PNNL-12135
UC-721

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Final Report
Spent Nuclear Fuel Retrieval System Manipulator System Cold Validation Testing

D. R. Jackson
G. R. Kiebel

August 1999

Prepared for the U.S. Department of Energy
Under Contract DE-AC06-76RLO 1830

Pacific Northwest National Laboratory
Richland, Washington 99352

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

PNNL-12135
UC-721

Final Report
Spent Nuclear Fuel Retrieval System Manipulator System Cold Validation Testing

D. R. Jackson
G. R. Kiebel

August 1999

Prepared for the U.S. Department of Energy
Under Contract DE-AC06-76RLO-1830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Manipulator system cold validation testing (CVT) was performed in support of the Fuel Retrieval System (FRS) Sub-Project, a subtask of the Spent Nuclear Fuel Project at the Hanford Site in Richland, Washington. The FRS will be used to retrieve and repackage K-Basin Spent Nuclear Fuel (SNF) currently stored in old K-Plant storage basins. The FRS is required to retrieve full fuel canisters from the basin; clean the fuel elements inside the canister to remove excessive uranium corrosion products (or sludge); remove the contents from the canisters; and sort the resulting debris, scrap, and fuel for repackaging. The fuel elements and scrap will be collected in fuel storage and scrap baskets in preparation for loading into a multi canister overpack (MCO), while the debris is loaded into a debris bin and disposed of as solid waste.

The FRS is composed of three major subsystems. The Manipulator Subsystem provides remote handling of fuel, scrap, and debris; the In-Pool Equipment subsystem performs cleaning of fuel and provides a work surface for handling materials; and the Remote Viewing Subsystem provides for remote viewing of the work area by operators. There are two complete and identical FRS systems, one to be installed in the K-West basin and one to be installed in the K-East basin. Another partial system will be installed in a cold test facility to provide for operator training.

The purpose of CVT was to provide validation of equipment layout and functionality and validate the FRS process logic. The test program was set up to accomplish these objectives through cold (non-radiological) testing of the Schilling Robotic Systems' Konan manipulator system. The K-West basin (KW) manipulator system, the K-East basin (KE) equipment operations center (EOC) and close circuit television system (CCTV), a prototype long pole tool for recovering dropped fuel pieces, a process table mockup, and various other major process equipment mockups were used for these tests. The Konan manipulator system was installed in a wide, elongated pit at the Hanford 305 Building Equipment Testing Laboratory (ETL) during February 1998 and was subjected to several months of burn-in testing prior to turnover for CVT, which took place in early September. Formal testing began September 18.

A grating platform was installed over the pit at a prototypic elevation referenced to the manipulators and process table below. There were also mockups of the Primary Clean Machine (PCM) and the MCO basket queue located in correct position in relation to the process table. These were included in an attempt to evaluate travel room and relative positioning during normal operations. To provide additional validation, trained K-Basin Nuclear Process Operators (NPO) were utilized to perform the CVT test functions. These individuals possess the required expertise for in-basin fuel handling activities associated with K-Basin fuels and provided valuable insight to the testing program and results. The operators chosen represented an average shift crew of four, where two of the operators were very experienced and exceptionally competent and the other two had significantly fewer hours of experience and represented more of the average competence level expected for future manipulator operators.

To validate both the equipment and the FRS process logic, the basic fuel handling process was performed using four distinct operating scenarios. The first was for equipment validation and was set up to use both

manipulators in the production mode to process a single canister consisting of a standardized mix of 14 dummy fuel assemblies, which is referred to as the "standard canister". The production mode refers to processing the fuel without performing any inspections on the individual fuel assemblies. Typically, the goal of the production mode is to move the fuel and repackage it as quickly as possible. The remaining three scenarios, referred to as process validation runs, were all designed to validate the FRS process logic. This was accomplished by setting up four canisters of 14 dummy assemblies each and included the standard canister.

The first process validation test used both manipulators in the process validation mode, which is where each and every piece of fuel is inspected for sludge/oxide adherence and/or gross physical damage in order to validate the fuel cleaning process. The second process validation test again used both manipulators, this time in the production mode, where no inspections were performed. The fuel was simply sorted, separated, and loaded into the MCO baskets. The third process validation test used only a single manipulator (north arm only) to process the fuel, also in the production mode.

For the dual manipulator tests the basic process was broken into two logical sub-processes:

- North table operations; where fuel sorting, disassembly of full length fuel elements, separation of fuel segments less than three inches long (scrap) from the remainder of the fuel, scrap basket loading, debris separation and loading, and finally transferring the good fuel down to the south table ramp, takes place.

- South table operations were completely concentrated on fuel basket loading, including checking each outer element for basket socket fit in the go no-go gage.

A total of 16 test runs were performed where the equipment validation tests confirmed that the Konan manipulator and the prototype support tools can perform the required processing steps for K-Basin fuel recovery and re-packaging. Process validation tests verified that the time required to process a single MCO basket (Mark IA) is approximately 4 to 4-1/2 hours, which is significantly better than the maximum required time of 12 hours per MCO basket.

Abbreviations and Acronyms

BNFL	British Nuclear Fuels Limited
CDR	Conceptual Design Review
CSB	Canister Storage Building
D&D	Decontamination and Decommissioning
DESH	Duke Engineering Services Hanford
DOE	Department of Energy
EOC	Equipment Operations Center
ETL	Equipment Testing Laboratory
FRS	Fuel Retrieval System
ID	Inside Diameter
IWTS	Integrated Water Treatment System
MCO	Multi Canister Overpack
NPO	Nuclear Process Operator
OD	Outside Diameter
PCM	Primary Clean Machine
PNNL	Pacific Northwest National Laboratory
SNF	Spent Nuclear Fuel
SRS	Alstom Automation Schilling Robotics
VCR	Video Cassette Recorder
WHC	Westinghouse Hanford Company
XXS	Double Extra Strong

Contents

Figures

Tables

Introduction

This document describes cold validation testing of the Fuel Retrieval System (FRS) Manipulator Subsystem, which is part of a much larger validation effort for the full FRS. Cold validation testing was performed in support of the FRS Sub-Project, a subtask of the Spent Nuclear Fuel Project at the Hanford Site in Richland, Washington. FRS test requirements are contained in HNF-SD-SNF-TP-027, "Test Plan and Strategy for the Fuel Retrieval Subproject" and manipulator system cold validation testing was performed to a formal released test procedure (Reference 4). A brief summary of the general FRS process is included in greater detail in Appendix G of this report.

The FRS will be used to retrieve and repackage K-Basin Spent Nuclear Fuel (SNF) currently stored in old K-Plant storage basins. The system will be used to clean and remove fuel from the fuel storage canisters, repackage it into new storage baskets, and transfer the baskets into a multi canister overpack (MCO). Once inside the MCO the fuel will undergo a cold vacuum drying process before the complete package is transferred for interim dry storage at the Canister Storage Building (CSB), also located on the Hanford Site. The FRS is required to retrieve full fuel canisters from the basin; clean the fuel elements inside the canister to remove excessive uranium corrosion products (or sludge); remove the contents from the canisters; and sort the resulting debris, scrap, and fuel for repackaging. The fuel elements and scrap will be packaged into MCO fuel storage and scrap baskets in preparation for MCO loading, while the debris is loaded into a debris bin and disposed of as solid waste.

Duke Engineering Services Hanford (DESH), formerly Westinghouse Hanford Company (WHC), was contracted to provide a retrieval system for safe repackaging of spent nuclear fuel in the K basins. DESH in turn let a subcontract to British Nuclear Fuels, Limited (BNFL) to provide design performance specifications for use in procurement of systems and equipment. In addition, a development test program was used in the design process to provide design information where experience and calculations could not provide or confirm the design basis (References 1 and 2). As a follow up to development testing a validation test program was implemented to confirm basic design assumptions and validate both the equipment design and the process logic for fuel recovery.

Pacific Northwest National Laboratory (PNNL) was requested to coordinate and lead the testing and computer simulation needs for development of the fuel handling retrieval system and for the validation test program. BNFL provided the applicable test specifications, indicating specific design needs, and tests were conducted in the Equipment Testing Laboratory (ETL), located in the 305 Building at Hanford. The ETL provided necessary facility space, test equipment design support, fabrication, engineering, and technician support for the FRS testing program.

The first phase of FRS testing was development testing, which was used to provide proof of concept and criteria, optimize equipment layout, initialize the process definition, and identify special needs/tools and required design changes in support of performance specification development (References 1 and 2).

Development testing was utilized in design of the primary cleaning machine (PCM), the canister decapper station, the stuck fuel station (canister slitter), the manipulator system, the remote CCTV viewing system, and many associated manual, or long reach, tools. In addition, development testing played a key role in developing a fuel handling and packaging process.

The second phase of FRS testing was cold validation testing. This was confined specifically to the manipulator system, the CCTV system (EOC), their respective interfaces, and the actual fuel handling and packaging process. Separate, individual validation test programs were developed for validation of the PCM, decapper station, and stuck fuel station designs. These test programs were also scheduled for fiscal year 1999. This report is limited to cover cold validation testing of the manipulator system only, which was performed in September 1998.

Test Objectives

The objective of Cold Validation Testing was to validate the final manipulator system design and the FRS fuel handling process as it applies to the process table. To ensure that the test procedures accomplished this task, they were developed, reviewed, approved, and released as a SNF controlled document. Final approval and distribution was accomplished using the Engineering Data Transmittal (EDT) system with final approval by the FRS Design Authority, the SNF-FRS Project Manager, SNF QA, the K-Basins Operations Manager, and the Engineering Laboratory Manager. Prior to distribution for approval, the procedures went through a rigorous review process, which included reviews by key project, operations, and startup staff. The approved test procedures were administered by the FRS Test Engineer and performed by qualified Nuclear Process Operators from the 100K Area operations crew.

To meet the general goal of cold validation testing, several sublevel objectives had to be met. These objectives were as follows:

- Prove that the equipment can adequately perform the required process steps for fuel repackaging.
- Provide validation that the FRS process description is viable and/or provide recommendations for process adjustments.
- Establish real-time production time lines based on actual performance times.
- Establish and/or refine basic equipment operating procedures.
- Establish and/or refine recommendations for hands-on operator time working the manipulators.

Test Method and Equipment

Test Method

The methodology used in CVT split the testing into the following major categories.

- Equipment Validation
- Process Validation

Equipment validation was performed to demonstrate that the system was able to perform all the basic functions required of it, while process validation focused on validating the fuel handling process as described in the FRS process description. In both cases, the throughput time was the major data point for performance comparison. During equipment validation testing the single standard canister was processed by each of two teams of two operators, where the test began with the standard canister dumped onto the north table ramp and concluded when the last piece of material was loaded into the appropriate container. There were a total of four equipment validation test runs where the operators switched places for their second run so that each operator ran each of the two manipulators during a test run.

Test Equipment

Cold validation testing was conducted in a non-radiologically controlled area and no radiological materials were used in any of the tests. A full scale, semi-prototypic mockup of the K-Basin processing area was erected in the 305 Building dry pit by NHC Engineering Laboratory personnel. It included mockups of the process table, the MCO scrap and fuel baskets, the primary clean machine (PCM), and a basin fuel rack. Actual Mark II fuel canisters, made up of two cylindrical cans or barrels joined together by an upper and lower lifting trunnion (ref. Figure 7), were used for CVT production simulations. The fuel was simulated using heavy wall pipe with similar diametric characteristics for both inner and outer elements, where the full-length dummy fuel elements were cut to 26 inches long, to simulate Mark IV fuel. The FRS Design Authority agreed that these tests adequately bounded the scope of canister and full types that FRS is designed to handle.

The mockup was set up in a prototypic arrangement, with component spacing and relative elevations being as accurate as could reasonably be achieved. To simulate basin monorail operations, a long-pole grapple, or hook, was deployed from an overhead crane for lifting operations such as retrieving fuel canisters and transporting them to the process table. In addition to the test article, the actual K-West production manipulator system, the K-East CCTV system and EOC racks were also installed in the mockup to complete the test set up.

The major test article was the K-West manipulator system, which includes two manipulator arms, two bridge/mast assemblies, the two target PCs (control system computers), and two master controller units (MCU). In addition to the K-West items, the EOC rack module, Basin Area J-Box, Hydraulic Distribution Manifold, hose/cable management system (e-chain), and the Hydraulic Pump Unit (HPU) for the training manipulator system were installed. These are all integral components to the manipulator system; however, these items are generic in nature and do not require specific component testing. This support system will remain in place after the K-West manipulator system has been transported to the basins for deployment. It will be used to perform run-in testing on the K-East manipulator system and then, later, for operating the training system.

The same wood process table mockup used in earlier development testing was again used during cold validation testing (Figure 1). Some minor modifications were included to adapt the table to the dry pit mockup area, such as adding longer legs and increased cross bracing to the supports. In addition, some small sections had to be cut out of the table to allow it to fit into the pit area. None of these modifications affected the normal process areas of the table. In addition to the table, the MCO fuel basket, MCO scrap basket, fuel basket back light, and the fuel basket lazy susan used, or developed, during development testing were also used during cold validation testing.

A plywood mockup was used to simulate the PCM in the test system layout and an abbreviated version of a basin fuel rack was set up just north of the PCM. The fuel rack, shown in Figure 2, held three Mark II fuel canisters, which were filled with 14 full-length dummy fuel assemblies (inners and outers). A fourth canister described as "the standard canister" included a mix of "broken" fuel elements, debris, scrap fuel, and full-length elements. The standard canister was developed for development testing and was used again in cold validation testing as a production standard for comparative purposes.

The standard canister makeup was based on K-East fuel condition as described in ECN 191405 (included in Appendix F) and is described in Table 1. It was made up of this mix of simulated scrap, debris, broken fuel, and full- length fuel. For control purposes, the standard canister contents were painted white. Figure 3 shows the contents of the standard canister dumped onto the north end of the process table.

TABLE 1. FRS Standard Canister Makeup.

• 10 full length inner elements • 10 full length outer elements • 2 half length inner elements • 2 half length outer elements • 14 pieces of inner element under 3" in length	• 14 pieces of outer element under 3" in length • 3 one-third length inner elements • 3 one-third length outer elements • 1 old glove (debris) • 1 screwdriver (debris)

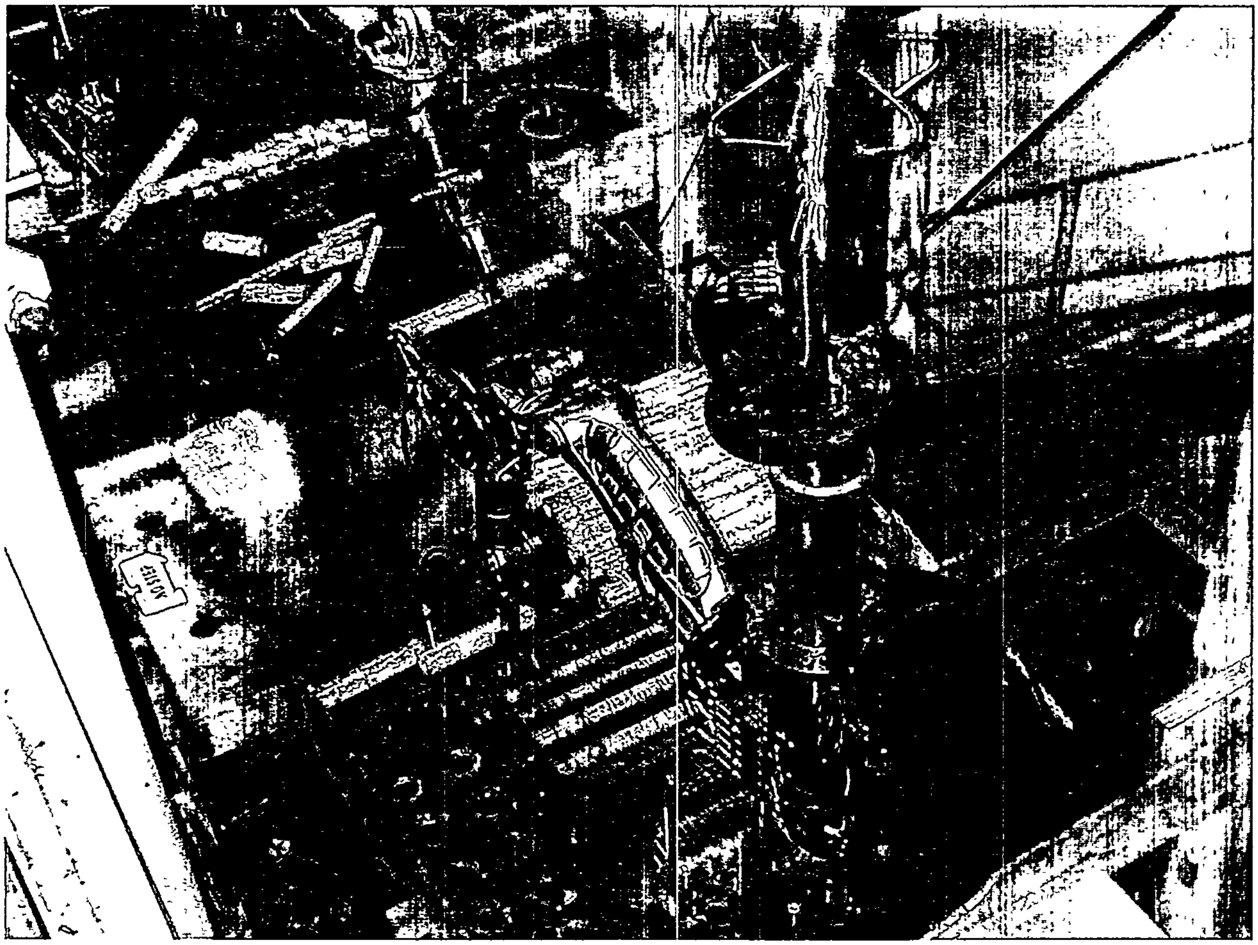


Figure 1. Process Table Mockup.

This approach, using the standard canister, puts all the broken fuel, scrap, and debris into one canister, which equates to approximately 25% of the fuel in this single canister being in one or more pieces. When performing single canister test runs this puts an ultra conservative condition into the test, which easily bounds the expected normal condition with no adverse interpretation of production results. In contrast, when the other three canisters are added to the test mix, the percentage of total elements in one or more pieces is closer to 7%. This gives a relatively close approximation to the expected gross fuel makeup in K-East, where the expected percentage of broken fuel is approximately 10%. For K-West it's 2%[1], with the raw average pieces per broken element equated to be 2.5. This mix was adjusted to three pieces per element, two pieces per element, and an odd mix of scrap fuel less than 3 inches in length. The scrap was included to add fine motion handling and scrap loading requirements to the production simulation and does not necessarily correspond specifically to defined fuel conditions, where 12% of the defective fuel is expected to be loaded out in scrap baskets. The assumption used for CVT is that the entire quantity of scrap consisted of fuel pieces less than three inches in length and greater than one inch in length. Longer sections of fuel categorized as scrap are not a concern with regard to loading or handling functions and pieces less than one inch.

[1] Statistics taken from ECN 191405, page 4 of 6, Section B, See Appendix F

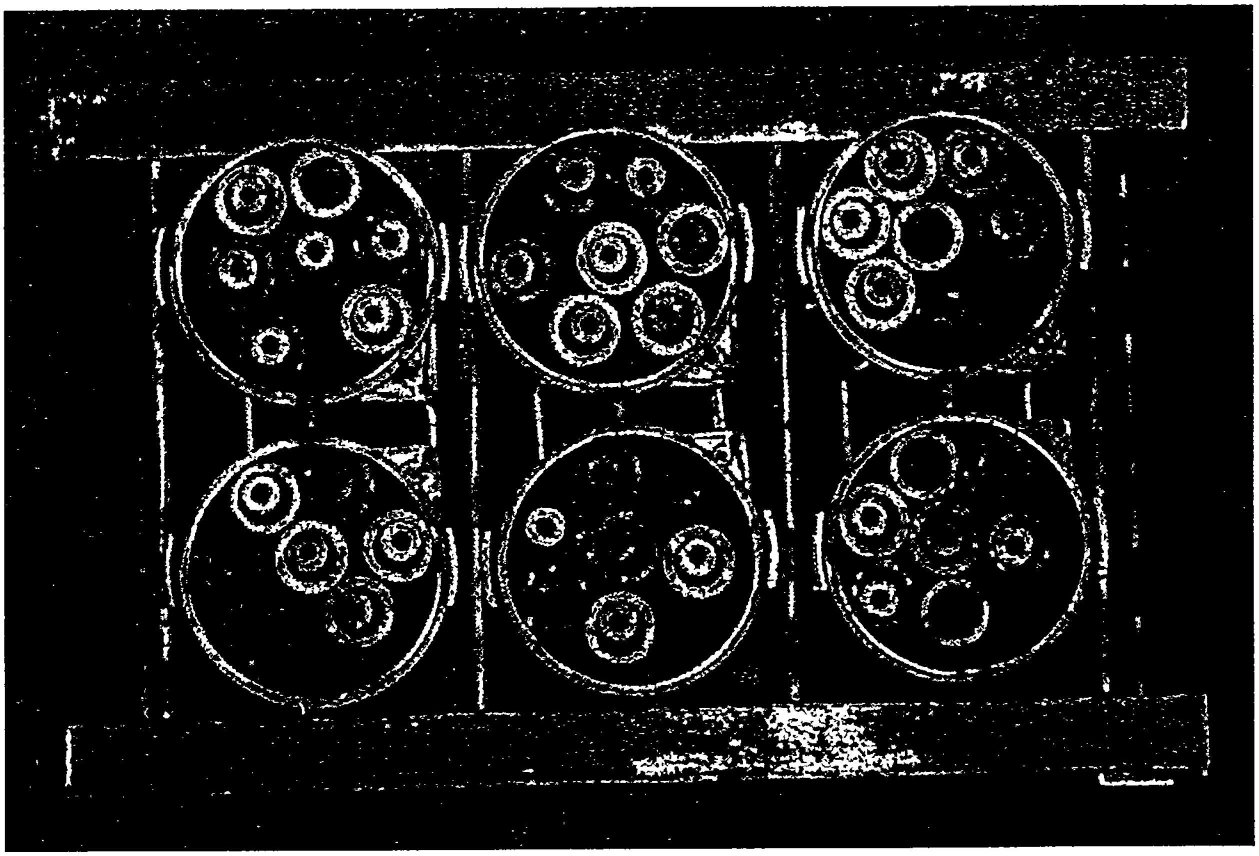


Figure 2. Fuel Rack Mockup with 3 Full Fuel Canisters.

Each fuel canister is made up of two individual barrels joined together by an upper and lower lifting trunnion. Each barrel holds 7 fuel assemblies resulting in each canister holding 14 assemblies.

will be treated as "fine scrap", which is being dealt with in a separate development and validation testing program and therefore not included in CVT.

The manipulator system used in CVT will be deployed in the K-West basin for fuel handling and repackaging, where each manipulator assembly includes a manipulator arm, a bridge/mast assembly, and a PC control computer. The bridge moves along a rail system that allows only straight line, forward and reverse movement. The bridge has the manipulator support mast suspended vertically from its center and remains stationary relative to the bridge. A helac is attached to the base of the mast and the actual manipulator arm attaches to the helac. The helac is a device that provides 360° rotational movement in the horizontal plane, which allows the manipulator to be deployed in any direction off the centerline of bridge travel. The manipulator arm is an electro-servo, teleoperated manipulator capable of a 375-lb. lift at full extension and is designed to simulate the joints of the human shoulder and arm. The system also includes two CCTV cameras, one mounted on the wrist of the manipulator arm and one suspended from the bridge. The bridge camera includes pan/tilt capability, while the wrist camera is a stationary mount.

