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PNL-10705, Vol. 2
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Hanford PUREX Exercise - March 29 to 31, 1994

Special Nuclear Materials Cutoff Exercise: Issues and Lessons Learned

Volume 2 of 3: Appendixes A - C

R. A. Libby
J. E. Segal
W. D. Stanbro
C. Davis

August 1995

Prepared for the Negotiations and Analysis Division Office of Arms Control and Nonproliferation
U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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

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PNL-10705, Vol. 2

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Pacific Northwest Laboratory
Richland, Washington 99352

(a) U.S. Department of Energy
(b) Los Alamos National Laboratory

Contents

Appendix A

Design Information Questionnaire

INTERNATIONAL ATOMIC ENERGY AGENCY
DEPARTMENT OF SAFEGUARDS AND INSPECTION

DESIGN INFORMATION QUESTIONNAIRE*

IAEA USE ONLY

The purpose of this document is to obtain the facility design information required by the Agency in order to discharge its safeguards responsibilities. It will also serve as a check list for examination of design information by Agency inspector(s). If, in any area, insufficient space is available add further sheets to the extent necessary.

IAEA USE ONLY	
COUNTRY	
COUNTRY OFFICER	
TYPE	
DATE OF INITIAL DATA	
VERIFICATION	
LAST REVIEW AND UPDATING	

* Questions which are not applicable may be left unanswered.

REPROCESSING PLANTS
GENERAL INFORMATION

1.	NAME OF FACILITY (Incl. usual abbreviation)	Plutonium/Uranium Extraction Facility (PUREX)
2.	LOCATION AND POSTAL ADDRESS	Hanford Reservation, Richland Washington Westinghouse Hanford Company PO Box 1970 Richland Wa. 99352
3.	OWNER (legally responsible)	U.S. Department of Energy
4.	OPERATOR (legally responsible)	Westinghouse Hanford Company
5.	DESCRIPTION	See PUREX Tech Manual, WHC-SP-0479, Section 2.2 and Figure 2-5.
6.	PURPOSE	Separate Plutonium and Uranium from N Reactor Fuels
7.	STATUS	Three scenarios available: - Operating - Operable - Deactivated
8.	CONSTRUCTION SCHEDULE DATES (If not in operation)	Operating or operable plant. Existing facility operable 1956
9.	NORMAL OPERATING MODE (Days only, two shift, three shift, number of days/annum, etc.)	three shifts per day, seven days per week for campaigns. Continuous operation for several months
10.	FACILITY LAYOUT	Drawings attached under ref. nos. PUREX Tech Manual, WHC-SD-0479, Figure 2-3, PUREX Area Plot
11.	SITE LAYOUT	Drawings and/or maps attached under ref. nos. PUREX Tech Manual, WHC-SD-0479, Figures 2-1 and 2-2
12.	NAME AND/OR TITLE AND ADDRESS OF RESPONSIBLE OFFICERS	Josh Segal

Questions

2.0 PUREX PLANT DESCRIPTION

This chapter presents a general description of the buildings and other facilities constituting the PUREX Plant with emphasis on architecture, general equipment layout, and utility services. Detailed descriptions of equipment are presented in Chapter 3.0.

2.1 SITE DESCRIPTION

The PUREX Plant is located in the southeast corner of the 200 East Area in the center of the 560-mi^2 Hanford Site (Figure 2-1) in southeastern Washington State. In the PUREX Plant, irradiated fuel elements are processed for the separation and recovery of uranium, plutonium, and, neptunium. Major facilities in the 200 East Area (Figure 2-2) include: the PUREX Plant; the Waste Fractionization and Encapsulation Facility (221-B and 225-B Buildings), where strontium and cesium can be separated from reprocessing wastes and encapsulated; the 242-A Evaporator-Crystallizer (242-A Building), used for dehydration of liquid radioactive waste; and the tank farms used for storage of high-level waste salt crystals and solutions.

The PUREX Plant is a complex of several buildings and support facilities. A detailed map of the plant is shown in Figure 2-3.

2.2 PUREX PROCESSING BUILDING (202-A)

The 202-A Building, in which the fuels are reprocessed, is a reinforced concrete structure 1,005 ft long, 119 ft wide at its maximum, and 100 ft high, with about 40 ft of this height below grade. It consists of three main structural components: (a) a thick-walled, concrete "canyon" in which the equipment for radioactive processing is contained (in cells below grade); (b) the Pipe and Operating (P&O), Sample, and Storage Galleries; and (c) a steel-and-transite annex that houses offices, process control rooms, laboratories, and the building services. The basic features and arrangement are shown by vertical cross section and plan views in Figures 2-4 and 2-5, respectively. The portion of the canyon below grade is subdivided into a row of process equipment cells paralleled by a ventilation air tunnel and pipe tunnel through which intercell solution transfers are made. The air tunnel exhausts the ventilation air from the cells to the main ventilation filters and stack.

Running nearly the full length of the canyon building, above the cells and pipe trench, is a craneway for three gantry-type maintenance cranes that are used to handle cell cover blocks, remotely remove and replace process cell equipment, and charge irradiated fuel into the dissolvers.

The galleries contain service piping to the cells, samplers for obtaining process samples, and electrical switchgear.

The service section next to the galleries consists of two separate annexes. The larger annex contains the maintenance shops, offices, lunchroom, locker room, radiation zone entry lobby (SWP lobby), blower room, a switchgear room, compressor room, Central Control Room, and the aqueous makeup (AMU) area. The smaller annex contains the Analytical Laboratory, the Headend Control Room, and a switchgear room. These general features are illustrated in Figure 2-5.

Question 5

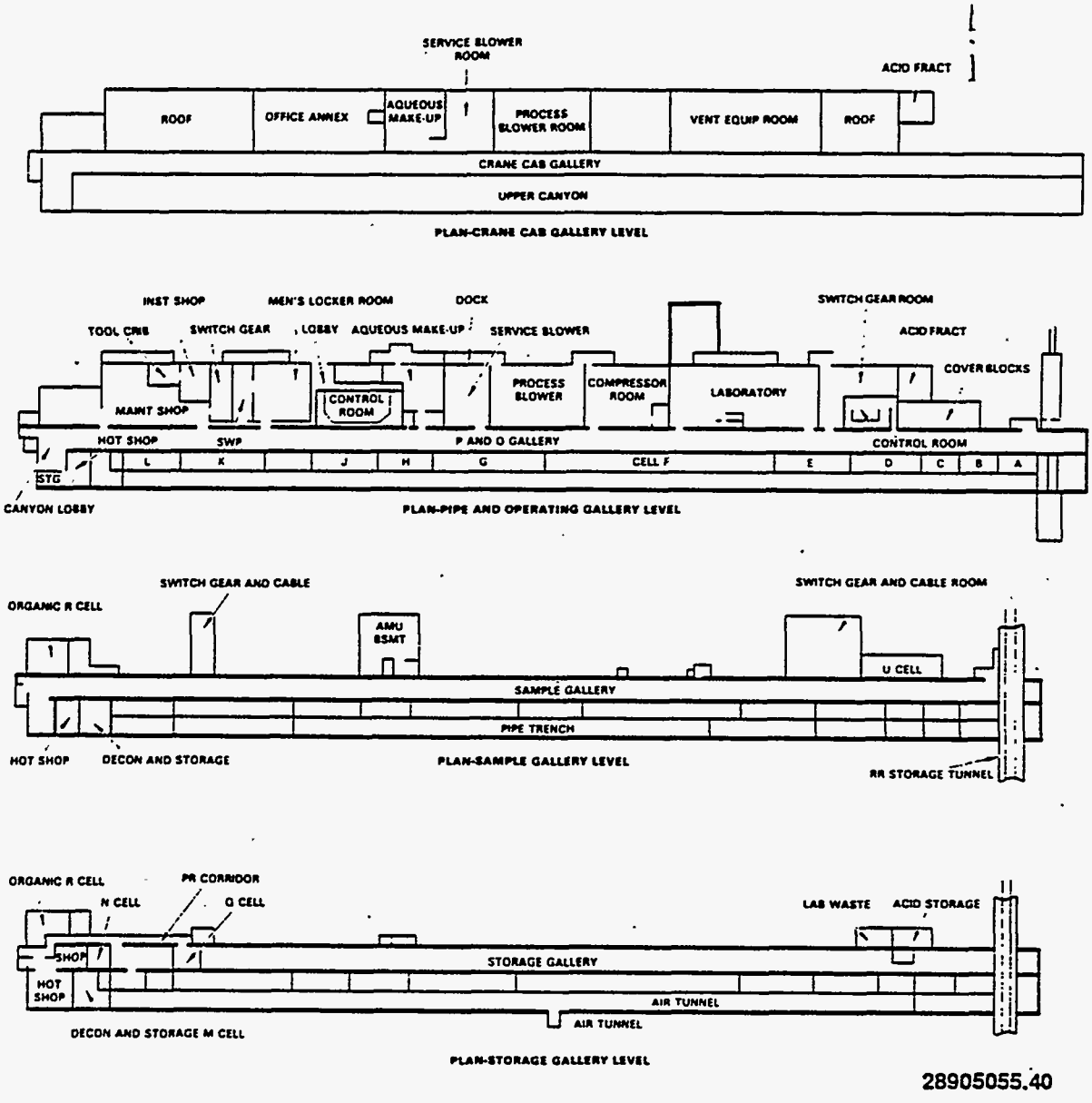


Figure 2-5. Plan Views of the 202-A Building.

Question #9

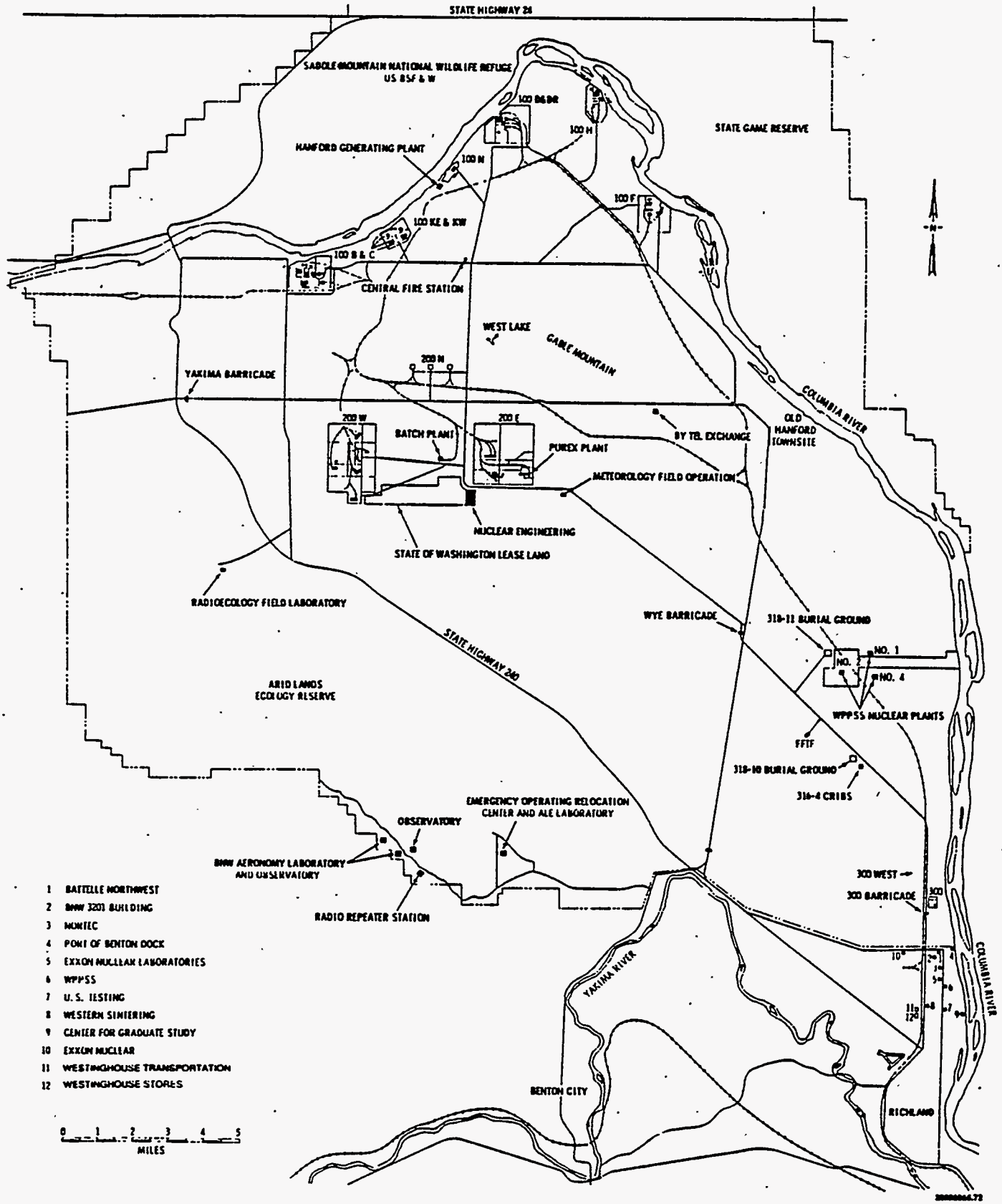


Figure 2-1. Map of Hanford Area.

