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5 Proj /Prog /Dept /Div
Pj Metal Stabilization

6 Design Authority/Design Agent/Cog Engr
S Hurlbut

8 Originator Remarks
The location assessment for installing Supercritical Fluid Extraction (SFE) Instrumentation is contained in this document

11 Receiver Remarks

11A Design Baseline Document? ☐ Yes ☒ No

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(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	HNF-5497		0	Location Assessment for the Supercritical Fluid Extraction Instrumentation	NA	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

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21 DOE APPROVAL (if required)
Ctrl No _____
☐ Approved
☐ Approved w/comments
☐ Disapproved w/comments

Location Assessment for the Supercritical Fluid Extraction Instrumentation

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U S Department of Energy Contract DE AC06 96RL13200

EDT/ECN EDT 702568

UC

Org Code 15100

Charge Code 110847

B&R Code

Total Pages 19

Key Words

PFP, Supercritical Fluid Extraction, Plutonium, SFE

Abstract

This plan provides a location assessment for the installation of Supercritical Fluid Extraction Instrumentation to be used to measure the moisture content of stabilized Polutonium compounds

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HNF-5497

**LOCATION ASSESSMENT FOR THE SUPERCRITICAL
FLUID EXTRACTION INSTRUMENTATION**

Revision 0, December 17, 1999

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EXECUTIVE SUMMARY

An evaluation was performed to assess potential glovebox locations in the Plutonium Finishing Plant (PFP) 234-5Z Building, Analytical Laboratory or operating areas for the installation of a Supercritical Fluid Extraction (SFE) system and its supporting equipment. This evaluation considered using existing gloveboxes along with an alternative of adding a new glovebox to existing process lines. The location evaluation criteria included glovebox size, relative cost, and schedule impacts associated with system implementation, radiological control, and interaction with other laboratory operations and processes. In addition, the possible colocation of a Thermo-gravimetric Analyzer (TGA) furnace system with the SFE system was considered. This would enable thermally stabilized material to be analyzed for residual moisture by either the TGA system or SFE system or both.

An initial screening was made of potential gloveboxes based on glovebox sizes needed to accommodate the SFE equipment with added clearances, and based on other process area concerns. Selected gloveboxes from this initial screening were evaluated in a relative manner based on evaluation criteria with scoring of the various gloveboxes on a scale of 1 to 10 for each of the generalized set of criteria. Each of the criteria scores were weighted by multiplying by a weight factor assigned to each criteria to account for the differences in importances or priorities between criteria. A total weighted score for each selected glovebox option was determined based on summing the individual criteria weighted scores.

The results showed that a new glovebox FA-30341, available from the Fuels and Materials Examination Facility (FMEF) fuel pellet sintering line, located in Room 235C, mated to conveyor HA-28 provides the best alternative solution. Advantages of using this glovebox include colocation of the SFE+TGA equipment and its uncontaminated state which facilitates equipment installation and testing outside of process areas. Once testing is complete, the new glovebox can be mated in modular fashion to the existing HA-28 line conveyor systems in room 235C to receive material samples directly, consistent with maintaining a streamlined material process flow. The relative costs and schedule impacts of certifying this new glovebox and installing at PFP were evaluated and found to be significantly less compared to preparing an existing glovebox to receive the SFE or SFE+TGA equipment. Future detailed cost and schedule analyses can verify this aspect.

Other FMEF gloveboxes and the existing Glovebox GB-136 would accommodate the SFE equipment but not colocated with the TGA equipment. Glovebox GB-136 also has the distinct disadvantage of requiring substantial sample movement off of the main process line, with its increased contamination risk, and requires demolition and removal of existing equipment to accommodate the SFE system. Again, using a new glovebox is recommended for the SFE equipment compared to using an existing glovebox.

Recent discussions concerning pending productivity improvements to the thermal stabilization process flow may limit the ability to make a final decision on the configuration of the SFE installation. However, the procurement of the SFE equipment, or design of the installation within the glovebox should be able to proceed while these issues are settled. Should the final

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location remain undecided, the SFE glovebox could be temporarily located in Room 235C until a final layout of the process line has been approved. This will enable the plant to take advantage of most of the process improvements associated with the SFE system while providing the least disruption to future modifications on the process line.

