve the macroencapsulation.

4.1.1.2 Reduced Scale Verification Plans. A task description has been issued to BNFL detailing the expectations of this testing. British Nuclear Fuels, Ltd. is preparing a detailed work plan to address those expectations. The plan is to use plastic, paper, cloth and rubber processed (shredded) in a manner consistent with WRAP 2A design. Approximately 3 ft square monoliths of this material will be prepared with grout and the results will be evaluated. BNFL will use their past expertise to demonstrate this process and transfer this technology to WHC. Westinghouse Hanford Company will utilize the formulations to perform rheological studies and determine if alternate materials need to be used or could be substituted. Final results should be available in the first quarter of Fiscal Year (FY) 1996.

4.1.2 Full-Scale Evaluation

As a follow-on to the reduced scale testing performed by BNFL, WHC will perform full-scale tests. These tests will be confirmatory in nature to ensure that scale-up is feasible. For this process, full scale is defined as using a 4 ft square box with the internals dictated by the BNFL efforts. Much of this work will need to be done concurrently with certain phases of the BNFL work as information becomes available.

4.1.2.1 Full-Scale Verification Needs. Full-scale tests will be performed to confirm that scale-up does not present any unforeseen problems. In addition, full-scale tests will more accurately define key process parameters that need to be incorporated into final design details and specifications (e.g., box internal configuration, fill rate, cycle time, vibration frequency). The full-scale tests will be performed to confirm the work done on a reduced scale at BNFL. It is expected that minimal full-scale testing will be required because of the BNFL work.

"Hard" material testing not performed by BNFL will be done by WHC to verify the earlier work performed on a drum scale. The information from this testing will be used as input to the design and to satisfy further as to the feasibility of this process.

4.1.2.2 Full-Scale Verification Plans. The full-scale test program will commence following receipt of key information from the BNFL testing on the box internal configuration and fill rate. Following receipt of that information, preparatory work (e.g., building boxes/internals, setting up system) will be done in parallel with the BNFL reduced scale work. Current plans are to begin this work in early FY 1995 and that cemented products will be produced in the last quarter of FY 1995.

A key portion of this testing covers evaluation of commercial shredders for producing waste feed. After evaluation, shredder services will be obtained to produce the testing materials. The existing vibratory table and cement silos and mixing equipment in the 305 Building of the Hanford Site will be used. This equipment will have been previously set up for work on the particulate sludge cementation process. Budget has been allotted to do 15 boxes at this scale. This will accommodate (1) tests to verify BNFL work, (2) tests to verify "hard" material debris tested on drum scale by WHC, and (3) tests to determine the operation limits by varying key parameters.

4.1.3 Full-Scale Process Control Verification

The primary equipment involved in the process control verification work for debris processing are the vibratory and filling equipment and, specifically, the instrumentation as related to process control. The process control verification will also include the feed system and mixer for premix, as required. Full-scale systems matching WRAP 2A current designs will be tested. The actual WRAP 2A equipment may be used for some or all of this verification work before full operational status of WRAP 2A.

4.1.3.1 Process Control Verification Needs. The process control parameters must be defined to allow WRAP 2A processing of actual LLMW to begin. Once the appropriate regulatory interests have established and approved the processing control parameters for the various waste streams, WRAP 2A will have a certified process that should produce acceptable LLMW processing by debris macroencapsulation. The primary requirement of the process control verification is to produce operational envelopes for all parameters key to running the process in the plant. This work will verify that equipment and instrument tolerances are acceptable as designed.

4.1.3.2 Process Control Verification Plans. The debris macroencapsulation process control verification does not have a work plan at this time. The work plan is awaiting results from the previous two debris testing programs and the schedule is several years away. Planned activities include (1) fully instrumenting and modifying the existing 305 Building equipment or purchasing design-specified equipment (this may be actual WRAP 2A equipment), (2) evaluating required instrumentation, and (3) performing full-scale confirmatory testing of surrogates to certify processing. The end product of this work will be a documented process control plan suitable for incorporation into PCs and operating procedures.

4.2 POLYETHYLENE PROCESS {EJ Berglin}

The WRAP 2A polyethylene (PE) encapsulation process has been designed to microencapsulate LLMW that is chemically incompatible with the grout process. The waste designated for the PE process is first removed from its container and screened to remove any material that qualifies the waste as debris. Once the screening is complete, the waste is mixed to homogenize the waste and create a waste mixture with a nearly constant density. The mixer is also capable of drying the waste if the moisture content is above 5% by weight and adding additives, if required, to make the waste chemically compatible for the microencapsulation process or to meet disposal requirements. After waste mixing is complete, an extruder is used to microencapsulate the waste into PE. The PE is then fed into the extruder in dry pellet form and melted. The waste is injected into the melted PE and then mixed and devolatilized before the viscous PE/waste product is placed into containers. These containers are a mold that contains the waste product as it solidifies. Once the waste product has solidified in the containers, the containers are stored until ready for disposal in an approved LLMW landfill.

4.2.1 Polyethylene Formulation Verification

Microencapsulation of waste in a PE binder has been chosen for WRAP 2A processing needs that cannot be processed efficiently or are chemically incompatible by grouting. The microencapsulation process meets regulatory disposal standards for LLMW. Each waste stream will have an optimum formulation combination of waste loading and any required additives to meet first the regulatory requirements and second the economic disposal requirements. The primary waste stream to the WRAP 2A PE line currently identified is the Liquid Effluent Treatment Facility C-018 salts and ion exchange resins.

