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TEST PLAN FOR TECHNIQUES TO MEASURE AND REMOVE COATINGS FROM K WEST BASIN FUEL ELEMENTS

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Abstract: This activity will (1) evaluate the thickness of $Al(OH)_3$ coating and (2) evaluate the effectiveness of various brushing methods to remove $Al(OH)_3$ coatings on representative samples of N Reactor fuel stored in the 105-K West Basin.

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TEST PLAN FOR TECHNIQUES TO MEASURE AND REMOVE COATINGS FROM K WEST BASIN FUEL ELEMENTS

1.0 INTRODUCTION

Several types of coatings have previously been visually identified on the surface of 105-K East and 105-K West Basins fuel elements. One type of coating (found only in K West Basin) in particular was found to be a thick translucent material (Figure 1) that was often seen to be dislodged from the elements as flakes when the elements were handled during visual examinations (Pitner 1997). Subsequently it was determined (for one element only in a hot cell) that this material, in the dry condition, could easily be removed from the element using a scraping tool (Figure 2). The coating was identified as $\text{Al}(\text{OH})_3$ through X-ray diffraction (XRD) analyses and to be approximately 60 μm thick via scanning electron microscopy (SEM). However, brushing under water in the basin using numerous mechanical strokes failed to satisfactorily remove these coatings in their thickest form as judged by appearance (Figure 3). Such brushing was done with only one type of metal brush; a brush design previously found satisfactory for removing $\text{UO}_4 \cdot x\text{H}_2\text{O}$ coatings from the elements.

In addition to the brush cleaning method, a related simple "washing machine" design concept (i.e., referred to as a "Sludge Adherence Test Cylinder") was tested in K East Basin (Figure 4). It was composed of a large cylinder which rocked back and forth, causing the enclosed fuel elements to move against each other and the cylinder walls. This simple washing machine method failed to fully remove the less tenacious coatings from the fuel elements in K East Basin. Based on these results, it was judged that this method would not remove the more strongly adherent subject coatings on K West Basin elements.

The $\text{Al}(\text{OH})_3$ coating is of concern in the design of the multi-canister overpack (MCO) to be used for housing fuel elements during interim dry storage. This and other coatings are a potential source of water release during storage and thus a source of oxidant, internal pressurization and potentially hazardous $\text{H}_2 + \text{O}_2$ gas mixtures. $\text{Al}(\text{OH})_3$ has been the greatest concern since it is the most difficult to remove of the various coatings seen to date. Design analyses have specified target removal percentages for this coating which will allow the MCO to remain within specified performance limits.

2.0 OBJECTIVE

The primary and secondary objectives of this testing activity, respectively, are to determine $\text{Al}(\text{OH})_3$ coating thicknesses in a representative way and to determine if a viable mechanical cleaning (i.e., brushing) system can be developed that effectively removes the $\text{Al}(\text{OH})_3$ coatings to levels

Figure 1. Surface Coating as Observed in K West Basin.

Figure 2. Partially Removed Surface Coating
as Observed in Air at Hot Cell.

Figure 3. Example of Brushing Attempts on
Subject Coating in K West Basin in 1997.

Figure 4. Testing of Simple Fuel Element Washing
Machine Concept in K East Basin in 1996.

beneficial to MCO design basis considerations. An eddy current device will be used to measure fuel element coating thickness and a brushing device will be tested to determine the significant parameters (brush geometry, brush material, operating speed, etc.) for successful coating removal. The two objectives are complementary in that the success of the Fuel Element Brushing Device will be determined by using the eddy current coating thickness measurement device (and/or a visual examination) and the clean cladding surface, produced by the "best" brushing device, will provide a "zero point" for eddy current measurements. The basic features from the brush test provide parameters (i.e., brush types, forces, etc.) that may be used during actual fuel retrieval. It is not implied by this work that the brushing machine being tested is the one to be used for fuel cleaning of large quantities of elements.

Functions and requirements for coating removal methods and measurement devices are provided in Appendix A. Specific functions and requirements were initially developed for the following concepts: (1) Fuel Element Brushing Device equipment; (2) fuel washing machine mockup and (3) ultrasonic and other innovative cleaning devices. The fuel washing machine mockup proposed to simulate, on a best effort basis, the primary K Basin fuel retrieval cleaning machine as it is currently planned. Subsequent to development of the functions and requirements, it was decided to limit the scope of this testing activity to one rather than three concepts with the choice being to retain the testing of the brushing techniques. Therefore, this test plan addresses only the Fuel Element Brushing Device and the measurement techniques needed to determine its degree of success at removal of the subject coating.

3.0 SCOPE

As described in Appendix E, fuel elements with the appropriate coating will be identified through review of existing video tapes of K West Basin elements. These tapes were made during the "lift and look" campaign where selected canisters were opened and the elements extracted for full length visual examination. Initially elements will be selected which exhibit the thicker examples of the coating and elements chosen for testing will have similar amounts of coating in order to facilitate valid comparisons between coating removal methods and to bound coating thickness. At least some aluminum canisters and coated elements however, will be selected randomly as suggested in Jensen (1998). Appendix E discusses the particular storage canisters and associated fuel elements to be used in the testing in more detail.

Criteria for judging the degree of success associated with the Fuel Element Brushing Device will be developed. While it is anticipated that visual examinations may suffice in assessing coating removal effectiveness, the more elaborate eddy current method will be applied to confirm the visual impressions and assess the partial success (partial removal) which could not be quantified visually. The actual magnitude of the coating thickness before and after brushing will allow full assessment of the techniques involved and assessment of thickness on virgin elements. Specifically, specially fabricated eddy current probes will be used to measure coating thicknesses

on the inner and outer fuel element surfaces. Calibration standards will be placed in the basin to permit periodic calibration checks on the eddy current probes. (If available, the probes will also be verified using pieces of tube on which coatings, similar to those on the fuel elements, have been grown in the cold laboratory simulation.) The criteria of success of the brushing tests will include assurance that the coating removal method is acceptable to the needs of the Spent Nuclear Fuel Project (SNFP) subproject staff responsible for the ultimate design and application of the cleaning method at the K Basins.

