FEB 26 1997

WS#16

16

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT

609914

2. To: (Receiving Organization) Distribution		3. From: (Originating Organization) 15530/PFP Process Engineering		4. Related EDT No.: N/A	
5. Proj./Prog./Dept./Div.: /K6178/PFP ENGINEERING/15500		6. Design Authority/ Design Agent/Cog. Engr.: G. G. Bergquist		7. Purchase Order No.: N/A	
8. Originator Remarks: SYSTEM DESIGN DESCRIPTION DOCUMENT FOR THE SAND, SLAG, AND CRUCIBLE CEMENTATION PROCESS AT THE PFP				9. Equip./Component No.: N/A	
				10. System/Bldg./Facility: 234-5Z, Room 235B	
11. Receiver Remarks: 11A. Design Baseline Document? ☐ Yes ☒ No				12. Major Assm. Dwg. No.: N/A	
				13. Permit/Permit Application No.: N/A	
				14. Required Response Date: N/A	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-CP-SDD-020 ANF CPM 2/13/97	—	0	SYSTEM DESIGN DESCRIPTION SAND, SLAG, AND CRUCIBLE CEMENTATION PROCESS PFP	S	1,2	1	

16. KEY											
Approval Designator (F)		Reason for Transmittal (G)				Disposition (H) & (I)					
E, S, G, 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
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		Env.									
18. C. D. Meng Signature of EDT Originator		19. N/A Authorized Representative Date for Receiving Organization		20. M. W. Gibson Design Authority/ Cognizant Manager		21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments					

SYSTEM DESIGN DESCRIPTION SAND, SLAG, AND CRUCIBLE CEMENTATION PROCESS PFP

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U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 609914 UC: 2050
Org Code: 15530 Charge Code: K6178
B&R Code: EW7003000 Total Pages: 17

Key Words: SDD, Sand, Slag, and Crucible, Cementation

Abstract: The SDD documents the Structures, Systems, and Components that establish the facility Safety Envelope for the Cementation of SS&C.

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Samuel K. Salazar 2-26-97
Release Approval Date

Release Stamp

Approved for Public Release

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1.0 PURPOSE

The purpose of this document is to provide a system design description (SDD) and design basis for the Plutonium Finishing Plant (PFP) Sand, Slag, and Crucible (SS&C) Cementation process. The chief objective of the SDD is to document the Structures, Systems, and Components (SSCs) that establish and maintain the facility Safety Envelope necessary for normal safe operation of the facility; as identified in the Final Safety Analysis Report (FSAR), the Operational Safety Requirements (OSRs), and Safety Assessment Documents (SADs). This safety equipment documentation should satisfy guidelines for the SDD given in WHC-SD-CP-TI-181, Criteria for Identification and Control of Equipment Necessary for Preservation of the Safety Envelope and Safe Operation of PFP.

The basis for operational, alarm response, maintenance, and surveillance procedures are also identified and justified in this document. This document and its appendices address the following elements of the PFP SS&C Cementation Process:

- Functional and design requirements
- Design description
- Safety Envelope Analysis
- Safety Equipment Class
- Operational, maintenance, and surveillance procedures

2.0 SUMMARY

The SS&C Cementation Process is designed to immobilize Plutonium (Pu) bearing Sand, Slag, & Crucible residues from the RMC button line operations in cement. The SS&C is currently stored in the vaults at the PFP. Stabilizing this material will facilitate disposal of the material as TRU waste and reduce worker exposure.

The SS&C material is cemented in glovebox HA-20MB (Room 235B) of the 234-SZ building. Cemented material, after curing, will be sealed out of a sealout port on the HA-20MB glovebox or the HA-28 conveyor (the sealout port may have a permanent containment tent around it). The cemented cans will be transferred to Transuranic (TRU) waste drums. The TRU waste drums are sent to the Transuranic Waste Storage and Assay Facility (TRUSAF) and later to the Waste Isolation Pilot Plant (WIPP).

There is no equipment defined as Safety Class or Safety Significant for this process. No OSRs are necessary for the PFP SS&C Cementation Process.