4.2.1.1 Polyethylene Formulation Verification Needs. The microencapsulation process formulation verification is required to ensure that the process currently identified meets all the regulatory requirements for LLMW disposal on the Hanford Site. Other U.S. Department of Energy (DOE) sites are pursuing similar PE microencapsulation programs (e.g., EG&G Rocky Flats, Inc. and Brookhaven National Laboratory [BNL]), but these sites do not have the same waste streams and processing rates that have been identified for WRAP 2A. Formulation verification at these other DOE sites is being incorporated into the WRAP 2A process as applicable. However, specific formulations for the WRAP 2A waste streams will not be verified and proven unless WRAP 2A has an active verification plan. The results of this formulation verification work will be qualified formulations for the WRAP 2A PE feedstreams.

4.2.1.2 Polyethylene Formulation Verification Plans. The plan for the WRAP 2A formulation verification is outlined in Burbank (1994). This plan uses surrogate waste forms of the WRAP 2A LLMW waste in the preliminary verification stages. The surrogate waste forms are nonradioactive and nonhazardous to allow economic verification and testing of various formulations. Formulations will first be proven on a small scale which will then followed by larger scale testing for verification and determination of boundary conditions. Surrogate testing will be proven by LLMW "hot" testing using actual WRAP 2A waste. Regulatory testing on the waste product formulations will include the ability of the hazardous and radioactive constituents to leach out of the waste form and the mechanical strength of the waste form.

The initial, smallest scale waste form testing is using a small 1 inch (27 mm) twin screw extruder at the EG&G to generate the samples. These samples are currently undergoing waste form testing by WHC and results should be available in the last quarter of FY 1995. Larger scale testing is planned in FY 1995 using a 1.6 to 2 inch (40 to 50 mm) extruder. The extruder is being procured by WHC for pilot-scale testing of the WRAP 2A PE processing line.

4.2.2 Polyethylene Mixing Process Definition

The WRAP 2A PE line has identified several equipment systems to process LLMW. A co-rotating, twin screw extruder will melt the PE and mix in the waste to achieve microencapsulation. A mixer/dryer will preprocess the waste, before introducing the waste into the extruder, by adding additives, homogenizing, and drying, if required, to meet formulation and/or processing needs. The melted product is removed from the extruder and is deposited into containers for ultimate LLMW disposal.

4.2.2.1 Polyethylene Mixing Verification Needs. The WRAP 2A PE equipment requirements must be defined to appropriately support equipment design. Although the WRAP 2A PE immobilization process is similar to the commercial polymer compounding process, the waste streams feed and final waste form requirements are significantly different. Therefore, equipment verification and testing are required. The LLMW feed material used in the WRAP 2A PE process is not a typical industrial processing material. In addition, the WRAP 2A final waste form performance requirements to meet LLMW regulatory standards are much different than the typical commercial polymer processing environment. Although the testing being done at both the EG&G and BNL will supplement the definition of the PE mixing process, it will not provide the necessary data for WRAP 2A waste forms and processing rates.

Twin screw extruder testing must be done to prove that current WRAP 2A extruder design criteria can be met and to define the extruder LLMW microencapsulation processing envelope. The testing should accomplish the following:

- Define how product containers that fail regulatory tests will be reworked;
- Prove that a large monolith container of waste will fill and cool adequately; and
- Prove that the mixer/dryer can meet the WRAP 2A processing needs.

In addition to testing, an investigation of alternative mixing equipment (i.e., consider cost and enhanced processing features) should be preformed.

4.2.2.2 Polyethylene Mixing Verification Plans. The WRAP 2A mixing verification plan is outlined in Berglin (1994). This plan is still in development as several special studies have been added. These studies include the product reworkability study, mixer/dryer verification study, and the product cooling study.

To provide a basis for doing larger scale extruder test work and formulation studies, a 1.6 to 2 inch (40 to 50 mm) co-rotating, fully intermeshing twin screw extruder is currently being procured by WHC. The bid is expected to be awarded in October 1994, and the extruder is expected to be available for testing in April 1995. Mixing process definition testing on this extruder will verify that the current extruder design parameters are achievable and that the extruder can achieve an acceptable product. Some of the operational parameters expected to be tested include moisture content, venting of volatiles, and mixing. Additionally, waste pretreatment and final waste product conditions will be evaluated to verify the need of auxiliary processes or equipment. Testing will be done during the spring and summer of FY 1995. The extruder will also be used to perform the larger scale formulation verification work.

A work plan and testing outline for the alternative polymer immobilization equipment assessment was presented to management in August 1994. This presentation recommended testing the Draiswerke Gelimat, Inc. equipment as a possible alternative to the twin screw extruder. The recommended alternative has a possible \$250,000 capital benefit to the project and could possibly eliminate the need for a dryer. This task was placed on hold for future reference until the current system is further evaluated. The reasons for this are: no definite improvements were identified; the current extruder system should meet all WRAP 2A polymer processing goals; and the current twin screw extruder system is also consistent with LLMW micro-encapsulation processing being pursued at other DOE laboratories. Other alternatives to the extruder presented were the Buss (America), Inc. kneader, the Farrel Corporation continuous mixer, and the Teledyne Specialty Equipment Company or Christian Engineering processor.