1 INTRODUCTION

1.1 BACKGROUND

Plutonium oxide material that is thermally stabilized at the PFP for long term storage is required to meet certain criteria before storage. One criterion is the amount of moisture present in the stabilized material. The amount of residual moisture is important because excess moisture can undergo radiolysis while in storage, generating hydrogen gas that would generate higher internal pressure in the storage container, that may lead to container rupture. This potential loss of containment is precluded by reducing the residual moisture to less than 0.5 mass %.

The current Department of Energy (DOE) standard method involves material thermal stabilization by calcination at 950°C. Thermal stabilization is verified by a Loss on Ignition (LOI) test, where the weight loss following calcination to 1000°C (e.g., using a TGA furnace system) is determined. A weight loss in excess of 0.5 mass % requires that the material be re-calcined. Unfortunately, LOI does not discriminate between the various volatilized components, including inorganic salts. A significant amount of plutonium oxide destined for storage is impure, containing large amounts of inorganic salts. The SFE process has been recommended for approval as an alternative method for moisture determination that can measure sample residual moisture without the interference from the other volatile impurities since it does not solubilize inorganic materials (LANL 1998, 1999).

2 SCOPE

The scope of this document is to evaluate glovebox locations in the PFP 234-5Z Building Analytical Laboratory or operating areas for the installation of the SFE system and its supporting equipment. This evaluation considers using existing gloveboxes along with an alternative of adding a new glovebox to existing process lines. The location evaluation criteria include glovebox size, relative cost and schedule impacts associated with system implementation, radiological control, and interaction with other laboratory operations and processes. In addition, the possible collocation of a TGA furnace system with the SFE system was considered. This would enable thermally stabilized material to be analyzed for residual moisture by either the TGA system or SFE system or both.

3 PROCESS DESCRIPTION AND ASSUMPTIONS

3 1 PROCESS DESCRIPTION

The SFE system permeates the material sample with a constant flow-rate of dry, supercritical carbon dioxide (CO₂). The CO₂ acts as a sweep gas, dissolving the sample residual water, and carrying the solubilized water to a detector. The amount of water dissolved in the CO₂ stream is measured using a high-pressure Fourier Transform Infrared (FTIR) cell. The response of the FTIR cell is compared to that obtained from an injection of a known amount of water or standard.

The SFE technique has been in routine commercial use for approximately 30 years. Major components are commercially available, and consist of the following:

- SFE extractor,
- FTIR controller,
- Restrictor,
- compressed CO₂ cylinder,
- syringe pump, and
- computer

All of the major components excluding the CO₂ cylinder, syringe pump, and computer, would be located inside a glovebox as shown in Figure 1. Therefore, the glovebox needs to have feed-through ports for the CO₂ gas feed and an RS 232 data transfer cable linking the FTIR to the computer. Glovebox seal-in ports or an open front box will be required to transfer materials and samples into the glovebox. Inclusion of the TGA furnace within the same glovebox would also require offgas processing consistent with current PFP systems.

3 2 ASSUMPTIONS/ REQUIREMENTS

The following are assumptions / requirements that were applied in the location evaluation:

- a One SFE setup will be required
- b Colocation of a TGA system with the SFE system will be considered and is preferred (See Section 5.3)
- c Location of the SFE equipment in the 234-5Z Building Analytical Laboratory or operating spaces would not impact or interrupt the routines in the laboratory (note that the use of personnel protective equipment (PPE) several times during the day to support the SFE or SFE+TGA system is considered normal for the analytical laboratory, and wouldn't introduce an additional burden)