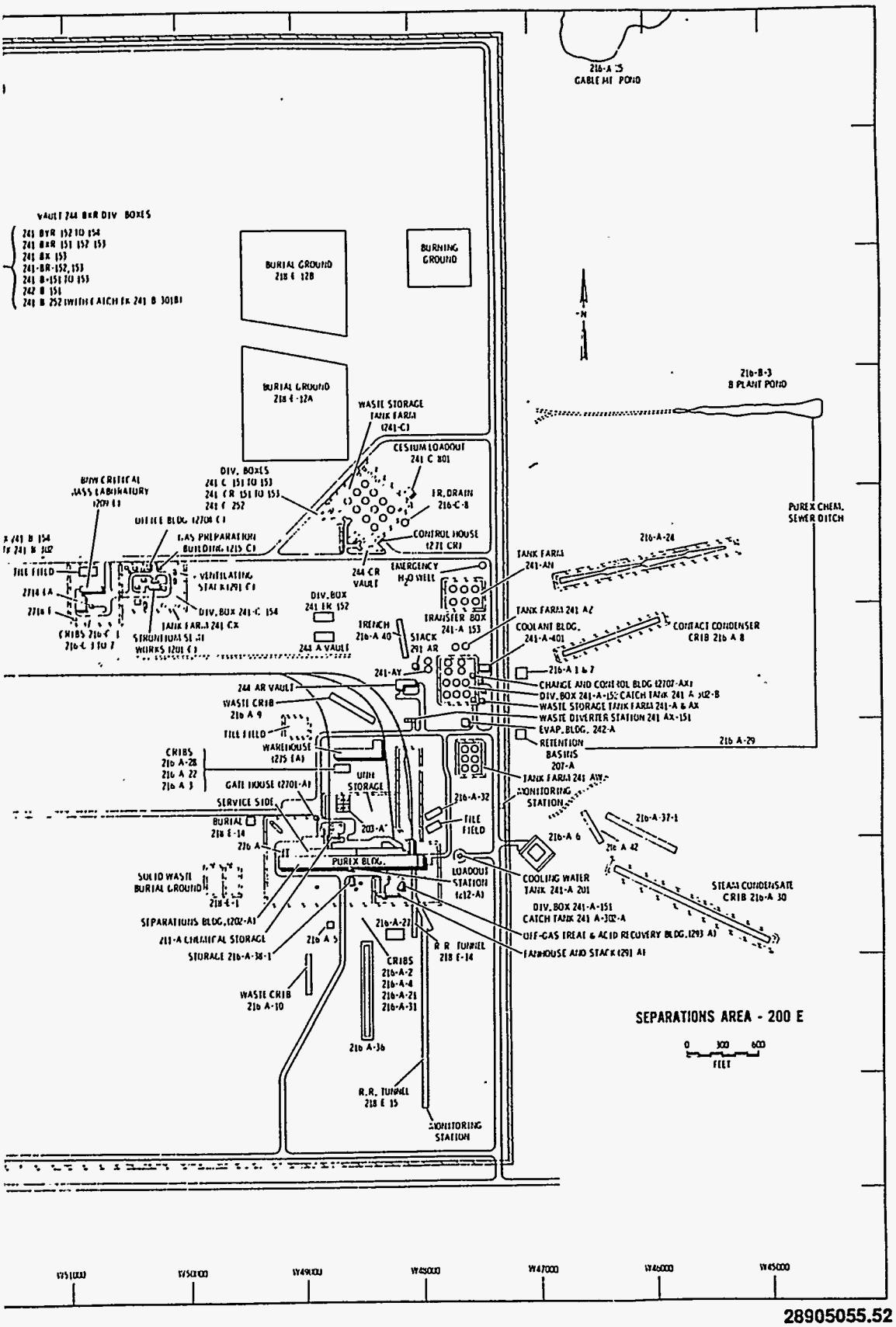
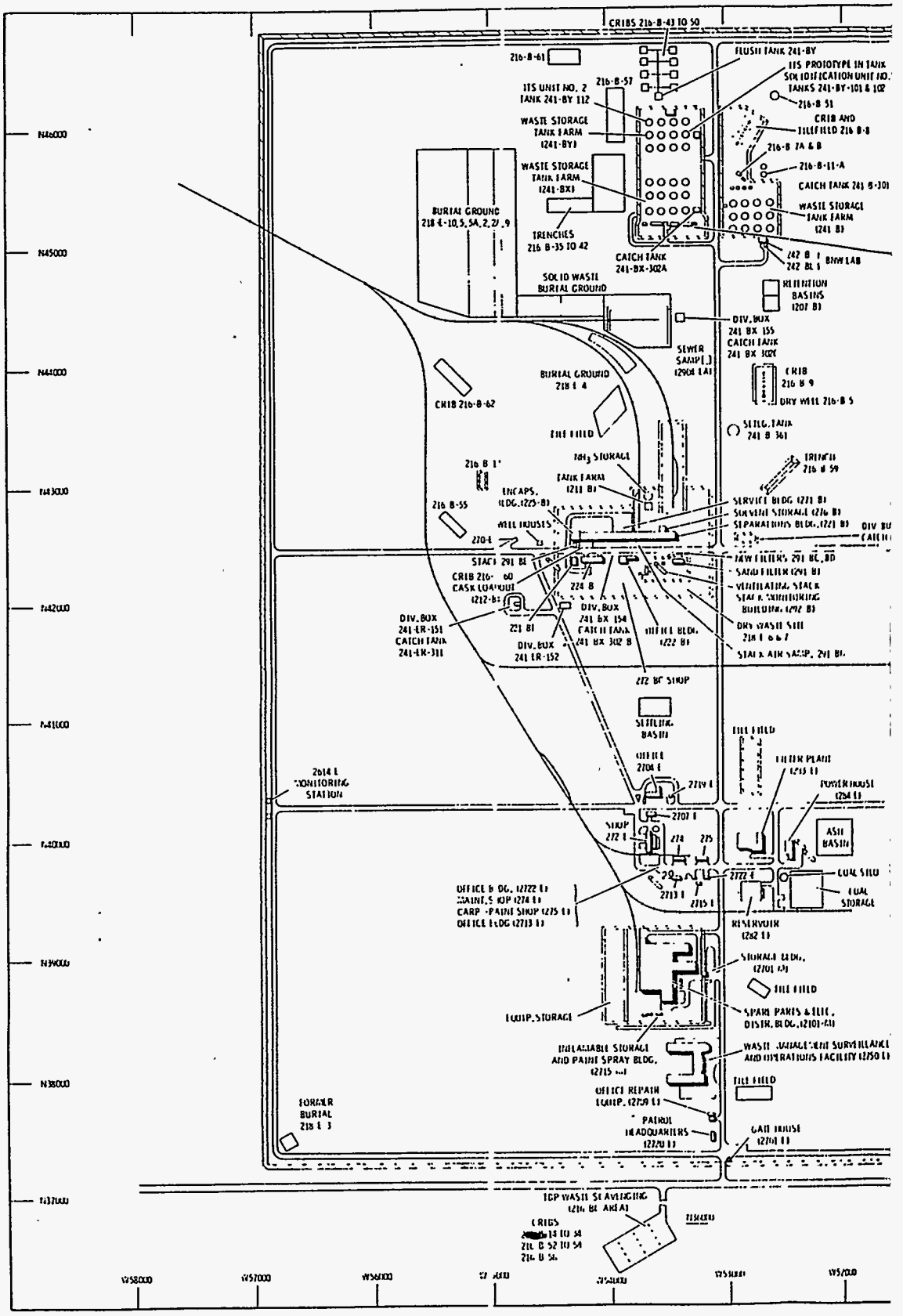


Figure 2-2. Detailed Map of Hanford 200 East Area.

Question #9


CRIBS 216-B-43 TO 50
216-B-61
FLUSH TANK 241-BY
ITS PROTOTYPE IN TANK SOLIDIFICATION UNIT NO. TANKS 241-BY-101 & 102
ITS UNIT NO. 2 TANK 241-BY 112
216-B-57
216-B-51
WASTE STORAGE TANK FARM (241-BY)
CRIB AND TILEFIELD 216-B-8
216-B-7A & B
216-B-11-A
WASTE STORAGE TANK FARM (241-BX)
CATCH TANK 241-B-301
BURIAL GROUND 218-E-10,5,5A,2,2A,9
TRENCHES 216-B-35 TO 42
WASTE STORAGE TANK FARM (241-B)
CATCH TANK 241-BX-302A
242-B
242-BL
BWW LAB
SOLID WASTE BURIAL GROUND
RETENTION BASINS (207-B)
DIV. BOX 241-BX-155 CATCH TANK 241-BX-302C
SEWER SAMPLE (2904-EA)
BURIAL GROUND 218-E-4
CRIB 216-B-62
CRIB 216-B-9
DRY WELL 216-B-5
SETLG. TANK 241-B-361
TILE FIELD
NH_3 STORAGE TANK FARM (211-B)
TRENCH 216-B-59
216-B-1
ENCAPS. BLDG. (225-B)
216-B-55
SERVICE BLDG. (221-B)
SOLVENT STORAGE (276-B)
SEPARATIONS BLDG. (221-B)
WELL HOUSES
270-E
STACK 291-B
CRIB 216-B-60 CASK LOADOUT (212-B)
224-B
DIV. BOX 241-ER-151 CATCH TANK 241-ER-311
221-B
DIV. BOX 241-ER-152
DIV. BOX 241-BX-154 CATCH TANK 241-BX-302-B
OFFICE BLDG. (222-B)
HEPA FILTERS 291-BC, -BD
SAND FILTER (291-B)
VENTILATING STACK
STACK MONITORING BUILDING (292-B)
DRY WASH SITE 216-B-66
STACK AIR SAMP. 291-B
272-BC SHOP
SETTLING BASIN
2614-E MONITORING STATION
OFFICE 2704-E
2719-E
TILE FIELD
FILTER PLANT (251-E)
POWERHOUSE (254-E)
2707-E
SHOP 272-E
274
275
ASH BASIN
2713-E
2715-E
COAL SILO
COAL STORAGE
OFFICE BLDG. (2722-E)
MAINT. SHOP (274-E)
CARP.-PAINT SHOP (275-E)
OFFICE BLDG. (2713-E)
RESERVOIR (262-E)
STORAGE BLDG. (2701-AY)
TILE FIELD
EQUIP. STORAGE
SPARE PARTS & ELEC. DISTR. BLDG. (2101-AU)
FLAMMABLE STORAGE AND PAINT SPRAY BLDG. (2715-AH)
WASTE MANAGEMENT SURVEILLANCE AND OPERATIONS FACILITY (2750-E)
TILE FIELD
OFFICE REPAIR EQUIP. (2719-E)
FORMER BURIAL 218-E-3
PATROL HEADQUARTERS (2720-E)
GATE HOUSE (2701-E)
TOP WASTE SCAVENGING (216-BC AREA)
CRIBS
216-B-52 TO 54
216-B-56
N46000
N45000
N44000
N43000
N42000
N41000
N40000
N39000
N38000
N37000
W58000
W57000
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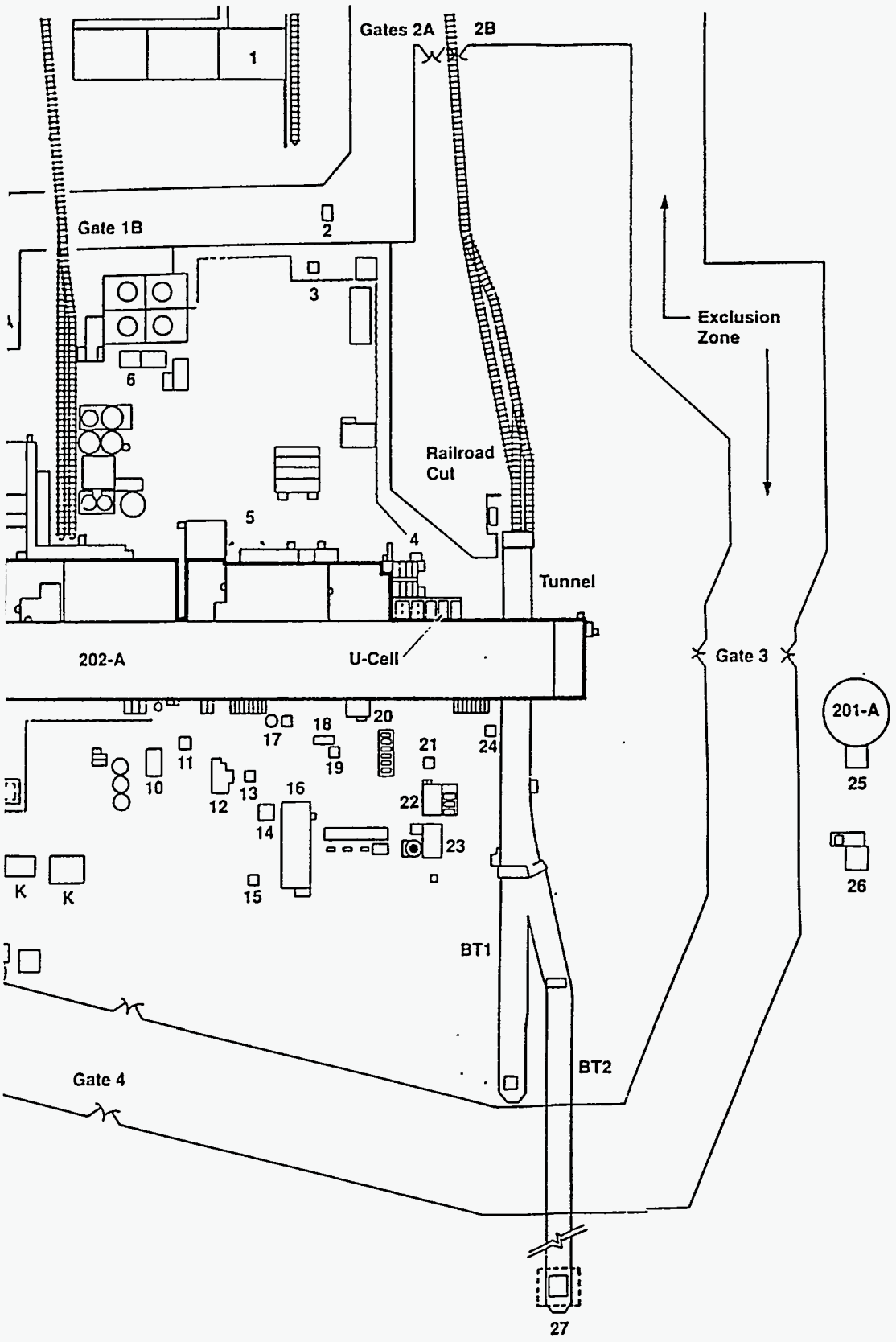