Three special studies have been planned for verification work and are planned to be done during FY 1995. Full-scale cooling verification of a 4-ft (1.2-m) cube product container at production rates is planned to verify cooling calculations and observe whether the single point filling mechanism is adequate. Plans are to conduct this study at an extruder vendor's facility. Reworkability of the product containers will also be studied to determine how the WRAP 2A design can accommodate a large product container that fails to meet disposal criteria. This study will include the complete recycle process, from size reducing the box to reprocessing through the extruder. A full-scale mixer/dryer demonstration at a vendor's facility is also planned to verify that the mixer/dryer can adequately meet the WRAP 2A LLMW processing requirements.

4.2.3 Polyethylene Process Control Verification

The primary equipment involved in the process control verification work include the extruder and, specifically, the instrumentation as related to process control. The process control verification will also include the dryer/mixer as required. A full-scale or scalable to full-scale system matching WRAP 2A current designs will be tested. The actual WRAP 2A equipment may be used for some or all of this verification work before full operational status of WRAP 2A.

4.2.3.1 Polyethylene Process Verification Needs. The process control parameters must be defined to allow WRAP 2A processing of actual LLMW to begin. Once the appropriate regulatory interests have established and approved the processing control parameters for the various waste streams, WRAP 2A will have a certified process that should produce acceptable LLMW processing by PE microencapsulation.

4.2.3.2 Polyethylene Process Verification Plans. The PE process control verification does not have a work plan at this time. The work plan is awaiting results from the previous two PE testing programs and the schedule is several years away. Planned activities include (1) developing specifications of the full-scale extruder design, (2) purchasing a production-capacity extruder (this may be the actual WRAP 2A extruder), (3) evaluating the required instrumentation, (4) performing full-scale confirmatory testing of surrogates to certify processing, and (5) possibly hot testing of actual LLMW, if required. The following verification work is currently specifically identified.

- Evaluate and test an infrared process monitor developed by Ames Research to monitor waste loading of the product.
- Test the macroencapsulation of large LLMW items in PE that cannot be processed through the extruder.
- Verify that the feed system performs adequately.

This testing is scheduled to occur between October 1995 through June 1998.

4.3 CEMENT STABILIZATION PROCESS {KE Weingardt}

A cement stabilization process to treat particulate and sludge type waste to permit disposal has been incorporated into the WRAP 2A design. The objective is to limit the leachability of the hazardous constituents and produce a solidified mass of waste product that is easier to handle. Waste in 55-gal (208-L) drums designated for cement stabilization will be routed to the cement process line and the contents of the drum will be emptied onto a 2 inch (60 mm) vibrating screen to remove material that may damage downstream equipment. Waste passing through the screen will be fed, in the appropriate amount, to a batch mixing tank. The stabilization materials (e.g., cement, water and adjuncts) will be added and thoroughly blended with the waste. The mixture will then be emptied into a product container (currently specified as a 4 ft square box). The box will then be transferred to a cure/store area for solidification.

To date, a significant amount of work screening various stabilization materials with surrogates has been done for a majority of the waste streams forecasted to come to WRAP 2A (Benar et al. 1993). The overall plan for formulation development work is outline in Burbank (1993). Westinghouse Hanford Company is currently completing a document detailing mixture experiments, which will define the formulation envelope for the well-understood feedstreams (Benar 1993). WHC has also completed testing and evaluation of various mixing approaches for the cement stabilization process. Small-scale and drum-scale mixes have been performed on a wide range of cement formulations. This testing has determined that a high-shear mixing regime is desirable for use in this process (Weber 1994b).

4.3.1 Cement Stabilization Formulation Verification

Cement stabilization has been chosen as the primary treatment for the bulk of the particulate and sludge waste destined for WRAP 2A. This choice is due to the economic and logistic advantages of cement materials. The cement stabilization process meets regulatory disposal standards for LLMW.

Currently, Portland cement, fly ash, blast furnace slag, and other additives are being focused on as binder materials. Each waste stream will have an optimum formulation consisting of various percentages of the above constituents, waste, and water.

4.3.1.1 Verification Needs. The formulations for the various waste streams that will be processed through the cement stabilization system must be developed in order to design the process and plan for the processing of materials through the plant. Once these formulations are developed, the information will validate the facility material balance and equipment sizing. Formulation development work will be performed with surrogates accurately resembling the waste and actual waste. Therefore, the resulting information will serve to substantiate the technical viability of the process as a treatment for these wastes. In addition, the information will be used to aid in permit validation and stakeholder confidence.

4.3.1.2 Verification Plans. The verification work plan will develop formulas for all waste streams currently planned to be processed in the cement stabilization process at WRAP 2A. The overall plan for this work is detailed in Burbank (1993). The first phase of this test work will be to perform mixture experiments on the various feedstreams (Benar 1993). These experiments will entail varying the quantities of cement additives and waste to determine an optimum formulation based on an assembly of waste form performance tests. A mathematical model will be developed based on these tests to define an acceptable envelope for each feed and to understand overlaps between the envelopes. Confirmatory tests will be performed to verify the accuracy of the model.

As a follow-on to the mixture experiments, variability tests will be performed to understand the boundaries of the various formulas with regard to contaminants of concern. Other studies will be performed as issues arise. A test program has been established with BNFL to determine the benefits of using a blast furnace slag-based cement as opposed to the fly ash-based system more commonly used in the United States. Experts in the stabilization field will be contracted to oversee the formulation development work and to perform some of the special studies. Outyear work in this area will involve investigating the nature of set retarders and accelerators for use in the cement cleanup system.

4.3.2 Cement Stabilization Mixing Process Definition

A critical element of the cement stabilization process is thorough mixing of the binder materials (cement, fly ash, etc.) with the waste and water. Based on testing and engineering evaluation, a batch mixing system sized to fill one product container (approximately 64 ft³ [1.8 m³]) will be used. Testing has also determined that a high shear mixing regime is most desirable for the process.