- d Direct access to the samples from the glovebox via existing process conveyor lines is preferred versus separate operation that requires material seal-in/out or transfer, and will be scored higher
- e Maintaining as low as reasonably achievable (ALARA) radiation dose rates for laboratory and operations personnel using the SFE or SFE+TGA systems will be considered in the location evaluation
- f Schedule impacts associated with SFE or SFE+TGA system implementation will be considered in the location evaluation
- g Glove access to all equipment within the glovebox is required
- h Ease of installation and relative cost and schedule impacts for SFE or SFE+TGA system implementation will be considered in the location evaluation
- i Dimensions of the glovebox must accommodate the equipment and enable personnel to operate and maintain the SFE or SFE+TGA system
- j Safeguards and security (S&S) requirements for plutonium process operations will be satisfied similarly for any glovebox considered (existing or new) by the location in the 234-5Z Building Analytical Laboratory or operating spaces
- k Criticality safety will be satisfied similarly for any glovebox considered (existing or new) since the SFE or SFE+TGA system, will be the only process equipment in the glovebox
- l Existing gloveboxes that may accommodate the SFE or SFE+TGA system will have existing miscellaneous equipment demolished and removed – applicable cost and schedule impacts will be noted for these gloveboxes (see Table 4)
- m Seismic analysis will be satisfied similarly for any glovebox considered (existing or new) to accommodate the SFE or SFE+TGA system - applicable cost and schedule impacts will be noted for those gloveboxes requiring new seismic analysis
- n Fire suppression requirements will be satisfied similarly for any glovebox considered (existing or new) to accommodate the SFE or SFE+TGA system – applicable cost and schedule impacts will be noted for those gloveboxes requiring installation (or removal) of fire suppression systems
- o Process interactions will be considered in the location evaluation (e g , nearby high radiation areas, congestion of processes, streamline of process flow, etc)
- p Available, uncontaminated gloveboxes considered for addition to existing process lines or operating areas will meet certification requirements – applicable cost and schedule impacts will be noted for such certification, along with applicable modifications to meet requirements for use in material stabilization processing (e g , glove specifications, seal quality, window quality, etc)
- q Design and procurement activities associated with fabrication of a new glovebox versus using an available, new uncontaminated glovebox from other facilities at the Hanford site would be prohibitive in terms of cost and schedule impacts (see Table 4)
- r Location evaluation will consider the gloveboxes existing on the Remote Mechanical C (RMC) line in rooms 228A,B,C, and separate gloveboxes located in rooms 136 and 157 (note that Glovebox HA-23S in room 235C will not be considered due to its future potential use as a material feed lag storage and staging area, glovebox in room 154 was not considered due to higher priority use identified for that glovebox, glovebox HC-9B will not be considered due to extra floors splitting glovebox)

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- s Location of a new glovebox will consider room 235C only (note that movement through double doors with 7'H x 6'W dimensions will allow glovebox transfer into room 235C), room 230C will not be considered due to congestion with other process operations
- t The SFE or SFE+TGA system will be located away from other processes or areas with high contact dose rates to reduce personnel dose (ALARA), note that the RMA line gloveboxes will not be considered in the location evaluation due to existing high radiation levels in this area
- u Installation and testing of the SFE or SFE+TGA system within an available uncontaminated glovebox is preferred and will be scored higher
- v The SFE or SFE+TGA system design will allow disassembly for transfer into the glovebox using available 24 in seal-in ports
- w The cost of connecting lines from the CO₂ cylinder, computer linking, electrical sources, and offgas (to existing process vacuum) to the equipment to be located inside the glovebox will be similar for all the identified gloveboxes
- x Clearance requirements around the SFE system equipment will consist of the dimensions as shown in Figures 2 and 3 for the SFE and TGA equipment, respectively The resulting dimensional envelope for the SFE system is approximately 68in W x 32in D x 12in H (W=width, D=depth, and H=height), 47in W x 45in D x 30in H for the TGA system, and 110in W x 45in D x 30in H for the combined SFE+TGA system The approximately 10 5in clearance above the TGA furnace allows for opening the lid while the 12in clearance in front of the furnace was considered adequate for staging the samples to be analyzed
- y New uncontaminated gloveboxes that exist on the FMEF pellet sintering line would be available for use at the PFP for less than approximately half the cost of fabrication of a new custom glovebox
- z Environmental requirements will be satisfied similarly for any glovebox considered (existing or new) to accommodate the SFE or SFE+TGA system, by system installation within the 234-5Z Building Analytical Laboratory in existing glovebox operating areas to enable using current environmental control equipment and processes (e g , control of air emissions via existing glovebox exhaust systems, contamination control via current plutonium material process and handling requirements, etc)

4 EVALUATION METHODOLOGY

An initial screening of gloveboxes was made based on glovebox sizes needed to accommodate the SFE equipment with clearances as shown in Figure 2, and based on other concerns reflected in Section 3 2, Assumptions r, s, and t Selected gloveboxes from this initial screening were then evaluated in a relative manner based on the assumptions and requirements provided in Section 3 2 The evaluation consisted of scoring the various gloveboxes on a scale of 1 to 10 for each of the generalized set of criteria that follows