3.0 FUNCTIONS AND DESIGN REQUIREMENTS

SS&C to be cemented is staged for preparation in the HA-20MB glovebox. It is opened, weighed, divided as needed in HA-20MB to meet the unreacted calcium limits, and a measured amount of SS&C is processed through a size reduction unit. The size reduction unit is a jaw crusher with an opening shimmed to approximately 1/16 inch so the crushed material passes through 8 mesh screen. The feed batch is then transferred to the reaction mixing bowl via the auger in HA-20MB and mixed with chilled water to react residual calcium metal. This step enables control of the exothermic reaction temperatures and hydrogen generation of calcium metal with water. Following the calcium oxidation, the reacted mixture of SS&C solids and water are mixed with cement to form a cement matrix. When the cement is cured, it is sealed out, packaged in a TRU drum, and shipped to TRUSAF.

3.1 PROCESS REQUIREMENTS

Process requirements for the SS&C Cementation process specify what types of material may be processed, process conditions, and what specifications the finished product must meet. An important feed criterion is the type of feed (SS&C). Important finished product criterion is no excess water on top of the cured cement. Process requirements for this system are defined and explained in PFD-Z-200-011, Sand, Slag, and Crucible Cementation Process Flowsheet, and OSD-Z-184-00039 Sand, Slag, and Crucible Cementation Process PFP.

3.2 INTERFACES

Feed materials (SS&C) will be transferred from the 2736-Z vaults and Room 192-B to HA-20MB glovebox twice a week during normal operations. Glovebox HA-20MB and Room 235B will be used as a staging area for both feed and product. Cemented material will be transferred to a TRU drum and the drum sent to TRUSAF. Off-gas streams from the HA-20MB glovebox are filtered by 2 stages of HEPA filters prior to discharging to the 291-Z stack through the E-4 ventilation system.

Gases enter the HA-20MB glovebox through several systems. HA-20MB has an inlet stream consisting of the former 'dry' air supply (Note: The dry air system no longer supplies dry air, air is supplied at atmospheric humidity). HA-20MB is also connected to the HA-28 conveyor glovebox which allows air to flow to this glovebox.

Air will exit the HA-20MB glovebox through a local HEPA filter before entering the E-4 exhaust system.

3.2.1 Power

Power (120 VAC) is supplied from CB-1 to glovebox HA-20MB through box PBI on the end of the glovebox. Conduit runs to the ARS-2 for the electrical equipment in the glovebox.

3.2.2 Control

Controls (on/off switches) for the cementation process are located on the outside of glovebox HA-20MB. The high temperature alarms for the cementation process are available on an alarm panel located on the North wall of Room 235B.

3.2.3 Mixer Bowl Reactor Temperature

The Mixer Bowl Reactor temperature is measured by a thermocouple (TC) which provides input to a high temperature alarm switch (TAS). To prevent water loss to the glovebox and prevent the water from boiling TAS-20MB-1 is interlocked to remove power from the SS&C feed auger if the temperature exceeds a high set point (80°C). A redundant high high temperature limit is set at 90°C (TAS-20MB-2) in the event the 80°C interlock were to fail.

When the set point temperature is exceeded the feed auger interlock actuates and an audible alarm sounds.

4.0 SAFETY INTERLOCKS, SET POINTS, AND ALARMS

4.1 SAFETY INTERLOCKS

The safety interlocks control power to feed auger. Power will be removed from the feed auger when either of the following conditions occur:

1. If the temperature exceeds the high set point at 80°C.
2. If the temperature exceeds the high high temperature set point at 90°C.

4.2 SET POINTS/RANGES

Set points and ranges for mixer bowl reactor temperatures, feed auger rate, alarms, etc. have been outlined in WHC-OSD-Z-184-00039, the operating specifications document (OSD) for the Sand, Slag & Crucible Cementation Process. The OSD also identifies off-standard conditions and recovery actions. Specific set points and ranges will not be stated here in order to avoid inconsistencies between this document and the OSD.

4.3 ALARM RESPONSE

Alarms associated with cementation process will display on an alarm display on the north wall of Room 235B. Alarm response operator actions for the SS&C Cementation process are documented in Z0-160-060.

5.0 OPERATION

5.1 OPERATING PROCEDURES

- Z0-160-060, **Stabilization Cementation**. This procedure provides instructions for stabilizing SS&C in a cement matrix.

5.2 OPERATING SPECIFICATIONS DOCUMENT

- WHC-OSD-Z-184-00039, **Sand, Slag, & Crucible Cementation Process PFP**. This document contains specification limits for feed items, auger feed rates, feed particle size, weight percent Plutonium in stabilized material, process water chiller starting temperatures, charge size, and cement requirements. Information detailing detection/control of process variables and recovery actions are also given.