4.3.2.1 Verification Needs. The mixing process must undergo engineering testing and evaluation to validate the selected design. To this point the design reflects the decisions noted above. However, all testing to date has been performed on a small scale and verification of the process at full scale must still be done. The full-scale testing will also provide information on the scalability of waste form performance factors, motor and drive sizing, mixing times and throughput, precise mixer configuration, cleanup, and risks and potential problems. All of this information will be factored into design and eventual mixer procurement both for process control testing and installation into the facility.

4.3.2.2 Verification Plans. The cement stabilization mixing process definition plans include completing the small-scale evaluations, completing the full-scale scoping tests, evaluating the vendor, and eventual specification and purchase of the vendor full-scale mixer for process control testing.

The first phase of full-scale tests (referred to as full-scale scoping tests) will be performed during FY 1995 using equipment configured by WHC to resemble the small-scale work. These tests are to determine key parameters affecting the process due to scale up. Key parameters include mixing time/efficiency, product quality and exotherm, flowability, and paddle configuration. The objective is to gain enough understanding of the key parameters to be able to evaluate off-the-shelf mixing equipment. These tests will use physical surrogates of the waste (sand, diatomite, etc.) and several formulas bounded in the formulation development efforts.

In parallel with the full-scale scoping tests, vendor capability will be investigated and a performance specification will be provided to vendors to propose configurations to be tested at their facilities. As proposals are received, selected vendors will be contracted to demonstrate their equipment on WHC-specified materials. Westinghouse Hanford Company will evaluate the performance of these mixers and, based on that evaluation, a detailed specification will be developed to procure a mixer for process control testing. This detailed specification will be incorporated into the design media by REC.

4.3.3 Cement Stabilization Process Control Verification

The primary equipment involved in the process control verification work for cement stabilization is the mixing equipment and, specifically, the instrumentation as related to process control. The verification work will also include the feed system for the mixer and the discharge system as required. Full-scale systems matching WRAP 2A current designs will be tested. The actual WRAP 2A equipment may be used for some or all of this verification work before full operational status of WRAP 2A.

4.3.3.1 Verification Needs. The process control parameters must be defined to allow WRAP 2A processing of actual LLMW to begin. When the appropriate regulatory interests have established and approved processing control parameters for the various waste streams, WRAP 2A will have a certified process that should produce acceptable LLMW processing by cement stabilization. Operational envelopes for all parameters key to running the process in the plant must be produced. This work will verify that equipment and instrument tolerances are acceptable as designed.

4.3.3.2 Verification Plans. The cement stabilization process control verification does not have a work plan at this time. The work plan is awaiting results from the previous two cement stabilization testing programs and the schedule is several years away. Planned activities include (1) installing and setting up the full-scale vendor mixing equipment (this may be actual WRAP 2A equipment), (2) evaluating required instrumentation, (3) performing full-scale confirmatory testing of surrogates to certify processing, and (4) possibly hot testing actual LLMW, if required. The end product will be a documented process control plan suitable for incorporation into PCSs and operating procedures.

4.4 FACILITY EQUIPMENT {DL Lamberd}

The current design approach to providing mechanical equipment is to use commercially available equipment with modifications as required to accomplish a specific task. Therefore, demonstration testing of the equipment must be performed to verify that the intended features perform as required and to identify any changes or improvements that are required or would enhance the operation of the equipment. Any maintenance features that would benefit plant operations and maintenance can also be identified during the testing activity. The following facility equipment uses commercial equipment modified to perform the desired functions. This equipment will be tested to verify operability.

4.4.1 Box Handling

Approximately 50% of the feed material (Kruger 1993) to be processed in WRAP 2A will be received in boxes up to 5 ft by 5 ft by 9 ft. The box must be opened and the waste removed. The box must then be disposed of as either LLW or as LLMW.

The various configurations of waste and boxes makes it difficult to determine the exact pieces of equipment and tooling needed to open a box, remove the waste, and cut up the box for disposal. Some assumptions have been made during the design; these design assumptions must be confirmed. In addition, the exact processing operation must be confirmed. Therefore, verification testing of the equipment to handle boxes and boxed waste will be performed to ensure that the entire operation can be accomplished as designed.

4.4.1.1 Box Handling Verification Needs. The following specific needs must be shown to function correctly for the box handling area of WRAP 2A.

- Demonstrate that a box lid can be removed.
- Demonstrate that all combinations of waste can be removed from the box (waste types include sludges/particulates, debris-type waste [both bagged and unbagged], large heavy items, light items, soft and hard materials).
- Demonstrate that all waste can be removed from the box with no residue remaining.
- Demonstrate that the box can be cut up or reduced in size to allow easy disposal into a product container or load out into a drum for disposal as LLW.
- Demonstrate that boxes and containers of various sizes can be handled.
- Demonstrate that all necessary equipment has been identified and designed to support the operations.
- Demonstrate that equipment maintenance can be easily performed. Demonstrate that equipment replacement can be accomplished in a timely manner.

4.4.1.2 Box Handling Verification Plans. The box handling verification plans are to (1) fabricate or procure component equipment based on the 60% Title I design; (2) setup the equipment similar to the configuration of the WRAP 2A box breakdown area; and (3) perform the functions required to open the box, remove the waste, transfer the waste, and dispose of the box as recommended in the Title I design. A full-scale mockup will not be used; however, specific features of the equipment or components will be used to demonstrate the various functions. Some nonplant-related equipment or facility features will be used to simulate the actual plant or equipment configuration. Full-sized boxes will not be necessary for all the testing; only certain features will be mocked up to demonstrate equipment operation. Any required actions that are remotely operated will most likely be simulated by non-remote devices.