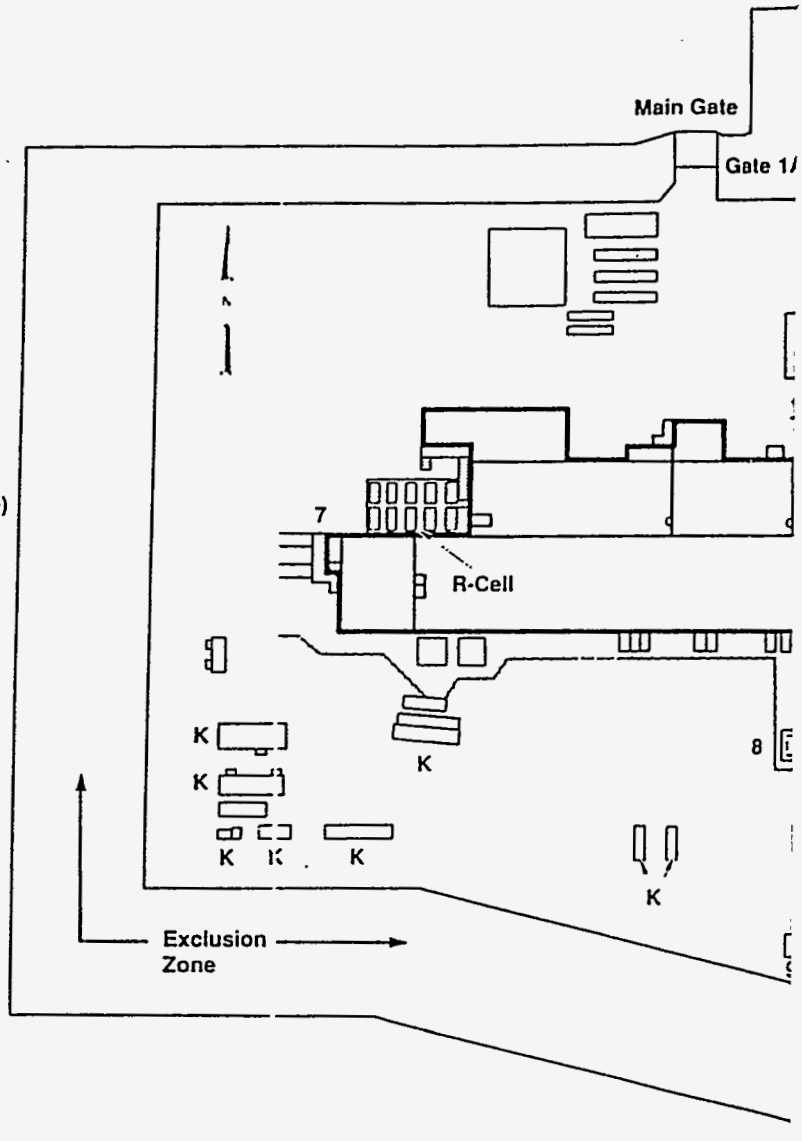
Figure 2-3. PUREX Area Plot Plan.

Question # 10

PUREX Radiological Status as of 1-11-89

1. 275-EA Warehouse
2. CSL PIT
3. 295-AC CSL (Chem. Sewer Line)
4. 206-A Fractionator
5. Laboratory Sample Receiving Dock
6. 203-A UNH Pump House/Control Room
7. PR-Dock
8. 295-AB PDD (Process Distilate Discharge)
9. A-4 PIT/PDD PIT
10. 213-A Reg Maint. Workshop
11. 291-AB Sample Shack
12. Shielded Valve PIT
13. 291-AC Instr. Shack
14. 291-AG Instr. Shack
15. 291-AJ Instr. Shack
16. 291-AE #4 Filter Bldg.
17. 295-AA SCD (Steam Condensate Discharge)
18. 291-AD Ammonia Offgas Filter Bldg.
19. 291-AH Ammonia Offgas Sampler Bldg.
20. 212-A Load Out
21. 294-A Instr. Shack
22. 293-A Dissolver Offgas Bldg.
23. 292-AB Main Stack Bldg.
24. 295-A ASD (Ammonia Scrubber Discharge)
25. 201-A Pump PIT
26. 295-AD CWL (Cooling Water Line)
27. BT2 Exhauster Area

K = Kaiser Related Facilities



13.	FACILITY DESCRIPTION	General flow diagrams attached under ref. nos. Found under section 2 of the PUREX Tech Manual, WHC-SD-0479, and old PUREX Training Manual, RHO-MA-228.
14.	PROCESS DESCRIPTION (Also indicating the modification of physical and chemical forms)	Found in sections 1 and 4 of the PUREX Tech Manual
15.	DESIGN CAPACITY (In weight of principle products per annum)	10.2 MTU/dissolver batch, 3 dissolvers 52 or 45 hr cycle. Waste processing for declad solutions limits cycle times under 2 or 3 dissolver operation
16.	ANTICIPATED ANNUAL THROUGHPUT (In the form of a forward programme (if applicable) indicating the proportion of various feeds and products)	Approximately 10.4 MTU/day for a maximum of 250 operating days a year (200 - 240 operating days common).
17.	OTHER IMPORTANT ITEMS OF EQUIPMENT USING, PRODUCING, OR PROCESSING NUCLEAR MATERIAL, IF ANY.	N/A, Neptunium is collected in Tank J2 in J Cell and is capable of being processed, if desired. See Question 14 answers for neptunium flow paths and processing information when it is processed.

2.2.1 Canyon

The canyon contains a single row of 12 process cells, with an overall length of 813 ft. The cells run east and west and each cell is 14 ft wide and 39.5 ft deep; lengths of the cells vary depending on function. In Cells A, B, and C (the first three cells from east to west), fuels are chemically declad and dissolved. These cells are essentially identical in function and equipment content. In addition to a dissolver, each cell contains dissolver off-gas (DOG) treatment equipment including a downdraft condenser, ammonia scrubber and absorber, steam and electric heaters, silver reactor, and filter.

Cells D and E are used for preparation of the metal solution feed for the solvent extraction columns. Also in E Cell, the coating waste is centrifuged and reacted with caustic prior to transfer to UGS. The centrifuge cake is metathesized and dissolved to recover uranium and plutonium, and the off-gas from the caustic reaction is water scrubbed to remove ammonia.

F Cell is used for the recovery of nitric acid used in the process, for treatment of the aqueous high-level waste from the fuel processing steps, and will be used for concentrating ammonia scrubber wastes from the dissolver and E Cell.

In G Cell, all the spent process organic solvent, except that from the Final Uranium Cycle, is washed and prepared for reuse.

The solvent extraction processing steps are carried out in H, J, K, and L Cells, which contain the tanks, pulsed extraction columns, concentrators, and auxiliaries needed in the continuous countercurrent aqueous-organic stream flow operations.

The pool cell (for storing contaminated equipment), M Cell (for equipment decontamination and plutonium nitrate storage), and the "hot" maintenance shop are located on the west end of the cell row at cell floor level. M Cell is separated from the hot shop by a 3-ft-thick concrete wall.

A 6-ft-thick concrete wall separates the cells from the galleries. The wall above the cells is 4 ft thick, and the extension of this wall upward forms a shielded cabway (Crane Cab Gallery) for the two gantry-type, 40-ton capacity master cranes. A 40-ton capacity slave crane, which may be operated either directly or remotely from the master crane controls, is located on rails above the master crane level. Crane maintenance platforms are located at crane cab level on both east and west ends of the craneway.

At the east end of the canyon is the basin where irradiated fuel may be stored either dry or under water. Casks containing fuel are brought into the canyon through a railroad tunnel running north and south on the west side of the storage basin. The tunnel, which is also the route for removing and delivering process equipment, connects to a railroad spur outside the 202-A Building.

The pipe tunnel, or "hot" pipe trench, contains an array of pipe headers connecting the cells permitting intercell solution transfers. The hot pipe trench also contains piping for transfers to and from cells to facilities external to PUREX. The pipe trench, which parallels the cells, is 30 ft deep and 12 ft wide at the top. It narrows to 11 ft as the wall between the cells and pipe trench widens from 1.5 ft to 2.5 ft. The wall between the cells and trench supports one edge of the 3-ft-thick concrete blocks covering the cells and the 2.5-ft-thick blocks covering the trench.

Question 13

The air tunnel directly under the pipe trench is 11 ft wide and 7.5 ft high. Through this tunnel, air from the cells is drawn to the ventilation exhaust filters and the outside stack. The south wall of the canyon at the air tunnel and pipe trench levels is 5.5 ft thick. From the canyon deck level to the master crane level, the south wall is 4 ft thick and narrows to 2.5 ft from the crane level to the roof. The roof is formed as a concrete beam 2.5 ft thick at the edges and 1 ft thick in the center. No internal trusses support the canyon roof.

2.2.1.1 Canyon Piping. Short intracell transfers between adjacent pieces of equipment are made by direct jumper piping connections within the cell; longer transfers require jumpers to the pipe trench wall. The connections are made via the trench piping, which terminates on the trench wall opposite the equipment piece being connected. The pipe trench also contains hot process and service headers for the equipment in the cells. The pipe trench contains three spare piping systems in addition to the spare process line intended for occasional use. These spare systems are known as General Spare Systems 1, 2, and 3. System 1 consists of a series of lines bent in semiloops in the pipe trench. The ends of each semiloop penetrate the trench wall and terminate with male connectors inside the cells. Adjacent lines can be connected with short "hairpin" jumpers to accommodate most jet or pump transfers. With System 2, connectors exist on both pipe trench and cell sides of the line penetrations. By installing hairpin jumpers in the trench and cells, liquid transfers can be made as with System 1. System 3 consists of pipe stubs spaced at 40-ft horizontal intervals in the pipe trench. These stubs originate as vertical connectors in the pipe trench and terminate with blanked ends outside the south shield wall of the building. By connecting Systems 2 and 3, it is possible to join canyon vessels to outside facilities.

2.2.1.2 Cell Washdown Nozzles. Washdown nozzles for decontamination are located in the cell walls 5 ft above the cell floors. Specially located nozzles are installed at different levels to aim at equipment with relatively high potentials for contamination. Flows from these special nozzles are controlled individually with controls separate from those of the main washdown nozzles.

2.2.1.3 Vessel and Condenser Vent Systems. Canyon vessels not used for boiling or denitration are vented to the vessel vent header running the length of the pipe trench. Vacuum on this header is maintained by a jet in F Cell. Boilup and denitration tanks for acid recovery and waste treatment in F Cell are exhausted through a condenser to the Process Vent System. All other tanks used for boiling solutions in the canyon are vented through condensers to the condenser vent header in the pipe trench. Vacuum on both boilup vent systems is maintained by separate jets located in F Cell. The jets on all three vent systems discharge to a condenser in F Cell where condensate is removed from the vent stream. Noncondensables are routed from the condenser through a heater, a silver reactor, and a filter, all in F Cell, before being discharged to the air tunnel. Vacuum on all of the vent systems is regulated by air bleed.

2.2.2 Galleries

The Storage, Sample, P&O (Pipe and Operating), and Crane Cab Galleries parallel the north wall of the canyon and are located at different levels, one above the other. The Storage Gallery is 19.5 ft wide and has a floor area of 15,900 ft^2, while the P&O, Crane Cab, and the Sample Galleries are 20 ft wide and have floor areas of about 19,000 ft^2 each. The gallery locations with respect to the rest of the 202-A Building are shown in Figure 2-5.

2.2.2.1 Storage Gallery. This area is used primarily for storage of dry chemicals and spare equipment. A 5-ton capacity elevator serves the Storage and P&O Galleries, as well as the four floors of the AMU area.

Question 13

2.2.2.2 Sample Gallery. The Sample Gallery contains remote equipment for taking process solution samples from the cell equipment. (Samples are sent on a dumbwaiter to the sample receiving room in the Analytical Laboratory.) A shielded pipe chase behind the remote sampler boxes contains headers for recovered nitric acid, organic solvent, sampler drains, and sampler lines to and from cell equipment. Spares for the acid and solvent headers are also installed in the pipe chase. Unshielded lines bearing recovered solvent and process condensate are located on the wall above the pipe chase. Other facilities in the Sample Gallery include:

- ASD neutralization system
- PDD neutralization system
- Diaphragm operated valves (DOV) and rotameters for flow control of recovered acid, recycled process condensate, and solvent feeds to the columns
- Chemical addition tanks for N Cell
- A centrally located dumbwaiter to convey solid waste material between the Sample Gallery and the outside loading dock
- Two vacuum pumps located in the west end of the gallery for sampling air throughout the building.

2.2.2.3 Pipe and Operating Gallery. The P&O Gallery provides space for the electrical switchgear, instrument racks, nonradioactive piping, and associated gang valves that serve the in-cell equipment. Since most of the valves are controlled from the control panels, only a few operations are required in the gallery. A few batch chemical addition tanks are located in this gallery.