5.3 PROCESS FLOWSHEET DOCUMENT

- PFD-Z-200-011, **Sand, Slag, and Crucible Cementation Process Flow Document**. The Process Flowsheet Document (PFD) contains detailed information on process parameters and design. It includes equipment description, process technology, control schemes and set points, off-standard conditions, and safety concerns.

6.0 MAINTENANCE

6.1 MAINTENANCE PROCEDURES

Calibration maintenance activities are initiated using the PMS system and PSCP and other general calibration procedures. Listed below are specific procedures used in the SS&C Cementation process.

Procedure Number	Description	Associated Equipment	Loop Number
ZCP-6-001	Eurotherm Model 93 Temperature Alarm Switch Calibration	TAS-20MB-1	2Z-6680
ZCP-6-001	Eurotherm Model 93 Temperature Alarm Switch Calibration	TAS-20MB-2	2Z-6681

6.2 VENDOR INFORMATION FILES

The vendor information (VI) file is compiled to address all of the components installed for Cementation of plutonium bearing SS&C materials in glovebox HA-20MB. The VI file is:

VI Number	Description
22682	Hobart Model N50 Mixer Item 3 Neslab CFT Series (R134a) Recirculating Chiller Item 4

7.0 SURVEILLANCE

Surveillance of equipment is controlled and monitored through the Preventative Maintenance System (PMS). The PMS is a large database which tracks when equipment surveillance needs to occur and what information needs to be recorded. This database also contains historical data (past calibration or functional checks) for the equipment. The following table lists all cementation equipment in the PMS database and the surveillance interval.

PMS ID	INSTRUMENT IDENTIFICATION	FUNCTION	VERIFICATION INTERVAL
2Z-6680	TAS-20MB-1	TEMPERATURE ALARM	12 MONTHS
2Z-6681	TAS-20MB-2	TEMPERATURE ALARM	12 MONTHS

8.0 SAFETY

The principle hazards associated with glovebox HA-20MB operations are fire, criticality, and radiation. The following section describes the potential hazards associated with cementation stabilization. In addition, glovebox HA-20MB was analyzed for a deflagration of hydrogen gas from the reaction of calcium metal with water. The analysis determined that the deflagration was bounded by an existing safety analysis for glovebox MT-5.

There are no OSRs associated with the PFP SS&C Cementation Process. The equipment installed by the SS&C Cementation Process was also determined to be "other equipment important to safety".

Worker safety and accident analysis are documented in the MT-5 Glovebox analysis. The two bounding accident scenarios for the MT-5 system, and thus the SS&C Cementation Process, are: a fire within the glovebox, and the rapid decomposition of tributyl phosphate (TBP) leading to the formation of combustible gases and deflagration of the gas.

Calculated consequences for glovebox fires were found to be within risk acceptance guidelines. The rapid decomposition of TBP leading to the formation of combustible gases was shown to be an incredible event. The probability of a seismically induced deflagration in glovebox MT-5 resulting from a design basis earthquake (DBE) and a small earthquake were quantified and shown to be incredible events.

For further detail on safety criteria, see WHC-SD-CP-SAR-021, PFP Final Safety Analysis Report and WHC-SD-CP-FHA-004, PFP Fire Hazards Analysis (FHA).

The following analysis was performed and documented in the USQ evaluation PFP-96-007. Calculations were performed using SS&C containing 20 wt% unreacted calcium metal. This conservative assumption exceeds the 9% calcium by weight given in the flowsheet values for RMC residues. The heat of combustion of the butene in the MT-5 scenario was compared to the heat of combustion of hydrogen.