4.4.2 Drum Handling

The remaining feed material to be processed in WRAP 2A will be received in 55-gal (208-L) drums with an inner liner in each drum. The liners will be a PE either 10 mm or rigid 90 mm thick. The 10 mm liners will be taped closed; the 90 mm liners will have a rigid liner bolted, glued, or clamped in position. The drum and liner must be opened and the waste removed from the drum for processing. The drum will be disposed of as either LLW or as LLMW.

In addition to the varying configuration of the drums and liners, the physical condition of the waste will also vary. Therefore, identifying a single set of equipment to provide the various functions for all waste types and container conditions is complex and difficult. Certain assumptions were made and those assumptions must be confirmed as appropriate for the equipment selected. Verification testing of the detail design for drum opening, waste emptying, and drum disposal will be performed.

4.4.2.1 Drum Handling Verification Needs. There are two drum handling areas of the plant. One is for debris-type waste and one the other for sludge/particulates. The following design criteria must be met for the drum handling areas of WRAP 2A.

- Demonstrate that the lid of a drum can be removed. It must be shown that a lid that is difficult to remove can be removed without impacting operator safety.
- Demonstrate that a 10 mm or a 90 mm liner can be opened.
- Demonstrate that sludge/particulate waste can be completely removed from the liner. Also demonstrate that debris-type waste can be removed from the liner. Waste removal methods include tipping the drum, using mechanical equipment to breakup and remove the waste, or a combination of both.
- Demonstrate that all necessary equipment has been identified and designed to support the operations.
- Demonstrate that equipment maintenance can be performed. Demonstrate that equipment replacement can be accomplished in a timely manner.
- Demonstrate that the lids and empty drums with a 90 mm liner can be compacted together.

4.4.2.2 Drum Handling Verification Plans. The drum handling verification plans include fabricating or procuring component equipment based on the 60% Title I design; setting up the equipment similar to the configuration of the WRAP 2A drum opening and handling area; and performing the functions required to open the drums, open the liners, remove the waste, transfer the waste, and dispose of the drum as recommended in the Title I design. A full-scale mockup will not be used; however, specific features of the equipment or components will be used to demonstrate the various functions. Some nonplant-related equipment or facility features will be used to simulate the actual plant or equipment configuration. Full 55-gal (208-L) drums may not be necessary for all the testing; only certain features will be mocked up to demonstrate equipment operation. Full-scale drums will be used as a final confirmation of equipment operations. Any required actions that are remotely controlled will most likely be simulated by non-remote devices.

4.4.3 Confinement Evaluation

Because all the waste will be processed in a restricted (ventilated) area, it is necessary to allow for the movement of waste and materials in and out of the ventilated areas. Some sort of confinement control is required to reduce the potential of contamination spread or operator exposure to unacceptable hazardous chemicals. Various confinement controls will be used in WRAP 2A and the ability to provide adequate contamination control must be verified.

4.4.3.1 Confinement Verification Needs. The following entry point ventilation control methods will be verified.

- Drum entry into confinement
- Box entry into confinement
- Sludge/particulate grout product container loadout from confinement
- Sludge/particulate pellet PE product container loadout from confinement
- Debris product container loadout from confinement
- Drum and box exit from confinement (box breakdown area and waste repackaging).

The confinement method used at each of the locations must demonstrate that the release of radioactive and hazardous materials is prevented. Required airflow must be demonstrated to ensure adequate confinement is maintained during all normal operations from introduction of containers into confinement to the removal of the containers from confinement.

4.4.3.2 Confinement Verification Plans. The confinement verification plans are to mockup each of the selected confinement control methods selected for the facility design and verify that release of radioactive and hazardous materials is avoided. Actual plant equipment will not be used; mockup configurations will be used. Testing will not be performed on systems that have been used in other operating facilities or demonstrated by others to operate adequately. Extensive testing of drum entry/exit methods has been performed by other sites and companies and entry/exit methods will not be tested unless an alternate method is selected. However, limited work has been performed on box entry/exit or box mating to confinement. Consequently, the testing will primarily concentrate on the box entry and/or mating of the box to confinement.

4.4.4 Product Sampling Evaluation

Treated waste must be sampled to support the certification process to allow the waste to be disposed. Since the waste is in a stabilized form of grout or PE, a method to obtain a representative sample of each type of treated waste is required. The current design approach is to core drill the treated waste to obtain a sample. Title I 60% design will select and provide a design for obtaining a sample of treated waste. This design will be tested. Sampling of both the grout and PE product will be demonstrated. The sample acquisition will occur in the sample management area of WRAP 2A.

4.4.4.1 Product Sampling Verification Needs. Product sample verification is required to ensure that the method and equipment selected for sampling performs as intended and provides an acceptable sample. This activity will also confirm operation and maintenance of the sample acquisition equipment.

4.4.4.2 Product Sampling Verification Plans. The verification plans call for fabricating or procuring the equipment selected in Title I design and testing the equipment. Product containers from the grout and PE verification testing can be used to verify core sampling equipment.