- 1 Location
- 2 ALARA

- 3 Ease of Implementation
- 4 Colocation of SFE and TGA
- 5 Process Interaction
- 6 Relative Cost Impact
- 7 Relative Schedule Impact

Note that the cost and schedule impacts considered modifications to existing gloveboxes to accommodate the SFE or SFE+TGA system (e g , demolition and removal of equipment from glovebox), installation (or removal) of fire suppression systems as needed, criticality and seismic analyses as needed, glovebox certification process as needed, etc) Since there is no definitive cost or schedule analyses the scoring was done in a relative manner However, Table 4 provides rough order of magnitude (ROM) cost values for procurement of SFE system equipment, certification of a new glovebox available at the Hanford site, installation of an access panel on the existing RMC conveyor line similar to what may be needed to accommodate the SFE system with a new glovebox, and preparation of an existing glovebox to accommodate the SFE system (i e , demolition and removal of equipment from glovebox)

Each of the criteria scores were weighted by multiplying by a weight factor assigned to each criteria above as discussed in Section 5 2 A total weighted score for each selected glovebox option was determined based on summing the individual criteria weighted scores

5 EVALUATION

5 1 INITIAL SCREENING OF GLOVEBOXES

An initial screening of gloveboxes was made based on glovebox sizes needed to accommodate the SFE equipment with clearances as shown in Figure 2, and based on other concerns identified in Section 3 2, Assumptions r, s, and t The results of the initial screening are shown in Table 1 Only glovebox GB-136 and new gloveboxes available from other site sources added to room 235C will meet the size requirements of the SFE system Table 2 shows GB-136 and these other new gloveboxes that are available compared to the combined SFE+TGA system dimensional requirements Only one new glovebox meets the size requirements of the combined SFE+TGA system The colocation of the SFE+TGA system was included as an evaluation criterion based on the advantages discussed in Section 5 3

Table 1 Initial Screening of Gloveboxes Considered for Installation of SFE Equipment

Glovebox	Dimensions (in)			Location in 234 5Z	Remarks
	Width (W)	Depth (D)	Height (H)		
Required Size	68	32	12		
GB-136	120	38	31	Room 136	Meets SFE dimensions
GB-154	86	33	30	Room 154	Meets SFE dimensions, Not considered due to other planned uses (see Sec 3 2,r)
GB-157	36	30	32	Room 157	Undersized for SFE
HC-7C	96	36	10	Rm 228A	Undersized for SFE
HC-9B	88	36	125	Rm 228A	Meets SFE dimensions, Not considered due to extra floors splitting glovebox (see Sec 3 2 r)
HC-10	26	17	25	Rm 228A	Undersized for SFE
HC-11	86	28	27	Rm 228A	Undersized for SFE
HC 12S	31	26	41	Rm 228B	Undersized for SFE
HC-13MD	38	35	58	Rm 228B	Undersized for SFE
HC-15	100	29	72	Rm 228B	Undersized for SFE
HC-16CC	26	24	47	Rm 228B	Undersized for SFE
HC-17DC	46	26	53	Rm 228C	Undersized for SFE
HC 17P	34	26	53	Rm 228C	Undersized for SFE
HC-17SBB	67	21	34	Rm 228C	Undersized for SFE
HA-23S	144	47	68	Rm 235C	Meets SFE dimensions Not considered due to other planned uses (see Sec 3 2 r)
New (FA-30341)	110	50	48	Rm 230C	Meets SFE dimensions Not considered due to congestion with other processes in room (see Sec 3 2 s)
New (FA-30341)	110	50	48	Rm 235C	Meets SFE dimensions
New (FA 30350)	138	34	56	Rm 235C	Meets SFE dimensions
New (FA-30344)	104	52	66	Rm 235C	Meets SFE dimensions
New (FA-30340)	99	38	42	Rm 235C	Meets SFE dimensions

Table 2 Initial Screening of Gloveboxes Considered for Installation of SFE+TGA Equipment

Glovebox	Dimensions (in)			Location in 234 5Z	Remarks
	Width (W)	Depth (D)	Height (H)		
Required Size	110	45	30		
GB-136	120	38	31	Room 136	Undersized for SFE+TGA
New (FA-30341)	110	50	48	Rm 235C	Meets SFE+TGA dimensions
New (FA-30350)	138	34	56	Rm 235C	Undersized for SFE+TGA
New (FA-30344)	104	52	66	Rm 235C	Undersized for SFE+TGA
New (FA-30340)	99	38	42	Rm 235C	Undersized for SFE+TGA

5 2 CRITERIA WEIGHT FACTORS

Criteria weight factors were assigned to the generalized evaluation criteria provided in Section 4 to aid in prioritizing the importance of the criteria for locating the SFE or SFE+TGA system equipment. The weight factors are discussed below.