The USQ comparison of the HA-20MB operations to MT-5/HC-21C operations shows that:

- 1) the fire scenario in MT-5/HC-21C (butene gas) is bounding for HA-20MB (hydrogen gas) due to the 500 grams at risk in HA-20MB, opposed to 2 kgs in MT-5 or the 5 kgs in HC-21C,
- 2) the deflagration scenario in MT-5/HC-21C is bounding for HA-20MB as the material at risk is no more than 180 grams per charge, 500 grams total in glovebox; as compared to 1000 grams in MT-5 and 500 grams in HC-21C. Also bounding this scenario is the 1.2 grams released to the room in the Radioisotope - Bearing Powder Spills, a probability 1 event, and
- 3) the Seismically Induced Deflagration in Glovebox MT-5/HC-21C is bounding for HA-20MB. The release of 0.36 grams comes from an analysis of a 500 grams plutonium item in Glovebox MT-5 spilling onto the glovebox floor and being dispersed by the resulting deflagration. By limiting the maximum plutonium in any unreacted can in HA-20MB to 100 grams plutonium, the same release would be equivalent to 8500 (five times the 1700 g in each can) grams of SS&C reacting in HA-20MB.

The results of this analysis are consistent with the PFP Fire Hazards Analysis (FHA). The PFP FHA requires automatic fire detection and suppression in an active glovebox which has combustible material, plastic windows, and is connected to other gloveboxes. Glovebox HA-20MB has hydrogen gas present during the reaction step of cementation, plastic windows, and it is connected to a conveyor glovebox. Glovebox HA-20MB has automatic fire detection and dry chemical fire suppression.

8.1 FIRE SAFETY

8.1.1 Glovebox Fire

The presence of flammable gas (hydrogen) is a factor which could lead to a glovebox fire in HA-20MB. Glovebox HA-20MB is equipped with an automatic dry chemical fire suppression system.

8.1.2 Combustible Material

In practicing good fire prevention, combustible materials must be kept to a minimum within the glovebox.

8.1.3 Flammability of Off-Gas

The process reacts the residual calcium in SS&C (9% by weight based on flowsheet values for RMC) with excess water. There is a concern for hydrogen generation when reacting calcium with water. To prevent the accumulation of flammable levels of gas, the addition of the SS&C to the water will occur at a controlled rate. The process reacts the SS&C at a maximum rate of 50 grams/minute. Calculations (WHC-SD-CP-0CD-041 Attachment 5) showed that hydrogen was generated at a rate of 0.0467 L/sec above the mixer bowl. The volume of free space above the mixer bowl is 3.4 liters, assuming the mixer bowl is at the specified operational volume of 1.4 liters. Further, four percent of mixer bowl volume free space is 0.14 L. The hydrogen generated at any one instant is less than the flammability point of hydrogen at four percent in a confined space. The calculations were performed assuming stagnate air within the glovebox. This calculation is very conservative as water vapor in the head space above the bowl dilutes the H_2 even further but was not included in the calculations. The glovebox air flow dilutes the hydrogen gas further as it is removed so a flammable concentration will not form above the bowl or in the off-gas equipment (piping, etc.).

8.2 CRITICALITY

Since plutonium is a fissile material, measures are taken to assure prevention of conditions which could lead to a criticality incident. A criticality prevention specification (CPS-Z-165-80634) has been prepared for glovebox HA-20MB to accommodate the SS&C Cementation process. Limits on plutonium quantities, container volume, stacking containers, and material spacings are specified in the CPS and shall be strictly adhered to during operations. A Criticality Safety Evaluation Report (WHC-SD-SQA-CSA-513) has also been prepared for cementation in the HA-20MB glovebox.

8.3 RADIATION SAFETY

During the design and operational preparations for the cementation process, ALARA considerations were instituted to decrease the expected dose. A summary of these actions are given below:

Minimize Operator's Time in Gloves

- Feed auger is used instead of hand feed.
- Equipment switches are outside the glovebox.
- Valves are outside the glovebox where possible.
- Remote temperature sensors don't need positioning.
- Mixing by machine where possible (previous cementing done by hand).
- Sphincter port was installed for product can and cement insertion.
- Commercial can opener speeds feed preparation.
- Maximum batch sizes are used where possible.

Lower Dose Location Used

- The area of highest dose is between HA-20MB and HA-21I near the conveyor. This area is avoided by grouping the equipment on the far side of HA-20MB which is opposite HA-21I and at the end of the glovebox away from the conveyor.
- The lowest dose in the glovebox and surrounding area is near where the mixers/auger have been installed. Most of the operations are performed in this area.
- Shielding is on the most commonly used side of the glovebox (where most of the equipment is grouped).

Vault feed material retrieval operations, transfer to Room 235B, seal in of feed, and seal out of stabilized material have been stream lined to reduce dose to personnel.