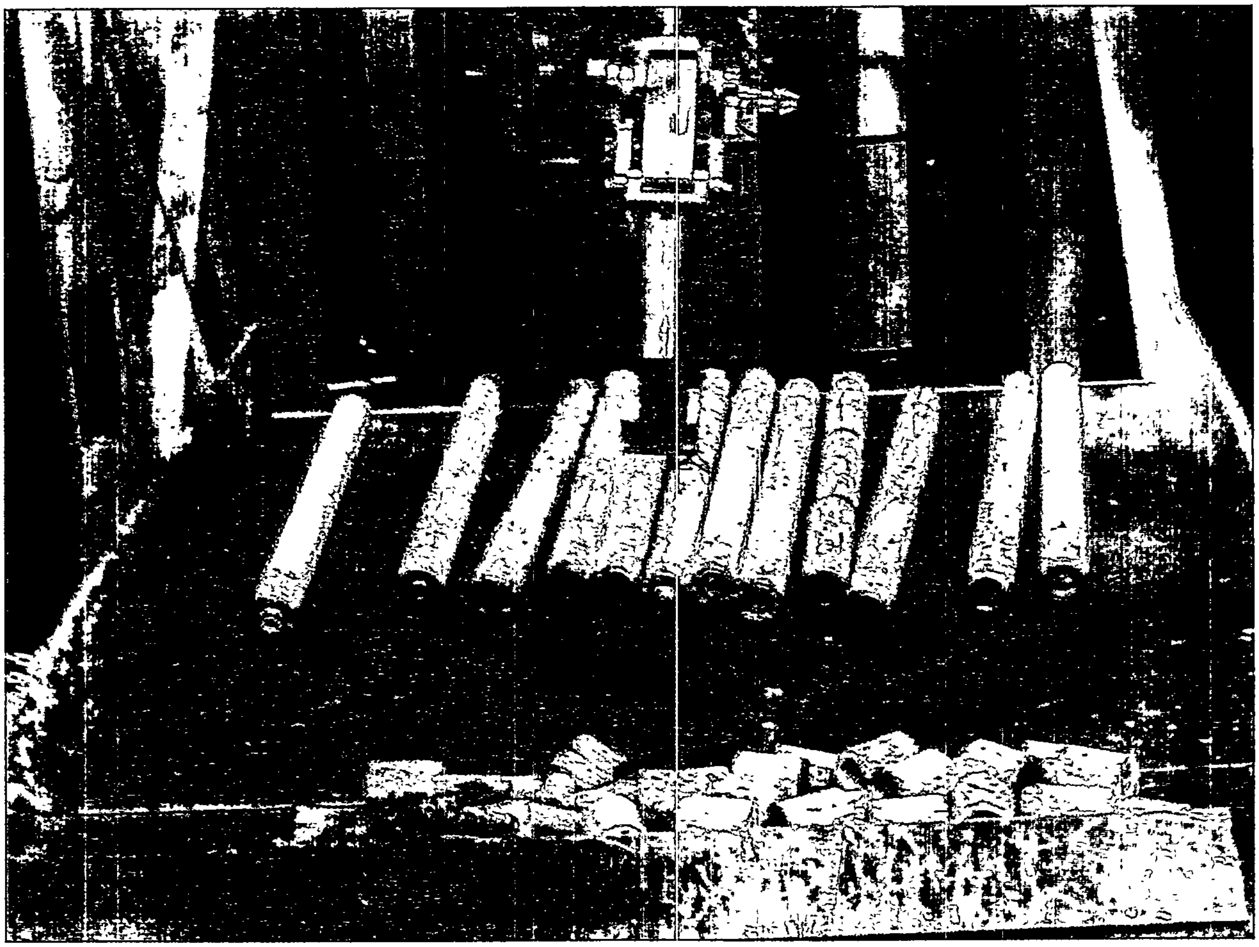


Figure 3. Standard Canister Contents Dumped onto North Table Ramp.

The system design and manufacture was provided by Alstom Automation Schilling Robotics (SRS) under contract to DESH. The design utilized a modified version of the SRS Conan manipulator arm, which SRS labeled "Konan". In spite of the unique label for the K-Basin version, both spellings are seen in various manuals, drawings, and other associated documents and should be considered equivalent. SRS also supplied the hydraulic supply system, the PC control system, the software, and all power/hydraulic distribution systems required to operate the manipulator.

During development testing a revised manipulator jaw design was tested in the first prototype mode (Figure 4). The design was refined and a second-generation prototype was fabricated and installed on the test manipulators. The modified jaws extend farther out than the standard SRS jaws like two long fingers. This enables the operators to reach into areas that they could otherwise not reach into because of the bulk of the wrist and jaw mounting section. In addition, the extended jaws allow a higher degree of visibility of what is being picked up, primarily because the wrist blocks the view when the standard jaws are used. During CVT, the need for refinement of the prototype extended jaw design was identified, modifications were drawn up and a revised design issued as a formal fabrication drawing. The first two sets of the new jaw design will be procured for, and tested with, the K-West manipulators.

The device used to pick up full-length fuel elements and load them into the MCO fuel basket was the result of earlier development testing. SRS took the basic concept and developed a modified version of the tool and improved the actuation system to work with the Konan manipulator jaw (Figure 5). The basic principle is that of expanding a urethane spring outward against the inside diameter (ID) of a fuel element. The pressure applied creates sufficient friction to hold the fuel element during transfer into the fuel basket. Actuation of the manipulator jaw was used to actuate the device. A lever arm is attached to the manipulator in such a manner that when the jaws are opened, the lever is pushed away from the anchor point on the manipulator wrist. The lever has a cable pull assembly attached to it and when the lever moves the cable is taken up, which then pulls an end piece back toward the anchor point. The urethane spring is sandwiched between the anchor point and the end piece and when the cable gets taken up, the urethane spring gets compressed. The axial compression then expands diametrically against the ID of the fuel element. When the fuel element is acquired in this manner it can be lifted up and will hang vertically no matter what position the arm is in. This ability is critical for loading fuel elements into the basket. This device was included in CVT as a tool, but is also undergoing its own development and improvement program.

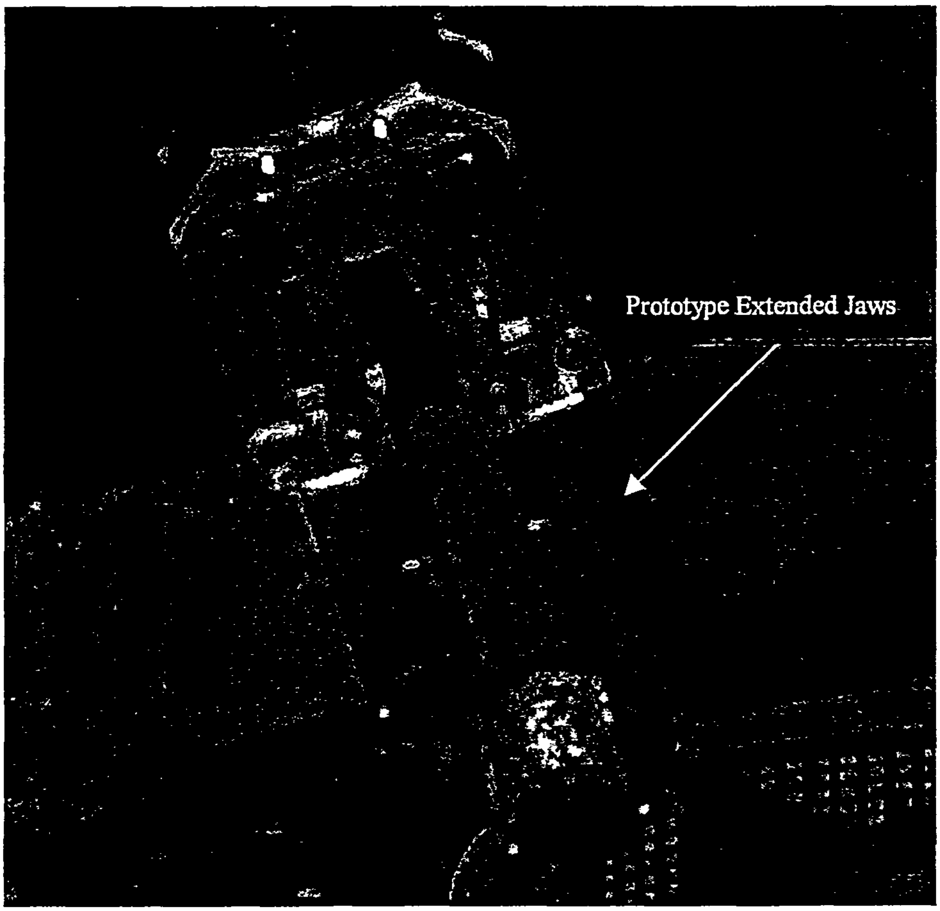


Figure 4. Extended Manipulator Jaws.

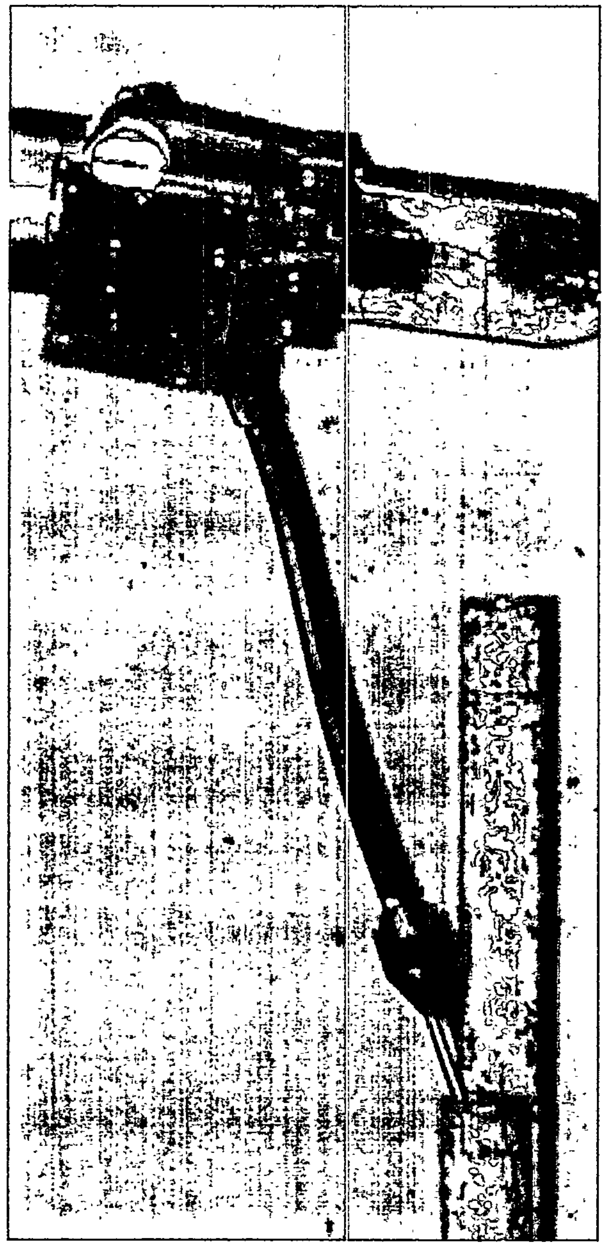


Figure 5. Fuel Grapple End-Effector.

All tests were performed using remote camera operations. The CCTV system procured for deployment in the K-East basin was set up in the test facility for CVT and early operator training. The CCTV system provided 12 cameras, including the two on each of the manipulators, and controllers for remote viewing capability. These cameras were deployed in the same manner and relative locations to be used in the basins. Both the camera and manipulator control systems were installed in the Equipment Operations Center (EOC) and testing was performed using the actual production control and viewing stations (Figure 6).

Figure 6. Equipment Operations Center.

Process Validation tests focused on the process and not on the equipment. Tests were performed in several different configurations and, as in equipment testing, each operator ran each of the machines at one time or another. Process validation tests also utilized a total of four fuel canisters rather than just a single canister. Using four canisters provided enough dummy fuel elements to fill a Mark IA fuel basket and leave eight fuel assemblies lying on the south table ramp. As in equipment validation, the tests began with the standard canister dumped onto the north table ramp. The other three loaded canisters remained in the canister rack until all the fuel dumped onto the north table ramp was moved to the south table ramp or loaded in the appropriate container. The second canister was then removed from the canister rack and dumped onto the north table ramp while the south manipulator continued to load fuel from the first canister into the fuel basket. The north manipulator had to be rotated to a due west position and parked in the center of the fuel inspection area of the table to provide sufficient clearance to dump the next fuel canister. The time taken to dump each successive canister was included in the production throughput times included in the test results. Every test run performed during CVT was video taped for additional documentation of test performance results.

Test Descriptions

Cold Validation Testing was made up of several individual test runs, each of which was performed as part of a standard test sequence. In total, there were three test sequences, each of which was designed to acquire pertinent data on specific operation and performance parameters. All three test sequences were built on one or the other of two basic test procedures (Reference 4). One test procedure represented the validation mode of operation, while the other represented the production mode. Copies of the test procedures are included in Appendix E of this report.

The CVT test procedures and sequences were built on knowledge gained from FRS development testing and ultimately on the FRS Process Description (Reference 3). Each of the three test sequences included several individual test runs, the results of which made up the aggregate data package for the test sequence. The three test sequences and a brief description of each are as follows:

- Equipment Validation
  Does the equipment perform the functions required of the process?
- Process Validation
  -Can the process be performed to meet the requirements of the following process modes?
  -Validation Mode – mode to be used during initial startup and operation of the FRS when efficacy of the process is being verified and key operating parameters are being optimized.
  -Production Mode – mode to be used for processing the bulk of the fuel once validation mode has been successfully completed.

In addition to the different test sequences, the Process Validation – Production Mode sequence was performed using both single-manipulator and dual-manipulator operating scenarios. In these two cases the tests were run with either one or both manipulators used to perform the normal fuel handling process. The dual manipulator process is the recommended standard operation and the single manipulator process is the fall back in the case where one of the manipulators becomes inoperable.

Equipment Validation Tests

This test sequence was intended to validate the equipment's capability to perform the necessary functions to process the fuel. As such, the primary focus of these tests was the equipment and its proper function.

The test sequence involved processing a single canister of dummy fuel elements, including simulated broken and scrap elements, from the north end of the process table to the south end of the table and loading each individual piece into the appropriate MCO basket. The canister contents included simulated debris, which was disposed of as described in the process description. Processing was performed using both manipulators, one to sort fuel on the north end of the table, load the scrap fuel and debris and a second manipulator to load full length fuel elements on the south end of the table. A limiting acceptance time of three hours was assumed based on results from early development testing in FY97 (Reference 2).

At the beginning of CVT, three practice runs of the equipment validation sequence were run. The practice runs were used to fully evaluate operator readiness to perform the battery of CVT tests. As expected, there was a mild learning curve during the practice runs, but the operators came up to full speed in a suitable time and regular testing commenced. For equipment validation a total of five test runs were performed, where the collected data included process throughput times, interruptions, exceptions, and system malfunctions. To readily assess the system's capability, tests were not stopped in the event of minor equipment problems. The definition of minor was applied to any occurrence that could be readily and quickly corrected. These included control system communications loss, control computer crashes, etc. In each case the interruption or problem was logged into the test exception log and the test run continued. Minor interruptions were included in the final process time recorded for each test run. It was determined during test preparations that such interruptions could be expected during production and that they were insignificant to long term production goals and certainly did not render the equipment unacceptable for its intended function.

Major equipment problems were also accounted for in the test exception log, but the test clock was stopped during the repair time for this level of interruption. In all cases the equipment test runs were restarted and completed. This type of interruption should not be expected during normal operations and for that reason they were diagnosed and corrected prior to restart of the test.

Process Validation Tests

The purpose of process validation testing was to validate the fuel handling process as described in the FRS process description. As such, the primary focus of these tests was on the process and the ease of which the operators could perform it.

In the process validation tests the fuel handling process steps required to process fuel from acquisition of the fuel canister to final loading of the MCO fuel basket were performed. To more accurately depict the actual process a total of four fuel canisters were used in the simulations. Four canisters were used because they held a sufficient quantity of fuel elements to completely fill the Mark IA fuel basket (48 assemblies) being used in the tests. The test run time included the time to move the remaining eight assemblies (eight inners, eight outers) onto the south table ramp as well. This provided sufficient data to more accurately estimate the loading time for the Mark IV fuel baskets, which hold 54 assemblies. Three canisters were filled with full length (no scrap or debris) dummy assemblies and set into a mockup canister queue, located just north of the Primary Clean Machine (PCM) mockup. The standard canister was used for the fourth canister and was dumped onto the north table ramp prior to starting each test run.

In all the process validation test runs the standard canister was the first of the four canisters processed and it was always dumped onto the north table ramp prior to starting the test. This set up the test run with one canister already dumped onto the ramp and three full canisters stored in the simulated queue. Test processing times included the time to dump each of the three queued canisters onto the north table ramp and to clear the empty canister away from the manipulator work area.

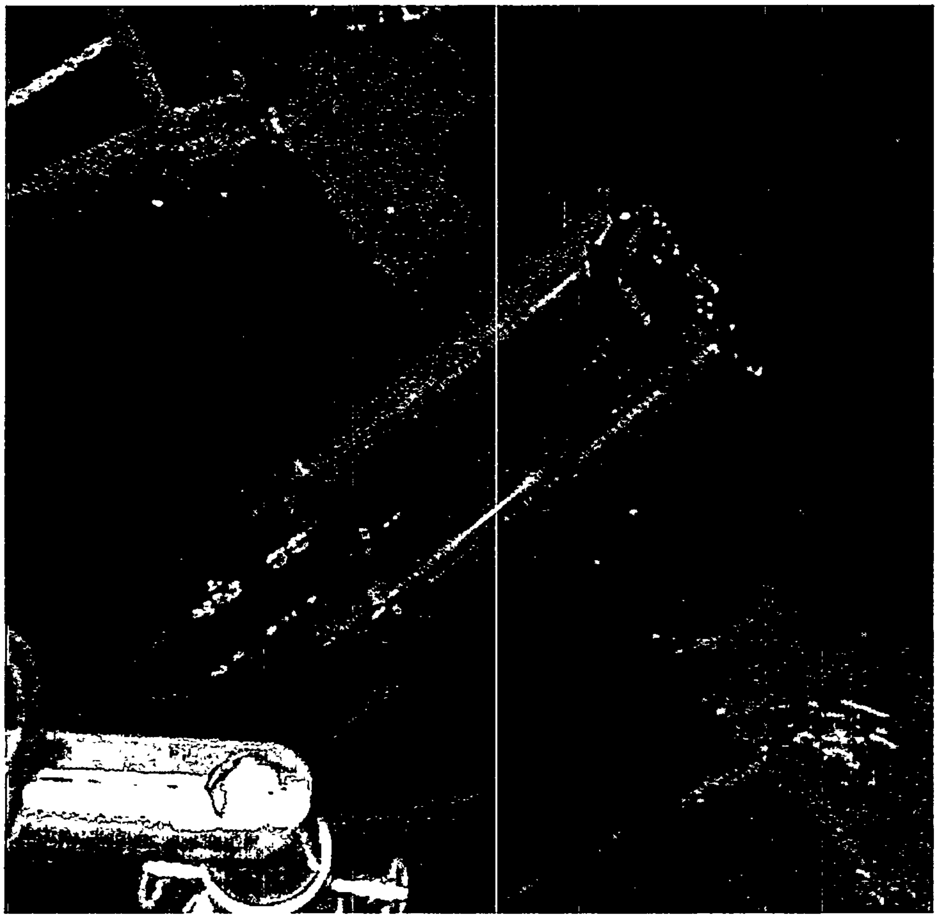


Figure 7. Dumping a Mark II Canister onto the Process Table North Ramp.

The general fuel handling process used in process validation testing started with sorting the standard canister fuel, scrap, and debris on the north end of the table, then moving the good fuel (pieces longer than three inches) to the south table ramp. After the good fuel was moved to the south table ramp, the south manipulator could be used to begin loading the fuel into the MCO fuel basket. The north manipulator would then be used simultaneously to finish sorting and loading the scrap and debris into the north scrap basket or debris bin. This process was repeated for each of the remaining three fuel canisters. In basket loading, the first fuel pieces to be loaded are the broken outer elements. These pieces of fuel get loaded first in order to provide more room for maneuvering the manipulator or the modified Peter's tool. The first step in this process is to recover the short, or broken, outer elements and stack them up in the measuring rack, where the overall length of broken outers can be determined. This sets up a nearly full-length column of fuel to load into one basket slot. Then the longest of the short pieces for each stack of broken outer elements were picked up and set into the go no-go gage, where they could easily be acquired with the manipulator fuel tool or grabbed with the Peter's tool. For the CVT, one of the broken outer elements was too short to load with the manipulator so the long-reach modified Peter's tool was used to load it into the basket slot (Figure 8). This short piece of outer element was usually the first to be loaded, with the other longer broken outer elements being loaded with the manipulator fuel tool. After loading these starter pieces, a full-length inner element was picked up with the manipulator jaws and placed inside one of the outer elements (Figure 10). The remaining pieces of this first broken outer element were slipped over the end of the inner element and dropped down in place, again using the manipulator jaws. This sequence was repeated until all the broken outer element pieces were loaded in the fuel basket. The next step was to use the manipulator to pick up the full-length outer elements from the south ramp and set them up in the go no-go gage. The go no-go gage is sized to verify that a fuel element will be able to be loaded into a fuel basket socket and allows the elements to be oriented in the vertical position. Once in the vertical position, the manipulator fuel tool was used to acquire an outer element and load it into an empty basket socket. After all the outer elements were loaded into the basket, the broken inner elements were picked up with the manipulator jaws and dropped into an outer element. Finally, the full-length inner elements were loaded into each remaining empty outer element so that each basket socket held a complete fuel assembly.

A basket-loading map was used to keep track of which sockets were loaded with each piece of dummy fuel for both inner elements and outer elements (Figure 11). The operator recorded what length piece was loaded into each socket as he loaded the piece into it. This keeps track of fuel pieces that cannot be easily seen once loaded and keeps track of where the empty sockets are in the basket. This becomes increasingly important as the basket becomes fuller as demonstrated in earlier development testing (Reference 2). It is possible to have an empty socket in the middle of several full sockets and not be able to see it from above. Without marking the map, an operator might assume that all the sockets are full and prematurely load the basket into the MCO. The map is also very useful for fuel accountability.

There were three variations of process validation testing performed during CVT. They were validation mode and dual manipulator-production mode, which use both manipulators as described above, and single manipulator-production mode, which uses only the north manipulator to perform all of the process steps.

Validation mode tests followed the validation mode fuel handling steps described in the FRS process description, which include all of the production mode operations described in the FRS process description plus mandatory fuel element separation and individual element inspection. For CVT the fuel element inspections included inspection of the scrap fuel pieces. Also, in validation mode tests the actual fuel separation ram and inspection stations were not available, so dummy elements were separated by simply dumping the inner element out of the outer element and onto the table. Simulated inspection steps were also included in the tests. Inspection simulations consisted of setting the dummy fuel piece onto the simulated inspection area and holding it there for five seconds. During validation mode testing, each and every piece of dummy fuel was "inspected" in this manner, including the scrap pieces.