The testing, described in Section 4.0, will be conducted in the 105-K West Basin using a detailed procedure, OP-07-125W/Clean K West Fuel Elements in Dummy Elevator Pit (Series 1998). The Spent Nuclear Fuel Characterization Project group will conduct the testing in conjunction with facility operation personnel.

Development of the Measuring Device and Fuel Element Brushing Device includes prototypic and acceptance testing. These cold tests will be recorded in a laboratory notebook and documented in a report.

4.0 DESCRIPTION OF TEST

Based on the requirements in Appendix E and other constraints (e.g., funding and K West Basin operation support windows), it is intended to develop a coating measurement technique and a Fuel Element Brushing Device to assess, respectively, coating thicknesses and the effectiveness of brushing parameters on the removal of the subject coating from fuel elements stored in K West Basin. Concepts for the devices would be developed during a conceptual design stage, followed by prototypes fabricated to the most promising design features. Cold testing would be used for verification of acceptable performance versus requirements. Upon completion of cold testing in the Engineering Testing Laboratory's Cold Test Facility (305 Building), the testing devices would undergo any needed modifications prior to deployment in the field (K West Basin Dummy Elevator Pit). The cold testing would, as a minimum, attempt to identify limitations such as interface, operator handling, etc. Field usage will identify the degree of success the methods and devices have in removing the subject coatings from the fuel elements.

4.1 COATING THICKNESS MEASUREMENT DEVICE

Limited hot cell measurements of coating thickness (Pitner 1998; Makenas 1998) have indicated that elements stored in K West Basin in aluminum canisters have an aluminum hydroxide coating approximately 60 μm in thickness. Reference Jensen (1998) suggests that elements from at least seven canisters must be examined to provide statistically meaningful data. A survey of onsite experience with various thickness measuring techniques indicated the highest probability of success for eddy current methods to provide quantitative thickness measurement. A device will be developed that will provide a survey of coating thicknesses as well as dove-tail with the coating removal equipment described below.

4.2 FUEL ELEMENT BRUSHING DEVICE

Past experience with mechanical removal of coatings from fuel elements stored in the K East and K West Basins (Bergmann 1996; Maassen 1997a, 1997b) indicates there is the probability that a Fuel Element Brushing Device will remove the subject coating (aluminum hydroxide) from a fuel element. The primary objective of this design is to investigate variations in brush design and materials that would be effective in dislodging this type of coating. Bristle type (stiffness), material (includes materials other than the stainless steel used in previous brush assembly), brush-element interference (force), bristle density, and brushing velocity are all variables that would be investigated in accordance with Appendix E.

4.3 K BASINS OPERATIONS INTERFACE ACTIVITIES

Integration of this activity will be coordinated with other ongoing activities in the K West Basin. It is planned to perform this work in the Dummy Elevator Pit in the K West Basin. It is recognized that there are ongoing debris removal activities in this area, but it is believed that all these test activities can be successfully integrated with that campaign.

The following activities will need to be addressed prior to initiating the field testing at the K West Basin: (1) modify the existing Safety Analysis Report (SAR) to allow decapping of fuel canisters in the Dummy Elevator Pit (not previously done), (2) revise and release the operating procedure, (3) prepare and issue a work package, (4) modify the Dummy Elevator Pit as needed, (5) perform an Unreviewed Safety Question (USQ) review, (6) perform a Hazard Category assessment, (7) update operator training, (8) prepare and issue a campaign letter to move fuel canisters, (9) review the existing air permit and modify if necessary, (10) develop an integrated schedule and interface with other projects at the basin, (11) perform an As-Low-As-Reasonably-Achievable (ALARA) review (time/dose study, etc.), and (12) prepare a Waste Management Plan. The critical path activity will be the modification of the existing SAR to permit decapping of fuel canisters in the Dummy Elevator Pit. This activity is estimated to take 12 to 14 weeks to complete. The other activities identified here will be completed during that time frame. A general schedule for these activities is provided in Table 1.

5.0 EXPECTED RESULTS

It is anticipated that the eddy current technique will demonstrate a distribution of coating thickness among elements from several canisters. It is also expected that varying degrees of success at removal will be experienced in the testing of various brush types and control parameters. For the most part, it is anticipated that visual appearance will be definitive in whether or not the coating has been removed. If necessary, scratch testing under closeup video will enhance the ability to determine if any coating remains on element surfaces, based on previous in-basin observations. Direct eddy current measurements will provide selected quantitative definition of coating thicknesses before and after brushing.

Table 1. Schedule for K Basin Interface Activities.

Activity	Start	Finish
Modify Safety Analysis Report	02/02/98	06/26/98
Prepare and Issue Operating Procedure	03/02/98	05/29/98
Prepare Dummy Elevator Pit Modifications Work Packages	03/02/98	04/24/98
Modify Dummy Elevator Pit	01/26/98	05/01/98
Perform USQ Review	05/04/98	05/08/98
Perform Hazard Category Assessment	04/27/98	05/01/98
Update Operator Training	06/08/98	06/12/98
Prepare and Issue Campaign Letter	06/15/98	06/20/98
Review Air Permit	01/26/98	05/04/98
Develop Integrated Schedule/Interface with K West Basin	01/26/98	05/22/98
Perform ALARA Review	05/05/98	05/14/98
Prepare Waste Management Plan	03/02/98	05/01/98

The brushing results are expected to delineate the relative effectiveness of the various brush concepts and control parameters investigated with respect to coating removal capability, and to provide guidance toward fuel processing design parameters should coating removal operations be deemed necessary in the fuel retrieval process.

6.0 TEST PROCEDURE

Eddy current probes will be employed to obtain quantitative coating thickness measurements. Special fixturing on these probes will assure proper alignment on the fuel element surface to permit accurate coating thickness measurements. Probes to measure the outside surface of both outer and inner fuel elements, as well as a probe to measure the inside surface of the outer element will be employed. Schematics of the probe designs are presented in Appendix B. Acceptance testing for the eddy current measuring devices will be performed in the Engineering Testing Laboratory using calibration standards. (A test traveler is included in Appendix C.)

Variability in eddy current signals occurs depending on whether correct probe placement on the element or calibration standard is achieved. Less than optimum placement typically causes low signal values to be generated. The objective in collecting a meaningful set of eddy current measurements is to select a relatively tight grouping of the highest-reading signals and averaging them.