- 1 **Location – WF = 9** This criteria evaluates the location in terms of ease of accessibility, storage of samples, access to a conveyor system, impacts on the process, and proximity to other laboratory facilities. This factor is very highly weighted due to the importance in location to the overall flow of materials, operational flexibility, and the need to seal-in and seal-out samples in areas not adjacent to the product conveyors. The seal-in and seal-out process can require as much as two hours per evolution.
- 2 **ALARA – WF = 8** This factor reflects the radiation environment of the installed glovebox.
- 3 **Ease of Implementation – WF = 8** This factor reflects the relative effort required for implementing the SFE or SFE+TGA system in a particular glovebox arrangement.
- 4 **Colocation of SFE and TGA – WF = 7** This factor reflects the preferred option of colocation of a TGA system with the SFE system (see Section 5.3).
- 5 **Process Interaction – WF = 6** This factor reflects the interfaces of the selected glovebox with the rest of the process operations, ease of process flow, productivity, etc.
- 6 **Relative Cost Impact – WF = 5** This factor reflects the relative cost of the installation. The criteria includes items such as the degree of difficulty to complete the installation to accommodate the SFE or SFE+TGA system (e.g., demolition and removal of equipment from glovebox), installation of fire suppression systems as needed, criticality and seismic analyses as needed, glovebox certification process as needed, utilities availability, etc.).
- 7 **Relative Schedule Impact – WF = 5** This factor reflects the relative time required to install and commission the equipment in the location option. A definitive schedule analysis has not been done at this point. The criteria includes items such as time needed for modifications to existing gloveboxes to accommodate the SFE or SFE+TGA system (e.g., demolition and removal of equipment from glovebox), installation (or removal) of fire suppression systems as needed, criticality and seismic analyses as needed, glovebox certification process as needed, etc.).

5 3 SFE/TGA COLOCATION

The original analysis was completed based primarily upon the proposed SFE installation as a stand-alone project. Indeed, the SFE equipment will have the capacity to process all samples required by thermal stabilization to support production throughput. The SFE equipment is capable of completing the quantitative analysis of a sample in approximately one half hour. This would provide a maximum capability of 48 samples a day which is far in excess of the current five furnace production rate of 10 batches a day.

Notwithstanding this fact, the colocation of the TGA furnace provides advantages to the analytical laboratory in side by side comparison studies, and provides the redundancy needed in the event of a failure of the SFE or during periods of preventative maintenance of the SFE equipment.

As a result, those options having the capability to accommodate the TGA furnace were graded higher. The decision to actually purchase this equipment will be made at a later date.

5 4 EVALUATION RESULTS

Table 3 provides the individual criteria weighted scores and total weighted score for each glovebox option determined by the evaluation. As shown, the new available glovebox FA-30341 had a slightly higher weighted score versus the other new gloveboxes due to the advantage of colocation of the SFE+TGA equipment. Other advantages of using a new glovebox would be its uncontaminated state which facilitates equipment installation and testing outside of process areas. Once testing is complete, the new glovebox can be mated in modular fashion to the existing RMC line conveyor systems in room 235C to receive material samples directly, consistent with maintaining a streamlined material process flow.

Other FMEF gloveboxes and the existing Glovebox GB-136 would accommodate the SFE equipment but not collocated with the TGA equipment. Glovebox GB-136 also has the distinct disadvantage of requiring substantial sample movement off of the main process line and requires demolition and removal of existing equipment to accommodate the SFE system.

The installation of which FMEF glovebox or other available gloveboxes will be made after the location assessment recommendation has been approved. The clean gloveboxes used during this study are only a few of the gloveboxes that are available for this installation. The typical cost of installing any of these gloveboxes is similar and is shown in Table 4. A definitive estimate would be needed once project details are refined.

The rough order of magnitude (ROM) cost for installing a clean glovebox on the HA-28 conveyor line and commissioning of the SFE equipment is approximately \$325,000. The ROM cost for a contaminated glovebox would be approximately \$800,000.