Shortly after initial plant startup, a wall about 9 ft high was installed across the gallery opposite the middle of K Cell after the gallery west of the wall location had become contaminated. After cleanup, the wall was put in to serve as a ventilation barrier in case this area became contaminated in the future. Protective special work permit (SWP) clothing is required to be worn for entry to the area west of the wall, now known as the White Room.

2.2.2.4 Crane Cab Gallery. The Crane Cab Gallery is located above the P&O Gallery, and is the corridor of travel for the two master crane cabs. The south wall of the gallery shields the cabs and crane operators from canyon radiation. Crane maintenance platforms are located at both ends of the gallery.

2.2.3 Product Removal Room

The Product Removal Room (PR Room), which is used for filling shipping containers and for sampling plutonium nitrate prior to transfer to the Plutonium Oxide Production Facility, is located at the west end of the Storage Gallery adjacent to L Cell. The PR Room is 41 ft long and 19.5 ft wide and contains a plutonium nitrate sampler tank (TK-L9) and a receiver tank (TK-L11) used to collect various plutonium solutions for rework. The tanks are shielded from the working area by concrete walls.

The loadout head tank (TK-L14) and associated equipment are located inside the L-14 Glovebox. The glovebox is constructed of stainless steel with laminated safety glass windows. The loadout

glovebox provides the capability to transfer plutonium nitrate to and from PR cans and FL-10-1 containers.

A doorway from the PR Room provides access to L Cell for contact maintenance of the Third Plutonium Cycle equipment. The room layout is shown in Figure 2-6.

2.2.4 Q Cell

The Neptunium Purification Facility, known as Q Cell, is located in the west end of the Storage Gallery adjacent to the east wall of the PR Room. As shown in Figure 2-7, Q Cell includes a control room, a shielded hot cell, a maintenance room with shielded access gloveboxes, a product loadout room, and an AMU area. The AMU area is on a separate floor above the control room. Entry to Q Cell is from the radiation zone entry lobby.

2.2.5 N Cell

N Cell is located in the Storage Gallery west of the PR Room. This cell was formerly used for plutonium product purification by ion exchange. The ion exchange unit was replaced by the L Cell Third Plutonium Cycle. N Cell has been modified for use as a facility for the preparation of plutonium oxide powder.

2.2.6 R Cell

The equipment in R Cell is used to wash the organic waste stream from the Final Uranium Cycle and prepare it for reuse. R Cell, also designated as the "cold" solvent building (276-A) is located at the northwest corner of the 202-A Building.

2.2.7 U Cell

U Cell, the acid storage vault, is located along the north wall of the 202-A Building, just east of the Headend Control Room. It is constructed below grade with removable concrete blocks 1 ft above grade forming the roof. The cell has reinforced concrete walls 1.5 ft thick, 76 ft long, 20 ft wide, and 35 ft deep. It contains four large tanks: two for collecting and sampling low-activity laboratory waste, and two for storage of recovered nitric acid that is returned to the process through a header in the Sample Gallery. Entry to the cell is from the Sample Gallery through an electrically operated door and air lock or through a hatchway at cover block level.

2.2.8 Service Areas

The service section of the 202-A Building lies just north of the galleries and consists of two separate annexes. The east annex is a two-level structure 216 ft long, 56 ft wide, and 34 ft high. The west annex consists of five levels 490 ft long, 56 ft wide, and 62 ft above grade at the highest point.

Question 13

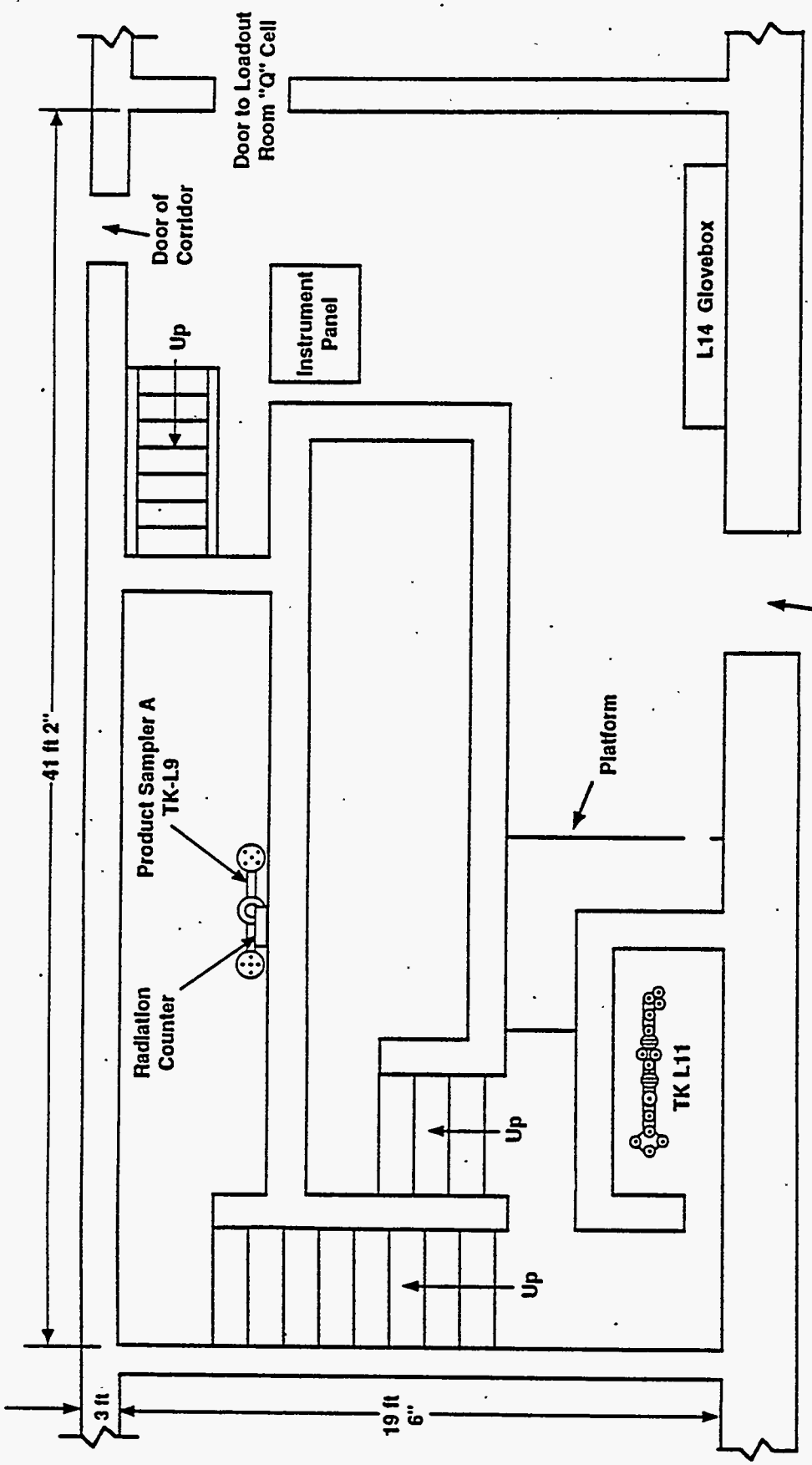


Figure 2-6. Product Removal Room--Plan View.

Question 17

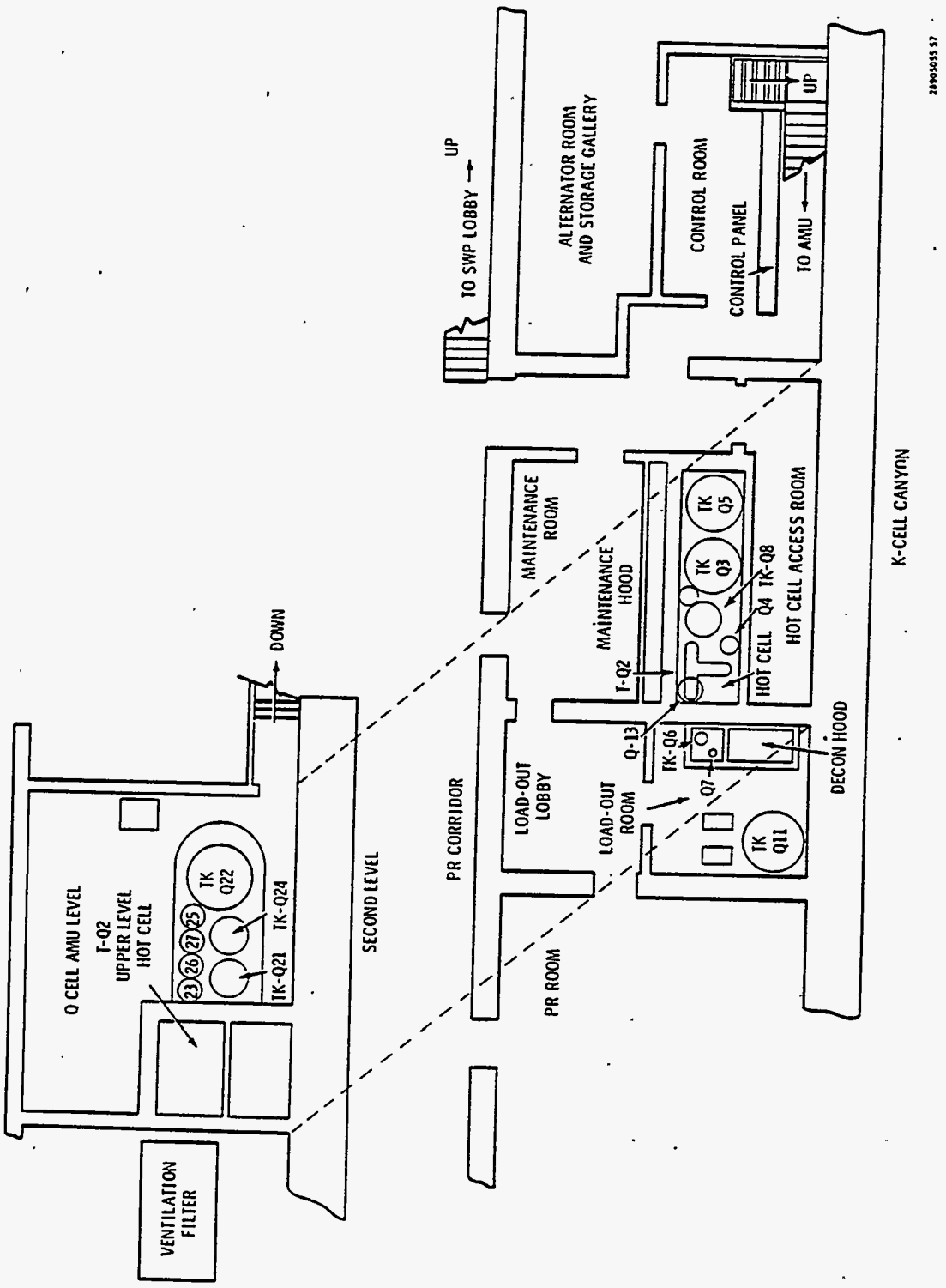


Figure 2-7. Q Cell Neptunium Purification Area--Plan View.

Question 13

2.2.9 Laboratory

The PUREX Analytical Laboratory, located in the western end of the east service annex, is 144 ft long and 34 ft high. The first floor, containing the laboratory work area and lunch and change rooms, is on the same level as the P&O Gallery. The floor and walls of the first floor are made of reinforced concrete for radiation shielding. The second floor, which houses the ventilation equipment and service piping, has transite walls. The layout of the laboratory work area and outside loading docks is shown in Figure 2-8.

2.2.9.1 Laboratory Utilities. The ventilation and equipment room (ventilation loft) on the second floor of the laboratory houses all the piping, ventilation duct work, and miscellaneous equipment for servicing the laboratory. The ventilation equipment is discussed in Section 2.2.12.4. Utilities and services are supplied to the laboratory through headers routed in common raceways located in the ventilation loft. Services to each room of the laboratory are brought through the ceiling and terminated at work stations. Service branches from the main building utilities include sanitary water, instrument air, and air sampling piping. A still and two vacuum pumps are located in the ventilation loft to provide distilled water and vacuum for the laboratory.

Industrial gases including methane in argon, helium, argon, and propane are piped to the laboratory from a central gas cylinder station located on the laboratory's north loading dock (Dock 6).

2.2.9.2 Laboratory Waste Disposal Facilities. There are four categories of solid wastes that are generated by the laboratory. The categories and form of disposal are as follows.

- Radioactive and chemically hazardous (radioactive mixed wastes)--This is typically low flash point material. It is put into glass or plastic bottles and then packed in absorbent material contained in a 55-gal steel drum. A drum full of material is accumulated in the laboratory. The drum is then shipped to the 90-day storage area. After 90-days the drum is shipped to the Hanford Central Waste Complex in the 200 West Area.

- Radioactive but not chemically hazardous--This material is segregated into the following categories:

  1. Material <10 mrem/h, but <100 mrem/h is packaged in 55-gal steel drums

  2. Material >100 mrem/h is packaged in concrete-lined steel drums.

  When a full container is accumulated, it is sent to the 200 West Area burial grounds.

- Nonradioactive but chemically hazardous--These are typically reagents in low flash point solvents that have exceeded the normal shelf life. They are sent to a 90-day storage area. After 90 days they are sent to the 616 Building and finally to offsite disposal.

- Nonradioactive and not chemically hazardous--This material includes such items as packing materials and lunch room waste. It is sent to the Central Landfill for burial.