Calibration standards, using known shim thicknesses, will be used to generate calibration curves. These standards will be checked daily to ensure proper calibration is maintained.

The objective of the Fuel Element Brushing Device is to determine the effect of brushing parameters on the removal of the $Al(OH)_3$ coating on the fuel elements. These brushing parameters include: (1) brush type (material, wire size, configuration, etc.); (2) brush velocity [revolutions per minute (rpm), wheel size]; (3) brush-fuel interference (force); and (4) power. A front view of the concept, presented at preliminary design meetings, is included in Appendix D. Basically, the Fuel Element Brushing Device will use the following operating steps: (1) the fuel element is positioned in a fixture and clamped in place (measurement of coating thickness would occur at this time); (2) the brush is moved axially to the fuel element location where brushing is to occur; (3)* the fuel element is moved laterally until it is against the brush, with the desired interference; (4)* the brush is turned on; (5) information on the brushing parameters is recorded (motor power, etc.); (6)* upon completion of the brushing action, the brush is turned off; (7)* the fuel element is retracted from contact with the brush; (8) the fuel element is inspected and the coating thickness is measured; and (9) Steps 2 through 8 are repeated at various axial and circumferential locations. In addition, brushes are changed when appropriate. Using the manual fuel handling tools to rotate the fuel element in the fixture will allow several brushing tests on the same fuel element. Linear scales on the Fuel Element Brushing Device will be used to assist in properly positioning the coating thickness measurement probes which will have an index line. Upon completion of the brushing tests, the fuel element is returned to its canister, and the next brushing candidate is selected.

The brush will be powered by a submersible motor (approximately 1.5 HP). Positioning of the brush and fuel element will be accomplished by using linear slides. These slides will be operated from the K Basin operations deck (grating) with removable extensions. The motor will be remotely controlled from the operations deck. Schematics of the Fuel Element Brushing Device are included in Appendix D.

A detailed K Basins procedure (Serles 1998) will be used to perform the in-field testing on fuel elements in the K West Basin. Prototypic and acceptance testing will be performed in the Cold Test Facility at the Engineering Testing Laboratory (305 Building) and/or the Engineering Development Laboratory (306E Building). Travelers for the Acceptance Testing are included in Appendix C.

*Steps 3 and 4 may be reversed, as determined in prototype testing. Similarly Steps 6 and 7 may be reversed.

It is expected that visual examination will determine, to some extent, whether or not the coating is totally removed by brushing. Closeup video inspection will be used in conjunction with an appropriate scratching action to confirm the presence or absence of coating. Eddy current thickness data will be obtained at each brushed location.

Coating samples will be taken during this activity. Control of these samples will be in accordance to HNF-PRO-1884, Rev. 1, *Spent Nuclear Fuel Project Fuel Sampling Control Requirements*.

7.0 SAFETY

A Job Hazard Analysis for the cold testing of the fuel coating removal testing equipment has been prepared and included in Appendix F. Similarly, a Job Hazard Analysis for the K West Basin activity has been prepared and is also included in Appendix F. The relevant work packages for preparing the Dummy Elevator Pit for the Fuel Coating Removal Testing activity, 1K-98-00618/W and 1K-98-00927/W, contain the required safety documentation. Other safety-related documentation included in Appendix F are:

1. Unreviewed Safety Question (USQ) Review
2. Hazard Category Review
3. As-Low-As-Reasonably Achievable (ALARA) Review.

8.0 QUALITY ASSURANCE

Quality Assurance (QA) requirements are identified in DESH-1, *Duke Engineering & Services Hanford, Inc., Manual*, Section 1.4, Attachment A, Rev. 3, *Spent Nuclear Fuel Project Quality Assurance Program Plan*, dated April 6, 1998. Portions of this work related to the characterization of fuel element coating thickness do fall under Office of Civilian Radioactive Waste Management (OCRWM) Quality Assurance. The work shall be performed by qualified personnel and data reported to the level of rigor defined in the Quality Assurance Requirement Description for SNF. Documentation of characterization personnel qualifications is proceeding as per Reference Lawrence (1998) and as such may occur in parallel with or subsequent to the performance of this work.

9.0 ORGANIZATION AND FUNCTION RESPONSIBILITIES

The Spent Nuclear Fuel Characterization Project group, managed by R. P. Omberg, has overall responsibility for design, fabrication, cold testing, in-field testing of the Fuel Coating Removal Testing Equipment

and coating thickness measurement devices, evaluation of the data, and issuance of the final evaluation report. The Equipment Development Laboratory, managed by J. R. Thielges, will support the design and fabrication tasks. Cold testing of the equipment may be performed in the Engineering Testing Laboratory, managed by M. J. Schliebe. Quality Assurance support will be provided by QA K Basins, managed by G. M. Davis. Any needed nuclear safety reviews will be performed by 100 Area Nuclear Safety, managed by D. W. Bergmann. Other reviews or actions related to Environmental, Safety and Health are the responsibility of P. G. LeRoy, Director of Environmental, Safety and Health.

9.1 ENGINEERING TASKS

The primary engineering tasks include:

- Conceptual design of the Fuel Coating Measurement and Removal Testing equipment
- Fabrication of prototypes
- Prototype testing, including test planning and procedure development
- Final design
- Final Fabrication or modification of prototype equipment.

The final approval authority for the design of the Fuel Coating Removal Testing equipment resides with Spent Nuclear Fuel Characterization Project. All engineering tasks will be performed in accordance with HNF-1613, *Spent Nuclear Fuel Project Engineering Practices*, Rev. 0A and WHC-IP-1026, *Engineering Practices Guidelines*, Rev. 15.

9.2 VERIFICATION

Verification of the Fuel Coating Measurement and Removal equipment performance will be in accordance with EP-4.1, *Design Verification Requirements*, of HNF-1613, and HNF-PRO-446, *Testing Requirements*. Primarily, verification will be by qualification testing of the equipment.

9.3 PROCUREMENT TASKS

Procurement of materials, initiated by Spent Nuclear Fuel Characterization Project, shall be in accordance with HNF-PRO-194, *Requisitioning Materials and Services*.