8.4 INDUSTRIAL SAFETY

8.4.1 Foaming

The addition of the SS&C to the water may be accompanied by foaming due to the reaction between calcium metal and the water.

When the foaming material approaches the top of the reactor, the auger feed is stopped until the foaming has subsided or the foam may be scraped away to feed into a cement mixture.

8.4.2 Jaw Crusher

The guard/hopper prevents the operator's gloved fingers from entering the crusher during operation.

8.4.3 Can Opener

Leather gloves are worn over the glovebox gloves to prevent cuts from handling the sharp lid.

9.0 EQUIPMENT SAFETY CLASS ANALYSIS

It was determined that no System 71H components would be rated as safety class or safety significant equipment due to the following:

- 1) the remote possibility of hazardous chemicals or radionuclides being released offsite, and
- 2) the low probability of a fatality or serious injury to an individual or group of workers in any accident scenario of the SS&C Cementation Process.

Items in the SS&C Cementation Process in glovebox HA-20MB which have safety importance to protect individual facility workers are listed below.

9.1 HA-20MB OFF-GAS SYSTEM

Item: E-4 System for Cementation process in HA-20MB.

DPI-2-HA20MB and V-28311-25A

Basis: The E-4 system provides off-gas from the glovebox which removes flammable (hydrogen) off-gases that are produced during the reaction of the SS&C with water and cement. The glovebox pressure is negative relative to room pressure to ensure contamination control. The differential pressure on the HA-20MB north HEPA filter indicates that the filter and off-gas are operating at the minimum flowrate of 20 cfm.

9.2 MIXER REACTOR #1 HIGH TEMPERATURE SHUTOFF INTERLOCK

Item: Temperature Elements (Thermocouples), High Temperature Switch, and Alarm Annunciator

TE-20MB-1, TE-20MB-2, TAS-20MB-1, TAS-20MB-2

Basis: The mixer reactor high temperature shutoff system ensures that excessive water vapor is not discharged to the ventilation ducts by stopping the feed auger. Also, if the calcium metal is not evenly dispersed in the feed, the temperature limit/interlock will provide a way to stop the feed and allow the heat of reaction to be dispersed before continuing the process.

The key component of this system is the high temperature switch (TAS-20MB-1). The switch monitors thermocouples located on the mixer reactor in the HA-20MB glovebox and alarms if one of the thermocouples exceeds the set point limit. Thermocouples for this system are important because they supply the high temperature interlock switch with information. The alarm annunciator is also important because it notifies the operator that the mixer reactor temperature is high and the feed auger needs to be stopped if the automatic shutoff has not done so.

10.0 REFERENCES

- 1 WHC-SD-CP-TI-181, Criteria for Identification and Control of Equipment Necessary for Preservation of the Safety Envelope and Safe Operation of PFP.
- 2 PFD-Z-200-011, Sand, Slag, and Crucible Cementation Process Flow Document. Stubbs, A. M., July 1996.
- 3 WHC-OSD-Z-184-00039, Sand, Slag & Crucible Cementation Process PFP. Stubbs, A. M., October 1996.
- 4 ZO-160-060, Stabilization Cementation
- 5 WHC-SD-CP-SAR-021, Rev. 5. Plutonium Finishing Plant Final Safety Analysis Report (FSAR). Sudmann, R. H. 9/30/96.
- 6 PFP-96-007, Rev. 0. Cementation of Sand, Slag, and Crucible Items in Glovebox HA-20MB. Funston, G. A. and Rodgers, L. H. 9/15/96.
- 7 CPS-Z-165-80634, Sand, Slag, and Crucible Cementation Process, Glovebox HA-20MB.
- 8 WHC-SD-SQA-CSA-513, Rev. 1. CSER-96-013: Cementation Process, Glovebox HA-20MB.
- 9 WHC-SD-CP-FHA-004, Rev. 0, Fire Hazards Analysis for Plutonium Finishing Plant Complex.