5.0 SOLID WASTE RETRIEVAL FACILITY

5.1 CHARACTERIZE WASTE FOR DRUMS

5.1.1 Vent and Sample Drums {VP Ocampo}

Drum venting equipment is required because all the 55-gal (208-L) drums being retrieved must be vented to relieve any buildup of gases generated during storage. Head gas sampling equipment is required for the retrieved 55-gal (208-L) drums, to determine whether the Lower Explosive Limit (LEL) has been exceeded and to analyze head space gases, ensuring safe storage. The drum venting system will vent, sample, analyze, purge (as required), and install a filter in each drum.

5.1.1.1 Vent and Sample Drums Verification Needs. Engineering design modifications to an existing WHC pilot retrieval demonstration project, container venting system (CVS) equipment, will have to be made meet all the Project W-113 specific needs. The modifications are described in Ocampo (1993).

The existing WHC pilot retrieval demonstration project CVS equipment design does not provide specific, online instrumentation system requirements for determining the drum head space gases for (1) the %LEL of hydrogen, butane, and methane; (2) the total VOCs concentration in parts per million; (3) the flammability of the gases if the total VOCs concentration exceeds the 500 ppm limit; and (4) the total VOCs concentration and respective constituents if the total VOCs concentration exceeds the 600 ppm.

The instrumentation proposed by the WHC Special Analytical Studies for sampling and analyzing the drum head space gases as described above must be performance tested. The following conditions must be verified:

- The minimum size and maximum length of the gas sampling line that could be used if the drums have to be vented and gas sampled in place before being removed from the module;
- The total time required for sampling and quantitative analysis of the total VOCs if the concentration exceeds 600 ppm; and
- The repeatability and accuracy of the instrumentation because there is no guarantee that the drums, as they are retrieved, will have the same drum head space and VOCs concentration and constituents as the preceding retrieved drum.

5.1.1.2 Vent and Sample Drums Verification Plans. The verification plan for drum venting and gas sampling is outlined in Ocampo (1994a).

A temporary engineering change notice (ECN) #164033 has been written to show that WRAP Mechanical Engineering is working on the gas instrumentation sampling/analysis lines to the existing CVS drill head assembly. The Special Analytical Studies Group is providing WRAP Mechanical Engineering with the details of the instrumentation hooked up to the CVS.

WRAP Mechanical Engineering, with technical procedure inputs provided by the Special Analytical Studies Group and Engineering Applications Technology, is conducting a demonstration test procedure. The Special Analytical Studies group is providing the gas sampling and analysis procedures. Engineering Applications Technology is providing the input to the CVS operation.

5.1.2 Nondestructive Drum Assay {JR Weber}

The NDA system for Project 113 will be Imaging Passive and Active Neutron (I-PAN) (Watson, 1994) of the WRAP 1 type.

5.1.2.1 Nondestructive Drum Assay Verification Plans. The verification plan includes a current literature and vendor search. Specific Retrieval Project needs were identified and design improvements will be incorporated into the NDA system specification at the 30% Title I design completion, November 20, 1994, and 90% Title II design completion stage, June 30, 1995.

5.1.3 Nondestructive Drum Examination {JR Weber}

The W-113 NDE real-time radiography system will draw heavily on the efforts completed to define the design of the WRAP 1 system. Changes from that design will be incorporated only if significant advances have been made in imaging equipment or the potential to examine the drums for internal corrosion is proven to be workable and is cost beneficial.

The Project W-113 FDC requires that ultrasonic testing be performed to verify the wall integrity of the retrieved container. This test is typically performed by placing an ultrasonic probe on a number of predetermined points on the container. The actual drum wall area examined is very small, being limited to the area of the actual transducer head. An alternative technology using an "oblique" or tangential X-ray would provide a more comprehensive pictorial examination to assess the condition of the drum wall and a portion of the drum bottom.

Potential imaging advances and emerging technologies;

- The Retrieval NDE imaging system (generally known as could use a 12 inch, seventh generation, "HX" type, high contrast image intensifier to produce real-time dynamic images. This presents an image field almost a 100 percent larger than the WRAP 1.
- The Retrieval NDE digital X-ray imaging system will also use a 36 inch length, flat mounted, continuous linear diode array to produce side-to-side, top-to-bottom full drum images. The scintillating material used in the WRAP 1 diode array is gadolinium-oxysulfide. Cesium iodide is a far more efficient scintillator and has a greater light output especially at higher X-ray energies. The "thicker" cesium iodide crystal also prevents the X-ray photons from impinging on the underlying silicon diode matrix, thus lengthening the life of the array.

- The W-113 NDE imaging system, (X-ray tube, drum rotator, and linear array/image intensifier staging) could be designed to have the ability to hold the drum in a fixed position and tilt laterally, 5 - 10 degrees, such that two digital images of the drum may be "captured and subtracted" with the image processor to aid in liquid detection and identification. This technique has been demonstrated using a digital scanner and is reported in literature. This is a design improvement beyond WRAP 1 that needs to be evaluated.
- The Retrieval NDA and NDE systems will have their own data storage capability. The WRAP 1 NDE image data will be stored on "century life", optical storage media using Write-Once-Read-Many (WORM) technology. Data (media) storage and retrieval systems are moving toward the future literally at "light speed". On-going work will verify that the 12 inch, bi-metallic, optical media as specified for WRAP 1 is the best, most current and proper choice for the Retrieval Project NDE and NDA systems.