9.4 INSTALLATION TASKS

Installation of the Fuel Coating Measurement and Removal equipment into the K West Basin Dummy Elevator Pit will be the responsibility of Spent Nuclear Fuel Characterization Project. Supporting organizations for these tasks include: Maintenance and Work Control, managed by W. C. Barker;

Facility Operations, managed by J. R. Gregory; Radiological Control, managed by P. G. Huntley; Work Control, managed by R. N. Casler; and K Basin subproject, managed by R. W. Rasmussen (Implementation manager is D. G. Dunnum).

9.5 PRE-OPERATIONAL AND OPERATIONAL TESTS

Prior to delivery of the Fuel Coating Measurement and Removal Testing equipment to Facility Operations, pre-operational or acceptance testing will be performed in the Cold Test Facility at the 305 Building (300 Area). This facility is managed by M. J. Schliebe, Engineering Testing Laboratory.

9.6 DUMMY ELEVATOR PIT MODIFICATION

Modification of the K West Basin Dummy Elevator Pit was the responsibility of Spent Nuclear Fuel Characterization Project. Supporting organizations for these tasks included: Maintenance and Work Control, managed by W. C. Barker; Facility Operations, managed by J. R. Gregory; Radiological Control, managed by P. G. Huntley; Work Control, managed by R. N. Casler; P. G. LeRoy, Director of Environmental, Safety and Health; Facility Systems Engineering, managed by C. S. Haller; and K Basins Subproject, managed by R. W. Rasmussen (Implementation manager is D. G. Dunnum).

The Dummy Elevator Pit modification consisted of two activities:
 (1) clean up of the pit (removal of old tools from past operations not associated with this task, etc.) and repositioning of equipment and
 (2) installation of grating and handrails. Work packages 1K-98-00618/W and 1K-98-00927/M were used to accomplish these tasks, respectively. This task was completed on May 1, 1998.

9.7 IN-FIELD (105-K WEST BASIN) TESTING

Primary responsibility for the Fuel Coating Measurement and Removal Testing activity at the 105-K West Basin resides with Spent Nuclear Fuel Characterization Project, managed by R. P. Omberg. Supporting organizations include: Maintenance and Work Control, managed by W. C. Barker; Facility Operations, managed by J. R. Gregory; Radiological Control, managed by P. G. Huntley; and Work Control, managed by R. N. Casler.

10.0 ESTIMATED OVERALL SCHEDULE AND BUDGET

Based on the activities discussed in Section 4.0, Description of Test, an estimated schedule was developed and is provided in Table 2.

Table 2. Overall Testing Schedule.

Activity	Start	Finish
Equipment Design and Development	01/26/98	05/31/98
Acceptance Test	06/15/98	06/19/98
K West Basin Interface Activities (see Table 1)	02/02/98	06/15/98
Prepare and Issue Test Plan	02/23/98	06/08/98
Perform Brushing Tests at K West Basin	07/06/98	07/17/98
Dispose of Equipment and Waste Materials	07/22/98	07/29/98
Prepare and Issue Final Report	07/09/98	08/14/98

These scheduled activities include: (1) Equipment Design and Development; (2) Acceptance Testing; (3) K West Basin Interface Activities; (4) Prepare and Issue Test Plan; (5) Perform Coating Measurement and Brushing Tests at K West Basin; (6) Clean Pit and Dispose of Equipment and Other Waste; and (7) Prepare and Issue Final Report.

Budget for this activity is implemented through SNF-BCR-98-006 (Bergman 1998). The original budget is \$475,000. Currently being assessed are the (1) impacts of elimination of two testing concepts (see Section 2.0), and the increased complexity and costs of equipment that was developed and (2) the impact of having to clean old debris and do detailed modifications to the K West Basin Dummy Elevator Pit [\$90,000 increase in work scope, see SNF-DN-98-051, (Omberg 1998)].

11.0 REPORTS

An evaluation report, describing the results of the Fuel Coating Measurement and Removal Testing activity, will be issued. This evaluation report will include detailed descriptions of the brushes tested along with the test parameter values, photographs presenting before and after appearances of the fuel elements subjected to brush testing, and coating thickness measurements before and after brushing (including eddy current probe calibration checks). Assessments of the relative effectiveness of the various brush designs, methods, and test parameters will be provided. Since the coating thickness measurements are considered OCRWM-related data, the evaluation report and any data reports will be written in accordance to AP 6-015, Rev. 0, *Control of OCRWM Scientific Investigation Work*.

12.0 DATA SHEETS AND RECORD KEEPING

A record of the in-field testing of the Fuel Coating Measurement and Fuel Coating Removal Testing equipment will be kept in a logbook. Prepared data sheets will be used to record coating thickness measurements and calibration checks. All pertinent activities will be recorded on video tape with date and time superimposed to allow correlation with hand-recorded data and observations. Examples of typical test data sheets for the Eddy Current Coating Measurement and Brushing Tests are shown in Figures 5 and 6, respectively. The brushes will be uniquely numbered, permitting the data sheets to be directly related to the brush parameters. Logs of the tapes and observations will be kept in the logbook. At the conclusion of this activity, all original test data, logbooks, etc. will be placed in the SNF Project Files, in accordance with AP 6-015, Rev. 0, *Control of OCRWM Scientific Investigation Work*.

Element	Value
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
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Figure 5. Example of Eddy Current Coating Measurement Test Data Sheet.

[illegible]

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A P P E N D I X A

**FUNCTIONS AND REQUIREMENTS FOR FEATURE TESTING REMOVAL METHODS
FOR ADHERENT COATINGS ON K WEST BASIN FUEL ELEMENTS**

(Includes washing machine mockup and ultrasonic cleaning
methods that were later canceled.)

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APPENDIX A

FUNCTIONS AND REQUIREMENTS FOR FEATURE TESTING REMOVAL METHODS FOR ADHERENT COATINGS ON K WEST BASIN FUEL ELEMENTS

GENERAL: INTERFACE WITH K WEST BASIN SYSTEMS AND OVERALL PERFORMANCE

Function

- The primary function of this work is to identify and demonstrate, on a feature test scale, if viable methods can be developed to
 - (1) remove the adherent coatings of concern, $Al(OH)_3$, and
 - (2) confirm this removal. In addition, on a best effort basis, all concepts should consider the ultimate application of the successful features or methods tested to SNFP fuel retrieval equipment design.