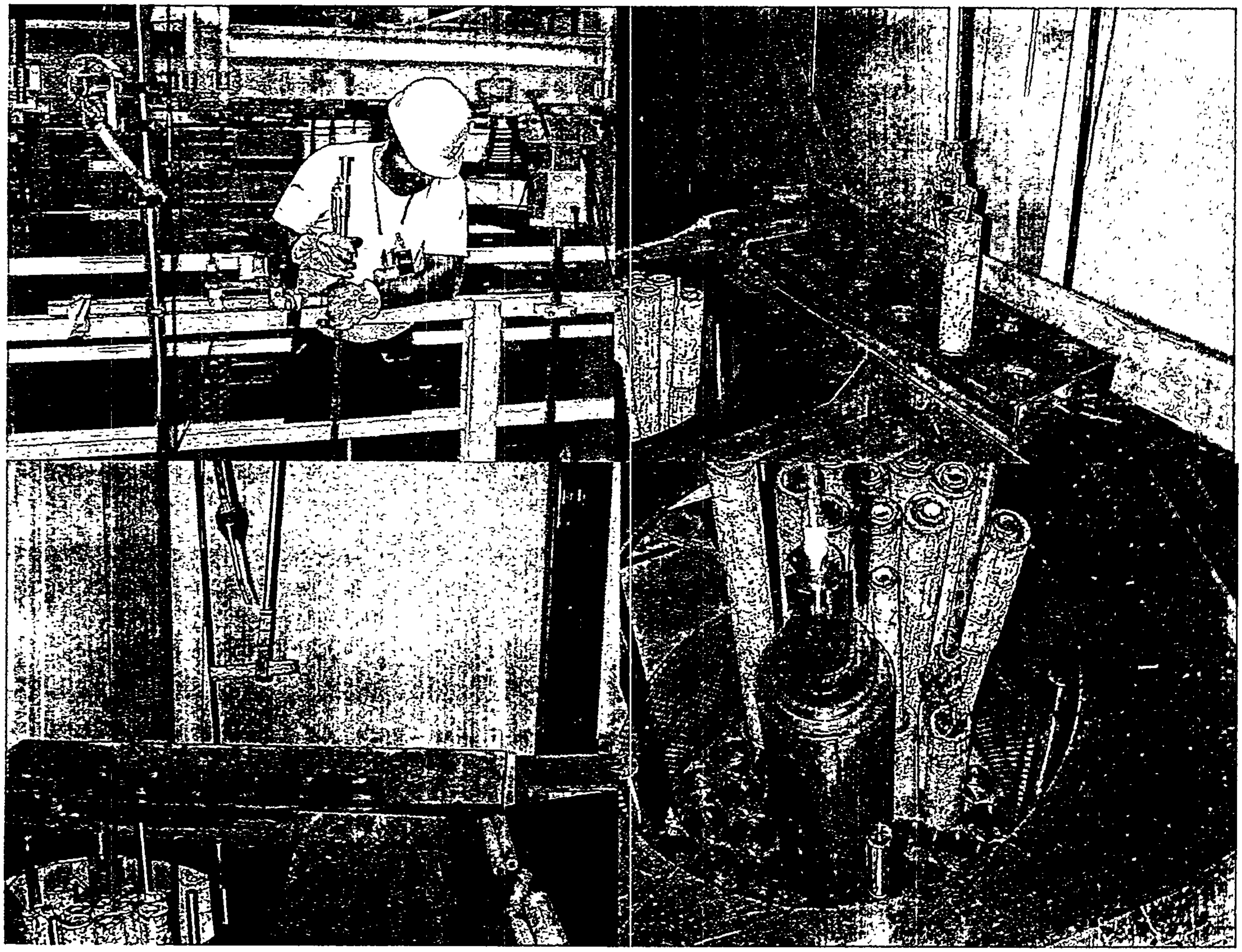


Figure 8. Using the Modified Long Reach Gripper to Load Short Fuel.

Clockwise from Top Left: a) Operator Clamping Modified Peters Tool Jaw onto Fuel Element; b) Placing Short Outer Fuel Element Into Go/No-Go Gage; c) Loading a Short Outer Fuel Element Into MCO Fuel Basket; and d) Picking up a Dropped Piece of Inner Fuel Element.

Dual-manipulator production mode tests followed the standard production fuel handling steps and used both the north and south manipulator to separate and load the fuel. As described above, the north manipulator is used to sort fuel, scrap, and debris, separate the inner elements from the outer elements, load the scrap into the north scrap basket, load the debris into the debris bin, and transfer the acceptable fuel to the south table ramp. The south manipulator is used to gage the outer elements in the go no-go gage and to load the fuel into the fuel basket. The latter operation utilized the Schilling-designed manipulator fuel tool, or stinger. These test runs also included steps to transfer loaded fuel canisters from the simulated queue to the process table and dump each canister onto the north table ramp. Resultant test times are for completely loading a Mark IA fuel basket with 48 element pairs, including simulated broken fuel elements, and transfer of the remaining eight element pairs onto the south table ramp.

Single-manipulator production tests followed the standard production fuel handling steps but used only the north manipulator. The south manipulator was moved as far south as possible and "parked". In this operational set up, the north manipulator is used to perform all of the fuel handling and packaging steps, including loading the fuel with the manipulator fuel tool. As before, these test runs included steps to transfer loaded fuel canisters from the simulated queue to the process table and dump them onto the north table ramp. Resultant test times are for the time taken to fully load a Mark IA fuel basket with 48 element pairs, including simulated broken fuel elements, and transferring the remaining eight element pairs onto the south table ramp.

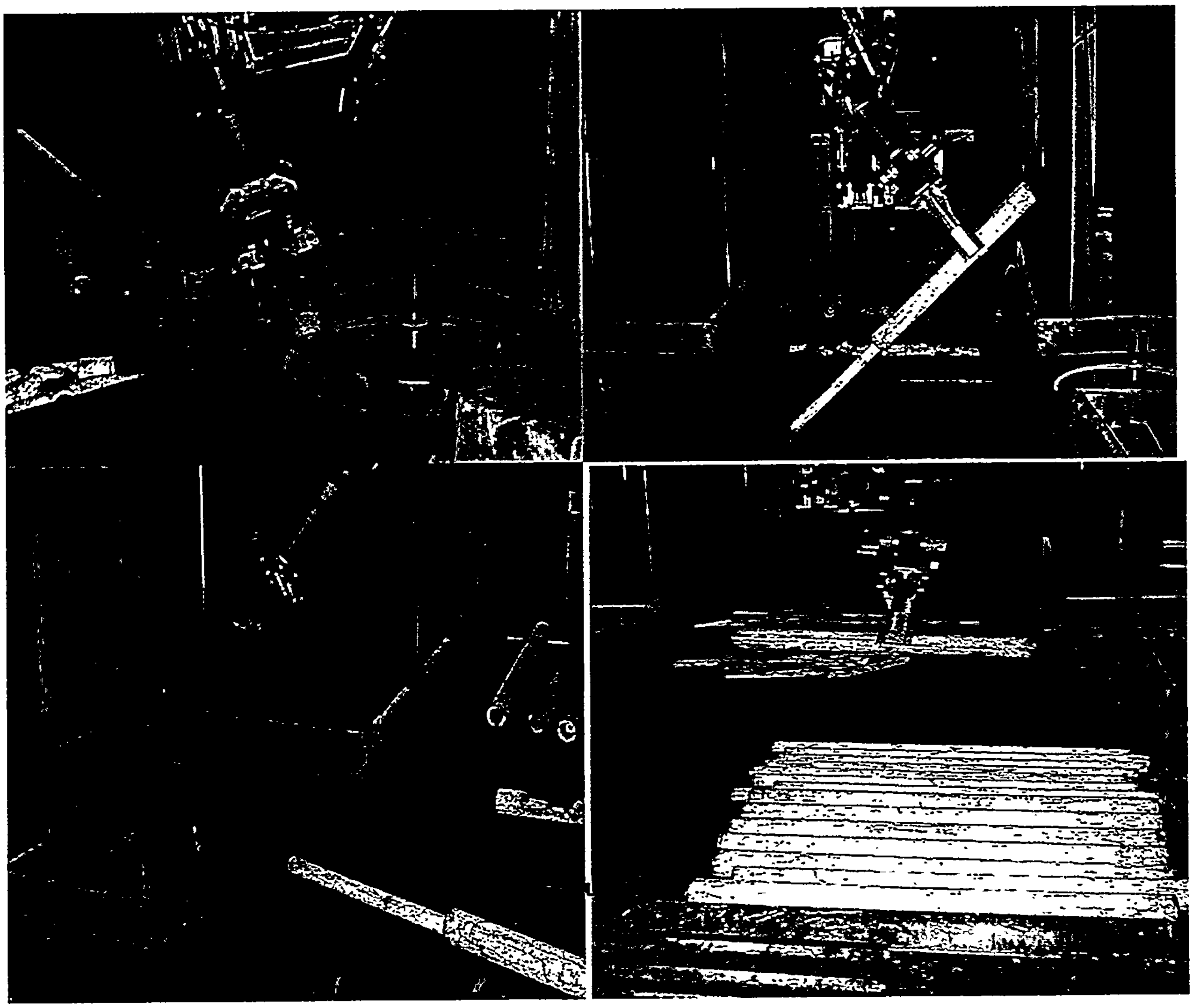


Figure 9. Manipulator Operations.

Clockwise From Top Left: a) Loading Scrap into North Scrap Basket; b) Separating an Inner Fuel Element from an Outer Element; c) Transferring Fuel to the South Table Ramp; and d) Loading Debris into Debris Bin.

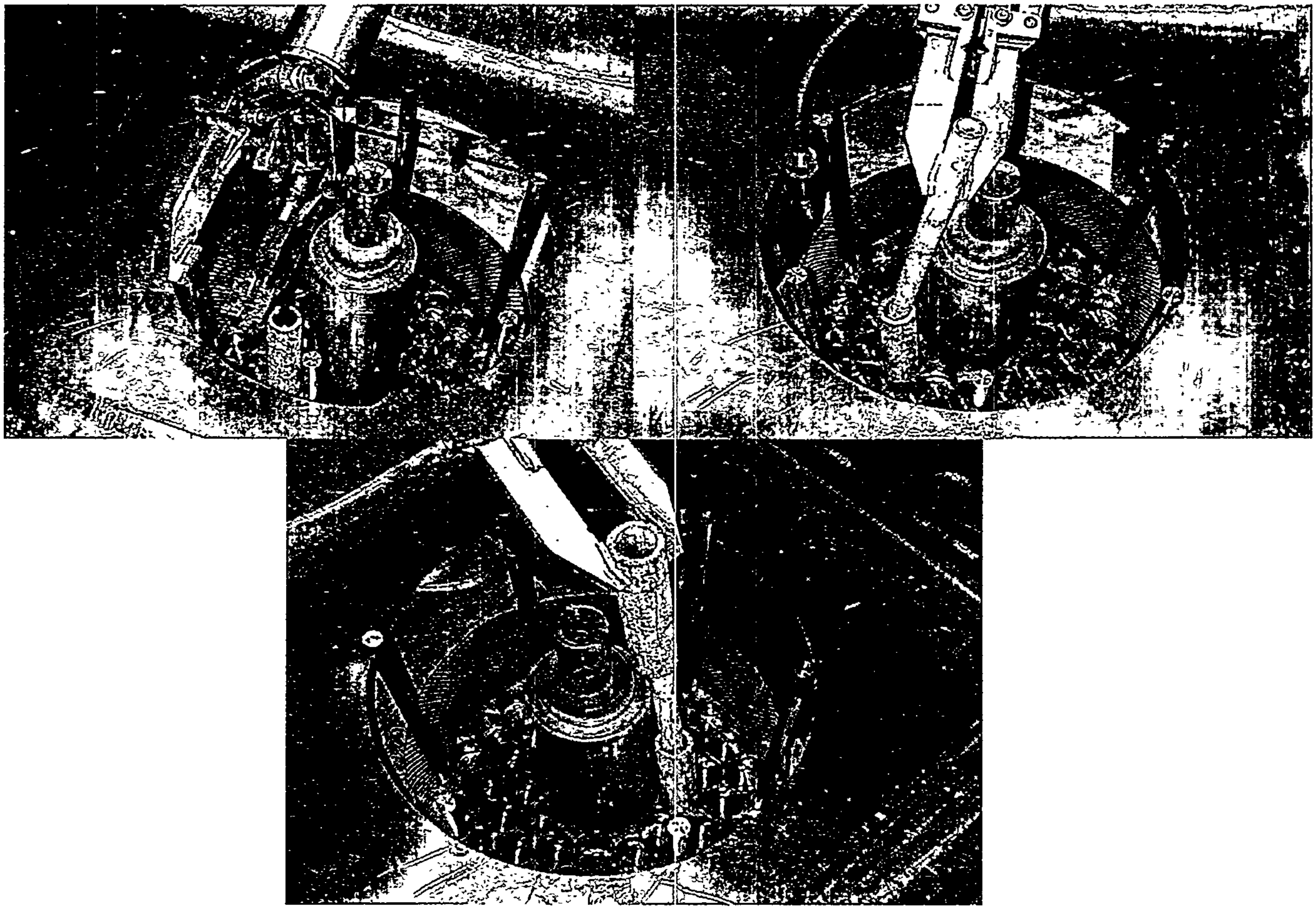


Figure 10. Loading Broken Fuel Elements.

Clockwise From Upper Left: a) Loading a Short Outer Element Into the MCO Fuel Basket; b) Loading a Full length Inner Element into a Short Outer Element; and c) Loading a Short Outer Element Onto the Full Length Inner Element.

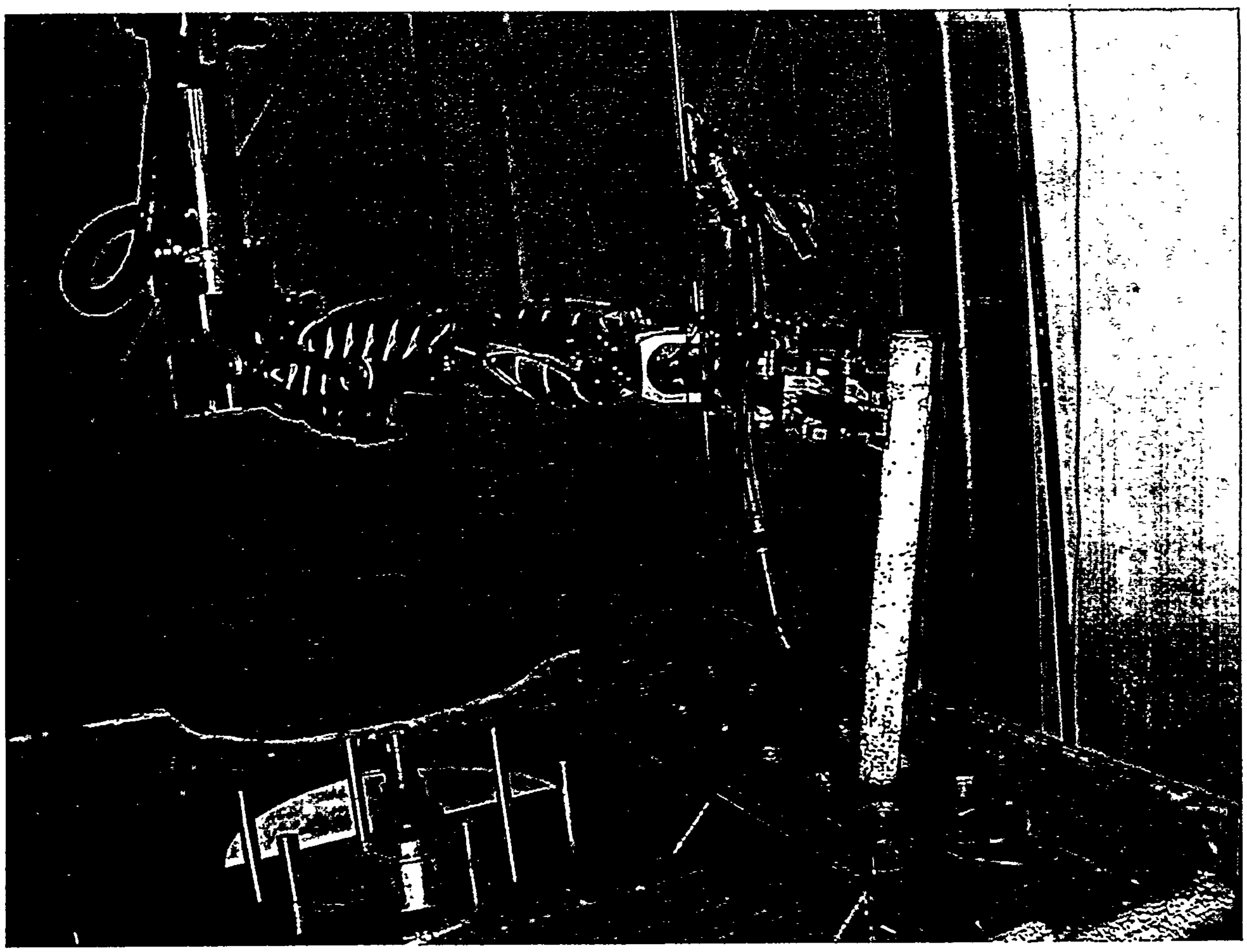


Figure 11. Gaging an Outer Element in the Go/No-Go Gage.

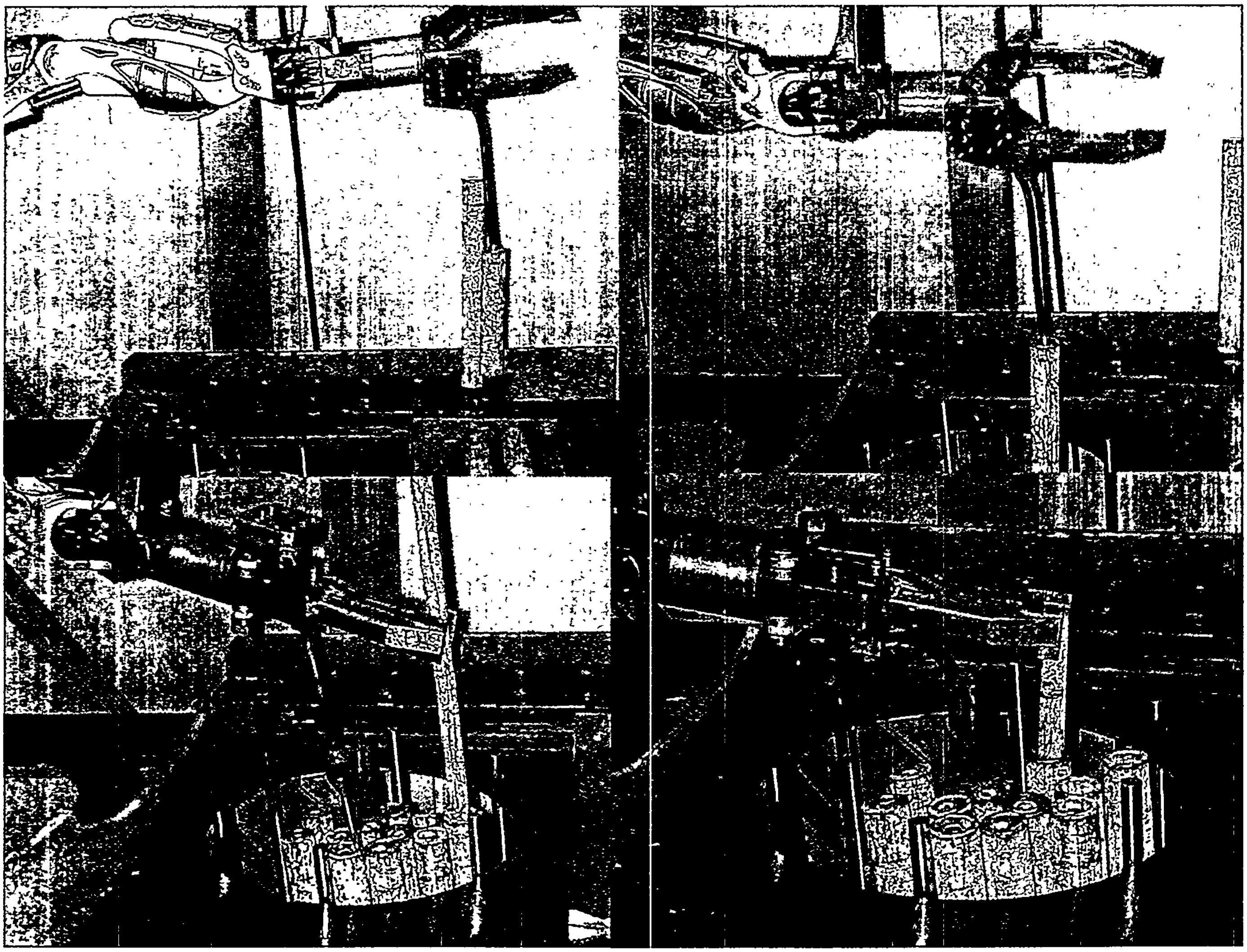


Figure 12. Loading Fuel into the MCO Fuel Basket.

Clockwise from Top Left: a) Picking a Short Outer Fuel Element up Out of the Go/No-Go Gage; b) Loading an Outer Fuel Element Into MCO Fuel Basket; c) Loading a Short Inner Fuel Element Into an Outer Fuel Element in MCO Fuel Basket; and d) Loading a Full Length Inner Element Into an Outer Element in the MCO Fuel Basket.

Test Results and Recommendations

Test Results

Equipment Validation

Equipment validation testing included five process runs. In addition to the canister process times being acceptable, ranging from 1 hour 4 minutes to 1 hour 54 minutes and an average time of 1 hour 30 minutes, the equipment performed all process steps in all cases both successfully and satisfactorily.

Process Validation – Production Mode

It was affirmed during process validation testing that the best process throughput times occurred using the dual manipulator approach. Using dual manipulators rather than a single unit for production was promoted as a result of earlier development testing. During process validation testing, in production mode, the average time to load a Mark IA fuel basket (48 Assemblies) using the dual manipulator approach was 4 hours, while the single manipulator approach produced an average production time of 6 hours and 16 minutes.

Process Validation – Validation Mode

The dual manipulator approach was also used during validation mode testing, with an average basket loading time of 4 hours 56 minutes. Some additional time should be expected during actual operations, as it was impossible to exactly imitate the validation inspection process.

TABLE 2. Average Production Test Results from Cold Validation Testing.

Average Production Test Results		
Mode of Operation	Average Canister Processing Times (Hours:Minutes)	Average MCO Basket Loading Time (Hours:Minutes)
Production Mode – Dual Manipulator	1:23	4:00
Production Mode – Single Manipulator	1:33	6:16
Validation Mode – Dual Manipulator	1:44	4:56

A Mark IA fuel basket was used in all the validation tests. The Mark IA basket holds 48 assemblies, whereas a Mark IV basket holds 54. Based on the production test results for the Mark IA, it is estimated that it would take approximately 4-1/2 hours to completely load a Mark IV basket, with its additional six assemblies.

Test Exceptions

A total of 20 test exceptions occurred during testing, however, in all but two cases testing was quickly resumed after correcting the problem. The majority of the test exceptions were associated with a cursor lock problem in the control software where the control PC had to be re-booted to correct the problem. Specifically, in these cases the test clock was kept running while the control system was re-booted. This was done to simulate actual conditions in the field should the cursor lock not be able to be eliminated from the software. In cases where support equipment failed or the system suffered a readily correctable case of infant mortality, the test clock was stopped to allow time for correcting the condition then restarted and the test run resumed after the exception was recorded in the data table. All occurrences of this type were determined to be short-term problems that were able to be permanently corrected or would be highly unlikely to occur or halt production during fuel repackaging operations. Examples of these are a power supply failure in the master control unit (MCU); a leaking seal in the pitch joint actuator; a pitch joint control problem (faulty wiring harness); having to adjust the cable tension on the fuel stinger; fuel stinger tool wouldn't fit inside the dummy fuel element; and failure of the modified Peters tool. The complete table of test exceptions is included in Appendix D.

In all, the cursor lock problem accounted for nine exceptions and the unrelated pitch joint control problem accounted for an additional four. In the latter case the problem was an intermittent problem traced down to a pinched, or smashed, wiring harness that required on line diagnostics to find. Once found, the faulty harness was replaced and testing resumed without further occurrences. The remaining test exceptions were able to be immediately corrected and did not pose a permanent threat to long term operability of the system, therefore testing was simply continued to completion. The cursor lock problem has subsequently been eliminated as a result of warranty work performed by the manufacturer. A complete mechanical refurbishment of the manipulators was also performed by factory technicians and followed by a two-week reliability test run, which essentially duplicated the production mode of the CVT. No equipment or control system failures occurred.

In addition to the 20 test exceptions, two test requirements from the test procedure were dropped from CVT. These were dropped by the test director to adapt to the conditions of the test set up and to data gathered during other tests.

The first requirement dropped from CVT, stated in Table 2 in the CVT procedure (Reference 4), was to perform single manipulator testing using each the north manipulator and the south manipulator, respectively. However, the test was only performed using the north manipulator. The south manipulator test was dropped because the north manipulator cannot be parked in a position that allows the fuel to be transported to the table from the PCM and still be accessible to the south manipulator for handling. The north manipulator is actually sitting directly in the load path for any material movement and would have to be moved manually south to dump a canister, then north to retrieve and separate the fuel using the south manipulator. This situation is created because the north manipulator cannot be moved north beyond the PCM due to the mast elevation extending below the elevation of the PCM. In addition, moving a canister while the north manipulator is parked up against the PCM cannot be accomplished because the hoist load path is directly in line with the manipulator and the load cannot "jump" the manipulator (would require hoisting the fuel canister out of the water). There are only two ways to use the south manipulator to process fuel in a solo production mode. One is to have the north manipulator completely removed from the basin and risk the possibility of having to alter the control system to allow the system to function as a single manipulator system[1]. The second is to manually move the north manipulator south to make room to dump a canister, then manually move it back north to make room for the south manipulator to retrieve and separate the fuel. Time constraints, testing deadlines, and presumed low added value were the primary drivers for not performing either of these described process alterations during CVT. This situation existed in our test mockup and also exists in the basin.