5.1.3.1 Drum Nondestructive Examination Verification Needs. An imaging technique using an "oblique" or tangential X-ray image could possibly provide a more comprehensive and complete examination (than ultrasonic) to assess the condition of the drum wall and a portion of the drum bottom. Preliminary tests have been performed at the 306 NDE Laboratory using the old Transuranic Waste Storage and Assay Facility "F-series", 9 inch (23 cm) image intensifier (1984-1985 manufacture) and X-ray film. A larger 12 inch (31 cm), "HX-type" image intensifier is required to pursue this and other imaging techniques onsite. The new image intensifier, together with other existing and available onsite equipment, would permit X-ray examination of actual waste drums at the 306 NDE Laboratory.

An emerging technology using an amorphous silicon "area detector" to directly produce a 16-bit digital, "real-time", X-ray image. The 16-bit deep data provides over 65,000 density or gray levels in the image data. This type of device is currently being used to provide qualitative and quantitative measurements of internal pipe-line wall thickness, corrosion, and weld seam integrity on the Alaska crude oil pipe-line with the line operating. This emerging technology, combined with the "oblique or tangential" X-ray technique described for drum wall and bottom integrity verification, could possibly provide a defensible technique for total evaluation of the condition of the drum interior sidewall and bottom. This evaluation would indicate whether or not a drum needed to be over-packed before shipment and storage. Equipment, currently not available onsite, would be required to evaluate, demonstrate and verify this technique. The required equipment might be available as early as November 1994. Some costs would be incurred to use the equipment and possibly the technology. An RFP will be generated as a first step in this evaluation.

In the WRAP 1 drum NDE system a 9 inch, "HP", low contrast type image intensifier was specified after viewing limited performance demonstrations. Penetration, resolution and sensitivity for the WRAP 1 image intensifier were specified. Additional qualitative and definitive performance testing of the 12 inch image intensifier will be accomplished. A side by side demonstration for image comparison using the 9 inch, "F-series" and the new 12 inch "HX" image intensifier, described above, each with identical charge coupled device cameras, and two identical high resolution black and white monitors would be conducted. The WHC 55 gallon test drums, containing the surrogate waste materials and standard Image Quality Indicators (IQI) would be rotated and scanned between the two image intensifiers. This allows items in the drum (and the IQIs) to be viewed first on one monitor, then on the other while operating at the same X-ray power level. It is felt that the larger field of view will benefit the examination. A cost benefit assessment (9 inch versus 12 inch) will be generated and the selected size will be specified in the design media for the 90% review. The penetration, resolution and sensitivity of the "HX-series" image intensifier would be measured using recognized ASTM standard pentrameters and this information will likewise be incorporated in the design media for the Retrieval project.

The Retrieval NDE X-ray imaging system will use a 36 inch minimum length, flat mounted, continuous linear diode array to produce side-to-side, top-to-bottom full drum images. A manufacturer has proposed to fabricate a new generation, 36 inch, high energy diode array using cesium iodide. This is potentially a design improvement. As an on-going effort, the "new generation", high energy, cesium iodide, linear diode array needs to be evaluated from a cost/benefit and imaging performance position as data and images become available.

In the Retrieval NDE system, the X-ray tube, the image intensifier and the linear array will have to move synchronously, vertically to acquire images of the waste container. This option was permitted in WRAP 1 design, however there probably isn't height enough to elevate the drum past the imaging chains in a trailer mounted system. The Retrieval NDE imaging system, (X-ray tube, drum rotator, and linear array-image intensifier staging) could have the ability to hold the drum in a fixed position and tilt laterally, 5 to 10 degrees, such that two digital images of the drum may be "captured and subtracted" with the image processor to aid in liquid detection and identification. This is a technique and design improvement over the WRAP 1 design whose benefits need to be evaluated.

5.1.3.2 Drum Nondestructive Examination Verification Plans. Verification plans include generating RFPs as indicated on the schedule. Test and demonstration plans will be prepared for review and approval. The Program Work Breakdown Structure is shown in Figure 4.

6.0 REFERENCES

- Benar, C. J., D. A. Burbank, and K. M. Weingardt, 1993, *Waste Form Qualification Status Report*, WHC-SD-W100-TI-003, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Benar, C. J., 1993, *Work Plan to Confirm the Process Selection of Cement Stabilization Technology for WRAP 2A*, WHC-SD-W100-WP-002, Revision 1, Westinghouse Hanford Company, Richland, Washington.
- Berglin, E. J., 1994, *Work Plan for the Extruder Development of the Waste Receiving and Processing Module 2A Polyethylene Process*, WHC-SD-W100-WP-006, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Brann II, E. C., 1994, *WRAP Module 1 Data Management System Software Requirements Specification*, WHC-SD-W026-CSRS-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Burbank, Jr., D. A., 1993, *WRAP 2A Waste Form Qualification Plan*, WHC-SD-W100-TP-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Burbank, Jr., D. A., 1994, *WRAP Module 2A Polyethylene Waste Form Test Plan*, WHC-SD-W100-TP-012, Westinghouse Hanford Company, Richland, Washington.
- Burgess, J. S., 1994, *C-Clip Crimper Test Report*, WHC-SD-W026-TRP-013, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Gilles, W. P., 1991, *Boxed Waste Assay System Test Plan*, WHC-SD-W026-TP-004, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Griffin, T. E., 1992, *Relidding 55 Gallon Waste Drums*, WHC-SD-W026-DTP-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Hull, K. J., 1992, *Test Report for Compacted Waste Drum Sampling*, WHC-SD-W026-TRP-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Hull, K. J., 1994, *Vibratory Mixing Test Report*, WHC-SD-W100-TRP-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Johnson, D. M., 1993, *Functional Design Criteria, Solid Waste Retrieval Facility Phase 1, Project W-113*, WHC-SD-W113-FDC-001, Revision 2, Westinghouse Hanford Company, Richland, Washington.
- Kanjilal, S., 1991, *Development Test Plan for Drum Deheading and Cutting*, WHC-SD-W026-DTP-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Kanjilal, S., and K. J. Leist, 1991, *Test Report on the Study of Drum Cutting*, WHC-SD-W026-TRP-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.