Requirements

The equipment (i.e., Fuel Element Brush Assemblies, Fuel Washing Machine Mockup, Ultrasonic Cleaning Device, and Fuel Coating Measurement Device) shall be designed to satisfy the following general requirements as appropriate:

- Interface with 105-K West Dummy Elevator Pit physical constraints, utilities, hoists, etc.
- Interface with existing Fuel Handling tools at K Basins.
- Comply with existing K Basins Fuel Handling restrictions (e.g., minimum 8 ft water between fuel and pool surface, decapping restrictions, etc.) and SAR (or modify SAR within the constraints of time allotted for this activity).
- Operate in a radiation field of 1000 R/hr with a minimum lifetime exposure of 500,000 R.
- Operation shall consider ease of use by K Basin staff and ALARA.
- Materials shall be compatible with the N Reactor fuel elements and the K Basins environment.
- On a best effort basis collect coating material removed that sinks to floor area or that is captured in washing machine concepts. Material should be collected into containers for later shipment to support testing for the sludge pretreatment subproject (i.e., use clean SFEC, remnant can, etc.). The option to provide small samples of material for near-term laboratory analyses will also be evaluated.
- All equipment designs shall be able to accommodate moderately damaged fuel elements with open breaches typical of those found in the K West Basin storage canisters.

- Designs shall minimize ultimate wastes being handled both during operation and final disposal.
- Equipment shall be designed to support ease of removal at the completion of the project.
- Equipment will be removed by this project.

FUEL ELEMENT BRUSH ASSEMBLY EQUIPMENT

Function

- Demonstrate the removal of subject adherent coatings on outer fuel elements stored in K West Basin using a mechanical brushing technique.

Requirements

The equipment shall:

- Handle one outer fuel element at-a-time, cleaning the outside surface (options: add cleaning the outer surface of the inner fuel element, and/or the inner surfaces of both elements).
- Be developed starting with the Fuel Element Brush Assembly design previously tested in the basins and modify this to include the parameters of bristle type (stiffness), material (include materials other than stainless steel), brush-element interference (include potential to vary applied force, rpm, etc.), bristle density, and fixed versus rotary concepts.
- Have sufficient lifetime to provide for each brush concept having at least 10 cleaning cycles (i.e., cleaning surfaces of 10 elements).

FUEL WASHING MACHINE MOCKUP

Function

- Simulate the process motion of the currently designed Primary Cleaning Machine (i.e., rotate axially at 4 rpm for 20 minutes with 4-inch drop of element(s) each half-rotation).

Requirements

The equipment shall:

- Accommodate up to seven N Reactor Fuel Assemblies from K West Basin storage canisters.
- Option: include simulation of a water jet with 20 gpm flow at 225 psi if practical.

- Option: include a suction flow of 80 gpm.
- Have sufficient lifetime to provide for at least 35 cleaning cycles (cleaning 35 loads of elements).
- On a best effort basis: provide for observation (video) from outside of the internal cleaning action.

ULTRASONIC AND OTHER INNOVATIVE CLEANING DEVICES

Function

- Demonstrate the removal of subject adherent coatings from outer fuel elements stored in K West Basin using ultrasound or other innovative methods (e.g., vibro abrasives, etc.).

Requirements

The equipment shall:

- Handle 1 to 7 outer fuel element at-a-time cleaning the outside surface (option: add cleaning the outer fuel element inside surface and inner element surfaces as well).
- Option: simulate water jet to assess its effectiveness in removing the coatings.
- Have sufficient lifetime to provide for at least 20 cleaning cycles (cleaning 20 loads of elements).
- On a best effort basis: provide for observation (video) from outside of the internal cleaning action.

COATING MEASUREMENT DEVICES

Function

- Measure subject adherent coating thickness (or surface area) on the outside (and inside) surface(s) of fuel elements in K West Basin before and after attempts to remove coatings.

Requirements

The equipment shall:

- Equipment must be sized to fit in Dummy Elevator Pit at K West Basin at the same time any of the coating removal equipment concepts are also in-place, this to allow monitoring of the success of the removal method.

- Have the capability to do one or both of the following (consistent with Appendix E):

Measure coating thickness from 0.001 in. to 0.010 in. with an accuracy of 0.0005 in., while the geometric location of the measurement on the surface of the fuel element is measured within 0.2 in. either by direct readout or combined mechanical observation with video equipment.

Measure coatings on a "go-no-go" basis (i.e., reliably detecting the presence or absence of the subject adherent coating) over the surface of fuel elements (e.g., proven visual observation method).

- Be designed to operate in K West Basin environment for a minimum lifetime of 2 months.
- On a best effort basis provide data to assist in analyses being made to develop estimates of the bounding inventory of $\text{Al}(\text{OH})_3$ in K West Basin.

A P P E N D I X B

EDDY CURRENT THICKNESS MEASUREMENT PROBE SCHEMATICS

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O.D. PROBE ASSEMBLY
SIDE VIEW

O.D. PROBE ASSEMBLY
FRONT VIEW

CONCEPT SKETCH ONLY	
FUEL ELEMENT O.D. OXIDE PROBE	
DESIGN NUMBER	RAY
DESIGNER	4567-1-A, 4567-2-A
C. LOUD	SHEET 1 OF 1

ZETEC

NOT DRAWN TO SCALE
L DIMENSIONS IN INCHES

I.D. PROBE ASSEMBLY
FRONT VIEW

CONCEPT SKETCH ONLY			
FUEL ELEMENT I.D. OXIDE PROBE			
DESIGN NUMBER 4568-1-A		REV	
DESIGNER	C. LOUD	SHEET 1 OF 1	
NOT DRAWN TO SCALE ALL DIMENSIONS IN INCHES			

ZETEC

A P P E N D I X C

ACCEPTANCE TEST TRAVELER

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TEST TRAVELER		Page <u>1</u> of <u>4</u>	Number		
Job Description: ACCEPTANCE TEST FOR FUEL ELEMENT BRUSHING DEVICE		Work Order No. E57645	Prepared by:		
Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamp	Date	Notes
1.0	Pre-operational Checkout		Q <u>NA</u> T _____ N <u>NA</u> E _____ O _____		
1.1	Stamp or write "TEST CONTROL COPY" on entire test traveler and attachments.		Q <u>NA</u> T _____ N <u>NA</u> E _____ O _____		
1.2	Conduct the "pre-job briefing" of operations, including a review of all procedures, drawings, and other engineering documents required to complete the test.		Q <u>NA</u> T _____ N <u>NA</u> E _____ O _____		
1.3	Verify that the performance criteria is included as Attachment 1 of this traveler.		Q _____ T _____ N <u>NA</u> E _____ O _____		