The second requirement dropped from CVT, described in Section 3.1 of the CVT procedure (Reference 4), was to transfer the loaded MCO fuel baskets and scrap baskets to the mockup MCO basket queue. This test process was dropped from CVT for two major reasons. One was because the mockup rail supports blocked the load path for transfer of a scrap basket to the queue table and the second was that the grapple intended to transport the baskets, or an acceptable prototype, was unavailable for use during CVT. An alternate method for transferring the fuel basket could have been used, but the similarity to the real system would have been so minute that the test director determined the data collected would have been relatively useless and not realistically comparable to the actual system being used in the basins.

Conclusions

The test data collected during CVT combined with test observations fully support the conclusion that the FRS manipulator system is suitably able to perform the required process functions it was designed for. It is also postulated that the manipulator system will readily provide a method for achieving superior throughput volume when compared to manual tool methods for fuel re-packaging.

Recommendations

As a result of CVT and associated pre-CVT burn-in, several recommendations for possible system improvement were formulated and are listed in TABLE 3. Although the recommendations are based on improving the manipulator system, acting on any single recommendation would not significantly alter the conclusions or throughput times indicated in this report, but would generally provide a more robust, reliable, and user-friendly system. This list of recommendations was transmitted to FRS project management under a separate cover letter in January 1999 while a few of these were in the process of being implemented.

---

[1] If the control system required any adjustment or modification, it would only be required if one of the two slave controllers was unable to provide telemetry communication through the telemetry chain. This is why the single manipulator operation is still possible using the north manipulator and parking the south manipulator against the south hard stop, assuming the slave controller is still communicating through the telemetry chain. No specific tests were performed in this area as of this writing, however, they are likely to be performed informally at a later date. Using the north manipulator only will still result in potential load transport issues for loaded fuel baskets moving south to the queue tables.

In addition to the following list, several recommendations were reported in the interim equipment report[1], issued in November 1998. A final version of the equipment report is scheduled for release in September 1999 and will cover general system burn-in activities on both the K-West and K-East manipulator systems and provide greater detail covering a longer period of time than the CVT report. The equipment report also provides a more detailed discussion of the technical issues and background information concerning system reliability. This information was not included as part of the CVT report in an attempt to contain the scope of CVT within its intended boundaries and to prevent the possibility of conflicting conclusions from future reports.

[1] SUMMARY EQUIPMENT REPORT - FRS Cold Operations, Interim Version, Rev. C; PNNL, October 30, 1998, GR Kiebel, DR Jackson.

TABLE 3. Recommended Changes to Manipulator System Installation.

Item No.	Description	Priority[1]	Explanation
1 A	Add Hydraulic Fuses to Individual Manipulator Supply on SRS Dist. Manifold.	1	Reduces Risk of Major Hyd. Spill In the case of a major joint failure downstream the fuses prevent continual pumping of hydraulic fluid into the basin. These are standard on the other in-pool equipment supply manifolds.
B	Add Double Isolation (ball) Valves to Individual Manipulator Supply on SRS Dist. Manifold.	2	Reduces Potential Downtime Would allow maintenance and repair work on individual manipulator while hydraulic system remained powered.
C	Add a Pilot Operated Solenoid Valve to Individual Manipulator Supply on SRS Dist. Manifold that operates from EOC.	3	Allows Quick Operator Switching to secure one or the other manipulators from the hydraulic feed.
2	Add Hydraulic Fluid Sampling Station @ HPU.	1	Normal Maintenance Enhancement Clean access for fluid sampling was not included in HPU design by manfacturing.
3	Put Manipulator Slave Controller Power Cycle Switch in EOC.	2	Reduces Potential Downtime Does not require a second party out on the deck to cycle power.
4	Add a Ball or Check Valve to Chiller Reservoir Fill Line.	4	Normal Maintenance Enhancement Prevents fluid siphoning when refilling or topping off the reservoir.
5	Adjust HPU Installation to Allow Sight Glass to be Easily Seen.	2	Normal Maintenance Enhancement The sight glass is located on the back of the HPU and must be used regularly to check reservoir fluid levels.
6	Replace Std. Slave Controller Cover with Plexiglass Cover.	4	Normal Maintenance Enhancement Allows for quick and easy access to slave controller PC board status LED's.
7	Add Hour Meters to Each Manipulator Slave Controller (ISO Valve Control) and the HPU.	4	Normal Maintenance Enhancement Mfg. maintenance recommendations are mostly based on machine hours.
8	Modify Slave Controller Mounting Brackets (for access).	3	Normal Maintenance Enhancement Allows for easier slave controller removal and replacement.
9	Add a Quick Connector to Mast to Slave Controller Umbilical Cable.	2	Normal Maintenance Enhancement Greatly reduces risk in terminating wiring on the slave controller terminal block. Current tagging system is "fragile" at best and it is very difficult to terminate wires accurately.
10	Add Hydraulic Quick Connectors to Bridge Drive Motors.	3	Normal Maintenance Enhancement Allows for quicker, easier slave controller removal.

[1] Priority values from 1 – 4: 1-required; 2-should do; 3-preferred but not required; 4-to cheap and simple not to do.

TABLE 3. Recommended Changes to Manipulator System Installation (continued)			
Item No.	**Description**	**Priority[1]**	**Explanation**
11	Change Bridge Drive Motor Mounting Bolts to Studs.	2	Normal Maintenance Enhancement Greatly reduces the risk of dropping the mounting bolts into the pool when changing the motors out. Current configuration is cumbersome and difficult to handle. Difficulty will increase when using PPE (rubber gloves).
12	Add a Pendent Mounted Control Switch for the Stuck Fuel Element Ram Control.	2	Ergonomics Issue (EOC) Prevents operator from having to put down the manipulator MCU and reach for the ram control button. Specifically requested by operators.
13	Add a High Temp. Cutoff to Kill the HPU at 130°F.	2	Equipment Protection Issue Currently there is no high temperature protection for the HPU. The alarms are visual only and do not require a response to keep operating. This presents the potential for thermal breakdown of the fluid and possible equipment damage at both the HPU and the manipulators.
14	Add Chiller/HPU Operating Parameter Read Out (other than PC).	2	Equipment Protection Issue Currently there is no indication in the EOC of temperature conditions for the chiller coolant. It is possible for the local chiller high temp alarm to go off and not have any indication in the EOC. There is also no indication in EOC that chiller is operational.
15	Replace original bumper stop on south manipulator with longer stop [REF NCR#98-DESH-039].	1	Equipment Protection Issue Per NCR, the modified bumper stop is required to protect the bridge cameras.
16	Add GFCI protection to basin e-stop pendants.	1	NEC Requirement
17	Rework extended PA Jaw attachments to prevent bearings from slipping out.	1	Prevents jaw bearings from falling out and having to pull the manipulator out of the water for replacement.

[1] Priority values from 1 – 4: 1-required; 2-should do; 3-preferred but not required; 4-too cheap and simple not to do

References

1. Ketner, G.L. June 1997. "Interim Report Spent Nuclear Fuel Retrieval System Fuel Handling Development Testing", PNNL-11423, Pacific Northwest National Laboratory, Richland, Washington.

2. Jackson, D.R.. September 1997. "Final Report Spent Nuclear Fuel Retrieval System Fuel Handling Development Testing", PNNL-11666, Pacific Northwest National Laboratory, Richland, Washington.

3. Kiebel, G.R.. April 8, 1998. "Fuel Retrieval Sub-Project Process Description", HNF-2529, Rev. 0, EDT 621125, Pacific Northwest National Laboratory, Richland, Washington.

4. Kiebel, G.R. and Jackson, D.R. May 26, 1998. "FRS Cold Validation Test Procedure", SNF-2710, Rev. 0, EDT 621104, Pacific Northwest National Laboratory, Richland, Washington.

5. Kiebel, G.R and Jackson, D.R. October 30, 1998. "Summary Equipment Report – FRS Cold Operations", Interim Version, Rev. C, Pacific Northwest National Laboratory, Richland, Washington.

Bibliography

Short S.M., S. Brewe, and G. Kugler. March 22, 1996. "*Spent Nuclear Fuel Project Integrated Testing Strategy*", WHC-SD-SNF-CM-004, Rev. 0, Westinghouse Hanford Company.

Jackson D.R. April 9, 1998. "*Test Plan and Strategy for the Fuel Retrieval Sub-Project*", HNF-SD-SNF-TP-027, Rev. 2, Westinghouse Hanford Company.

Appendix A

Test Data

Equipment Validation Test Data **Dual Arm, Standard Canister Test Run**

Run No.	Operation Description	Operator	Start Time	Finish Time	Elapsed Time	Standard Canister Process Time
EV-1	North Arm: Sort Fuel, Load Scrap	2	7:53	8:35	0:42	
	South Arm: Load Fuel	1	7:54	8:57	1:03	
						1:04
EV-2	North Arm: Sort Fuel, Load Scrap	3	9:17	9:42	0:25	
	South Arm: Load Fuel	4	9:18	10:14	0:56	
	South Arm: Load Fuel		13:05	14:02	0:57	
						1:54
EV-3	North Arm: Sort Fuel, Load Scrap	2	14:11	14:37	0:26	
	South Arm: Load Fuel	1	14:12	16:05	1:53	
						1:54
EV-4	North Arm: Sort Fuel, Load Scrap	4	8:10	8:37	0:27	
	South Arm: Load Fuel	3	8:12	8:44	0:32	
	South Arm: Load Fuel	3	9:05	9:48	0:43	
						1:17
EV-5	North Arm: Sort Fuel, Load Scrap	3	10:31	10:57	0:26	
	South Arm: Load Fuel	4	10:33	11:52	1:19	
						1:21

Average Fuel Sorting, Scrap Loading Time (Arithmetic Mean)	0:29
Average Fuel Loading Time (Arithmetic Mean)	1:28
Average Standard Canister Processing Time (Arithmetic Mean)	1:30

Operator Key

Team No.	Operator No.	
Team #1	#1	Bob Crow
	#2	Ron Lorenzen
Team #2	#3	Don Benson
	#4	Tim VanReenan

Process Validation Test Data **Production Mode; Single Manipulator (North)**

Run No.	Operation Description	Operator	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVPMS-1	North Arm: Sort & Load Can #1		7:51	8:47	0:56		
			8:51	9:45	0:54	1:50	
	North Arm: Sort & Load Can #2		9:46	11:14	1:28	1:28	
	North Arm: Sort & Load Can #3		11:14	12:51	1:37	1:37	
	North Arm: Sort & Load Can #4		12:51	14:11	1:20	1:20	
							6:15
PVPMS-2	North Arm: Sort & Load Can #1	1 & 2	14:41	17:33	2:52	2:52	
	North Arm: Sort & Load Can #2	4	17:33	18:49	1:16		
		4	7:17	8:07	0:50	2:06	
	North Arm: Sort & Load Can #3	3 & 4	8:07	9:36	1:29	1:29	
	North Arm: Sort & Load Can #4	3	9:36	10:22	0:46		
		3	10:25	10:45	0:20	1:09	
							7:36

Run No.	Operation Description	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVPMS-3	North Arm: Sort & Load Can #1	11:05	11:35	0:30		
	Down Time	11:35	11:49	0:14		
	North Arm: Sort & Load Can #1	11:49	12:35	0:46	1:16	
	North Arm: Sort & Load Can #2	12:35	14:25	1:50	1:50	
	North Arm: Sort & Load Can #3	14:25	15:51	1:26	1:26	
	North Arm: Sort & Load Can #4	15:51	16:39	0:48	0:48	5:20
PVPMS-4	North Arm: Sort & Load Can #1	7:19	8:59	1:40	1:40	
	North Arm: Sort & Load Can #2	8:59	10:51	1:52	1:52	
	North Arm: Sort & Load Can #3	10:51	12:24	1:33	1:33	
	North Arm: Sort & Load Can #4	12:24	13:07	0:43	0:43	5:48

Average Fuel Canister Processing Time (Arithmetic Mean)	1:33
Average Mark IA MCO Fuel Basket Loading Time (Arithmetic Mean)	6:16

Run No.	Operation Description	Start Time	Finish Time	Elapsed Time	Operation Description	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVPMD-1										
	North Arm: Sort Can #1	12:54	13:20	0:26	South Arm: Load Can #1	12:56	13:52	0:56	0:58	
	Set Up Can #2	13:20	13:27	0:07						
	North Arm: Sort Can #2	13:27	14:08	0:41	South Arm: Load Can #2	13:52	14:59	1:07	1:32	
	Set Up Can #3	14:08	14:18	0:10						
	North Arm: Sort Can #3	14:38	14:56	0:18	South Arm: Load Can #3	15:01	15:41	0:40	1:03	
	Set Up Can #4	14:56	15:01	0:05						
	North Arm: Sort Can #4	15:01	15:19	0:18	Restart #3 and Load #4	15:53	17:10	1:17	2:09	4:16

Run No.	Operation Description	Start Time	Finish Time	Elapsed Time	Operation Description	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVPMD-2	North Arm: Sort Can #1	7:25	7:48	0:23	South Arm: Load Can #1	7:26	7:48	0:22	0:23	
	Down Time	7:48	11:11	3:23	Down Time	7:48	11:11	3:23		
	North Arm: Sort Can #1	11:11	11:47	0:36	South Arm: Load Can #1	11:11	12:07	0:56		
	Set Up Can #2	11:47	11:50	0:03						
	North Arm: Sort Can #2	11:50	12:14	0:24	South Arm: Load Can #2	12:07	13:03	0:56	1:13	
	Set Up Can #3	12:14	12:17	0:03						
	North Arm: Sort Can #3	12:17	12:40	0:23	South Arm: Load Can #3 & #4	13:03	14:47	1:44	2:30	
	Set Up Can #4	13:08	13:11	0:03						
	North Arm: Sort Can #4	13:13	13:29	0:16						3:59

Process Validation Test Data **Production Mode; Dual Manipulator**

Run No.	Operation Description	Start Time	Finish Time	Elapsed Time	Operation Description	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVPMD-3										
	North Arm: Sort Can #1	12:21	12:42	0:21	South Arm: Load Can #1	12:22	13:41	1:19	1:20	
	Set Up Can #2	12:42	12:46	0:04						
	North Arm: Sort Can #2	12:46	13:09	0:23	South Arm: Load Can #2	13:41	14:34	0:53	1:52	
	Set Up Can #3	13:09	13:13	0:04						
	North Arm: Sort Can #3	14:28	14:48	0:20	South Arm: Load Can #3	14:35	15:27	0:52	0:59	
	Set Up Can #4	14:48	14:52	0:04						
	North Arm: Sort Can #4	14:53	15:08	0:15	South Arm: Load Can #4	15:28	16:08	0:40	1:20	3:47

Average Fuel Canister Processing Time (Arithmetic Mean)	1:23
Average Mark IA MCO Fuel Basket Loading Time (Arithmetic Mean)	4:00

Run No.	Operation Description	Operator	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVVM-1	North Arm: Sort Can #1	1	12:23	13:12	0:49		
	South Arm: Load Can #1	2	12:24	13:21	0:57	0:58	
	Dump Can #2	3 & 4	13:15	13:18	0:03		
	North Arm: Sort Can #2	4	13:18	13:43	0:25		
	South Arm: Load Can #2	3	13:22	14:32	1:10	1:17	
	Dump Can #3	1 & 2	13:42	13:45	0:03		
	North Arm: Sort Can #3	4	13:45	14:17	0:32		
	South Arm: Load Can #3	3	14:32	15:57	1:25		
		4	15:57	16:03	0:06	2:21	
	Dump Can #4	1 & 2	14:19	14:22	0:03		
	North Arm: Sort Can #4	4	14:22	14:44	0:22		
	South Arm: Load Can #4	4	16:03	16:07	0:04		
		3	16:08	16:58	0:50	2:39	
							4:35

Operator Key

Team No.	Operator No.	
Team #1	#1	Bob Crow
	#2	Ron Lorenzen
Team #2	#3	Don Benson
	#4	Tim VanReenan

Run No.	Operation Description	Operator	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVVM-2	North Arm: Sort Can #1	3	7:17	7:52	0:35		
	South Arm: Load Can #1	4	7:18	8:36	1:18	1:19	
	Dump Can #2	1&2	7:53	7:56	0:03		
	North Arm: Sort Can #2	3	7:56	8:17	0:21		
	South Arm: Load Can #2	4	8:36	9:03	0:27		
		4	9:13	9:58	0:45		
		1	10:04	10:19	0:15	2:07	
	Dump Can #3	1&2	8:18	8:21	0:03		
	North Arm: Sort Can #3	3	8:37	8:58	0:21		
	South Arm: Load Can #3	1	10:19	11:46	1:27	3:12	
	Dump Can #4	1&2	8:58	9:01	0:03		
	North Arm: Sort Can #4	2	10:04	10:29	0:25		
	South Arm: Load Can #4	1	11:46	12:33	0:47	2:32	
							5:16

Operator Key

Team No.	Operator No.	
Team #1	#1	Bob Crow
	#2	Ron Lorenzen
Team #2	#3	Don Benson
	#4	Tim VanReenan

Run No.	Operation Description	Operator	Start Time	Finish Time	Elapsed Time	Canister Process Time	MCO Basket Loading Time
PVVM-3B	North Arm: Sort Can #1	3	7:41	8:23	0:42		
	South Arm: Load Can #1	4	7:42	8:38	0:56	0:57	
	Dump Can #2				0:00		
	North Arm: Sort Can #2	3	8:23	8:38	0:15		
		3	9:52	10:01	0:09		
	South Arm: Load Can #2	4	9:52	10:47	0:55	1:10	
	North Arm: Sort Can #3	3	10:01	10:23	0:22		
	South Arm: Load Can #3	4	10:47	11:12	0:25	1:11	
	Dump Can #4		10:24	10:30	0:06		
	North Arm: Sort Can #4	1	10:58	11:12	0:14		
		1	11:28	11:44	0:16		
	South Arm: Load Can #4	2	10:47	11:12	0:25		
		2	11:26	12:40	1:14	1:53	
							4:59

Operator Key

Team No.	Operator No.	
Team #1	#1	Bob Crow
	#2	Ron Lorenzen
Team #2	#3	Don Benson
	#4	Tim VanReenan

Appendix B

Test Log

APPENDIX B TEST LOG

Sheet 1 of 4 log sheets

Date / Time	Comments	Initials
9/18/98 7:53	BEGAN EQUIPT. VALIDATION RUN EV-1 VCR STARTED 7:56 - OOPS!	SRK
9/18/98 8:57	COMPLETED EV-1 RUN WAS SUCCESSFUL	SRK
9/18/98 9:17	BEGAN EQUIPT. VALIDATION RUN EV-2 VCR STARTED PROPERLY THIS TIME.	SRK
9/18/98 14:02	Completed EV-2 logged interuptions, restarts, etc. Run completed with interuptions & difficulty	DRJ
9/18/98 14:11	Began EV-3 Team #1 Lorenzen/Crow VCR started @ 14:10	DRJ
9/18/98 16:05	Completed EV-3 Run was Successful	DRJ
9/18/98 16:12	Began EV-4 Team #2 VanReenan/Benson	DRJ
9/18/98 16:~~13~~ 15 DRJ	Stopped Test due to unexplained ~~erratic~~ erratic behavior in South arm	DRJ
9/19/98 08:10	Reset & Restarted Run EV-4 ~~aft~~ DRJ 9-19-98 VCR started approx 08:05	DRJ
9/19/98 08:44	stopped Test due to MCU malfunction	DRJ
9/19/98 09:05	Restarted Test & Clock on EV-4	DRJ
9/19/98 09:48	Completed EV-4 Note test exceptions —	DRJ
9/19/98 10:31	Began EV-~~3~~ 5 DRJ 9-19-98 started VCR @ 10:31	DRJ
9/19/98 ~~10:~~ 11:52	Completed EV-5 Run was successful	DRJ

MASTER COPY

APPENDIX B TEST LOG

Sheet 2 of 4 log sheets

Date/Time	Comments	Initials
9-19-98 12:23	Began Process Validation Mode Test #1 PVVM-1 Started VCR @ 12:26 - Started new tape @ 12:33	[signature]
9-19-98 16:35	VCR Tape #2 Run PVVM-1 stopped @ 16:35 Did not start a new tape	[signature]
9-19-98 16:58	Completed PVVM-1 Run was successful	[signature]
9-20-98 07:17	Began Process Validation Mode Test #2, PVVM-2 VCR started @ 07:14	[signature]
9-20-98 12:33	Completed PVVM-2 Run was successful	[signature]
9-20-98 12:48	Began Process Validation Mode Test #3, PVVM-3 VCR started @ 12:48	[signature]
9-20-98 15:11	Terminated Test Run PVVM-3	[signature]
9/23/98 07:51	Began Process Validation ~~Mode~~ Production Mode single manipulator Tests VCR Start @ 07:51 Test Run # PVPMS-1	[signature]
9/23/98 14:11	Completed Run PVPMS-1 Run was Successful Tape ran approx 10 minutes short	[signature]
9/23/98	Began Run # PVPMS-2 VCR Start @ 14:41	[signature]
9/23/98	INTERRUPTED R# PVPMS-2 AT END OF DAY	
9/24/98	RESUMED RUN # PVPMS-2 VCR START @ 7:17 | SWITCHED TAPE #2 9:19	[signature]
9/24/98	INTERRUPTED ~~R#~~ AT 9:24 TO REPAIR BASKET AND SEE WHICH HOLE IN BASKET OPEN	[signature]
9/24/98	RESUMED RUN PVPMS-2 AT 9:25	[signature]

MASTER COPY

APPENDIX B TEST LOG

Sheet 3 of 4 log sheets

Date / Time	Comments	Initials
9/24/98	RUN PVPMS-2 COMPLETED successfully 10:45 TAPE STOPPED	[illegible]
9/24/98	RUN PVPMS-3 BEGUN TAPE Running 11:05	[illegible]
9/24/98	DOWN FOR VIDEO MONITOR Replacement 11:34 - 11:49	[illegible]
9/24/98	Resumed PVPMS-3 at 11:49	[illegible]
9/24/98 16:39	Completed PVPMS-3 16:39 Run Completed Successfully	DRJ
9/26/98 07:41	Began Re-Run for Test 3, Process Validation mode Run # PVVM-3B No VCR start	DRJ
9/26/98 08:38	Stopped PVVM-3B due to pitch joint hydraulic cylinder leak (extruded o-ring). Leak was caused because cylinder locking nut was not torqued to value (65 ft-lb)	DRJ
9/26/98 09:52	Restarted test after service check on hydraulics run # PVVM-3B VCR start @ 09:52	DRJ
9/26/98 12:40	Completed Run PVVM-3B Run was successful w/ exceptions	DRJ
9/26/98 12:54	Began 1st 2 man sp Production Run PVPMD-1 Run # ~~PVPMD~~ VCR started @ 12:52	DRJ
9/26/98 15:41	Hold on test - Fuel Stinger became stuck in Fuel element. Had to replace fuel Stinger	DRJ
9/26/98 15:53	Restarted PVPMD-1	DRJ
9/26/98 17:10	Completed PVPMD-1 Run was successful w/ exceptions	DRJ
9/27/98 07:25	Began Run PVMD-2 VCR started @ 07:24	DRJ

MASTER COPY

APPENDIX B TEST LOG

Sheet 4 of 4 log sheets

Date / Time	Comments	Initials
9-27-98 07:48	Stopped Test # PVPMD-2 Pitch malfunction on S. arm & failure of Peters Tool	DJ
9-27-98 11:11	Restarted Run PVPMD-2 VCR ST 11:11 after repairing arm	DJ
9-27-98 11:17	Stopped Test for fuel tool failure	DJ
9-27-98 11:38	Restarted PVPMD-2 after putting the last new fuel stinger on	DJ
9-27-98 14:47	Completed Test Run PVPMD-2 Run was successful with exceptions	DJ
9-28-98 12:21	Began Test Run No PVPMD-3 Started VCR @ 12:34	DJ
9-28-98 16:08	Completed Test Run No. PVPMD-3 Run was successful	DJ
9-29-98 7:19	BEGAN TEST RUN PVPMS-4 VCR STARTED 7:19	CWL
9-29-98 13:07	Completed Test Run PVPMS-4 13:07	DJ