Laboratory sink drainage is collected in one of two 8,000-gal stainless steel tanks (TK-U3 and-U4) located in U Cell. The tank solution is sampled, made alkaline, and jetted to UGS with ultimate evaporation in the 242-A Building.

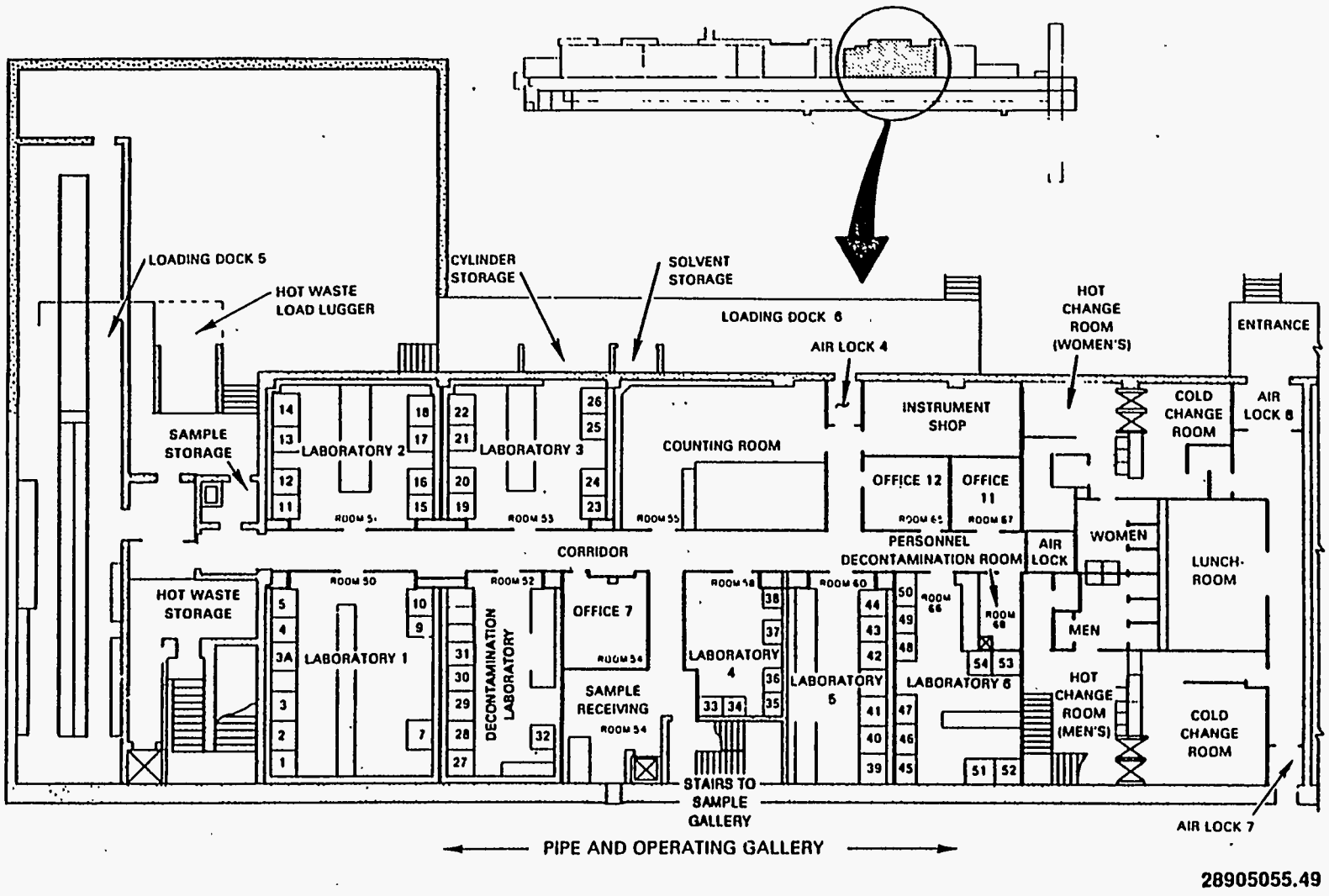


Figure 2-8. 202-A Building Analytical Laboratory--Plan View.

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Radioactive liquid wastes accumulated in the decontamination room receiving and slurping hoods are routed to the acid waste accumulation tank (TK-F10) in the Backcyle Waste System. A water jet (aspirator) is used to slurp and dilute the waste.

2.2.10 Utilities

2.2.10.1 Steam. The powerhouse (284-E Building) supplies steam at 225 lb/in^2 (gage) at 450°F to the PUREX exclusion area through an 18-in. overground line. At the northwest corner of the exclusion area, the line divides into an 8-in. and 16-in. line. The 8-in. line supplies high pressure steam to outside facilities such as the 203-A, 211-A, and 244-AR Buildings, then enters the 202-A Building where it supplies the heating and ventilation system and one end of the silver reactor steam header.

The 16-in. line divides into two 14-in. lines that enter the 202-A Building at opposite ends of the P&O Gallery. A loop is formed within the gallery by connecting the 14-in. lines with a 16-in. header and a 2-in. header. The 16- and 2-in. headers are maintained at 100 and 25 lb/in^2 (gage), respectively, by pressure reducing stations. The 100-lb/in^2 (gage) header supplies steam jets, some tank coils, and 29-lb/in^2 (gage) steam to the concentrators through individual pressure-reducing valves. The 25-lb/in^2 (gage) header supplies most of the tank coils and all service outlets.

A 2-in. line branches off the 225-lb/in^2 (gage) line at the east end of the building to supply the silver reactor steam header and to connect with the outside facilities' heating and ventilation steam supply.

High-pressure steam to the emergency exhaust turbine-driven fan is supplied from the 14-in. line before it enters the east end of the building. The steam turbine and off-gas heaters have first priority on high-pressure steam. If the steam demand causes the supply pressure to drop below 185 lb/in^2 (gage), other flows are throttled manually to raise the supply pressure to at least 185 lb/in^2 (gage).

While the plant is operating, about 85% of PUREX steam consumption (100,000 to 125,000 lb/h at full operation) is directly related to processing activities and is discharged as condensate to the 216-A-30 and/or 216-A-37-2 Crib via a radiation-monitored tank. The remaining 15% is consumed in space and water heating with condensate discharge to the chemical sewer.

2.2.10.2 Compressed Air.

2.2.10.2.1 Process Air. Process air is used for purging jet transfer lines; operating vent jets; purging tank jackets, coils, and steam sparge lines; and operating sampler jets.

Process air at 100 lb/in^2 (gage) is provided by three, 250-hp rotary screw compressors and one, two-stage, 200-hp piston-operated compressor. Each of the four compressors, which operate in parallel, has a capacity of 1,200 ft^3/min. After passing through an after-cooler and a drain pot, the compressed air flows join and enter a 4-ft diameter by 12-ft high receiver tank. From the receiver tank the air passes through parallel filters and splits into two flows: process air and instrument air.

2.2.10.2.2 Instrument Air. The instrument air passes through two filters in series, and then through one of two regenerative-type air dryers containing activated alumina absorbent. From the dryer, the air flows through a 4-in. line to the instrument air header in the P and O Gallery. Subheaders furnish instrument air to various parts of the 202-A Building and to outside facilities.

2.2.10.2.3 Breathing Air. Breathing air for mask use is provided at 100 lb/in^2 (gage) by one rotary screw compressor with 105 stdft^3/min capacity driven by a 40-hp electric motor located in the

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compressor room. The compressed air passes through a water separator into a 3.5-ft diameter by 9-ft high receiver tank.

From the receiver tank, the air passes through a filter to a 3-in. line that branches into a 2-in. header in the Sample Gallery, P and O Gallery, and the laboratory ventilation loft. Outlets and branch lines from these headers provide breathing air at 100 lb/in^2 (gage) to N Cell and the railroad tunnels. This system is not in use.

2.2.10.3 Raw Water. Raw water drawn from the Columbia River is used for process cooling, process air and compressor cooling, fire fog supply, and cell washdown. It is supplied at 100 lb/in^2 (gage) to the PUREX Plant from the 282-E Reservoir through an underground 24-in. pipe. This pipe divides into two 20-in. lines that enter opposite ends of the P&O Gallery, and connect to an 18-in. header to form a service loop. A 6-in. fire fog supply connects into each end of this header, and runs through the gallery as a separate line. Raw water to the Sample Gallery is supplied by a 3-in. header running the length of the gallery. This header connects to both ends of the P&O Gallery 18-in. header. An 8-in. supply line to the tank farm emergency cooling water supply tank, 251-A-201, ties into the east end of the 18-in. raw water header.

Raw water requirements for PUREX are about 240-million gal/month. Essentially all raw water used at PUREX is discarded to the B Pond (216-B-3 Pond).

2.2.10.4 Filtered Water. Filtered, sanitary, chlorinated water is used at the PUREX Plant for safety showers, fire protection, drinking and toilet facilities, operating area washdown, and for making demineralized water (see Chapter 4.0 for details on the demineralized and distilled water processes). The filtered water is supplied to the PUREX Plant through a 12-in. underground line from the 283-E Filter Plant. This line services facilities within the exclusion area, then branches to enter the 202-A Building at both ends of the P&O Gallery. The gallery 12-in. header runs the length of the gallery and completes a loop.

Since this water is the source of domestic supply to the area, care must be taken to avoid contamination of the system by backup flow from a raw water system or introduction of harmful chemicals. The major headers are equipped with antisiphon valves, and connections to process systems or potentially contaminated services are avoided.

The exclusion area elevated 50,000-gal tank, 2901-A, provides an emergency supply of filtered water in the event of a filter plant failure or a rupture in the distribution system.

Seven fire hydrants are located on the filtered water line around the building.

2.2.10.5 Main Power Supply. Electric power is supplied to PUREX through the 251-W Substation, which is located ~4 mi northwest of the PUREX Plant. Incoming power to the substation is supplied by the Bonneville Power Administration by two parallel 230-kV lines, with either line capable of providing the necessary power demand. At the substation, the 230-kV power is reduced to 13.8 kV and sent in two overhead lines to a switching station located ~200 yd north of the 202-A Building. If one line is impaired, the load is automatically switched to the other line. A third 13.8-kV line is also available, but requires manual switching at the plant.

From the switching station, the two buried 13.8-kV lines run to two 3,750-kVA transformers at the northeast corner of the 202-A Building. These transformers reduce the voltage to 2.4 kV. Current from the 2.4-kV supply is delivered through two normally closed buses to the east switchgear room, then to two substations, one at the east end and one at the west end of the building. Each of these substations has two 1,000-kVA transformers and one 500-kVA transformer to convert the

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2.4-kV supply to 480 V. The 1,000-kVA transformers are used for normal service, and the 500-kVA transformers are for emergency power (see discussion of standby service below).

2.2.10.6 Standby Power Supply. Standby power is available from three diesel generators located within the 202-A Exclusion Area. The three, 375-kW generators automatically deliver 2.4 kV to the standby services through the PUREX switchgear room. An approximate 30-s power outage occurs while the standby generators are reaching full load speed. After they reach full load speed, the circuit is automatically energized.

The following equipment is on the standby power circuit:

A. One instrument air compressor

B. Standby lighting throughout the 202-A Building

C. Motor Control Center 1 (MCC 1):
   1. One laboratory exhaust fan (either)
   2. Agitator in waste denitration tank (TK-F16)
   3. Instrument power and standby lighting to 203-A and 211-A Tank Farms
   4. Breathing air compressor
   5. Standby lighting in 291-A Ventilation Stack Building
   6. East Sample Gallery hood exhaust fan
   7. Building 295 ac
   8. 216-A-42A Valve Box.

D. Motor Control Center 3 (MCC 3):
   1. One Sample Gallery vacuum pump (either)
   2. Solvent Pump R5-1
   3. Instrument recorder, exterior south wall of the 202-A Building
   4. White Room exhaust fan
   5. PR Room exhaust fan
   6. West Sample Gallery hood exhaust fan
   7. Evacuation sirens
   8. Building 292-AA
   9. K Cell process controller.

E. Motor Control Center 60 (MCC 60):
   1. Agitator in acid feed tank (TK-U5)
   2. Acid Pump U5-1
   3. Acid Pump U5-2
   4. 206-A Building lighting
   5. Acid pump U8-1
   6. Acid pump U8-2.

F. Instrument power panels at both ends of the 202-A Building.

G. Power Panel A Building 2701-AB.

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2.2.11 Fire Protection System

In the 202-A Building, the canyon cells containing large inventories of organic solvent (i.e., G, H, J, and K Cells) are equipped with a temperature-activated automatic sprinkler foam system using the Light Water Aqueous Film Forming Foam System which simultaneously applies foam to the adjoining ventilation tunnel. A similar system is used in R Cell and for TK-RIA in the white room. Detection of fire in these cells is by rate-compensated thermal detectors that sound alarms locally and at the central fire station located between 200 East and 200 West Areas. Detectors are spaced approximately every 20 ft, and are tested and supervised. Fire fighting personnel and equipment can arrive on the scene from the 200 Area Fire Station within 6 min.

Fire protection in the other canyon process cells is provided by a system of peripherally mounted spray nozzles controlled by manual gate valves. The nozzles were installed at the time of construction, and are mounted at 9- to 12-ft spacing in the cells.

Manual actuation of the systems is dependent upon the detection of abnormal conditions by "Fireye" photoelectric flame detectors, set approximately every 50 ft through the cells. The fire detection units activate alarms in the Central Control Room and in the dispatcher's office. The Fireye detectors will be replaced, if they fail, with Fenwal "Detect-a-fire" elements, which actuate alarms when the elements reach 275 °F.