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

TEST TRAVELER (Continuation Sheet)

Page 2 of 4

Number

Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamped	Date	Notes
2.0	Calibration Checks: Verify that all instruments and equipment have current calibration stickers.		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		
3.0	Issue and verify the equipment list (Attachment 2).		Q <u>NA</u> _____ T _____ N <u>NA</u> _____ E _____ O _____		
4.0	Complete and verify the test layout/schematic (Attachment 3).		Q <u>NA</u> _____ T _____ N <u>NA</u> _____ E _____ O _____		
5.0	Set up the test equipment per the test layout/schematic. This includes installing the dummy fuel element on the device.		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

TEST TRAVELER (Continuation Sheet)

Page 3 of 4

Number

Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamp	Date	Notes
6.0	Perform brush test(s)				
6.1	Install brush on device. Perform initial test (Attachment 1, Part 1). Perform interface test (Attachment 1, Part 2).		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		
6.2	Position brush and dummy fuel element for proper interference. Energize brushing device to initiate coating removal test (Attachment 1, Part 3). (Record observations in logbook: motor power, speed, etc.)		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		
6.3	Upon completion of observations, de-energize brushing device at the direction of the Test Cognizant Engineer. Move dummy fuel element away from brush. (Note any observations of brush condition, etc.)		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		
6.4	Move brush to a different axial location and repeat Steps 6.1 through 6.3.		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

TEST TRAVELER (Continuation Sheet)

Page 4 of 4

Number

Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamp	Date	Notes
7.0	Verify that all steps in this traveler have been completed.		<div>Q</div> <div>T</div> <div>N NA</div> <div>E</div> <div>O</div>		
List of Required Attachments: <ol style="list-style-type: none"> Performance Criteria Equipment List Test Layout/Schematic Optional Attachments: <ol style="list-style-type: none"> Acceptance Criteria for K West Basin Fuel Element Brushing Device. 					

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

ATTACHMENT 1

PERFORMANCE CRITERIA FOR FUEL ELEMENT BRUSHING DEVICE

1. Demonstrate functional operation of the Fuel Element Brushing Device, including:
 - A. Full range of motion for the linear slides
 - Brush slide moves to top and bottom of dummy fuel element
 - Dummy fuel element slide moves approximately 7 in. between front and back stops
 - B. Ability to replace the brush
 - C. Installation/Removal of dummy fuel elements
 - D. Full range of operation of the motor (0 rpm to 700 rpm)
 - E. All electrical/electronic components operate as expected.
2. Demonstrate ability of the Fuel Element Brushing Device to interface adequately with the Eddy Current Probes.
3. Perform brushing tests on dummy fuel elements (inner and outer) to determine/verify calibration curves (motor power, etc. versus brush type/size).

ATTACHMENT 2

EQUIPMENT LIST FOR FUEL ELEMENT BRUSHING DEVICE

Fuel Element Brushing Device

Dummy Outer Fuel Element

Dummy Inner Fuel Element

Underwater Video Camera with VCR

Logbook/Data Sheets

ATTACHMENT 3

LAYOUT SCHEMATIC FOR FUEL ELEMENT BRUSHING DEVICE

TEST TRAVELER

Page 1 of 4

Number

Job Description: ACCEPTANCE TEST FOR EDDY CURRENT PROBES

Work Order No. E57645

Prepared by:

Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamps	Date	Notes
1.0	Pre-operational Checkout		Q <u>NA</u> T _____ N <u>NA</u> E _____ O _____		
1.1	Stamp or write "TEST CONTROL COPY" on entire test traveler and attachments.		Q <u>NA</u> T _____ N <u>NA</u> E _____ O _____		
1.2	Conduct the "pre-job briefing" of operations, including a review of all procedures, drawings, and other engineering documents required to complete the test.		Q <u>NA</u> T _____ N <u>NA</u> E _____ O _____		
1.3	Verify that the performance criteria is included as Attachment 1 of this traveler.		Q _____ T _____ N <u>NA</u> E _____ O _____		

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

TEST TRAVELER (Continuation Sheet)		Page <u>2</u> of <u>4</u>	Number		
Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamps	Date	Notes
2.0	Calibration Checks: Verify that all instruments and equipment have current calibration stickers.		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		
3.0	Issue and verify the equipment list (Attachment 2).		Q <u>NA</u> _____ T _____ N <u>NA</u> _____ E _____ O _____		
4.0	Complete and verify the test layout/schematic (Attachment 3).		Q <u>NA</u> _____ T _____ N <u>NA</u> _____ E _____ O _____		
5.0	Set up the test equipment per the test layout/schematic.				

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

TEST TRAVELER (Continuation Sheet)

Page 3 of 4

Number

Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamp	Date	Notes
6.0	Perform Eddy Current Probe Test(s) (Attachment 1).				
6.1	Position Eddy Current Probe on Calibration Standard. Activate Eddy Current Probe, initiating the test, per instruction from Test Cognizant Engineer. Record observations on data sheets.		Q _____ T _____ N NA _____ E _____ O _____		
6.2	Move Eddy Current Probe to another axial location on the Calibration Standard, activate the probe, and record observations. Repeat this step until directed to stop by Test Cognizant Engineer.		Q _____ T _____ N NA _____ E _____ O _____		
6.3	Repeat Step 6.1 and 6.2 for other Eddy Current Probes and Calibration Standards.		Q _____ T _____ N NA _____ E _____ O _____		

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

TEST TRAVELER (Continuation Sheet)		Page <u>4</u> of <u>4</u>	Number		
Operation Number	Test Instruction	Ref., Dwg., Proc. Spec.	Completion Sign/Stamps	Date	Notes
7.0	Verify that all steps in this traveler have been completed.		Q _____ T _____ N <u>NA</u> _____ E _____ O _____		
List of Required Attachments:					
1. Performance Criteria 2. Equipment List 3. Test Layout/Schematic					

Q = QC Inspector, T = Technician, N = NDE Inspector, E = Engineer, and O = Other

ATTACHMENT 1

PERFORMANCE CRITERIA FOR EDDY CURRENT THICKNESS
MEASUREMENT PROBES ACCEPTANCE TEST

1. Demonstrate capability for proper placement of eddy current probes in/on calibration standards simulating inner and outer fuel elements.
2. Establish proper setup of eddy current analyzer (MIZ-40) to obtain meaningful measurement signals.
3. Confirm measurement accuracy of 0.0005 in. for various shim thicknesses on calibration standards for each of the eddy current probes.
 - A. Generate a calibration curve for each probe.
 - B. Place the probe against a blindly chosen shim (i.e., the person reading the probe signal does not know which shim is chosen).
 - C. The person reading the eddy current analyzer determines the thickness by:
 - Determining the proper eddy current signal
 - Reading the shim thickness from the calibration curves.