MASTER COPY

Appendix C

Test Configuration

APPENDIX E TEST ITEM CONFIGURATION RECORD

Sheet 1 of 1 Test Item Configuration Record sheets

Subsystem / Component	Serial number	Initials
KW North manipulator & Bridge Assembly [includes I&C, HPU, PC's etc]	MANIP-FRS-105-B (Tag #) SRS S/N C124 (Arm)	[signature] 9-14-98
KW South manipulator & Bridge Assembly (with re-configured System #2 North Slave Controller)	MANIP-FRS-105-A (Tag #) SRS S/N C125 (Arm)	[signature] 9-14-98
EOC Camera System North — Control Rack — South —	FRS-3-OP-1 FRS-3-EQ-1 FRS-3-OP-2	[signature] 9-14-98
Schilling Fuel Tool (Stinger) Adjusted ~~[illegible]~~ tighter than SRS Spec	N/A	[signature] 9-14-98
South Master Controller Unit (M.C.U.) North Master Controller Unit (M.C.U) Practice Tests No. 1,2,3	22414-4 22414-3	[signature] 9-14-98
Changed South M.C.U. —	22414-1	[signature] 9-18-98
Changed South MCU - removed 22414-1	Replaced w 23613-1	[signature] 9-19-98
Changed urethane bushing on fuel tool 14:37	N/A	[signature] 9-23-98
Changed to new fuel Tool 9-26-98	N/A	[signature] 9-26-98
Changed to another new fuel Tool 9-27-98	N/A	[signature] 9-27-98
Replaced wiring jumper in S. slave Controller (to fix intermittent pitch joint problem)	N/A	[signature] 9-27-98
Completed CUT	—	[signature] 9-29-98

MASTER COPY

Appendix D

Test Exceptions

APPENDIX D TEST EXCEPTIONS

Sheet 1 of 3 test exception sheets

#	Description	Resolution	Approval
1	Run EV-2 - 9/18/98 Experienced various difficulties with arm & fuel tool operation. Continued test with several stops & restarts.	Continued test & recorded stop & restart times to obtain an actual lapsed time for fuel handling / loading.	DRf 9-19-98
2.	Run EV-4 9/18/98 Suffered South Arm Failures, which required termination of test run. Performed diagnostics & brought arm back on line	After diagnostic review, arm was brought back-on line & EV-4 was reset & restarted on 9-19-98. Same team operating - ST 08:10	DRf 9-19-98
3	Run EV-4 9-19-98 Suffered M.C.U. failure - stopped test @ 08:44 Restarted @ 09:05	Continued Test - stopped & restarted clock after replacing MCU Note Test Config. Record	DRf 9-19-98
4	Run PVVM-1 @ 9-19-98 13:51 Cursor Lock on South PC	Reset South PC & restarted @ 13:55 Continued with test run Kept clock running	DRf 9-19-98
5	Run PVVM-2 9-20-98 several of the new outer elements are to small an ID to pick up using the fuel stinger. Also have 4-6 that are too big an ID to pick up	• will bore out the small ID to work w stinger • will leave large ID in test & ld load with Peters Tool.	DRf 9-20-98
6	Run PVVM-2 Cursor Lock on South PC 09:19	Shut down ~~PC~~ HPU & reset PC - Kept Test Clock running 2 minute delay	DRf 9-20-98
7	Run PVVM-2 Cursor Lock on South PC 11:56	Shut down HPU & reset PC Kept Test Clock Running 2 minute delay	DRf 9-20-98
8	Run PVVM-3 Cursor Lock on South PC ~~DRf 2:06~~ 14:06	Shut down HPU Reset PC Kept clock Running 2 minute delay	DRf 9-20-98
9	Run PVVM-3 Continuous Pitch Joint Errors are causing trouble in loading operations South Arm Only @ 14:19	Did a cold boot (Power off) on PC to try to recover from Pitch joint feedback errors	DRf 9-20-98

MASTER COPY

APPENDIX D TEST EXCEPTIONS

Sheet 2 of 3 test exception sheets

	Description	Resolution	Approval
10	Run PVVM-3 Cursor Lock on S. PC - Bridge kept moving 14:31	Hit E-Stop Cold Booted PC	[signature]
11	Run PVVM-3 Pitch Joint Alarm & feedback Problems 14:49 Clocked the held & restarted	Cycled Power to Slave controllers — Shutdown disconnect for 1 minute before turning back on	[signature]
12	Run PVVM-3 Terminated Test Continued failure of S. Arm	Test Terminated No - Restart 15:11	[signature]
13	RUN PVPMS-2 CURSOR LOCK ON N. PC 5:18	REBOOT N. PC AND CONTINUE	[signature]
14	RUN PVPMS-2 CURSOR LOCK ON N. PC 10:05	REBOOT N. PC AND CONTINUE	[signature]
15	Run PVVM-3B Hydraulic Leak on pitch joint 8:35	Dan Cormany repaired leaking actuator & checked all other joints for tightness	[signature]
16	Run PVPMD-1 Fuel Tool became stuck in fuel element	Replaced fuel Stinger with a new one	[signature]
17	Run PVPMD-2 a) Pitch joint malfunction on S. arm b) failure of Peter's Tool	a) Contacted Dan Cormany, diagnosed & repaired slave b) Repaired Peter's Tool c) Returned to service	[signature]
18	Lost end effector off tip of fuel The rubber & metal	Replaced This new one with the one used previously.	[signature]

MASTER COPY

APPENDIX D TEST EXCEPTIONS

Sheet 3 of 3 test exception sheets

#	Description	Resolution	Approval
19	Cursor locked on N. PC Alarm would not reset	Rebooted both N. & S. PC	[illegible]
20	CURSOR LOCK ON N. PC. PVPMS-4, BRIDGE RUNAWAY - ESTOP	REBOOTED N. PC AND RESUMED OPERATION	[illegible]

MASTER COPY

Appendix E

Test Procedures

S

Stk#19 (15) JUN 5 1998

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 621104

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) SNF Fuel Retrieval Sub-Project	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: SNF/FRS	6. Design Authority/ Design Agent/Cog. Engr.: E.J. Shen	7. Purchase Order No.: N/A
8. Originator Remarks: Supporting document transmitted for review and approval		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: Sys. 70/105-KE, 105-KW
11. Receiver Remarks: 11A. Design Baseline Document? [] Yes [X] No		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date. 5/22/98

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	SNF-2710		0	Fuel Retrieval Sub-Project Cold Validation Test Procedure	N/A	1,4	1	

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
1,4	1	Design Authority EJ Shen X3-75 [signature] 6/2/98	4		W. A. Frier S1-53
1,4	1	Project Manager R W Rasmussen X3-75 [signature] 6/4/98	1,4	1	CA Thompson R3-85 [signature] 6/2/98
4		Cog.Eng. ~~[struck]~~ [signature] 6/4/98	4		D. R. Jackson K5-22
		Cog. Mgr. [signature] FOR R. RASMUSSEN 6/4/98	4		W. H. Cloos X3-75
1,4	1	QA G. M. Davis X3-80 [signature] 6/2/98	4		J. M. Henderson G6-81
4		~~Safety~~ ROY PEDIGO S1-53	1,4	1	M. J. Schliebe L6-13 [signature] 7/1/98 L6-13
		~~Env.~~ MJ LANGEVIN X3-74	4		T. G. Vanreenen X3-61

18.	19.	20.	21. DOE APPROVAL (if required)
[signature] 6/1/98 Signature of EDT Originator Date	[signature] 6/4/98 Authorized Representative Date for Receiving Organization	[signature] 6/4/98 Design Authority/ Cognizant Manager Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

MASTER COPY

BD-7400-172-1

S

FRS Cold Validation Test Procedure

E. J. Shen
DE&S Hanford, Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 621104 UC: N/A (JKB 6/5/98)
Org Code: 2T980 Charge Code: LDG05
B&R Code: N/A (JKB 6/5/98) Total Pages: ~~26~~ 42 JKB 6/5/98

Key Words: Fuel Retrieval, Validation, Testing

Abstract: Cold Test Procedures of Prototypic or Near Prototypic FRS Equipment in the 305 Building

JUN 5 1998
DATE: HANFORD RELEASE ID.
STA: #19
15

Janis Breden 6/5/98
Release Approval Date Release Stamp

Approved for Public Release

A-6400-073 (01/97) GEF321

MASTER COPY

FRS COLD VALIDATION TEST PROCEDURE

Prepared by:

D. R. Jackson,
Test Director

G. R. Kiebel
System Engineer

Rev 0
May 26, 1998

CONTENTS

GLOSSARY – ACRONYM LIST

CCTV	Closed Circuit Television
CVT	Cold Validation Test
EOC	Equipment Operations Center
ETL	Engineering Test Laboratory
FAT	Factory Acceptance Tests
FRS	Fuel Retrieval Subproject
FTC	Flexible Transfer Crane
HP	High Pressure
HPU	Hydraulic Power Unit
IWTS	Integrated Water Treatment System
MCO	Multi-Canister Overpack
MSDS	Material Safety Data Sheet
PAT	Pre-operation Acceptance Tests
PCM	Primary Clean Machine
SBG	Stiff Back Grapple
SCS	Secondary Cleaning Station
SNFP	Spent Nuclear Fuel Project
TSB	Telescoping Stiff Back

1.0 INTRODUCTION

1.1 Purpose

This document describes the procedure for performing the Cold Validation Test (CVT) for the Fuel Retrieval Subproject (FRS) equipment.

1.2 Scope

The CVT is a validation test that is intended to show that the FRS design and equipment will function as intended and that key FRS requirements can be met. The CVT is distinct from other FRS tests, such as Factory Acceptance Tests (FAT) and Pre-operation Acceptance Tests (PAT), and is not intended to supplant them in any way.

The test procedures in the CVT are based on the FRS Process Description [1] that describes in detail the operating steps in the FRS process.

1.3 Background

The overall goal of the Spent Nuclear Fuel Project (SNFP) is the safe retrieval, preparation, and removal of spent nuclear fuel currently stored at the K East (KE) and K West (KW) basins. This also includes vacuum drying, transport to the Canister Storage Building, cold vacuum drying, and interim storage in the Canister Storage Building,

The Fuel Retrieval Subproject (FRS) is the part of the SNFP that is responsible for retrieving the spent fuel from storage; separating fuel elements, scrap, and debris; preparing the fuel; and loading it into Multi-Canister Overpack (MCO) baskets.

The performance requirements established for the FRS system required design solutions that were non-traditional with respect to normal K Basin equipment and practices. The CVT program was commissioned in order to validate the performance of the design and equipment, to gather specific data, and to provide documentation to support the FRS and SNFP startup review and approval process. The CVT described in this document is a specific, formal activity that will be performed near the end of the program in order to provide formal documented results and data.

2.0 TEST ITEM IDENTIFICATION

2.1 Equipment

The items to be tested are:

- FRS Manipulator System
  - North manipulator and bridge
  - South manipulator and bridge
  - Fuel tool (several)
  - EOC control rack module
  - North control PC
  - South control PC
  - Hydraulic Power Unit (HPU) and Chiller
  - Basin area J-Box
  - Master control units (4 ea)

3.2 Test Method

The equipment to be tested will be operated in near prototypic conditions using K Basin operators to perform near prototypic fuel retrieval process steps. Simulated fuel elements (broken and whole), debris, and scrap are provided for the equipment to handle and process. A mockup of the process table is provided by the facility that is an accurate representation of the processing area of the actual process table. Mockups of the various containers (scrap baskets, fuel canisters, fuel baskets, and so forth) used in the fuel retrieval process are also provided.

The most significant deviation from actual K Basin conditions is that the equipment will not be submerged during any of the testing. However, a careful evaluation by the FRS Design Authority has shown that operator and equipment performance will not be significantly altered by this change.

3.3 Overview of Test Procedures

The basic unit of testing for the CVT is the test run. A test run is performed according to one of the two basic test procedures defined in sections 15.2 and 15.3 and one of the Process Operating Procedures defined in APPENDIX H or APPENDIX I. Individual test runs are grouped into a test sequence. The test sequences to be performed are all defined in the overall CVT schedule of tests in section 15.1.

The <u>equipment validation</u> test procedure (section 15.2) focuses on validating that the equipment can perform its required functions. The <u>process validation</u> test procedure (section 15.3) primarily focuses on validating the process. The Process Operating Procedures in APPENDIX I are tightly coupled to the FRS Process Description [1] while the ones in APPENDIX H are representative of the Process Description, but have been summarized and collected into a single procedure for each manipulator.

The test procedures specify what data is to be collected for each test run and included in the test data package. This data includes observations of the equipment and processes performance times. All data is recorded on copies of the data sheets (see section 10.0).

The test procedures have been designed for people who are familiar with the FRS process and equipment and do not contain detailed instructions for equipment operation. Accordingly, the equipment operators shall be sufficiently trained and authorized to operate the system, or shall be under the direct supervision of an authorized person. The Lead Operator, with the concurrence of the Test Director, shall determine who is authorized to operate the equipment (see Section 11.0 for further explanation of roles and responsibilities).

4.0 CHANGES

4.1 Changes to This Document

The Test Director shall maintain a master copy of this test procedure document. Field copies may be made and distributed as desired to facilitate testing. The number of such field copies should be kept small and the distribution controlled so that the Test Director can easily retrieve copies.

Minor changes to the test procedures shall be made during actual testing by marking the master copy by hand in red ink. Minor changes are defined as those that do not affect the scope, goals, or fundamental intent of the test being performed. Such changes shall be approved and initialed by the Test Director. When such changes are made, the Test Director shall assure that the change is correctly reflected in all field copies.

An Engineering Change Notice (ECN) shall be used to approve and document changes to the CVT Test Procedure that affect the scope, goals, or fundamental intent of any of the tests. All minor (redlined) changes to date shall be incorporated whenever an ECN is issued. If there are only minor changes during the whole of testing, a single ECN shall be prepared at the close to incorporate all the minor changes. The deliberately exceed them. An approved procedure for startup and shutdown of the equipment shall be followed - a copy has been appended to this document (see APPENDIX L).

There is no limit imposed on the minimum or maximum number of hours that the equipment can be operated during this test, nor is there a limit on the number of times that a test can be repeated.

5.3 Test Exceptions

Test conditions that could cause a test procedure to be interrupted would be a loss of power in the facility, complete failure of the equipment to perform its intended function, gross failure to meet process time requirements, or the identification of a health/safety concern. If any of these conditions occur, the test procedure shall be suspended and a test exception shall be declared, resolved, and documented in the test exception log (copies of form provided in APPENDIX C). After problem resolution, the Test Director shall determine where testing shall be resumed. If testing was interrupted by a health or safety concern, the ETL Facility Manager shall also concur with the decision to resume testing.

6.0 INSTRUMENTS AND CALIBRATION

There are presently no test instruments that are required by any of the procedures in the CVT. Should the use of any test instruments become necessary (for example, to resolve a test exception), they shall have a current calibration sticker and shall be recorded on the Test Instrumentation Record (a blank form is provided in APPENDIX F).

The FRS equipment being tested will have been calibrated by the manufacturer either prior to shipment or as part of the contracted field support for equipment setup. No additional calibration is expected to be necessary for the CVT.

7.0 FACILITIES, EQUIPMENT, AND MATERIALS

The FRS CVT test facility is set up in the 305 Bldg. and provides a model of the K-Basin area that allows performance of a near-prototypic fuel recovery and handling operation. Mockups of the FRS process table are installed in the test facility, and simulated fuel elements, canisters, and long pole tools are provided. The equipment mockups are arranged in the bottom of the 305 Bldg. dry pit in a near-prototypic arrangement, however, spacing between equipment does not exactly duplicate the actual K Basin installation (due to bldg. physical restraints). The manipulator system and the EOC are also installed in a near-prototypic manner and shall be operated accordingly.

Testing oversight shall be conducted by the Test Director and in-field support shall be supervised by the ETL Facility Engineer. Changes shall be addressed as described in the Changes section of this document.

7.1 Process Table Mockup

- Fuel canister rack
- FRS Primary Clean Machine (PCM)
- MCO scrap and fuel baskets
- FRS MCO Queue (2 positions only)
- Grating (similar interference and operating conditions to K-Basins.

7.2 Long Pole Tools/Mockups

- Telescoping stiff back (TSB)[1]
- Fuel basket grapple

[1] It shall be acceptable to use small overhead crane in lieu of the actual tool.

8.2 Equipment Safety

It is possible for the manipulators to come into contact with structural members of the test mockup support frame and with parts of the process equipment. Care shall be taken not to damage the manipulator or process equipment by applying excessive force. Special care shall be taken when operating the manipulator in proximity to in-pool CCTV equipment - it is relatively fragile and contact shall be avoided.

Training of operators shall emphasize the confined and congested nature of the manipulator workspace and the above cautions. In addition, gross azimuth moves of the manipulator (which are most likely to cause unplanned contact with structures) have been eliminated from the test procedures.

9.0 MAINTENANCE AND FAILURES

9.1 Failures

Exceptions noted during the execution of the procedure shall be recorded in the test log (blank forms to be copied are provided in APPENDIX B) and the exception sheet (blank forms to be copied are provided in APPENDIX C). If an exception is noted, testing shall be suspended until approval to continue is obtained from the Test Director. Approval to continue shall be documented by signature in the test log and test exception sheet.

9.2 Maintenance

There are no components in the FRS equipment that are expected to require maintenance during the CVT test period. If a component fails or requires adjustment during testing, the failure shall be documented as a test exception and testing suspended until the problem is corrected and approval to resume testing is obtained.

10.0 TEST DATA

Individual Test Data Packages

All results and observations called for by the individual detailed test procedures shall be recorded on copies of the appropriate test data sheets that are included in section 16.0 of this document. These records shall become part of the Test Run Data Package for that test run. There will be many such Test Run Data Packages and each will be associated with one, and only one, test run.

Overall CVT Data Package

Additional results and observations that are not specifically required to be recorded on the data sheets for individual test runs shall be recorded into a general CVT data package on copies of forms that are provided as appendices to this document. There shall be a single copy of the general CVT data package for all the Cold Validation Testing. The forms that are used for the general CVT data package include:

- Test Readiness Checklist (blank form provided in APPENDIX A)
- Test Item Configuration Record (blank form provided in APPENDIX E)
- Test Log (blank form provided in APPENDIX B)
- Test Exceptions (blank form provided in APPENDIX C)
- Test Instrumentation Record (blank form provided in APPENDIX F)
- Personnel Record (blank form provided in APPENDIX D)

Videotapes shall be made during several of the detailed test procedures and shall be considered to be test results. These videotapes shall be properly labeled and stored and noted in the test log. The Test Director shall maintain custody of all test records whenever they are not actually being used during testing.

Quality Engineer (QE)
- Approves test procedures.
- Ensures that quality requirements are defined and satisfied for tests.

Industrial Safety Engineer
- Reviews and approves facility safety documentation associated with testing (JHA).

All personnel that participate in the performance of this test shall print and sign their name, initials, position, and date of signature in the personnel record section of APPENDIX D .

Only individuals who have been properly trained and certified to operate equipment shall do so for this procedure (unless they are under the direct supervision of a qualified and approved operator). The Lead Operator shall determine who is approved to operate the equipment and shall identify them in writing to the Test Director.

12.0 WITNESSES

There are no hold points for quality control in the CVT, nor any other requirements for witnessing by any organizations not directly involved in the testing activities. Representatives of the receiving organization are invited to observe as many of the actual tests as they wish, but are not required to. It should be noted that the operators that operate the equipment for all the tests will be the same operators of the equipment when it is installed in the K Basins.

13.0 REFERENCES

1. Kiebel, G. R. et al, HNF-2529, Rev. 0, "Fuel Retrieval Sub-Project Process Description", Duke Engineering Services Hanford, Richland, WA, 1998.

2. Shen, E. J., HNF-SD-SNF-PAP-003, Rev 0, "Fuel Retrieval System Process Validation Plan", Duke Engineering Services Hanford, Inc., Richland, WA, 1997

3. Jackson, D. R., HNF-SD-SNF-TP-027, Rev 2, "Test Plan and Strategy For The Fuel Retrieval Sub-Project", Duke Engineering Services Hanford, Inc., Richland, WA, 1998

4. WHC-S-0461, Rev 0, "Specification For The Design of the SNF Project Fuel Retrieval Sub-Project", Westinghouse Hanford Co, Richland, WA, 1996. (As modified by following ECNs: ECN 191405, ECN 191406, ECN 631388, ECN 6400507)

5. Kettner, G. L., PNNL-11423, "Fuel Handling Interim Report", Pacific Northwest National Laboratory, Richland, WA 1996

6. Jackson, D. R.., PNNL-11666, "Fuel Handling Final Report", Pacific Northwest National Laboratory, Richland, WA 1997

14.0 DISPOSITION OF TEST ITEMS

The K-West system will be used in the ETL mockup until construction forces are scheduled to receive the system at K-Basins. At this time the K-West system will be removed from 305 Bldg. and transferred to K-Basins for installation. It is assumed that the K-East manipulator system will arrive by this time and installation of this second system will take place after the first system has been removed. Further testing will take place using the K-East manipulator system combined with the already installed K-East EOC. After CVT has been completed, including both the K-West and K-East manipulator systems, the K-East manipulator system will remain in the 305 Bldg. for use as the K-Basin Operations training system. Use of the K-East system for operator training will continue until construction forces are ready to install it in K-

15.0 TEST PROCEDURES

15.1 CVT Schedule Of Tests

The CVT consists of a number of individual test runs that will be performed individually. Several test runs will be grouped into a test sequence. Test runs within a test sequence will often be repetitions of prior test runs performed to identical or very similar procedures. This section describes the nature of the test sequences that comprise the CVT and describes the test runs (and minimum required repetitions) that make up each test sequence.

Each of the test runs use one of the two basic test procedures defined in sections 15.2 and 15.3 and one of the Process Operating Procedures defined in APPENDIX I. Test sequences build on knowledge gained from previous FRS development testing [5], [6].

Each test sequence is designed to focus on a particular aspect of the system or the process. There are different test sequences that address the two distinct operating modes (validation and production) of the process. The following list highlights the areas of focus of the test sequences and summarizes the key questions to be addressed by the testing:

- Equipment Validation – does the equipment perform the functions required of the process
- Process Validation – can the process be performed to meet the requirements of the particular proceess mode:
  - Validation Mode – mode to be used during initial startup and operation of the FRS when efficacy of the process is being verified and key operating parameters are being optimized.
  - Production Mode – mode to be used for processing the bulk of the fuel once validation mode has been completed.
- Failure mode – (this test sequence is optional) what performance is the system capable of under conditions of gross manipulator failure

A. Equipment Validation Test Sequence

This sequence of test runs validates the capability of the equipment to perform all the functions necessary in order to perform the process and establishes baseline performance data. The primary focus of the testing is on the equipment and its proper function.

1. Perform a minimum of 3 test runs using:
   - Equipment Validation Test Procedure (section 15.2)
   - Process Operating Procedures in APPENDIX H.
   - Goal:
     - Perform all functions required by procedure and process
     - Establish baseline performance data
   - Acceptance criteria: All functions successfully performed
2. This test will be performed for the K West manipulators only

D. Process Validation Test Sequence (Production Mode with Two-Manipulator Operation)

This sequence of tests validates the ability of the equipment to successfully operate in a variation of the production mode whereby all canisters are dumped onto the North table and both manipulators are used to handle the fuel elements. The primary focus of this testing is to validate the ability of the system to achieve process throughput requirements in this mode. A secondary focus is gathering information for process optimization. This variation in the baseline process is being investigated because preliminary data gathered from development testing [5], [6] indicated that it may be faster than the baseline process.

1. Perform a minimum of 3 test runs using:
   - Process Validation Test Procedure (Section 15.3)
   - Process Operating Procedures outlined in Table 3 of APPENDIX I.
   - Goal: identify and incorporate any improvements to the Process Operating Procedure.
   - Acceptance criteria: N/A

2. Perform a minimum of 3 test runs using:
   - Process Validation Test Procedure (Section 15.3)
   - Improved versions of the Process Operating Procedures from the first set of test runs.
   - Goal:
     - Verify that process functions can be successfully performed
     - Establish baseline processing time data to be used for comparison with normal production mode
   - Acceptance criteria:
     - All functions successfully performed
     - 3 consecutive successful runs achieved, each under the acceptable maximum processing time (1 MCO every 2 days [4]).

E. Failure Mode Impact Test Sequence (Operation with one manipulator failed)

This sequence of tests evaluates the degradation in performance when process is carried out with a single manipulator when the other is out of commission. This test sequence is optional.