5 5 OTHER EVALUATION CONSIDERATIONS

During the preparation of this location assessment, several discussions with plant operating groups indicate that there are several studies being prepared to modify the thermal stabilization process lines. These proposed modifications will improve the process flows and productivity of the process. At the same time, these studies result in modifications that directly impact the baseline criteria of this document.

The net result is that a final location for the SFE equipment should not be established until the results of the productivity improvements are known. However, this study is still valid for the following reasons:

- 1) The basic location for the SFE equipment within the current process lines provides many advantages. These advantages can be realized with or without completing the productivity modifications.
- 2) The discussions of using a clean glovebox versus a contaminated glovebox is not adversely effected by the productivity improvements.
- 3) Interim actions can be put in place which will enable the SFE installation schedule to be met independent of the productivity improvements.

6 REFERENCES

LANL, 1998, *A Novel Analytical Method for the Determination of Residual Moisture in Plutonium Dioxide - Supercritical Fluid Extraction/Fourier Transform Infrared Spectroscopy*, Los Alamos National Laboratory, Los Alamos, New Mexico

LANL, 1999, *A Comparative Study Of Methods For The Determination Of Residual Water In Impure Plutonium Oxides And Recommendation Of Method For Site Implementation*, LA-UR-99-3019, June 1999, Los Alamos National Laboratory, Los Alamos, New Mexico

Table 3 Evaluation of Selected Gloveboxes Against Criteria Using Weighted Scoring

Evaluation Criteria	1 Location		2 ALARA		3 Ease of Implemen- tation		4 Colocation of SFE & TGA		5 Process Interaction		6 Relative Cost Impact		7 Relative Schedule Impact		Total Weighted Score
Weight Factor (WF)		9		8		8		7		6		5		5	
	S	S*WF	S	S*WF	S	S*WF	S	S*WF	S	S*WF	S	S*WF	S	S*WF	S*WF
GB 136	5	45	10	80	5	40	4	28	7	42	6	30	5	25	290
New (FA-30341)	10	90	7	56	7	56	8	56	9	54	7	35	7	35	382
New (FA-30350)	10	90	7	56	7	56	4	28	9	54	7	35	7	35	354
New (FA-30344)	10	90	7	56	7	56	4	28	9	54	7	35	7	35	354
New (FA-30340)	10	90	7	56	7	56	4	28	9	54	7	35	7	35	354

S = Score (Scale of 1 – 10)

WF = Weight Factor (Scale of 1 – 10)

S*WF = Score * Weight Factor

Table 4 ROM Costs for Potential Major Equipment/Work Activities Associated with SFE System Location

Item	ROM Cost (\$)	Basis
SFE Equipment includes		
1) Extractor + Syringe Pump + Pump Controller	60 000	LANL Report LA UR 99 3019, pp 21
2) Restrictor (coaxially heated) + Restrictor Controller		Quotation From Isco, Inc
3) FTIR Detector System + High Pressure Cell and		Quotation From Isco, Inc
4) Computer + Software		Quotation From MIDAC Corp
CO₂ Cylinder (99 995% pure)	585	Based on phone conversation with Jim Rubin
Glove Box Certification includes	38 200	Quotation From Diversified Metal Inc
A- Perform Mechanical and Chemical Testing on Box Material		
B Repair Glove Box Sample Area		
C- LP all Welds		
D Inspect and Repair interior Surfaces		
E Replace 3 window Gaskets		
F- Add one 6' Port		
G Perform Helium Leak Test		
H Shipping and Handling (pick up and return)		
Panel Replacement Design Engineering and Installation	133 000	From Paul Sato based on costs for design, engineering and installation work for the HC 3 panel at PFP
Installation of equipment and glovebox	48 000	Engineering judgment based on cost estimation
Glove Box D&D includes		
1) D&D activities planning training engineering etc	500 000	Engineering judgment based on cost estimation
2) Waste Disposal	10 000	\$500/drum x 10 drums + other costs
New Custom Glovebox	150,000	Engineering judgment based on discussion with PFP staff
Seismic and Criticality Analyses	20 000	Engineering judgment based on cost estimation

Figure 1 SFE System Components

Figure 2 SFE Equipment and Glovebox Space Requirements

Figure 3 TGA Equipment and Glovebox Space Requirements

[illegible]