- Kruger, O. L., and M. L. Sheriff, *Waste Receiving and Processing, Module 2A, Feed specification*, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- LeClair, M. D. et al., 1993, *Waste Receiving and Processing/Solid Waste (WRAP/SW) Engineering Development Program Plan*, WHC-SD-W026-PAP-001, Revision 1, Westinghouse Hanford Company, Richland, Washington.
- Leist, K. J., 1994a, *Aerosol Can Puncture Device Operational Test Plan*, WHC-SD-W026-TP-008, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Leist, K. J., 1994b, *Aerosol Can Puncture Device Test Report*, WHC-SD-W026-TRP-015, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Lucas, D. R., 1992, *Recommendations for Box Nondestructive Examination (NDE) System in WRAP 1*, WRAP Correspondence Letter 9254160, Westinghouse Hanford Company, Richland, Washington.
- Mayancsik, B. A., 1994a, *WRAP Module 1 - Data Identification Document*, WHC-SD-W026-TI-008, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Mayancsik, B. A., 1994b, *Waste Receiving and Processing Module 1 Operating Plan*, WHC-SD-W026-SD-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ocampo, V. P., 1993, *Project W-113 Drum Venting and Head Gas Sampling System*, WHC-SD-W113-ES-003, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ocampo, V. P., 1994a, *Project W-113 Drum Venting and Gas Sampling Work Plan*, WHC-SD-W113-WP-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Ocampo, V. P., 1994b, *Project W-113 Drum Venting and Gas Sampling Test Procedure*, WHC-SD-W113-TC-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq.*
- Ruff, D. T., 1992a, *Test Plan for Sphincter Seal Testing*, WHC-SD-W026-TP-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1992b, *Test Report for Vacuum Lift Drum Delidding*, WHC-SD-W026-TRP-003, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1992c, *Hydraulic Crimp Drum Relidding Test Report*, WHC-SD-W026-TRP-004, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1992d, *C-Clip Drum Relidding Test Report*, WHC-SD-W026-TRP-005, Revision 0, Westinghouse Hanford Company, Richland, Washington.

- Ruff, D. T., 1993a, *Entry/Exit System Modification Test Report*, WHC-SD-W026-TRP-008, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1993b, *Test Plan for Entry/Exit System Final Test Phase*, WHC-SD-W026-TP-007, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1993c, *Test Report for Entry/Exit Final Test Report*, WHC-SD-W026-TRP-012, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1993d, *WRAP-1 Sphincter Seal Test Report*, WHC-SD-W026-TRP-010, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1993e, *One Trip Bagless Transfer System Test Plan*, WHC-SD-W026-TP-006, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Ruff, D. T., 1994, *One Trip Bagless Transfer System Test Report*, WHC-SD-W026-TRP-014, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Sexton, R. A., 1992, *Waste Receiving and Packaging Facility, Module 1 Characterization and Processing Alternatives Study*, WHC-SD-W026-ES-009, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Watson, A. N., 1994, *WRAP 1 Drum Passive-Active Neutron Assay System Specification*, WRAP-1 Specification Number 13538, United Engineers & Constructors/British Nuclear Fuels Limited, Denver, Colorado.
- Weber, J. R., 1991a, *Evaluation of Alternatives for Nondestructive Assay and Examination of Drummed and Boxed Waste in WRAP-1*, WHC-SD-W026-ES-004, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Weber, J. R., 1991b, *Nondestructive Examination Development and Demonstration Plan*, WHC-SD-W026-TP-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Weber, J. R., 1992a, *Test Plan for Nondestructive Examination of Boxes*, WHC-SD-W026-TP-003, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Weber, J. R., 1992b, *Drum Waste Non-Destructive Examination Interim Status Report*, WHC-SD-W026-DTR-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Weber, J. R., 1993a, *Waste Drum Delidding, C-Clip Installation, and Feed Mechanism Development Test Plan*, WHC-SD-W026-DTP-003, Revision 0, Westinghouse Hanford Company, Richland, Washington.
- Weber, J. R., 1993b, *Schilling Hydraulic Robotic Arm Development and Test Report*, WHC-SD-W026-DTR-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Weber, J. R., 1994a, *Mailscope V Packet X-Ray System Development Test Report*, WHC-SD-W026-DTR-003, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Weber, J. R., 1994b, *WRAP 2A Phase I Mixing Tests Status Report*, WHC-SD-W100-DTR-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Weber, J. R., and J. K. Keve, 1992, *Drum Waste Non-Destructive Examination Interim Status Report*, WHC-SD-W026-DTR-001, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Weidert, J. R., 1994a, *WRAP 1 Project Activity Plan for Facility Control and Data Management System Development*, WHC-SD-W026-PAP-002, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Winkleman, R. H., 1993, *Entry/Exit Port Testing Test Report*, WHC-SD-W026-TRP-006, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Winkleman, R. H., 1993, *Entry/Exit Port Testing Test Plan*, WHC-SD-W026-TP-005, Revision 0, Westinghouse Hanford Company, Richland, Washington.