1. Perform a minimum of 3 test runs using:
   - Process Validation Test Procedure (Section 15.3)
   - Process Operating Procedures outlined in Table 3 of APPENDIX I.
   - Perform operations with South Manipulator only
   - Goal: Determine process throughput under this failure mode.
   - Acceptance criteria: N/A

2. Perform a minimum of 3 test runs using:
   - Process Validation Test Procedure (Section 15.3)
   - Process Operating Procedures outlined in Table 3 of APPENDIX I.
   - Perform operations with North Manipulator only
   - Goal: Determine process throughput under this failure mode.
   - Acceptance criteria: N/A

15.3 Process Validation Test Procedure

Setup

4 (2) DRJ 9-19-98

1. Verify availability of 3 simulated MK1A or MKIV canisters and sufficient simulated fuel assemblies to fill them. One of the canisters is to be filled with the standard canister makeup described in section 7.3, the other two are to be filled with full-length elements.

2. Set up the Process Equipment mockup with the small tool rack, the Schilling fuel tool and extractor device, MCO fuel and scrap baskets, and the Schilling squeegee.

3. Stage the Long Pole Tools (as described in section 7.2) in their storage locations.

4. Make copy of blank data sheets (section 16.0) to record results of test run and enter the test run number and date, and a brief summary description of the test run.

5. Videotape all tests and clearly label each cassette with the test run number and date of the test.

6. Obtain, from the Test Director, copies of the Process Operating Procedures to be used for the test run. Record the title and revision date of the Process Operating Procedures on the data sheet.

7. Set up to run in a one- or two-manipulator operation, as required by the test sequence (section 15.1).

Procedure

1. Set up the 3 simulated MK1A or MKIV canisters filled with simulated fuel assemblies in the fuel canister rack mockup. and dump the standard canister onto the north table ramp. DRJ 9-19-98

2. Process all simulated fuel contained in the simulated canisters. Process the simulated fuel and transfer the loaded MCO baskets to the MCO queue according to the Process Operating Procedures.
   - Record, on the data sheet, the required information when operators begin and end their session.
   - Be aware of and observe criticality limits on the amount of material on process table (to assure accuracy in process performance times)
   - Record the starting time and stopping time of the Process Operating Procedures on the data sheet.
   - Record the starting time and completion time for processing the contents of each canister (time begins with emptying the canister and ends with loading of last fuel element).
   - Fill out basket loading maps as required by Process Operating Procedures
   - Note where and how process might be improved, and record observations in the Test Log

3. The end of processing occurs when the MCO fuel basket is loaded into the MCO Queue, the long pole tools have been returned to their storage location, and the manipulators are returned to their home, or parked, positions.

4. Repeat steps 1, 2, and 3 above as directed by the Test Director

Data Package

- Test data sheet
- Fuel basket loading maps
- Video tape of test operations
- Process Operation Procedure

DATA SHEET (continued) **CVT Test Run Number:**____________________

Operation Times

Process Step	Start Time	Finish Time	Elapsed Time	Initials/Date (Test Perf.)

APPENDIX A TEST READINESS CHECKLIST

TD:______ Date:______ Manipulator system (as described in section 2.1) installed and operable.

TD:______ Date:______ EOC (as described in section 2.1) installed and operable.

TD:______ Date:______ CCTV (as described in section 2.1) installed and operable.

TD:______ Date:______ Extended jaw sets have been installed onto the manipulators

TD:______ Date:______ Suitable placements for manipulator tools and tool holders has been determined

TD:______ Date:______ The Process Table (as described in section 7.1) has been installed.

TD:______ Date:______ Examples or mockups of Long Pole Tools (as described in section 7.2) are available.

TD:______ Date:______ Simulated fuel elements (as described in section 7.3) are available.

TD:______ Date:______ Initial complement of test items recorded in Test Item Configuration Record (APPENDIX E)

TD:______ Date:______ Sufficient trained and authorized operators are available to support CVT test schedule

LO:______ Date:______

APPENDIX C TEST EXCEPTIONS

Sheet _____ of ______ test exception sheets

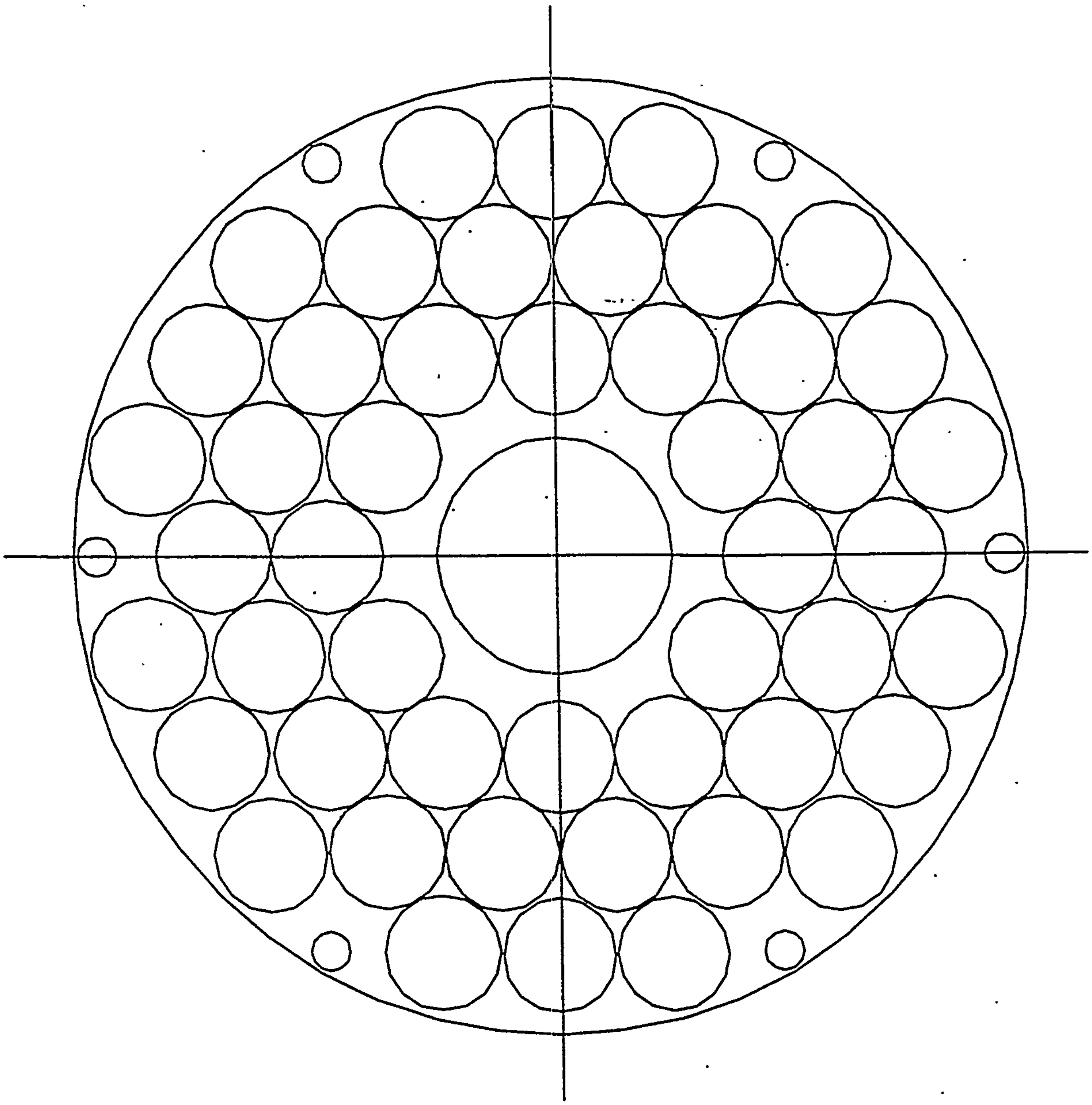
#	Description	Resolution	Approval

APPENDIX E TEST ITEM CONFIGURATION RECORD

Sheet _____ of _____ Test Item Configuration Record sheets

Subsystem / Component	Serial number	Initials

APPENDIX BASKET LOADING MAP



South Manipulator Process Operating Procedure

1. ~~Set the squeegee back into the tool rack~~ North Arm — Eliminated step from testing ②RJ 9-14-98

2. ~~Repeat above operations continuously and record specific difficulties encountered~~ ②RJ 9-14-98

3. Pick up any "broken" outer fuel elements that are at least 14" in length (use table measuring devices to remotely measure) off the South ramp and set up vertically in the go-nogo gage until gage is full or no more elements this size are available

4. Attach the Schilling fuel tool to the manipulator

5. Using the fuel tool, acquire a 14" or longer outer fuel element from the go-nogo gage and load it into the fuel basket

6. Record the remotely measured element length on a basket loading map indicating the loaded position and measured length for the element

7. Load all remaining 14" or longer, except full length, outer elements into the fuel basket in a quadrant loading pattern while recording the remotely measured length on the basket loading map

8. Using the jaws, pick up a full length inner element from the South table ramp and load it into the center of one previously loaded 14" or longer outer element

9. Repeat the preceding step until all the 14" or longer outer elements have a full length inner element loaded into them

10. Recover the short pieces (3" – 14") of outer fuel elements from the South table ramp (using manipulator)

11. Measure the length of each piece remotely then load it onto one of the full length inner elements loaded into a short outer element (measuring each piece allows the operator to know exactly how much length remains available for loading)

12. Record both the length and location on the loading map

13. Continue with the preceding 3 steps, stacking each piece onto an inner element until the full normal height is reached, or as close as practical.

14. Pick up the full length outer fuel elements off the South ramp and set up vertically in go-nogo gage until gage is full

15. Using the fuel tool, acquire the full length fuel elements in the go-nogo gage and load them into the fuel basket

16. When all the full length outer elements have been loaded, use the jaws to pick up the short inner element pieces

17. Measure each short inner element piece and load them into the full length outer elements previously loaded into the basket

18. Record the length and loaded location for each short inner on the loading map

19. Using the jaws, pick up additional outer elements and load the go-nogo gage again.

APPENDIX I PROCESS OPERATING PROCEDURES FOR PROCESS VALIDATION

This section contains outlines of the Process Operating Procedures to be used for process validation test sequences. Each Process Operating Procedure is described in a table that lists all the operations for FRS that are presently defined in the Process Description. The table briefly describes whether or not each operation is to be performed as part of the test run, and also if there are any modifications in the performance. The Process Operating Procedures in this section are:

Table 1 Process Operating Procedure for Validation Mode

This Process Operating Procedure represents the baseline process in validation mode where 100% of the fuel is inspected, requiring the all fuel elements to be dumped onto the North table ramp.

Table 2 Summary Of Process Operating Procedure For Production Mode (Single Manipulator)

This Process Operating Procedure represents the baseline definition of production mode where every attempt is made to load fuel elements directly from the canister using the South manipulator. No inspections are performed.

Table 3 Summary Of Process Operating Procedure For Production Mode (Two-Manipulator)

This Process Operating Procedure represents a variation on the production mode whereby canisters are dumped onto the North table and both manipulators are used to handle the fuel elements, and no attempt is made to load fuel elements directly from the canister. No inspection shall be performed.

Table 2 Summary Of Process Operating Procedure For Production Mode (Single Manipulator)

This Process Operating Procedure represents the baseline definition of production mode where every attempt is made to load fuel elements directly from the canister using the South manipulator. No inspections are performed.

No.	NAME OF OPERATION	ROLE IN TEST
	Wash Operations (Validation Mode)	
1	Load Primary Clean Machine (PCM)	No
2	Wash Fuel	No
3	Open PCM Lid	No
4	Transfer Fuel In Wash Basket (Validation Run)	No
5	Clean Out PCM	No
6	Clean Out PCM Strainer	No
7	Dump Fuel With Tipper (Validation Run)	No
8	Re-Use PCM	No
13	Close PCM Lid	No
18	Process Empty Canister	Perform by hand – not part of test
27	Decap Canister (KW Only)	No
	Production Mode Operations	
18	Process Empty Canister	Yes[5]
28	Transfer Fuel In Canister (Production Run)	Yes
29	Dump Unloaded Canister (Production Run)	Yes
30	Remove Basket From PCM	No
	Sort Operations	
9	Select And Identify Item	Yes
10	Rotate Scrap Basket	~~Yes~~ No - Capability Not Available [illegible] 9-22-98
11	Put Item Into Scrap Basket	Yes
12	Transfer Full Debris Basket	No
14	Put Item Into Debris Bin	Yes
15	Clean Up Fine Scrap And Sludge	No[6]
23	Place Empty Basket Into Process Table	Perform by hand – not part of test
25	Transfer Full Scrap Basket	~~Yes[5]~~ No - Capability Not Available 9-22-98
	Inspection Operations	
16	Separate Inner And Outer Fuel Elements	No
17	Inspect Fuel Element	No
19	Disposition Acceptable Fuel Element	No
20	Perform Secondary Cleaning	No
	Loading Operations	
21	Load Fuel Basket	Yes
22	Transfer Empty/Clean Dry Baskets	No
23	Place Empty Basket Into Process Table	Perform by hand – not part of test
24	Transfer Loaded MCO Fuel Basket	~~Yes[5]~~ No [illegible]
25	Transfer Full Scrap Basket	~~Yes[5]~~ No [illegible] 9-22-98
26	Clean Loading Process Area	No

[5] Weighing and inspection steps will not be performed. Estimated times will be added to the test results.
[6] Deviation notice for requirement is not yet approved

APPENDIX J MANIPULATOR MAJOR COMPONENT LIST

Manipulator System 199-0186

Component	Qty.	Part Number
Bridge/manipulator assembly	1	101-3624
Fuel Handling tool kit	2	101-3632
Distribution manifold	1	101-3625
J-Box, basin area control	1	005-2993
Master controller	4	101-3814-1
Hydraulic power unit	1	101-3629
PC system, EOC	2	101-3705
Cable Assy, RJ45 to DE9P, 7 ft	7	005-3028
Cable Assy, DE9P to DE9S, 10 ft	7	005-3029
E-stop switch, push-pull	4	005-3030
Console Rack module, EOC area	1	005-2992
Remote video camera controller	2	005-3027
Video cable assy, splashplate to EOC	2	005-3026
Switchbox, manual, RJ45, 2-way	1	005-3047
Foot-pedal assy, bridge control	1	101-3987
Cable Assy RJ45 straight, 25 ft	2	005-3048
Parallel interface control cable	2	101-3989
Software group, North	1	101-3727
Software group, South	1	101-3728

Manipulator System 199-0187

Component	Qty.	Part Number
Bridge/manipulator assembly	1	101-3731
Fuel Handling tool kit	2	101-3632
Distribution manifold	1	101-3625
J-box, basin area control	1	005-2993
Master controller	4	101-3814-1
Hydraulic power unit	1	101-3629
PC system, EOC	2	101-3705
Cable Assy RJ45 to DE9P, 7ft	7	005-30~8
Cable Assy, DE9P to DE9S, 10 ft	7	005-3029
E-stop switch, push-pull	4	005-3030
Console Rack module, EOC area	1	005-2992
Remote video camera controller	2	005-3027
Video cable assy, splashplate to EOC	2	005-3026
Switchbox, manual, RJ45, 2-way	1	005-3047
Foot-pedal assy, bridge control	1	101-3987
Cable Assy, RJ45 straight, 25 ft	2	005-3048
Parallel interface control cable	2	101-3989
Software group South	1	101-3728

APPENDIX K MANIPULATOR SYSTEM ENGINEERING DRAWING LIST

DRAWING TITLE	DWG NO
AZIMUTH ASSY, 360 DEG, HELAC	101-3622
BRIDGE/MANIPULATOR ASSY-BASIN AREA	101-3624
BRIDGE/MANIPULATOR ASS Y-BASIN AREA, TRAINING	101-3731
CABLE ASSY, AZIMUTH POT	005-3032-1
CABLE ASSY, BRIDGE J-BOX	101-3719
CABLE ASSY, ELBOW POT	005-3032-3
CABLE ASSY, MANIPULATOR SENSOR	005-3001
CABLE ASSY, PITCH POT	005-3032-4
CABLE ASSY, SCU PWR/TELEM	101-3701
CABLE ASSY, SHOULDER POT	005-3032-2
CABLE ASSY, VIDEO, AZIMUTH TO WRIST	005-3004
CABLE ASSY, VIDEO, BRIDGE TO AZIMUTH	005-3003
CABLE ASSY, VIDEO, BRIDGE TO SPLASH PLATE	005-2977
CABLE ASSY, VIDEO, SPLASH PLATE TO EOC	005-3026
CABLE ASSY, WRIST POT	005-3032-6
CABLE ASSY, YAW POT	005-3032-5
CABLE, PARALLEL INTERFACE CONTROL	101-3989
CABLE/HOSE CLAMP ASSY	101-3699
CONSOLE RACK MODULE, EOC AREA	005-2992
DRAWING TREE (NEW DRAWINGS)	300-0461
EXTRACTOR, FUEL HANDLING TOOL	101-3768
FOOT PEDAL ASSY	101-3987
HPU CONTROL AND INSTRUMENTATION PANEL	005-2991
HYDRAULIC DISTRIBUTION MANIFOLD	101-3625
HYDRAULIC POWER UNIT, 25 HP	101-3629
HYDRAULIC SCHEMATIC	025-0054
INTERFACE CONTROL DRAWING	050-0679
JAW, PA, 6in, RAD HARD, REMOTE	101-3715
J-BOX SOUTH, BRIDGE, K-BASIN	101-3726
J-BOX, BASIN AREA CONTROL	005-2993
J-BOX, NORTH BRIDGE, K-BASIN	101-3700
K-BASIN MANIPULATOR SYSTEM	199-0186
K-BASIN MANIPULATOR SYSTEM-TRAINING	199-0187
K-BASIN TEST AREA LAYOUT	050-0722
K-BASIN TOOL INTERFACE	050-0710
LOWER HOSE/CABLE HANDLING-NORTH	101-3623-1
LOWER HOSE/CABLE HANDLING-SOUTH	101-3623-2
MASTER CONTROLLER, 115V, 30FT CABLE	101-3814-1
PC SYSTEM, DESKTOP	101-3705
POT HOSE & CABLE ASSY	101-3753
POT HOSE & CABLE ASSY, J-BOX TO SLAVE CONTROLLER	101-3627
SLAVE ARM, KONAN 7P W/INCR PA JAW,W/RMT VALVES	101-3595
SLAVE CONTROLLER, NORTH BRIDGE	101-3765
SLAVE CONTROLLER, SOUTH BRIDGE	101-3601
SQUEEGEE TOOL	101-3717
TOOL HOLDER	007-0352
TOOL, FUEL HANDLING	101-3737
TOOL, HOOK	007-0350
TOOL, SHOVEL	101-3716
TOW BAR ASSY, NORTH BRIDGE	101-3723
TOW BAR ASSY', SOUTH BRIDGE	101-3722

APPENDIX L POWER UP EOC, HPU AND MANIPULATOR (Rev. B)

1. Switch chiller disconnect to the "ON" position
2. Allow compressor oil heater to warm oil (if temperature is less than 50°, allow to warm for 3 hours)
3. Check chiller fluid level
4. Turn on chiller water pump
5. Turn on chiller compressor
6. Turn on HPU MCC main disconnect (powers EOC)
7. Verify that HPU is switched to "remote" operation
8. Walk-down hydraulic system from HPU to manipulators (check for leaks or other potential failure points)
9. Verify that master consolettes are powered up
10. Turn on PC monitors
11. Turn on PC/CPU and allow it to boot up
12. Verify that mouse works (if not, reboot)
13. Clear dialogue boxes (click on "OK")
14. Acknowledge alarms on both systems (alarm reset)
15. Check manipulator positions, bridges and azimuth, to see if screen readings make sense with existing conditions
16. Check HPU operation page to see if readings make sense
17. Check various screen buttons to verify that they work
18. Verify valve alignment on distribution manifold is set correctly
19. Clear HPU E-stops
20. Adjust cameras to allow good view of arms
21. Check location and position of arms
22. Switch on (energize) HPU at EOC rack
23. Check HPU operating settings (3000 psi)
24. Check HPU and distribution manifold filter bypass indicators for correct position, reset if required
25. Enable the manipulators for normal operation (hit E-stop if at any time, sudden uncontrolled movement occurs)

Appendix F

Fuel Makeup in K-Basin Fuel Canisters

ENGINEERING CHANGE NOTICE

Page 1 of 6

1. ECN 191405

Proj. ECN

2. ECN Category (mark one) Supplemental [X] Direct Revision [] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	3. Originator's Name, Organization, MSIN, and Telephone No. E. J. Shen, Spent Nuclear Fuel Engineering, R3-86, 376-7045	3a. USQ Required? [] Yes [X] No	4. Date 6-25-96
	5. Project Title/No./Work Order No. Spent Nuclear Fuel	6. Bldg./Sys./Fac. No. Fuel Retrieval	7. Approval Designator ESQD
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-S-0461, Rev. 0	9. Related ECN No(s). N/A	10. Related PO No. N/A

11a. Modification Work	11b. Work Package No.	11c. Modification Work Complete	11d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)	N/A	Cog. Engineer Signature & Date	Cog. Engineer Signature & Date

12. Description of Change

See pages 3-6.

13a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

13b. Justification Details

The Spent Nuclear Fuel (SNF) Project is proceeding on a fast track basis, which has resulted in gaps in the information needed for the design of the systems and equipment at the sub-project level. This ECN provides assumptions that address these gaps and are meant to provide the Fuel Retrieval Subproject (FRS) design agent a basis for proceeding into the detailed design phase. These assumptions shall be incorporated with the data and requirements that have been provided in the Specification for Design of the SNF Project Fuel Retrieval Subproject, WHC-S-0461.

14. Distribution (include name, MSIN, and no. of copies)

B. S. Carlisle, R3-85 (1)
G. M. Davis, X3-80 (1)
J. R. Frederickson, R3-86 (1)
D. O. Hess, X3-80 (1)
G. L. Ketner, K5-22 (1)
W. C. Mills, R3-85 (1)
Project Files R3-11
S. H. Peck, R3-85 (1)
M. A. Reilly, R3-86 (1)
E. J. Shen, R3-86 (2)
G. R. Waymire, R3-85 (1)
T. L. Yount, R3-85 (1)
K. D. Bazzell, S7-55 (1)
D. J. Watson, X3-79 (1)

RELEASE STAMP
DATE: JUL 08 1996
STA: 4
HANFORD RELEASE
ID: 2.

A-7900-013-2 (11/94) GEF095

A-7900-013-1 (08/92)

ENGINEERING CHANGE NOTICE

Page 2 of 6

1. ECN (use no. from pg. 1): 191405

15. Design Verification Required
[] Yes
[X] No

16. Cost Impact

	ENGINEERING		CONSTRUCTION	
Additional	[X] $22K	Additional	[] $
Savings	[] $	Savings	[] $

17. Schedule Impact (days)
Improvement []
Delay []

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog. Eng. E. J. Shen	6/25/96	PE	
Cog. Mgr. B. S. Carlisle	7/2/96	QA	
QA G. M. Davis	7/1/96	Safety	
Safety D. O. Hess FOR PER TELECON	6/27/96	Design	
Environ. ~~N/A~~	7/3/96	Environ.	
Other		Other	
T. L. Yount	7/1/96		
		DEPARTMENT OF ENERGY	
		Signature or a Control Number that tracks the Approval Signature	7-3-96
		ADDITIONAL	

A-7900-013-3 (11/94) GEF096

12. Description of Change

The Specification for Design Of The SNF Project Fuel Retrieval Subproject, WHC-S-0461, shall be amended or supplemented with the following information and/or requirements.

A) Function: Overall Fuel Retrieval--

1) Process Validation - The fuel retrieval process will utilize a process validation approach for assuring compliance with fuel cleanliness criteria. The process line will be operated and process parameters adjusted until the fuel retrieval system meets product criteria. At that time, a minimum of 25 basket loads (fuel and scrap) up to a maximum of 50 basket loads of fuel will be run through the system with 100% visual inspection (as defined in the performance spec., WHC-S-0461) to validate the process is functioning adequately. This includes 100% separation of the inner and outer fuel elements. Following the successful completion of the validation run, fuel will be loaded directly into baskets without inspection. Every 100th fuel assembly will be inspected to ensure the process continues to function adequately. The design should assume that the process remains stable and will successfully pass the every 100th fuel assembly inspection.

2) Accountability - The accountability strategy shall be as defined in the FRS 100% Conceptual Design Report.