ATTACHMENT 2

EQUIPMENT LIST FOR EDDY CURRENT PROBES ACCEPTANCE TEST

Outer element calibration standard

Inner element calibration standard

Reference assembly block

Underwater camera and VCR

MIZ-40 analyzer

Outer element outer surface measurement probe and cable

Outer element inner surface measurement probe and cable

Inner element outer surface measurement probe and cable

Reference assembly measurement probe and cable

Handling rods for measurement probes

Logbook/data sheets

ATTACHMENT 3
LAYOUT SCHEMATIC FOR EDDY CURRENT PROBES ACCEPTANCE TEST

A P P E N D I X D

FUEL ELEMENT BRUSHING DEVICE SCHEMATIC

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A P P E N D I X E

**DETAILS OF IN-BASIN TESTING OF MEASUREMENT AND REMOVAL
TECHNIQUES FOR ALUMINUM HYDROXIDE COATINGS**

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APPENDIX E

DETAILS OF IN-BASIN TESTING OF MEASUREMENT AND REMOVAL
TECHNIQUES FOR ALUMINUM HYDROXIDE COATINGS

E.1 GAUGING REMOVAL EFFECTIVENESS

The effectiveness of the coating removal will be judged in two ways: visually and by eddy current. The presence of a relatively thick (e.g., 60 μm) $\text{Al}(\text{OH})_3$ coating can be detected visually from a milky translucent appearance of the element. A scratch test can confirm this presence (with a white scratch indicating the presence of coating). It is also expected that the nearly complete removal of the coating will reveal the original (i.e., normal) autoclaved black zirconium finish. High resolution under water video cameras will be used to observe and record these conditions during the testing in K West Basin.

An eddy current technique for coating thickness measurement will be utilized. It is expected, that before and after cleaning activities, an eddy current apparatus would furnish a coating thickness profile along the length of a fuel element. The eddy current probe could be held by a tool for discrete individual thickness measurements or be mounted on a traversing apparatus (such as the brush stand) to give a relatively continuous profile. Again high resolution video cameras under water will confirm positioning of the probe and the thickness mapping.

E.2 CHOICE OF FUEL ELEMENTS TO TEST

Elements with the appropriate coating have been identified through review of existing video tapes of K West Basin elements. These tapes were made during the "lift and look" campaign (Pitner 1997) where selected canisters were opened and the elements extracted for full length visual examination. The elements selected exhibit the thickest examples of the coating found and were chosen to have similar amounts of coating in order to facilitate valid comparison between coating removal methods.

Table E1 lists those canisters that are known to contain examples of the thick translucent coating. Of the four canisters, 0315 apparently has the thinnest coating. Canister 0161 is the source of laboratory coating samples positively identified as $\text{Al}(\text{OH})_3$. These four canisters contain enough elements to perform the anticipated tests. Testing will involve elements from all four canisters to judge the general applicability of the results. Both inner and outer elements will be brushed. Badly damaged elements will not be utilized. Since not all elements within a canister are well characterized and damage may have occurred during previous handling, undamaged elements are preferred but those with slight to moderate end cap damage may be utilized.

Table E1. Mark I Aluminum Canisters Containing Known Examples of Aluminum Hydroxide Coating.

Canister Barrel	Element Type	Number of Elements and Condition*
0315M	Inners Outers	6A, 1B 5A, 2B
0315U	Inners Outers	6A, 1B 4A, 3B
0161M	Inners Outers	7A 1A, 2B, 3C, one shipped**
0161U	Inners Outers	7A 4A, 2B, 1C
1860M	Inners Outers	7A 4A, 2B, 1C
1860U	Inners Outers	3A, 1B, 2C, one not examined 3A, 1C, 3 not examined
0309M	Inners Outers	5A, 1C, one not examined 3A, 3 not examined, one shipped**
0309U	Inners Outers	7A 4A, 2B, 1C
Total	Inners Outers	48A, 3B, 3C, 2 not examined 28A, 13B, 7C, 6 not examined, two shipped**

*A = Good condition, no significant damage.

B = Some damage, but should hold together.

C = Serious damaged, further breakup likely.

**For examination in hot cell.

Specific elements for testing within a given canister will be chosen by the cognizant engineer during the actual in-basin campaign. Short elements (<20 in. axial length) will be avoided in order to maximize the usable length per element.

Since it is not certain that the four canisters (eight barrels) discussed above contain the most challenging coatings for removal, three additional canisters (six barrels) will be chosen at random from among K West Basin aluminum canisters containing fuel encapsulated in the early 1980's. Whatever cleaning parameters are judged most effective (from work with the above four canisters) will be used to clean at least two fuel element assemblies from each of the three newly chosen canisters and appropriate coating thickness measurements will be performed.