Smoke detectors are installed in the canyon crane cabs. The detectors sound an alarm in the Central Control Room and in the central fire station. The crane electrical panels are enclosed and provided with a Halon-1301 extinguishing system connected to the fire alarm system.

Automatic sprinkler protection on standard wet and dry pipe systems is installed in the Hot Shop and the storage portion of the Storage Gallery in the 202-A Building. In addition, N Cell, Q Cell, and the plutonium storage area have automatic wet-pipe sprinklers with both local and 200 Area Central Fire Station alarms. All sprinkler installations are low-temperature, closed-head systems.

Automatic sprinkler protection on standard wet and dry pipe systems is also installed in the 202-A Annex, including the laboratories, laboratory storage area, AMU area, offices, and shops.

2.2.12 Ventilation

The ventilation system in the 202-A Building is designed and operated to keep normal work areas free of radioactive contamination by maintaining airflow from zones with no radionuclide content into zones of progressively greater contamination potential. The ventilation air is supplied by four systems: canyon, Sample Gallery, service area, and laboratory.

2.2.12.1 Ventilation System 1. This system serves the areas of greatest radioactivity (the canyon and process cells), including all process vessel vents except the metal dissolvers, the ammonia scrubber waste (ASW) concentrator, and all E Cell vessels except TK-E6. A schematic diagram of Ventilation System 1 is shown in Figure 2-9.

Air that has been filtered, washed, humidified, and temperature-adjusted is supplied to the canyon at ceiling level and dispersed through ducts located above the craneway. The air then flows down to the canyon deck where it is drawn down around the cell cover blocks into each of the cells. From the cells, the air is exhausted through ports into the air tunnel, then through the 291-A Filter to the stack.

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The supply air is delivered by three air-handling systems. Blowers SF-1 and SF-1A, rated at 73,000 ft^3/min each, are located in the process blower room in the west service annex. Normally these blowers operate in parallel, throttled sufficiently to maintain the desired static pressure in the canyon. Either blower will furnish the minimum safe airflow to the canyon. A booster fan (BSF-1), which can furnish 6,640 ft^3/min, augments the air supply to the Hot Shop. Blower SF-1B, rated at 19,100 ft^3/min and located in the end of the east crane area, supplies ventilation air to the east crane maintenance platform and exhausts to the canyon.

The exhaust side of the system from the canyon air tunnel consists of two fiberglass filters, one standby high efficiency particulate air (HEPA) filter in parallel, a two-stage testable HEPA filter downstream of the fiberglass filters, three electric exhaust fans (EF-1-1, EF-1-2, EF-1-3), and a steam turbine fan (EF-1-4) for emergency standby, which exhaust to the 291-A-1 Stack. These four fans are mounted on a concrete platform near the base of the stack. In addition, the vent flow from the dissolver off-gas (DOG) Treatment System is discharged to the stack.

Equipment Disposal Tunnel 218-E-15 is exhausted through a high efficiency, replaceable cartridge filter to Exhaust Fan EF-1-7. Tunnel 218-E-14 vents back through the partially sealed entrance into the railroad tunnel and the canyon.

The vent system is designed to maintain safe differential pressures (d/p) between the process area and the personnel-entry portions of the building, assuming that the ventilation systems in these areas are functioning properly. If a power failure or loss of instrument air shuts down the supply and exhaust blowers, the steam-driven fan (EF-1-4) automatically starts and the supply fan dampers open.

If the canyon pressure increases above 0.05 in. of water below atmospheric, the supply fans shut down with the dampers open so the pressure can be reduced. Gravity dampers (vacuum breakers) in the canyon open to admit air to prevent the canyon pressure from decreasing below 0.7 in. of water below atmospheric.

2.2.12.2 Ventilation System 2. This system services the areas of the building that are routinely occupied or entered by the work force, but are regulated because of a potential for contamination. As shown in Figure 2-10, the areas serviced by this system include the Sample Gallery, N Cell, canyon lobby, PR Room and corridor, R Cell (276-A Vault), Q Cell, and U Cell.

The supply air is filtered, water-washed, temperature-adjusted, and delivered by two air-handling systems. Blowers SF-2 and SF-2A, both rated at about 40,000 ft^3/min, are located in the process blower room and, except for R Cell and U Cell, supply the serviced areas through ducts extending to both ends of the Sample Gallery. The R Cell and U Cell air supply streams are delivered at atmospheric pressure through evaporative coolers and steam coil heaters, with either the heaters or coolers operating, depending on the seasonal conditions.

As shown in Figure 2-10, air from this system is exhausted through HEPA filters in five streams by five electrical motor-driven fans. A sixth fan (EF-2-7A) is maintained for backup for EF-2-7, which exhausts the PR Room, N Cell, and Q Cell. From the fans, each stream is vented to the atmosphere through five, 70-ft high stacks outside the building.

2.2.12.3 Ventilation System 3. This system, shown schematically in Figure 2-11, services the areas considered to be uncontaminated and to have the least potential for becoming contaminated. These areas include the P&O Gallery, Storage Gallery, Pulse-Infinitely Variable Room (PIV Room), AMU levels, and service areas (shops, offices, lunchroom, etc.) except for the analytical laboratory.

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The supply air is filtered, water-washed, humidity-adjusted, and delivered by two air-handling systems. Fans SF-3 and SF-3A in the service blower room, located west of the process blower room in the west service annex, supply the serviced areas through ducts, dampers, and local area reheat coils. Each fan has a capacity of 70,000 ft^3/min, which is 50% of the required flow for the system. Booster Supply Fans BSF-6 and BSF-7 are employed to increase airflow from the PIV Room to the Storage Gallery. Fans BSF-8 and BSF-9 recirculate PIV Room air through water coil coolers to remove the heat produced by the motor-generator sets.

The exhaust side of the system contains several individual fans. All exhaust streams are presently unfiltered, except the White Room exhaust air duct, which contains a single-stage HEPA filter. Radiation detection devices, which automatically shut the fans off if radioactive material is entrained in the exhaust air, are installed in the other exhaust air ducts of the P&O Gallery. Several other fans not shown in Figure 2-11 are used to exhaust the office and shop areas.

2.2.12.4 Ventilation System 4. This system services the PUREX Analytical Laboratory and is largely independent of other building ventilation systems. As shown in Figure 2-12, the supply air is filtered, water-washed, humidified, and delivered by two air-handling systems. Supply Fans SF-4 and SF-4A are located in the laboratory ventilation loft, which is the floor above the laboratory. The air supply of 30,000 ft^3/min is furnished by operating both of these identical fans in parallel. A portion of this air is used for makeup of constant-humidity air to replenish losses from the supply (furnished by two refrigeration air conditioners) to the laboratory counting room and instrument shop.

The exhaust side of the system consists of two parts. The decontamination room, laboratory hood rooms, and sample storage room are exhausted through HEPA filters by Fans EF4-1 and EF4-A. Normally, one blower is operating and one is in standby mode. Both are connected to the emergency power supply. If the normal power supply is interrupted, one of the fans will be automatically switched to emergency power. The fan must be manually switched back to normal power for resumption of service. Each fan exhausts to a separate 70-ft stack (296-A-5A and 296-A-5B).

2.3 OUTSIDE FACILITIES

Facilities for air filtration, chemical storage, solid and liquid waste disposal, cask loading, acid recovery, and office space are located in the vicinity of the 202-A Building.

2.3.1 Air Ventilation System (291-A Facility)

The 291-A Facility discharges filtered process ventilation air and gases from PUREX to the atmosphere. The equipment includes the ventilation air filters, fans, stack, and stack sample house.

2.3.1.1 Ventilation Air Filters. There are three ventilation air filters located south of the 202-A Building for removal of solids from PUREX process air before it is discharged to the atmosphere. The two older filters were designed to remove 99.9% of the particulates from the air stream. These two filters, operated in parallel, are similar in design but have significant differences. Each has two glass-fiber bed sections--the prefilter and the cleanup filter. The overall dimensions of each filter are 82 ft long by 52 ft wide by 13 ft deep. In the northern filter (Filter 1), the prefilter is one bed, 7 ft deep, packed with 115-K Fiberglas (Owens-Corning Fiberglas Company, Inc.). In the middle filter (Filter 2), the prefilter consists of five separate layers, each packed with a different density of fiber glass. The airflow direction is downward through Filter 1 and upward through Filter 2. The

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cleanup filter in each unit consists of 132 American Air Filter Company "Deep Bed Filter" units 1 in. thick with a total area of ~50-ft^2/unit. The filters are designed for a pressure drop of 4 in. of water with air velocities of 50 ft/min in the prefilters, and 20 ft/min in the cleanup filters.

A third main filter (Filter 3), which could operate in parallel with the older two filters, is in standby service. The filter cell, which is below grade, is about 56 ft long, 44 ft wide, and 13 ft deep. The cell is equipped with two banks of 85% American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) bag-type prefilters and three banks of HEPA filters, all in series. The two prefilter banks and the first bank of HEPA filters are designed to permit the upper quarter of the banks to be lowered while the remaining three-quarters of the banks stay in place. This feature permits bypassing of a bank or banks of filters in case an excessive pressure drop from particulate loading occurs across one or more of the filter banks. The final two HEPA banks cannot be lowered. The filter elements required are in the Storage Gallery to be installed when the filter is activated.

Fire screens are installed in the inlet duct to the new filter cell and in front of all the filters except the final HEPA bank. A water seal, which when filled with water will stop airflow, is in the exit air duct. The seal is automatically filled by gravity discharge from a 10,000-gal capacity water storage tank when fire is detected by a sensing element located in the filter cell inlet duct, or by a manually operated switch located in the 291-A Facility (Sample House).

Instrumentation is provided to monitor d/p across the filter, the individual filter banks, and the fire screen in the filter inlet duct. Differential pressure indicators and high-level alarm switches are located in Sample House 4. Differential pressures in excess of established limits are annunciated in the 202-A Building Power Control Room.

The south filter (located in the 291-AE Building) is downstream of and operated in series with filter numbers 1, 2, and 3. Thus the fourth filter utilizes the other three as prefilters. It contains 10 modular filter units incorporating isolation valves upstream and downstream of each unit. A typical module filter unit consists of a housing with the following order of internal components: filter-in-place testing assembly, 4 by 3 array of HEPA filters, and filter-in-place testing assembly. Each 4 by 3 array of HEPA filters accomodates 14,000 ft^3/min at 1-in water gage (WG) dp. A coarse fire screen is installed upstream of the filters. Flow monitoring stations are located in this ductwork downstream of each filter module. Instruments for readout of the airflow are located on the instrument panel of the 291-AE Building. Exhaust air upstream and downstream of the HEPA filters can be sampled.

Instrumentation is provided to measure: the pressure drop across the first and second stage of each module and the gamma radiation at the first stage of each module. Two common alarms, one for high d/p and one for high radiation are located in the dispatcher's office.

2.3.1.2 Process Stack 291-A-1. Located immediately south of the southeast corner of the 202-A Building is Process Stack 291-A-1, which is constructed of reinforced concrete and rises to 200 ft above grade. The exhaust air rises through a free-standing, 7-ft inner diameter (ID), stainless steel liner. The top of the stack is capped to cover the annulus between the stack and the liner. The bottom of the liner has a dished head that drains to a collection tank. The inlet breaching for the ventilation air is baffled and welded to the liner at an angle of 45° upward.

Six 8-in. nozzles enter the liner below the ventilation air breaching. Three are for routing DOG to the stack, while the other three are spares.

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Stack gas sampling points are located near the top and bottom of the stack. Lines from these points run to the 292-A Stack Gas Sampling Building located east of the stack. Radiological and environmental sampling and monitoring equipment is located in the sample house. The stack is also equipped with flowrate and totalizing instrumentation. A wash system including a booster pump is installed to flush the inside wall of the liner.

2.3.2 293-A Building

The 293-A Building is a small reinforced concrete structure near the 291-A-1 Exhaust Stack. The building has four processing cells on two levels containing two absorption columns that remove some of the oxides of nitrogen (NO_x) from the DOG before it is released through the process stack to the environs. The oxides of nitrogen are recovered as nitric acid, which is recycled for concentration and process use. The building cells and pipe pit are vented through a single-stage HEPA filter by a fan and exhausted to a 50-ft stack (296-A-14).

2.3.3 293-AA Facility

The 293-AA Facility, located south of the 202-A Building, is a concrete retention area that houses equipment supporting the Back-up Facility located in the 293-A Building. Included in the 293-AA Facility are three 10,000-gal hydrogen peroxide storage tanks, four metering pumps, and the piping and instrumentation required for handling hydrogen peroxide. Liquids spilled in the 293-AA Facility will flow to a sump in the north end of the building. A sump pump will transfer liquids from the sump to either the chemical sewer, storage drums, or to the ground.

2.3.4 294-A Building

The 294-A Building, located north of the 293-A Building, consists of an above-grade steel shack over a covered below-grade cell containing three filters, one for each of the DOG streams from the 202-A Building. Each filter provides secondary deentrainment of the off-gases prior to treatment in the 293-A Building.

2.3.5 212-A Building

This building, now inactive, was formerly used for delivering or withdrawing liquid radioactive waste to or from the 202-A Building. The 212-A Building is located against the outside south wall of the 202-A Building, and is constructed of steel. A roll-up door for entry of trucks transporting casks or tank trailers is located in the west end of the building.

Underground pipes connect PUREX cell tanks with a shielded cubicle in the 212-A Building, where connections are made to transfer the solutions into or out of the transport vessel. The building contains tanks for makeup of chemical solutions for flushing transfer lines and casks.