B) Function: Canister Retrieval--

1) The following categories of fuel condition have been identified for the in basin fuels. These categorizations and the number of fuel assemblies in each of these categories are based upon information developed in the current fuel characterization campaign. Improvement upon the information pertaining to the K East fuels is expected later in the calendar year, as laboratory examinations and evaluations are completed. This information supersedes the information provided in WHC-S-0461, Section 3.1.16.1

K East Fuel Condition

- Intact Fuel - 49% (No incidence of clad breach)
- Breached - 9% (Minor breach, but no reacted fuel present)
- Defected - 38% (Definite breach with reacted fuel present)
- Bad - 4% (Gross failure with split clad)

K West Fuel Condition

- 7% of the fuel was damaged when discharged from the reactor. The assumption is that the damaged fuel in K West remains at the 7% figure and that the damage distribution is in the same percentages as found in K East (9% breached, 38% defected, and 4% bad). In other words, 9% of the 7% damaged K West fuel is in the breached category.

ENGINEERING CHANGE NOTICE CONTINUATION SHEET	Page 4 of 6	ECN 191405 Date 06/25/96

2) Percentage of Fuel in 2 or More Pieces - 10% of the fuel located in K East Basin is expected to be in 2 or more pieces. This number drops to 2% in the K West Basin. Of the fuel found in pieces, the average is 2.5 pieces. These percentages have been established from the past experience with fuel handling operations and the number of broken fuel elements that were loaded into the canisters.

3) SPR Fuel - The SPR fuel will be found in both the K East and K West Basins at the start of the fuel retrieval campaigns. The quantities of SPR fuel in each basin is described in WHC-SD-SNF-TI-015, Technical Databook, with the exception that the SPR fuel originally located at PUREX has been relocated to the K West Basin. The design agent will make provision for the handling and re-racking of SPR fuel in both basins.

4) Damaged Canisters - The number of canisters damaged to the point where the integrity of the bottom is compromised is expected to be .05% of the total number of canisters per basin.

5) Fuel Stuck in Canisters - 110 canisters of fuel located in K East are expected to contain stuck fuel. 20 canisters of fuel located in K West will contain stuck fuel. In order to preclude a concentrated loading of bad fuel into a MCO, the stuck fuel canister must be addressed on a routine basis to facilitate a distributed loading of bad fuel.

C) Function: Canister Delidding--

1) Canister Lid Removal Based Upon Existing Methods - 99+% of canister lids will be removable by the existing methods (hydraulic pressurization) in the K West Basin.

2) Canister Gas Processing - Gases found in the K West canisters will be captured and processed similar to what has been described in the FRS CDR. Small uncontrolled releases during initial tie-in to the canister with the hydraulic line may be permissible, based upon evaluation against allowable release limits.

D) Function: Primary Fuel Cleaning--

1) Fuel Damage Following Cleaning - Some level of damage to the fuel is expected as a result of the primary fuel cleaning operation. The design shall assume that this damage will be found as small debris from fuel, fuel cladding, and deformation of the empty clad. The material smaller than 1/4" will be removed by the Integrated Water Treatment Subproject as sludge. Larger non-reactor origin material, which is visually obvious, will be disposed of as debris, while reactor origin material will be placed into scrap baskets and then the MCO. Of the original projection of fuel existing as pieces (section B.2), a 50% increase is to be assumed as damage due to the primary wash process.

2) Free Separation of Inner and Outer Fuel Elements - Based upon what was observed during the packaging of the fuel at N Basin, 15% of the fuel located in K West Basin will have inners that slide freely or with little assistance from the outers. In K East basin, the numbers will be higher, since some of the fuel was disassembled during the earlier segregation program. 35% of the K East fuel will have inners that slide freely or with little assistance from the outers.

ENGINEERING CHANGE NOTICE CONTINUATION SHEET	ECN 191405
Page 5 of 6	Date 06/25/96

3) Canister Sludge - In the K East Basin, the canisters that have been rated in the defected/bad category will contain an average of 2.7" of sludge. The canister in the remaining two categories (intact/breached) will contain .25" and 1" respectively. The canisters in the K West Basin are assumed to contain .25" of sludge.

4) Sludge Properties - The sludges found in K East and K West Basins demonstrates a range of behaviors. The free sludges (exterior to the fuel cladding) will be lightly adherent in nature and freely disperse into the basin water. The dispersed sludge may be of low density and require hours to settle or the density may be significantly greater and demonstrate rapid settling. FRS must design to accommodate the range of observed behaviors.

E) Function: Preparation For Loading/Basket Loading--

1) Fuel/Scrap Basket Loading - Due to concerns associated with the quantity of defected/damaged fuel to be loaded into each MCO, a maximum of one scrap basket will be allowed per MCO. Therefore, the fuel loading plan will try to evenly balance the canisters containing good fuel with canisters containing damaged fuel.

K East fuel will be loaded into fuel and scrap baskets according to the following assumptions:

a) All fuel in the intact and breached categories will be loaded into fuel baskets.

b) 26% of the fuel in the defected category will load into fuel baskets with the remaining 12% going into the scrap baskets.

c) All fuel in the bad category will be placed into the scrap baskets

K West fuel will be loaded in similar distributions relative to the 7% damaged fuel (see B-1 above).

Due to damage to the ends of fuel elements (based upon the above projections) and the inability to load these fuel elements into a fuel basket, the FRS process design must be able to load full length, end damaged, fuel elements into the scrap baskets. The goal will be to evenly distribute these full elements throughout the scrap basket in a manner which does not compromise packing efficiency.

2) Debris Found in Canisters - Obvious non-reactor origin material shall be separated by visual means and disposed of as solid waste. In K West canisters, no debris is assumed to be present. The canisters in K East will contain the occasional nut, bolt, pen/pencil, paper, tool, plastic, etc. The majority of debris will be the aluminum plates used for identification of the canisters in K East. Of the above listed debris except the aluminum ID tags, the frequency is assumed to be 1 item per 50 canisters retrieved. The aluminum tags will occur quite frequently, every 5th canister will contain a tag.

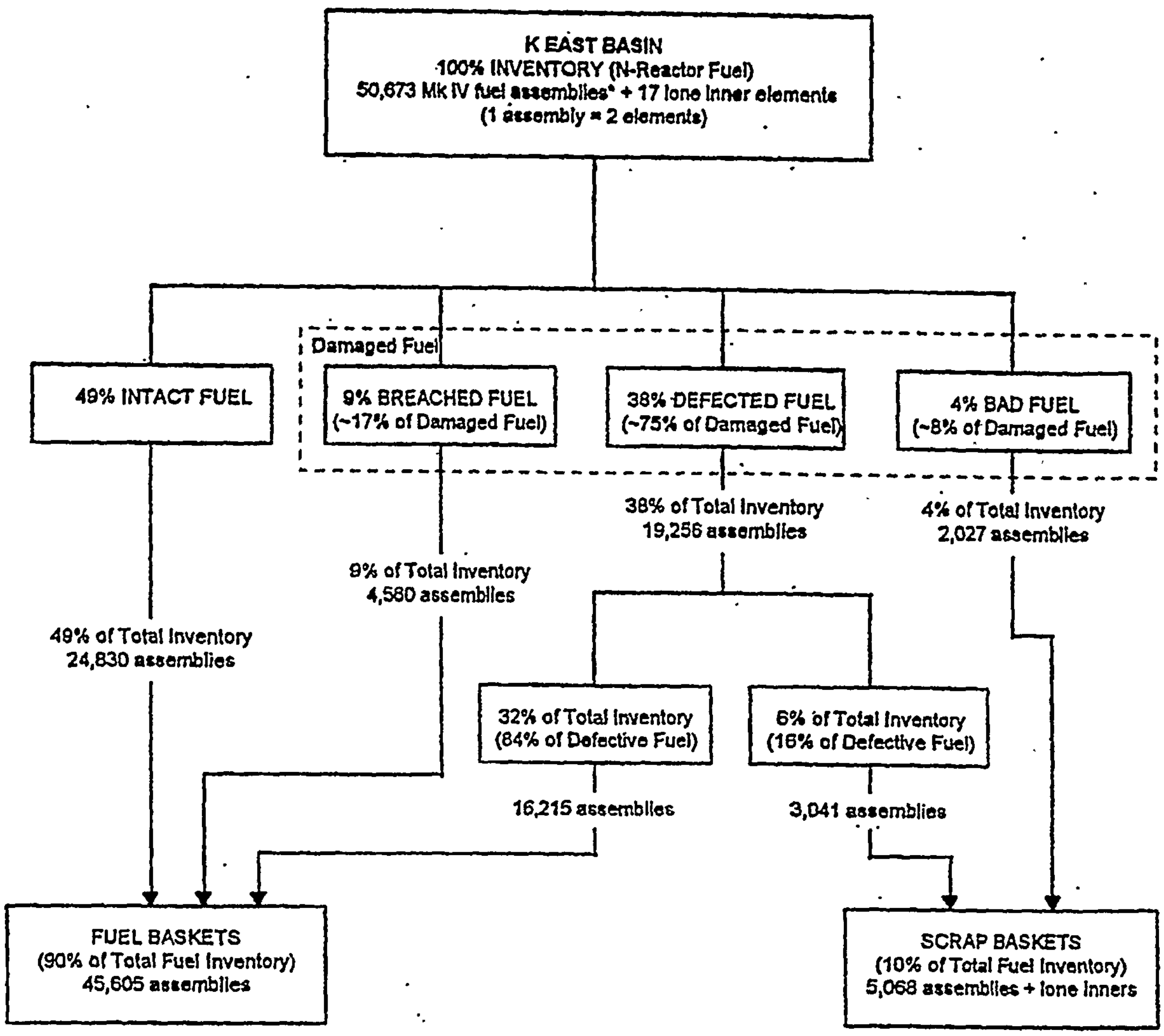
F) Function: Queuing--

1) Fuel Basket Backlog - The fuel retrieval sub-project shall be capable of maintaining a backlog of 8 loaded MCO baskets and a backlog of 2 loaded scrap baskets. The peak throughput of the fuel retrieval process must be based upon the ability to rebuild the queue following a maintenance outage or other factor that reduces or halts fuel handling/loading production. The queue must be rebuilt following an outage in a time frame that is compatible with projections from the reliability/availability analysis, however the maximum time allowable will be two weeks (an additional MCO basket per day). FRS shall assume a shutdown mode if a bottleneck develops in the downstream processes rather than expand the queue storage above what has been assumed above.

Reference:

1) Internal Memo, E. W. Gerber to B. S. Carlisle, "Fuel Retrieval Assumptions Letter of Instruction," 2C000-96-031, dated May 23, 1996.

Figure 1. KE Basin Fuel Loading Model - Nominal Case



* Assumes lone inners and outers are reassembled to reduce fuel basket positions used, with leftover lone elements becoming scrap.

Appendix G

Brief Summary of General FRS Process

Brief Summary of the Fuel Retrieval System and Associated Processes

The fuel retrieval system (FRS) is generally comprised of the systems required to repackage the K-Basin fuel into multi-canister overpack (MCO) fuel and scrap baskets. This includes the grapples and hoists required to lift and transport the fuel canisters, the underwater camera system used to view underwater operations, a system to remove canister lids (K-West only), a fuel cleaning machine (PCM), a canister slitting system (FRS Stuck Fuel Station), an underwater work table, and the manipulator systems. These combined systems make up the FRS, where the intent of the manipulator system is to allow the operators to handle fuel from a remote location whereby personnel exposure to radiation is greatly reduced.

The basic operation begins by recovering an existing fuel canister from its current storage location in the basin. The canister is then transported to the decapping station (for K-West only), where the canister lids are removed. The decapper includes a confinement box, which is used to capture the plume of liquor expected to be released when the lids are removed. Captured liquor is pumped from the confinement box to a filtration system where the radioactive contamination is removed and the water recycled back to the basin.

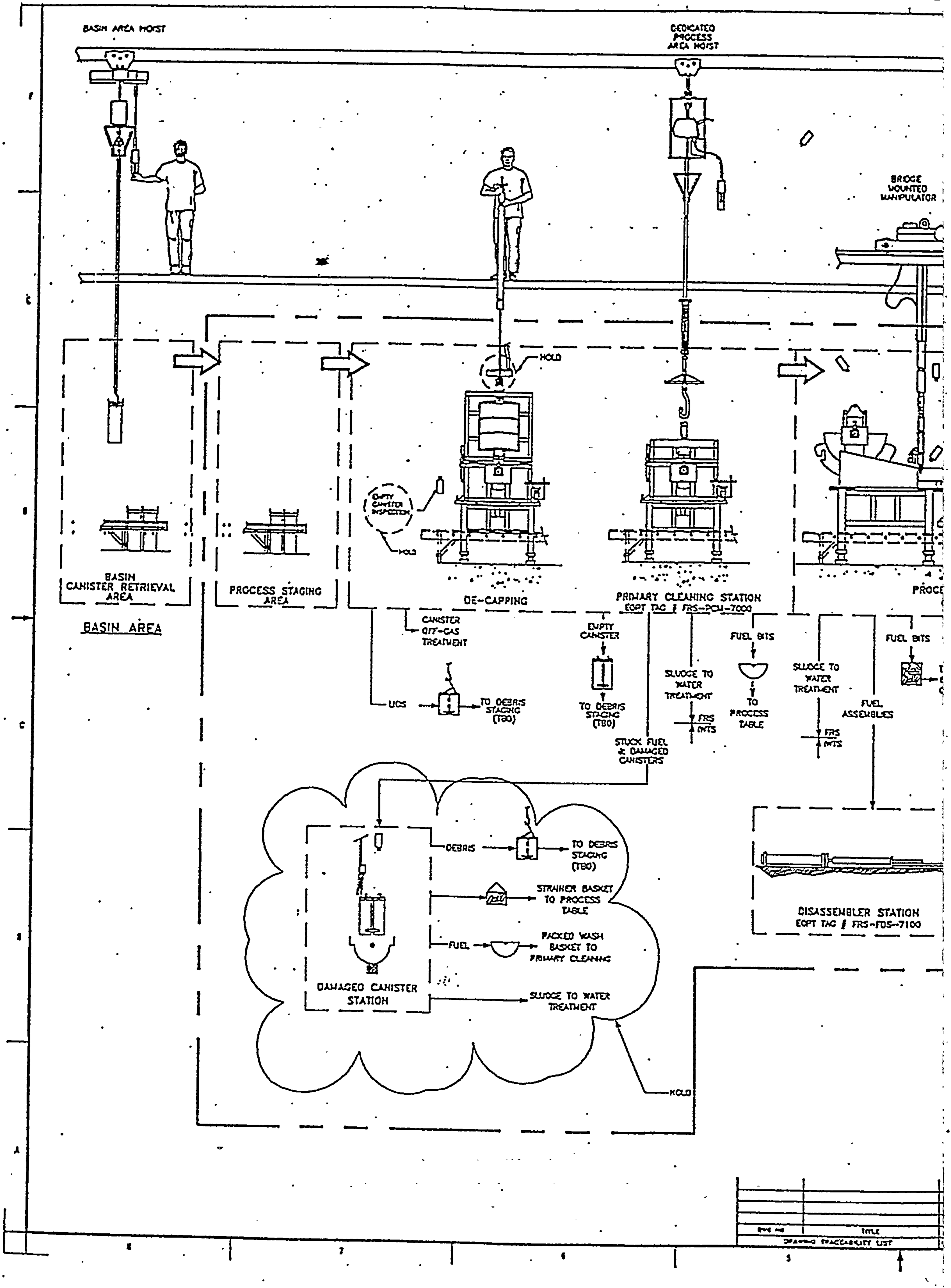
After the lids have been removed the canister is moved to the fuel cleaning station called the primary clean machine (PCM). The PCM is very much like a top-loading washing machine, where the items to be cleaned are placed inside, the machine's lid gets closed, then the internal basket is agitated to scrub the product clean. For our fuel, the entire canister is set into an internal basket in the PCM. This basket holds the canister in the upright position and will prevent it from moving during the wash cycle. The wash cycle in the PCM rotates the internal basket so that the fuel canister rolls end-over-end in the PCM. As a result of this action, the fuel slides out of the canister by as much as four inches and then slides back again as the canister is rotated vertically again, thus causing a rubbing and sucking action. This action is combined with a high-pressure water spray being directed into the top of the open canister to perform the complete cleaning process. As with the decapping system, the resulting dirty water is suctioned out a drain and sent to the filtration system.

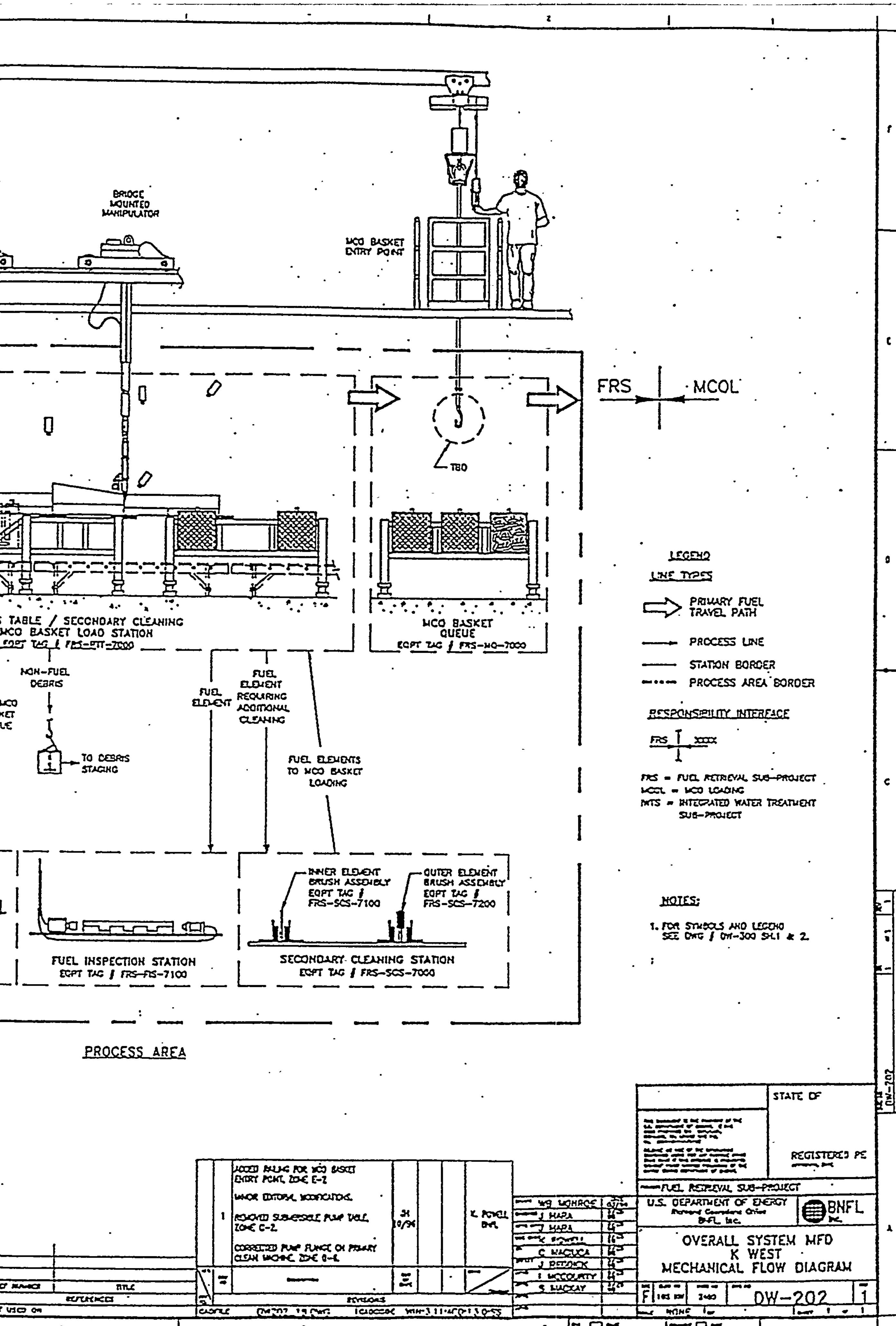
Once the fuel has been cleaned the canister is moved to the process table, where the fuel is dumped out onto the work surface. From here the operators use the manipulators to sort and load the fuel into the MCO baskets. The sorting process is used to separate smaller fuel pieces from larger ones and to separate out any debris material not intended for packaging in the MCOs. The pieces that are to small too load into a fuel basket go into a scrap basket instead. The scrap baskets still go into the MCO; they just have minor differences in their design to accommodate dissipation of more heat than the fuel baskets are required to. Also included in the process table operations is the inspection of at least one canister per day, which is inspected to confirm that the fuel is being cleaned to the base standard. The manipulators are also used to move the fuel to the inspection station.

The fuel is loaded into the fuel baskets in a vertical orientation. This orientation is much more favorable to drying in a vacuum chamber, which is performed on the loaded baskets after they are loaded into the MCO. Once the MCO is loaded and its contents vacuum dried, the MCO is sealed and transported to the interim storage facility, called the Canister Storage Building, or CSB. The fuel, packed into the MCOs will be stored here in the CSB until a permanent repository is opened and ready to receive the material for permanent disposal.