E.3 TESTING STRATEGY

As indicated in the main text, the primary objective of eddy current testing is to provide a defensible distribution for $Al(OH)_3$ thickness and the primary objective of the Fuel Element Brush Assembly is to determine the effect of brushing parameters on the removal of the $Al(OH)_3$ coating on the actual fuel elements. These brushing parameters include: (1) brush type (variable material, wire size, configuration, etc.); (2) brush velocity (a function of rpm and wheel size); (3) brush-fuel interference (force); and (4) time. The Fuel Element Brush Assembly will use the following operating steps: (1) the fuel element is positioned in a fixture and clamped in place (measurement of coating thickness, would occur at this time); (2) the brush is moved axially to the fuel element location where brushing is to occur; (3) the fuel element is moved laterally until it is against the brush, with the desired interference and/or force; (4) the brush motor is turned on at the desired velocity; (4) information on the brushing performance is recorded (motor power, etc.); (5) upon completion of the brushing action, the brush is turned off; (6) the fuel element is retracted from contact with the brush; (7) Steps 2 through 6 are repeated at various axial and circumferential locations; and (8) upon completion of all brushing, the fuel element is inspected, the coating thickness is measured and the element is returned to its canister. Using the manual fuel handling tools to rotate the fuel element in the fixture will allow two or more sets of brushing tests on the same fuel element. Note, Steps 3 and 4 may be reversed based on cold testing results. Also, measurement (Step 8) may need to be performed independently after each cleaning operation if one brush pass alters data from a previous adjoining area.

It is the intent to be as prototypic as possible of the general K Basin fuel conditions; brushing will be made in the K Basin 20 foot deep pool with fuel elements as they come from the canisters (i.e., not exposed to air, etc.). The brush will be powered by a submersible motor (approximately 1.5 HP). Positioning of the brush and fuel element will be accomplished by using linear slides. These slides will be operated from the K Basin operations deck (grating) with removable extensions. The motor will be remotely controlled from the operations deck.

Two or more sides of each element will be utilized for complementary tests. All operations will be video taped. All elements will be inspected visually (including scratch tests) and via eddy current before and after brushing. Since fuel element clips are often axially mounted in staggered fashion, the circumferential locations offering the most continuous axial brush traverse (i.e., those areas with clips mounted closest to the element ends) will be utilized (see Figure E1). Care must also be exercised to avoid the point where the element is clamped near its midsection and the bottom end restraining cap. The eddy current tester is a device which is about 3 in. in axial dimension with an actual spring-loaded measuring head of approximately 0.090 in. in diameter. To facilitate positioning of this thickness measuring device in brushed areas of cladding, the areas of coating removal should be at least 1 in. wide (preferably by using a brush with a minimum 1 in. face). The eddy current testing device must subtend an arc of less than 180 degrees when resting on the fuel element in order to avoid interfering with fuel element clips mounted 90 degrees to the brushed locations. It is possible that very thick and or very rough $\text{Al}(\text{OH})_3$ deposits may make initial eddy current thickness measurements inaccurate but this will not affect measurements of the residual after brushing. Approximately a 0.5 in. strip will be left unaltered between each brushed strip assuming adjacent regions are not affected by the brushing (i.e., regions of coating dislodge as major flakes). This should allow five brush contacts (with five before and after thickness measurements) per element side (ten maximum per element if two sides are cleaned). The apparatus force-deflection characteristics will be determined prior to testing so that machine deflections can be taken into account when evaluating data.

Table E2 outlines the specific brushing tests to be performed for the first canister opened. The selection of brushes was based on a survey of commercially available brushes leading to the selection of a range of brush types. At a minimum, all of the parameters in Table E2 must be recorded for each brush contact along with any data on motor torque, contact force, and the accumulated time of brushing. Wire wheel brushes will be calibrated to determine their force/deflection characteristics prior to in-basin testing. Carbon steel brushes are common and strong, while stainless steel brushes minimize transfer of rust from brush to element. An abrasive flap wheel or carbide impregnated brush may rapidly remove material. Brass brushes may be a softer alternative. If 12 brush contacts are performed then three velocities, two interferences, and two times with one brush material could be tested on a single element. Brushes at least 6 in. to 10 in. in diameter are required for proper equipment configuration. Only the most promising (but at least two) combinations of parameters would be carried forward to the testing of elements from subsequent canisters. Since the first canister addressed must have the largest number of relatively undamaged elements for testing, Table E1 should guide the choice of initial canisters to test. The accumulated time of brushing for a given set of brush type, rpm and interference will be chosen based on cold testing and in-basin experience at long times. Stiffer brushes have the potential to damage the cladding which is a situation to be avoided.

Figure E1. Brushing Locations for a Mark IV Outer Element.

RG98050015.5a

Table E2. Parameters for Brushing Aluminum Hydroxide-Coated Fuel Elements from First K West Canister.

Assembly Number	Inner/Outer Element	Brush Material	Brush*/Element Interference	Wire Size (in.)	rpm**
1	O	Carbon steel	Light and heavy	0.006	400, 550, 700
1	I	Carbon steel	Light and heavy	0.006	400, 550, 700
2	O	Stainless steel	Light and heavy	0.006	400, 550, 700
2	I	Stainless steel	Light and heavy	0.006	400, 550, 700
3	O	Abrasive filament or flap wheel	Light and heavy	N/A	400, 700
3	I	Abrasive filament or flap wheel	Light and heavy	N/A	400, 700
4	O	Carbon steel	Light and heavy	0.012	400, 550, 700
4	I	Carbon steel	Light and heavy	0.012	400, 550, 700
5	O	Stainless steel	Light and heavy	0.012	400, 550, 700
5	I	Stainless steel	Light and heavy	0.012	400, 550, 700
6	O	Brass	Light and heavy	0.01	400, 550, 700
6	I	Brass	Light and heavy	0.01	400, 550, 700
7	O	Brass	Light and heavy	0.02	400, 550, 700
7	I	Brass	Light and heavy	0.02	400, 550, 700

*A knot-twist brush and larger wire diameter brushes will be held in reserve if other techniques do not give satisfactory results.

**Probably in combination with a 6 in. to 8 in. diameter brush (brushes will be applied for at least two different lengths of time). The rpm range is dependent on the hydraulic characteristic of individual brushes and, hence, are brush dependent.

The SNF Characterization Project engineer for the brushing test effort will choose and document those parameters carried forward after the first canister. A general constraint is the period of time allotted to the testing which is approximately 2 weeks (single shift).

It is intended to perform the whole series of eddy current and brushing tests with corresponding resulting data indicated in Table E2, even if initial brushing attempts are successful. The resulting data will be evaluated and documented to provide a design basis for the development of an $\text{Al}(\text{OH})_3$ thickness distribution in the basin and of a brushing machine that will handle large volumes of elements if required by the MCO processing.

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SAFETY DOCUMENTATION

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