APPENDIX A
SYSTEM DRAWING LIST

SS&C CEMENTATION PROCESS IN GLOVEBOX HA-20MB	
Drawing Number	Title
H-2-99536 SH. 1	HA-20MB SS&C CEMENTATION GLOVEBOX ARRANGEMENT
H-2-99536 SH. 2	HA-20MB SS&C CEMENTATION GLOVEBOX ARRANGEMENT LAYOUTS
H-2-99536 SH. 3	HA-20MB SS&C CEMENTATION GLOVEBOX ARRANGEMENT DIAGRAM
H-2-99536 SH. 4	HA-20MB SS&C CEMENTATION GLOVEBOX ARRANGEMENT DIAGRAM
H-2-96400 SH. 1	WASTE STABILIZATION CEMENTATION PROCESS WIRING DIAGRAM
H-2-96400 SH. 2	WASTE STABILIZATION CEMENTATION PROCESS WIRING
H-2-96400 SH. 3	WASTE STABILIZATION CEMENTATION PROCESS WIRING
H-2-825866 SH. 1	FIRE PROTECTION DRY CHEMICAL EXTINGUISHING SYSTEM, GLOVEBOX HA-20MB

APPENDIX B

MASTER COMPONENT INDEX LIST
SS&C CEMENTATION PROCESS

SS&C Cementation Process Master Component Index					
SYS No.	CID	DESCRIPTION	DRAWING	VENDOR MFR	COMPONENT DATA
71H	AUGER#1	AUGER FOR CEMENTATION FEED	H-2-99356 SH. 1	ACCURATE CORPORATION	MODEL# 102
71H	MIXER#1	REACTOR/MIXER FOR CEMENTATION	H-2-99536 SH. 1	HOBART CORPORATION	MODEL# N-50
71H	HS-20MB-1	ON/OFF SWITCH FOR AUGER #1	H-2-96400 SH. 1	COMMON	N/A
71H	HS-20MB-2	ON/OFF SWITCH FOR PUMP P-20MB-1	H-2-96400 SH. 1	COMMON	N/A
71H	HS-20MB-1	ON/OFF SWITCH FOR MIXER #1	H-2-96400 SH. 1	COMMON	N/A
71H	HS-20MB-5	ON/OFF SWITCH FOR CRUSHER	H-2-96400 SH. 1	COMMON	N/A
71H	HS-20MB-7	EMERGENCY STOP HA-20MB	H-2-96400 SH. 1	GENERAL ELECTRIC	MODEL# CR104PBM01R5C
71H	JY-20MB-1	CONTACTOR FOR AUGER# 1	H-2-96400 SH. 1	SQUARE D	MODEL# 8502-SB05-V-02
71H	PB-20MB-1	MIXER #1 HIGH TEMP RESET	H-2-96400 SH. 2	GENERAL ELECTRIC	MODEL# CR104PBG91B12
71H	PB-20MB-2	MIXER #1 HI-HI TEMP RESET	H-2-96400 SH. 1	GENERAL ELECTRIC	MODEL# CR104PBG91B1
71H	RPT-20MB-1	RECEPTICAL FOR AUGER 1	H-2-96400 SH. 1	COMMON	N/A
71H	RPT-20MB-2	RECEPTICAL	H-2-96400 SH. 1	COMMON	N/A
71H	RPT-20MB-3	RECEPTICAL FOR MIXER #1	H-2-96400 SH. 1	COMMON	N/A
71H	RPT-20MB-5	RECEPTICAL FOR CRUSHER	H-2-96400 SH. 1	COMMON	N/A
71H	CRUSHER	JAW CRUSHER	H-2-99536	GILSON	MODEL# LC-8 with hardened steel plates

SS&C Cementation Process Master Component Index					
SYS No.	CID	DESCRIPTION	DRAWING	VENDOR MFR	COMPONENT DATA
71H	TAS-20MB-1	MIXER #1 HIGH TEMPERATURE ALARM	H-2-96400 SH. 1	EUROTHERM	MODEL# 93/0/0/96651/A0
71H	TAS-20MB-2	MIXER #1 HI-HI TEMP. ALARM	H-2-96400 SH.1	EUROTHERM	MODEL# 93/0/0/96651/A0
71H	TC-20MB-1	THERMOCOUPLE MIXER #1 HIGH TEMP	H-2-96400 SH. 1	OMEGA	MODEL# OS36-K-180F
71H	TC-20MB-2	THERMOCOUPLE MIXER #1 HI-HI TEMP	H-2-96400 SH. 1	OMEGA	MODEL# OS36-K-180F
71H	WATERTANK	MAKEUP WATER TANK	H-2-99536		
71H	CHILLER	RECIRCULATION CHILLER	H-2-99536	NESLAB	MODEL# CFT SERIES R134a

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