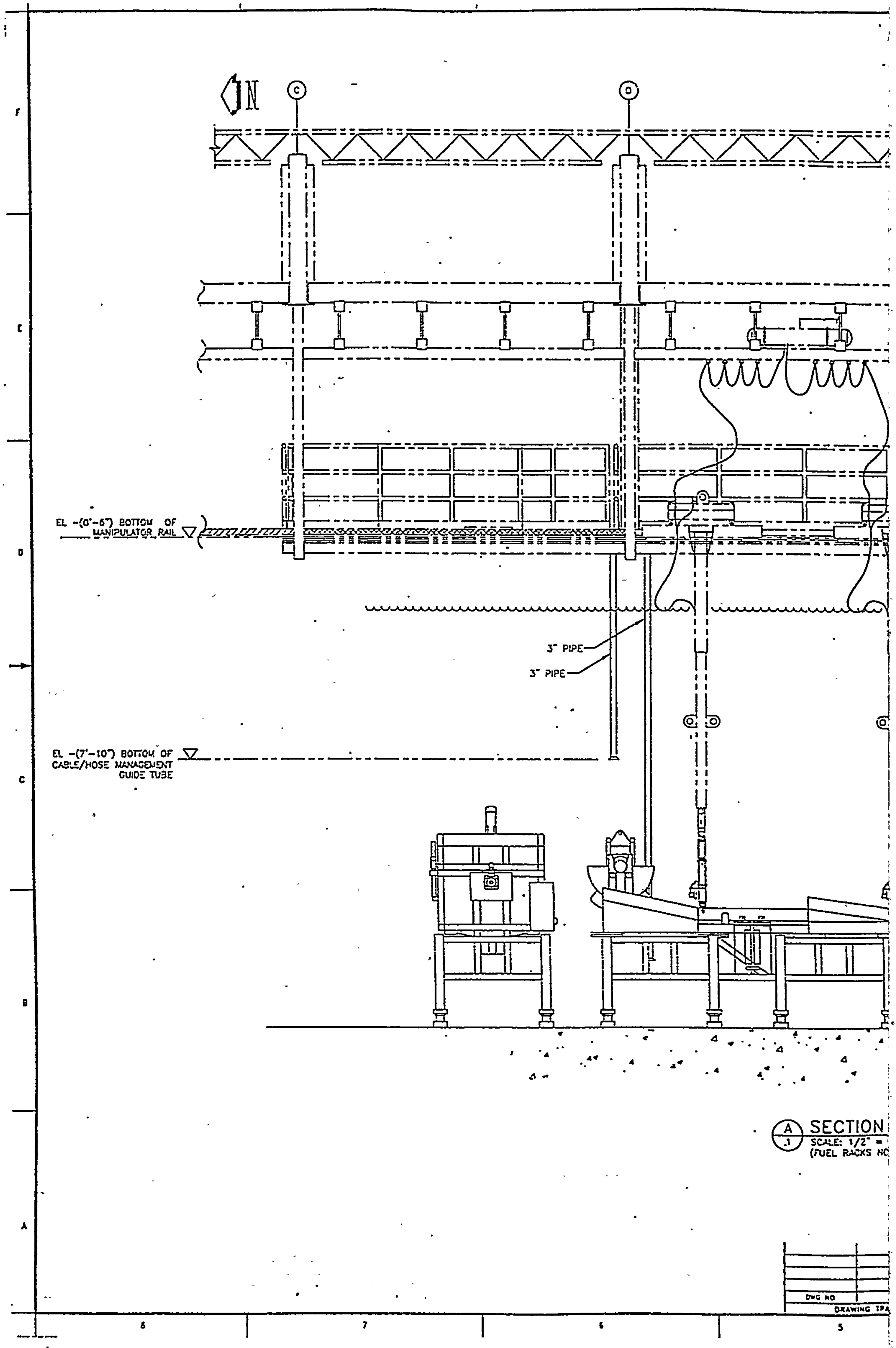
Appendix H

Basic Process System Diagrams

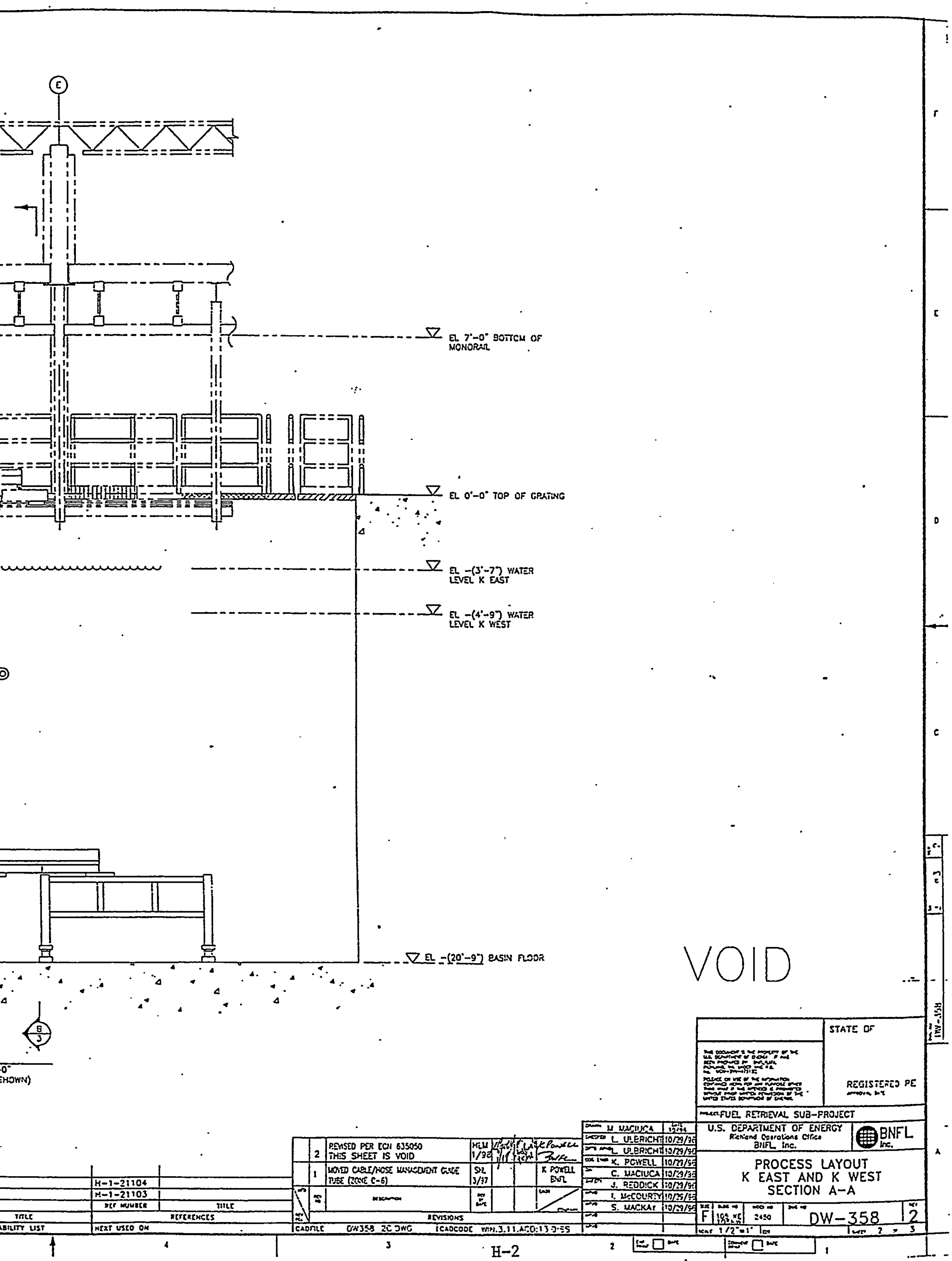

BASIN AREA HOIST
DEDICATED PROCESS AREA HOIST
BRIDGE MOUNTED MANIPULATOR
HOLD
EMPTY CANISTER INSPECTION
HOLD
BASIN CANISTER RETRIEVAL AREA
PROCESS STAGING AREA
DE-CAPPING
PRIMARY CLEANING STATION
EQPT TAG # FRS-PCM-7000
BASIN AREA
CANISTER OFF-GAS TREATMENT
EMPTY CANISTER
FUEL BITS
SLUDGE TO WATER TREATMENT
FUEL BITS
SLUDGE TO WATER TREATMENT
UCS
TO DEBRIS STAGING (TBD)
TO DEBRIS STAGING (TBD)
FRS
IWTS
TO PROCESS TABLE
FUEL ASSEMBLIES
FRS
IWTS
STUCK FUEL & DAMAGED CANISTERS
DEBRIS
TO DEBRIS STAGING (TBD)
STRAINER BASKET TO PROCESS TABLE
FUEL
PACKED WASH BASKET TO PRIMARY CLEANING
DAMAGED CANISTER STATION
SLUDGE TO WATER TREATMENT
HOLD
DISASSEMBLER STATION
EQPT TAG # FRS-FDS-7100
TITLE
DRAWING TRACEABILITY LIST

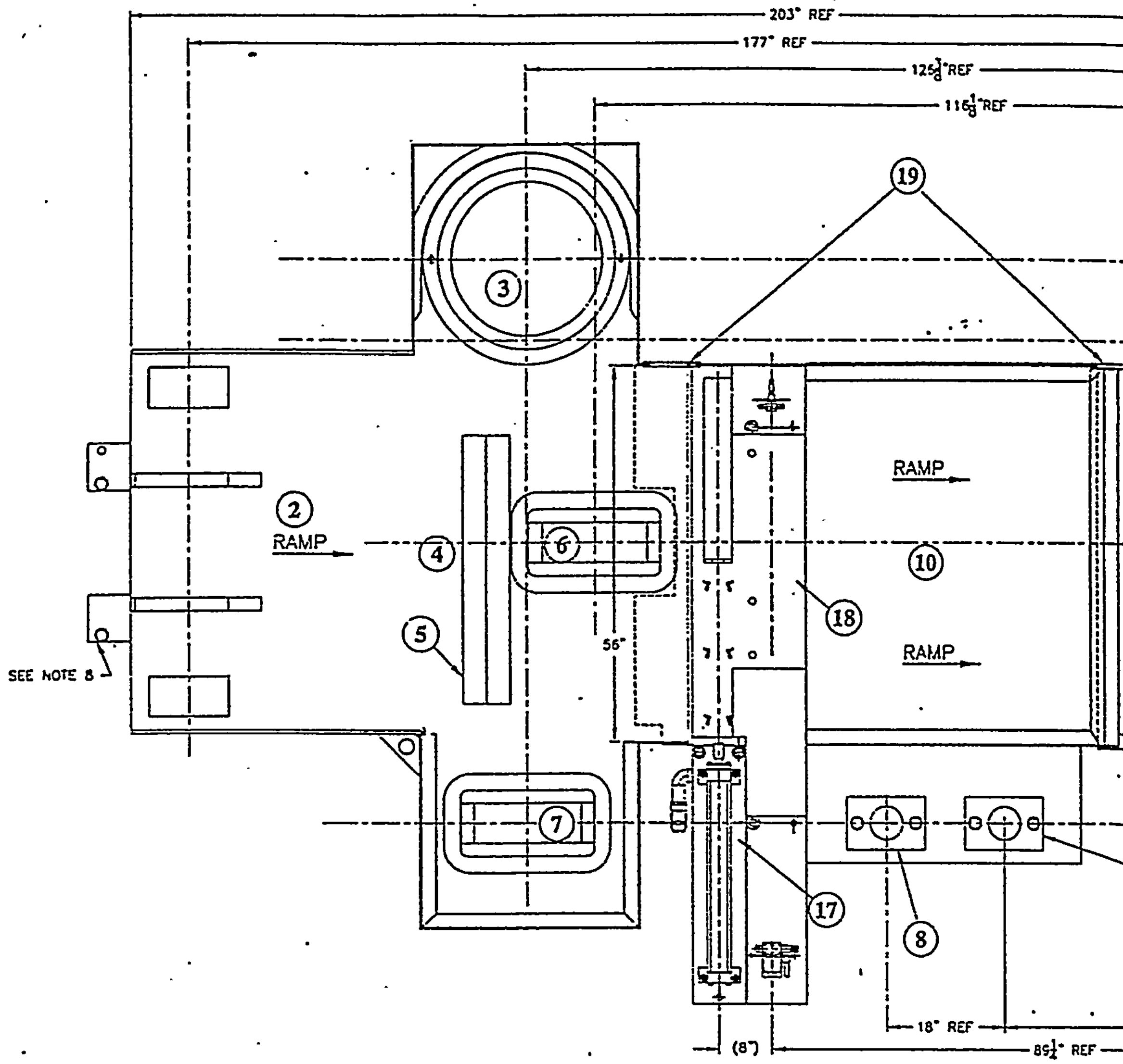


BRIDGE MOUNTED MANIPULATOR
MCO BASKET ENTRY POINT
FRS
MCOL
TBD
S TABLE / SECONDARY CLEANING
MCO BASKET LOAD STATION
EQPT TAG # FRS-PTT-7000
MCO BASKET QUEUE
EQPT TAG # FRS-MQ-7000
NON-FUEL DEBRIS
TO DEBRIS STAGING
FUEL ELEMENT
FUEL ELEMENT REQUIRING ADDITIONAL CLEANING
FUEL ELEMENTS TO MCO BASKET LOADING
INNER ELEMENT BRUSH ASSEMBLY EQPT TAG # FRS-SCS-7100
OUTER ELEMENT BRUSH ASSEMBLY EQPT TAG # FRS-SCS-7200
FUEL INSPECTION STATION
EQPT TAG # FRS-FIS-7100
SECONDARY CLEANING STATION
EQPT TAG # FRS-SCS-7000
PROCESS AREA
LEGEND
LINE TYPES
PRIMARY FUEL TRAVEL PATH
PROCESS LINE
STATION BORDER
PROCESS AREA BORDER
RESPONSIBILITY INTERFACE
FRS = FUEL RETRIEVAL SUB-PROJECT
MCOL = MCO LOADING
IWTS = INTEGRATED WATER TREATMENT SUB-PROJECT
NOTES:
1. FOR SYMBOLS AND LEGEND SEE DWG # DW-300 SH.1 & 2.
ADDED RAILING FOR MCO BASKET ENTRY POINT, ZONE E-2
MINOR EDITORIAL MODIFICATIONS.
REMOVED SUBMERSIBLE PUMP TABLE, ZONE C-2.
CORRECTED PUMP FLANGE ON PRIMARY CLEAN MACHINE, ZONE D-6.
K. POWELL BNFL
REFERENCES
REVISIONS
STATE OF
REGISTERED PE
FUEL RETRIEVAL SUB-PROJECT
U.S. DEPARTMENT OF ENERGY
BNFL Inc.
BNFL
OVERALL SYSTEM MFD
K WEST
MECHANICAL FLOW DIAGRAM
DW-202
NONE

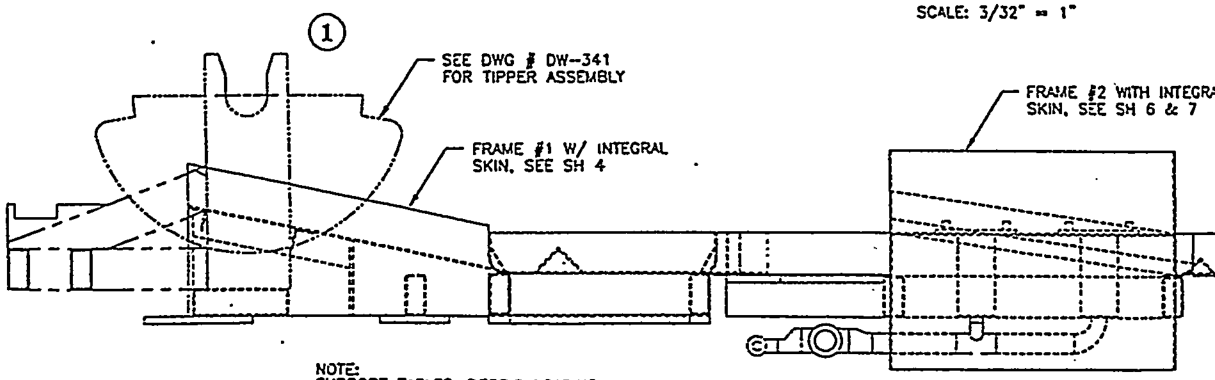


EL -(0'-6") BOTTOM OF MANIPULATOR RAIL
3" PIPE
3" PIPE
EL -(7'-10") BOTTOM OF CABLE/HOSE MANAGEMENT GUIDE TUBE
SECTION
SCALE: 1/2" =
(FUEL RACKS NO
DWG NO
DRAWING


EL 7'-0" BOTTOM OF MONORAIL
EL 0'-0" TOP OF GRATING
EL -(3'-7") WATER LEVEL K EAST
EL -(4'-9") WATER LEVEL K WEST
EL -(20'-9") BASIN FLOOR
VOID
STATE OF
REGISTERED PE
FUEL RETRIEVAL SUB-PROJECT
U.S. DEPARTMENT OF ENERGY
Richland Operations Office
BNFL, Inc.
BNFL Inc.
PROCESS LAYOUT
K EAST AND K WEST
SECTION A-A
DW-358
2
REVISED PER ECN 635050
THIS SHEET IS VOID
MOVED CABLE/HOSE MANAGEMENT GUIDE TUBE (ZONE C-6)
M. MACIUCA
L. ULBRICHT
L. ULBRICHT
K. POWELL
C. MACIUCA
J. REDDICK
I. McCOURTY
S. MACKAY
K POWELL BNFL
H-1-21104
H-1-21103
REF NUMBER
TITLE
REFERENCES
REVISIONS
NEXT USED ON
CADFILE DW358 2C.DWG
SCALE 1/2"=1'

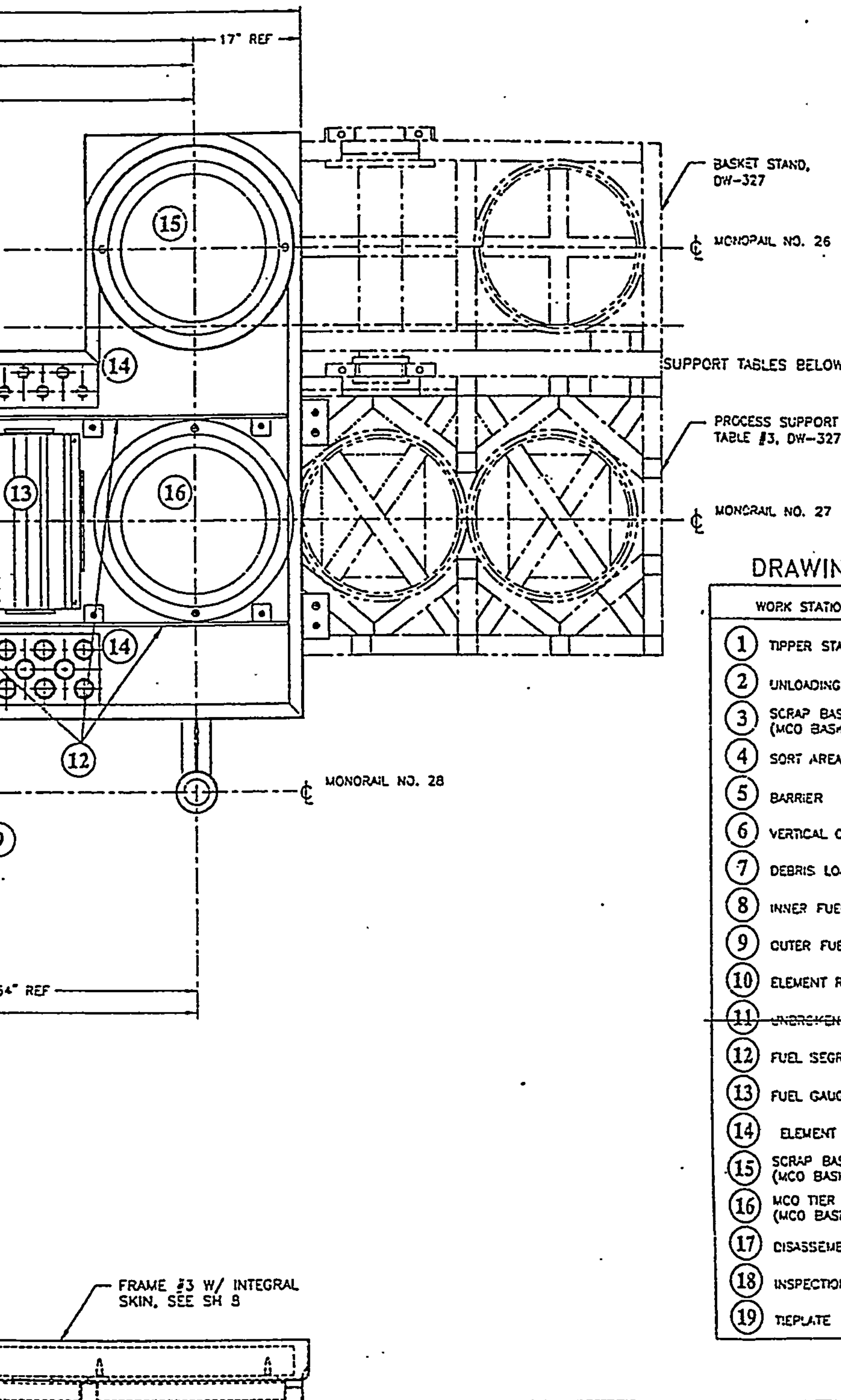


PLAN VIEW
PROCESS TABLE TOPS
SCALE: 3/32" = 1"



NOTE:
SUPPORT TABLES, DEBRIS LOADING STATION, DISASSEMBLER AND INSPECTION STATION NOT SHOWN FOR CLARITY.

SIDE VIEW
PROCESS TABLE TOPS AND FRAMES
SCALE: 3/32" = 1"



REV	DESCRIPTION	REV BY DATE
9	REVISED PER ECN 635050 DELETED WORK STA # 11, REVISED TABLES 1,2 & 3 ADDED ITEM 19	HLM 11/97

SEE SHT # 1 FOR GENERAL NOTES AND PARTS/MATERIAL LIST

DRAWING LEGEND

WORK STATIONS	REF DWG	ITEM #	K WEST EQPT TAG #	K EAST EQPT TAG #
(1) TIPPER STATION	DW-341-010	–	FRS-CTS-7100	FRS-CTS-3100
(2) UNLOADING RAMP	DW-205, SH 4	2	–	–
(3) SCRAP BASKET FUEL SCRAP LOADING (MCO BASKET GAUGE)	DW-342-020	60	FRS-PTT-7910	FRS-PTT-3910
(4) SORT AREA	DW-205, SH 4	–	–	–
(5) BARRIER	DW-205, SH 4	–	–	–
(6) VERTICAL CANISTER UNLOADING	DW-205, SH 7	–	–	–
(7) DEBRIS LOADING STATION	DW-205, SH 4	10	–	–
(8) INNER FUEL ELEMENT BRUSH ASSY	DW-339-010	57	FRS-SCS-7100	FRS-SCS-3100
(9) OUTER FUEL ELEMENT BRUSH ASSY	DW-339-020	58	FRS-SCS-7200	FRS-SCS-3200
(10) ELEMENT RAMP	DW-205, SH 7	5	–	–
~~(11) UNBROKEN ELEMENT RAMP~~	~~DW-205, SH 7~~	~~5~~	–	–
(12) FUEL SEGREGATOR	DW-205, SH 8	–	–	–
(13) FUEL GAUGE STATION	DW-340-010	54	FRS-PTT-7900	FRS-PTT-3900
(14) ELEMENT STAGING	DW-205, SH 8	–	–	–
(15) SCRAP BASKET LOADING (MCO BASKET GAUGE)	DW-342-010	52	FRS-PTT-7910	FRS-PTT-3910
(16) MCO TIER BASKET LOADING (MCO BASKET GAUGE)	DW-342-010	52	FRS-PTT-7910	FRS-PTT-3910
(17) DISASSEMBLER STATION	DW-323-010	55	FRS-FDS-7100	FRS-FDS-3100
(18) INSPECTION STATION	DW-337-010	56	FRS-FIS-7100	FRS-FIS-3100
(19) TIEPLATE	DW-205, SH 9	12	–	–

REV NO	DESCRIPTION	REV BY DATE	CHKD	APVD	CNE DSGN
8	DW-342-020 WAS DW-342-010 & ITEM 60 WAS 52 IN Z B-2	HLM 5/97			
7	CHANGED WORK STATIONS 3, 6, 8, 9, 11, 13, 17 AND 18. SEE DETAILS ON SHEETS 3 TO 8.	MM 5/97			K. POWELL BNFL
6	CORRECTED SIDE VIEW OF FRAME #3 (ZONES B-4 & B-5). DELETED ONE TABLE CLAMPING ASSY (ZONE D-8). CORRECTED ITEMS 6 & 7 ON PLAN VIEW (ZONES D-6 & D-7). MINOR EDITORIAL MODIFICATIONS FOR CLARITY.	MM 3/97			K. POWELL BNFL
5	MINOR EDITORIAL MODIFICATIONS TO REV BLOCKS TO REDUCE AREA. NO CHANGES TO THE DESIGN	JH 2/97			
4	REV 4 DOES NOT AFFECT SHEET 2.	MM 2/97			
3	REV 3 DOES NOT AFFECT SHEET 2.	JH 2/97			
2	ADDED TABLETOP CONNECTIONS AND MODIFIED PIPING COMPONENTS. (ZONES B-6, C-6, D-5, C-5, B-6)	SMS 1/97			K. POWELL BNFL
1	MINOR EDITORIAL MODIFICATIONS. REVISED DISASSEMBLER & INSPECTION STATIONS TO SHOW THE CURRENT DESIGN IN THE PLAN VIEW. CORRECTED MCO BASKET STAND TO SHOW CURRENT DESIGN, ZONE E-4. REMOVED DOWN DRAFT TUBE, REPLACED WITH FUEL BARRIER, ZONE B-7. GENERAL REF DIMENSIONS ADDED	MMM 10/96			K. POWELL BNFL

REVISIONS

CADFILE DW205_2K.DWG CADCODE WIN:3.11:ACD.13.0:SS

DRAWN	MW MCLEOD	8/96
CHECKED	J. HARA	8/29/96
	J. HARA	8/29/96
CNE DSGN	K. POWELL	8/29/96
	C. MACIUCA	8/29/96
	J. REDDICK	8/29/96
	I. McCOURTY	8/29/96
	S. MACKAY	8/29/96

STATE OF

REGISTERED PE

FUEL RETRIEVAL SUB-PROJECT

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
BNFL, Inc.

BNFL Inc.

FRS IN-POOL EQUIPMENT PROCESS TABLE GENERAL ASSEMBLY

SIZE F | 2450 | DWG NO DW-205 | REV 9

SCALE 3/32"=1" | SHEET 2 OF 9

Distribution

No. of Copies		
5	ARES	
	B. D. Groth (5)	X3-88
3	Fluor Daniel Hanford	
	W. H. Cloos	X3-65
	T. G. VanReenan	X3-61
	R. M. Yanochko	R3-86
1	Numatec Hanford Corporation	
	M. J. Schliebe	L6-13

No. of Copies		
3	Technical Resources	
	J. M. Henderson (2)	X3-88
	V. R. Enderlin	X3-88
24	Pacific Northwest National Laboratory	
	D. A. Clark	K5-17
	D. R. Jackson (12)	K5-22
	G. R. Kiebel	K5-17
	R. E. Rhoads	K5-22
	M. W. Rinker	K5-22
	K. D. Wiemers	A0-21
	Information Release (7)	