2.3.6 213-A Building

The 213-A Building, located south of the 202-A Building, is a steel "Butler Building" formerly used for transporting liquid waste from shipping casks to PUREX cells. After the solution transfer

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lines became permanently plugged, the solution load-in function was moved to the 212-A Building. The 213-A Building is currently used for temporary storage of contaminated dry waste.

2.3.7 Contaminated Equipment Storage Tunnels (218-E-14 and 218-E-15)

An earth-covered tunnel with two parallel branches extending southward from the 202-A Building is used for storage of large pieces of failed process equipment. The tunnel is an extension of the rail spur on which reactor fuels are delivered to the plant for chemical processing. Failed equipment that is too radioactive and bulky for immediate removal from the canyon, is loaded on railroad cars and moved southward into the tunnel branches, uncoupled, and stored. When significant decay of the radioactive fission products contaminating the equipment has occurred, the equipment may be retrieved and sent to the burial ground for permanent disposal. Railroad cars in the tunnel are moved by a remote-controlled, battery-powered locomotive.

Both tunnel branches are nominally 19 ft wide and 22 ft high. The older branch (218-E-14) is a straight extension of the main tunnel from 202-A Building, while the newer branch (218-E-15) angles off eastward from the main tunnel about 150 ft south of the 202-A Building, then straightens and parallels the older branch. The older branch is supported by wood shoring, but steel is used to line the ceiling of the newer branch. Both branches are isolated by water-filled shielding doors. The older branch extends 358 ft south of the shielding door, while the newer branch is 1,680 ft in length.

2.3.8 Uranium Storage Tank Farm (203-A Tank Farm)

The 203-A Tank Farm is used for the storage and shipment of UNH product from PUREX. In addition, UNH waste solutions from the UO_3 Plant are concentrated for rework, and nitric acid recovered at the UO_3 Plant is stored. The 203-A Tank Farm is located about 100 yd north of the 202-A Building, and contains four 100,000-gal stainless steel tanks for UNH storage, and two 7,300-gal tanks and one 13,800-gal tank for nitric acid storage. A 14,000-gal tank containing a steam coil and vents to a condenser is used for organic removal and concentration of waste UNH. Condensate from waste UNH concentration is collected in a 4,000-gal tank.

The storage tanks are mounted on concrete pads and surrounded by dikes that provide containment basins in the event of tank leaks.

Uranyl nitrate hexahydrate solution is pumped from the 203-A storage tanks to tank-trailers for shipment to the UO_3 Plant. The 203-A Building, located outside the containment dike, houses the pumps and controls for solution transfers.

2.3.9 205-A Building

This structure is a transite shack containing lead-encased silica gel beds formerly used for decontamination of UNH product. The building, now unused, sits on a concrete pad located inside the 203-A Tank Farm enclosure.

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2.3.10 Acid Fractionator Building (206-A Building)

The 206-A Building houses the vacuum fractionator and associated equipment used for concentrating nitric acid recovered from PUREX and the UO_3 Plant. The concentrated acid is stored in U Cell before it is returned to the PUREX process. The 206-A Building is a reinforced concrete structure located at the northwest corner of U Cell. Outside dimensions of the building are 28 by 35 by 45.5 ft abovegrade at its maximum height. Inside the building, a pit containing the condensate tank extends 10 ft below grade. Equipment may be removed through a port in the building ceiling normally sealed with 8-in. thick cover blocks. On the east wall of the building are two personnel access doors secured with electrically operated locks.

2.3.11 Chemical Tank Farm (211-A Tank Farm)

Bulk liquid chemicals for use in the PUREX process are stored in the 211-A Tank Farm located north of the 202-A Building. The service, capacity, and material of construction of each tank are given in Table 2-1.

Adjacent to the tanks is the 211-A Building constructed from steel and transite. The 211-A Building contains pumps to supply chemicals from the tanks to the AMU area in the 202-A Building. The water demineralizer equipment is also located in this building.

2.3.12 Chemical Storage Warehouse (2714-A Building)

Dry and liquid containerized chemicals for PUREX are stored in the 2714-A Building located north of the 202-A Building. The corrugated steel building is set on a concrete dock next to a railroad spur. A paint shop is housed in the north end of the building.

Table 2-1. Tanks in 211-A Tank Farm.

Tank	Service	Volume (gal)	Material
TK-10	$Cd(NO_3)_2$	4,300	309 stainless steel
TK-11	NH_4F - NH_4NO_3	100,000	304-L stainless steel
TK-12	57 wt% HNO_3	100,000	304-L stainless steel
TK-20	50 wt% NaOH	30,000	Carbon steel
TK-21	45 wt% KOH	30,000	Carbon steel
TK-30	Demineralized water	50,000	Aluminum
TK-40	Hydrocarbon diluent (NPH)	65,000	Carbon steel
TK-41	Tributyl phosphate (TBP)	30,000	Carbon steel
TK-42	$Al(NO_3)_3$-$9H_2O$ (ANN)	7,850	347- and 304-L stainless steel
TK-50	93 wt% H_2SO_4	8,400	Carbon steel

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2.3.13 Low-Level Radioactive Liquid Effluent Disposal Facilities

The principal low-level radioactive liquid effluents from PUREX are process cooling water, chemical sewer waste, steam condensate, process condensates, and ammonia scrubber waste (ASW) condensate.

2.3.13.1 Pond 216-B-3. Cooling water and chemical sewer liquids are usually uncontaminated and are discharged to a surface pond. Cooling water is routed through a diversion station with capability for proportional sampling, radiation monitoring, and emergency discharge to a lined trench (216-A-42) in case the liquid is radioactive. Normally flow goes to a second diversion box where flow is directed to the 216-B-3 Pond. The 216-B-3 Pond, which also receives chemical sewer waste, is an artificial lake covering several acres about 1 mile northeast of the 202-A Building. Chemical sewer waste is routed through a diversion station with capability for proportional sampling, radiation monitoring, and emergency routing to the diversion basin.

2.3.13.2 Cribs. Steam condensates (considered low activity liquids) are sent to rock-filled caverns (or cribs) located at various sites in the vicinity of the 202-A Building. Typically, a cavern, or crib (see Figure 2-13) consists of a perforated distributor pipe laid at a slight slope on a bed of coarse rock covered with layers of gravel and sand. This bed is covered with paper or plastic sheeting to prevent silt from seeping into and plugging the gravel bed. The upper portion of the crib is backfilled to grade with dirt. A riser at the end of the distribution pipe vents to the surface. Liquid waste entering the distributor pipe leaks out through the perforations and disperses throughout the porous bed. A percolation rate of 200 gal/d-ft^2 of crib is estimated for this disposal method.

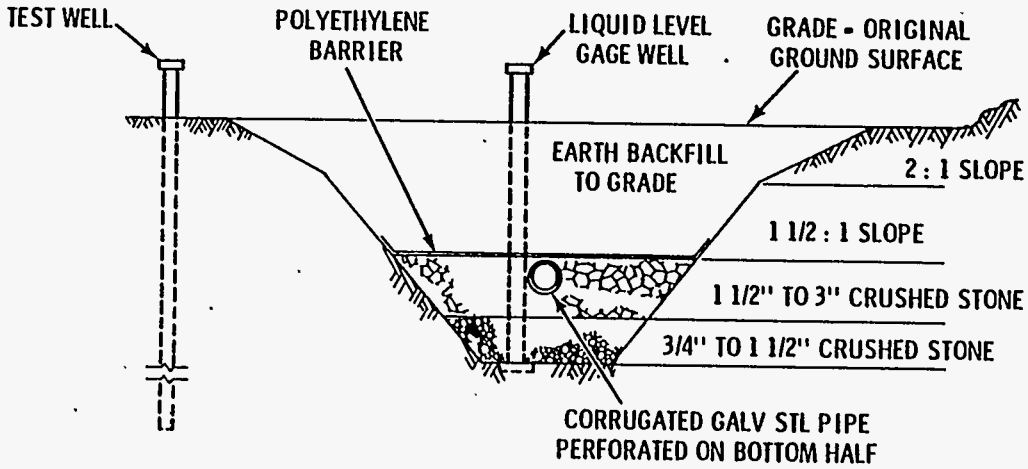
Process condensate (PDD) from the Final Uranium Cycle (and occasionally from Concentrators E-J8-1 and E-H4-1) is neutralized with KOH, combined with the ammonia scrubber distillate (ASD) (see below), sampled, monitored for pH and radioactivity (an alarm sounds if the preset limits are exceeded and the stream is diverted to an 18,000-gal holding tank), and discharged through an 8-in. diameter stainless steel pipe to UGS. The distributor pipe, which is 222 ft long, is buried 30 ft below-grade and is paralleled by an abandoned 8-in. diameter vitreous clay distributor pipe. The crib runs north and south and is "vee-shaped" in cross section.

Steam condensate (SCD) from PUREX is routed through a tank south of the 202-A Building before final crib disposal. The liquid is continuously checked for radioactivity with an in-line monitor. An automatic flow diversion to the diversion basin is activated if radioactivity is detected. Crib 216-A-30, used for the disposal of steam condensate, is located about one-fourth mile east of the 202-A Building. The crib contains two distributor pipes arranged so that either or both ends of the crib can be used. A 15-in. diameter, perforated, corrugated, galvanized steel pipe extends for 700 ft along the center of the crib. Another 16-in. steel pipe parallels the first pipe for 700 ft, then angles across to the centerline of the crib and extends another 700 ft down the center of the crib.

For the final 700 ft, this pipe is made of corrugated, 15-in. diameter steel, and is perforated for water drainage. Because of the uneven surface of the crib, the pipes are buried beneath from 4 to 18 ft of fill.

Ammonia scrubber waste condensate (ASD) is sent to the 216-A-45 Crib. In addition to the monitoring and diversion provisions described above for the PDD disposal system, this combined stream is sampled and analyzed for ammonia concentration.

TYPICAL CRIB CROSS SECTION



TYPICAL CRIB LONG. SECTION

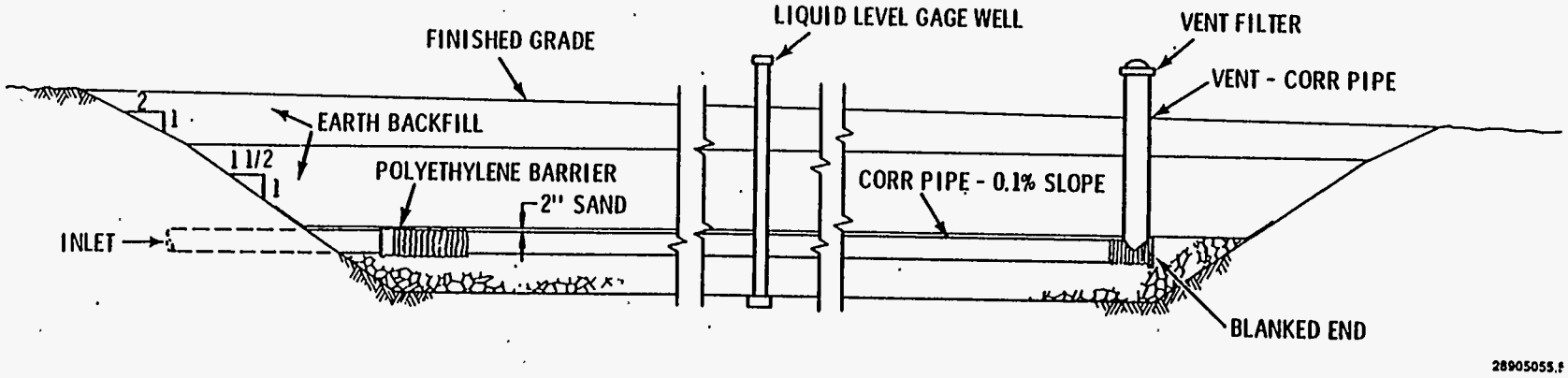


Figure 2-13. Typical Liquid Disposal Crib.

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Steam and process condensates and acid overflow from the 203-A Tank Farm are batch collected, sampled, and, depending on sample radioactivity, are routed to either the chemical sewer or PUREX solvent extraction for rework.

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CANYON

The Canyon area is a long (1005'), narrow structure which is subdivided into a single row of 12 process cells (see Figure 6-14, 6-15). The cells run the length of the building between a Hot Pipe Trench and the Sample Gallery. The cells are designated as follows:

Cells	Function
A, B, C,	Metal Dissolution
D	Metal Solution Storage
E	Feed Preparation
F	Waste Treatement and Process Ventilation
G	No. 1 Solvent Recovery
H	First Cycle Codecontamination
J	First Cycle Partition
K	Uranium Decontamination and Concentration
L	Plutonium Decontamination and Concentration
M	Equipment Decontamination and Storage

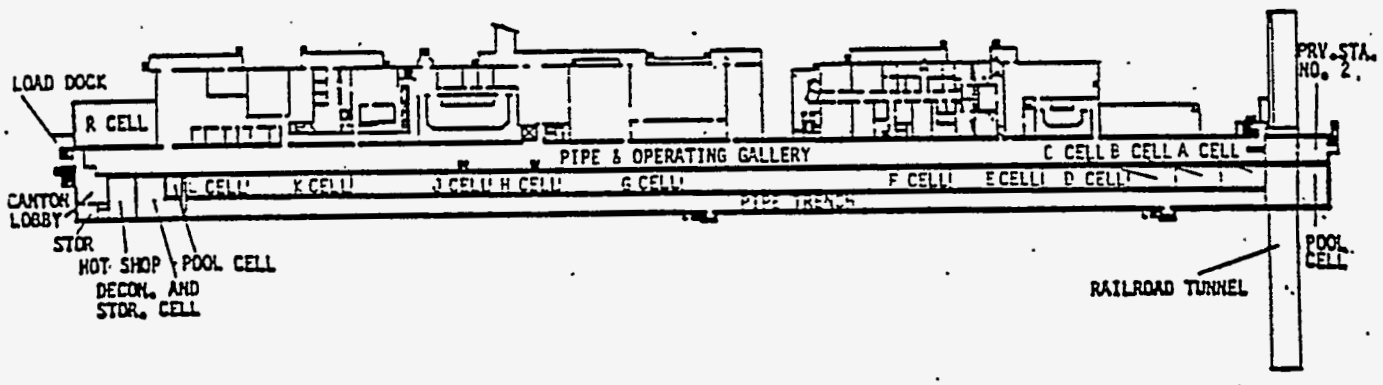

FIGURE 6-14. Purex Cell Location

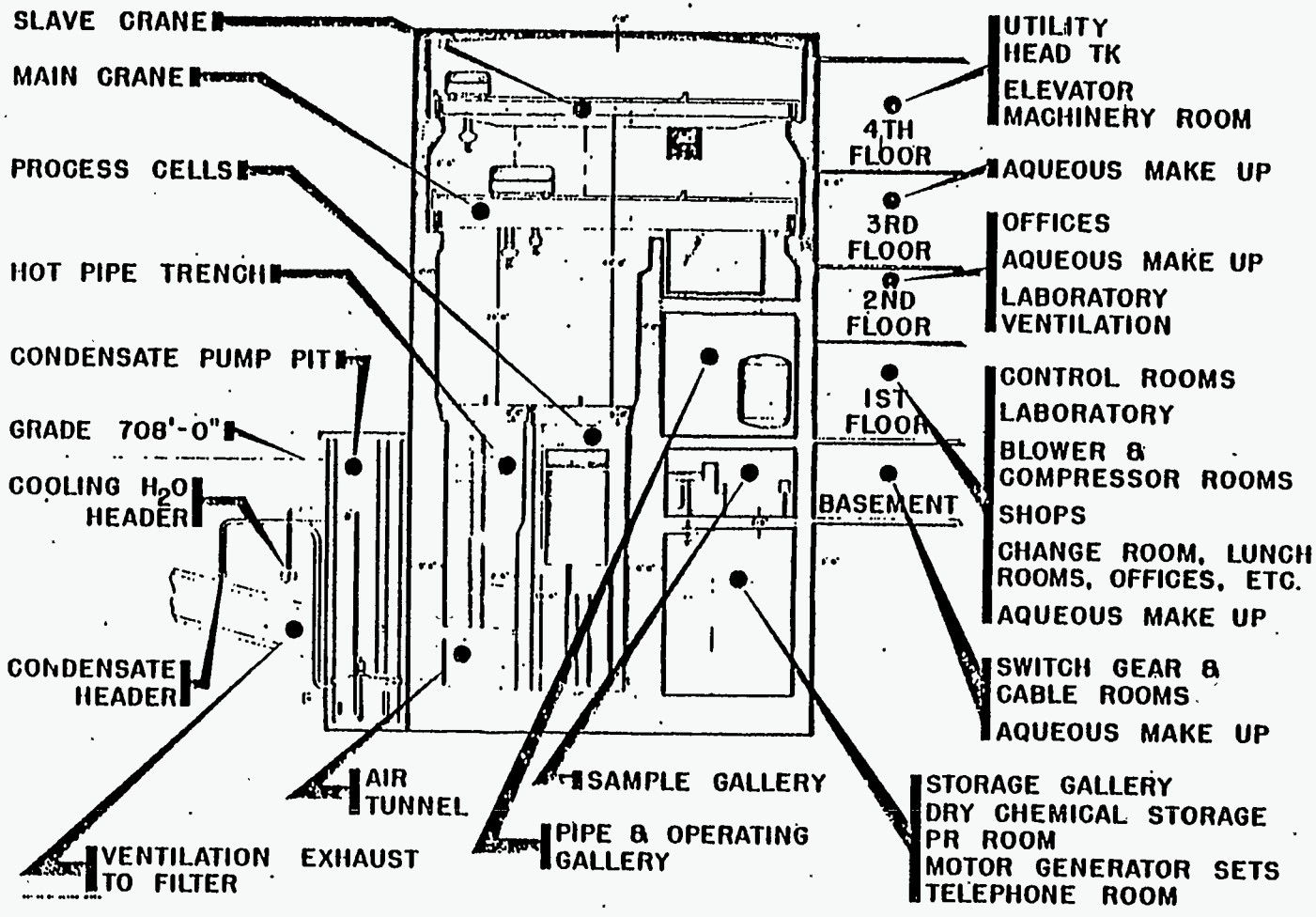

FIGURE 6-15. Typical Cross Section, 202-A Building.

The cell designations indicate individual processing functions. The designations do not mean that physical partitions separate one cell from another. The actual cell locations were determined by ventilation and radiation criteria, rather than by functional boundaries.

Three other cells not in the canyon proper (see Figure 6-16) include:

Q Cell - Neptunium Ion Exchange and Loadout Cell
R Cell - No. 2 Solvent Recovery
U Cell - Acid and Lab Waste Storage Vault.

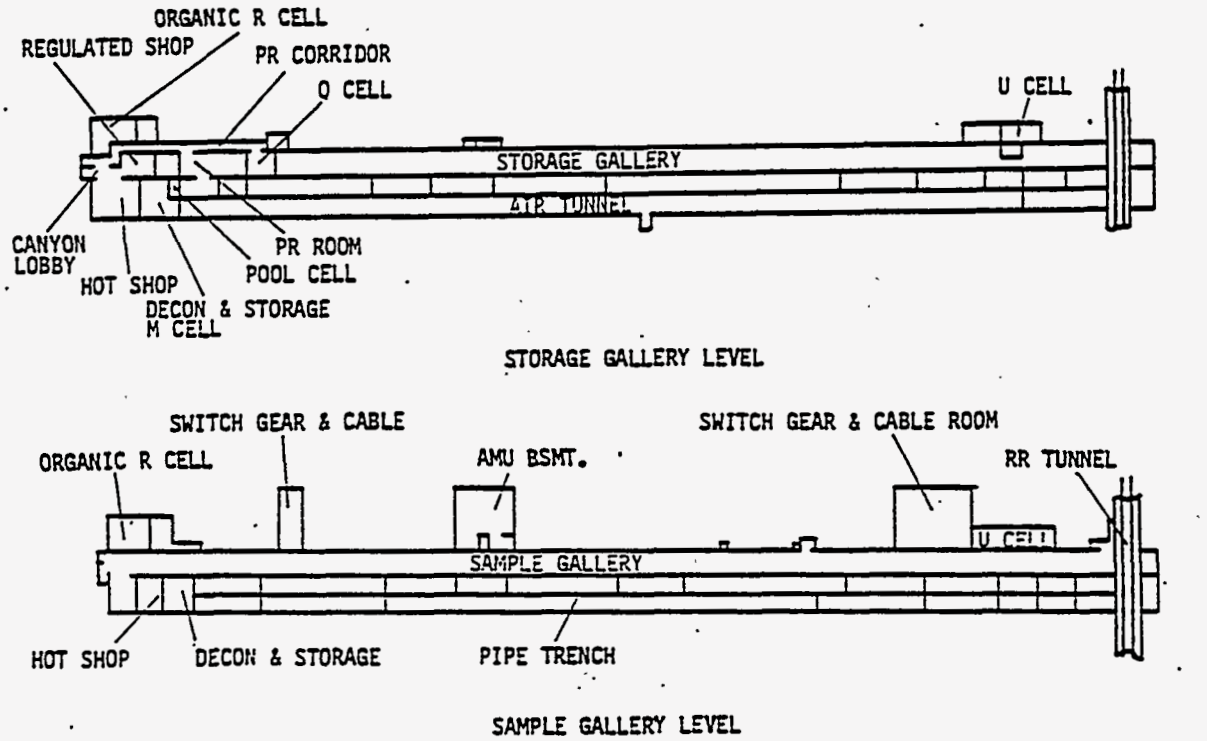

FIGURE 6-16. Q, R and U Cell Location

Q Cell is located at the storage Gallery level, adjacent to the PR Room. Q Cell was added to the building so that neptunium recovered and decontaminated in the J Cell Package could be purified before it is shipped off-site.

R Cell (276-A) decontaminates and stores solvent recovered in the No. 2 Solvent Recovery System. R Cell is located below grade at the west end of 202-A. This cell is operated from the Central Control Room.

The Air Tunnel(4), which lies directly below the Pipe Trench, exhausts ventilation air from the individual cells to the main ventilation exhaust filters. From there, exhaust is routed to the main stack.

Two Crane Ways(1) extend most of the length of the upper part of the canyon. The lower Crane Way supports two gantry-type, 40-ton-capacity cranes. A 10-ton-capacity auxiliary crane is on the upper crane way. The two large cranes are equipped with periscopes to view remote maintenance of cell equipment. The operators work in shielded cabs(2) behind a parapet. The third crane, a slave unit, is remotely controlled from the other two cranes. The smaller crane assists in removing large equipment items from cells.

Crane Cab Gallery

The Crane Cab Gallery is located above the P & O Gallery. A parapet wall, between the Gallery and upper Canyon, provides a shielded area so that the operator entering or leaving the cab is protected from direct radiation coming from the Canyon. The cabway extends the full length of the Crane Cab Gallery.

Since the Canyon is so large and complex, we could not possibly study it in detail in an introductory manual. So far, we have mentioned particular cell functions. We have glimpsed the Hot Pipe Trench, the Air Tunnel and the Crane Ways in the upper canyon. Next, we will look at the four galleries bordering the canyon on the north.

GALLERIES

Four galleries, located on different levels, parallel the Canyon on its north side. The galleries, from the bottom level to the top level, are (see Figure 6-18):

- Storage Gallery (4)
- Sample Gallery (3)

Storage Gallery

The Storage Gallery (see Figure 6-19) contains dry chemicals and operating supplies. Pulse generator alternator controls and telephone exchanges are located in this gallery. The west end of the Storage Gallery, a separate zone, contains:

- The neptunium purification and loadout facility (Q Cell)
- The plutonium product handling and removal (PR) room
- The oxide conversion facility.

These facilities are discussed in other manuals.

Sample Gallery

The Sample Gallery (see Figure 6-19), located above the Storage Gallery, extends the full length of the building. The Sample Gallery contains the remote samplers for obtaining process solution samples from the cell equipment. The samples are sent to the Sample Receiving Room in the laboratory by a dumbwaiter.

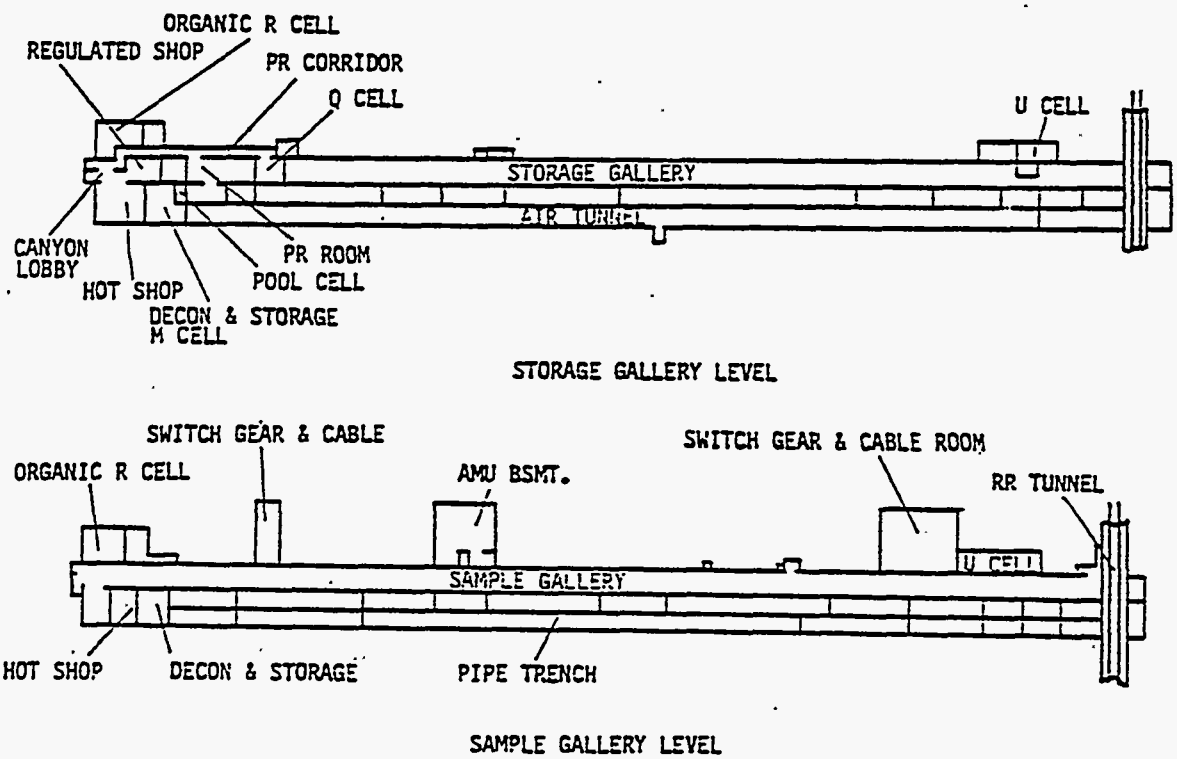

FIGURE 6-19. Storage and Sample Gallery Levels

major portion of the P & O Gallery. The ventilation barrier allows the air to be drawn from the P & O Gallery through the White Room to prevent potential contamination from reentering the Gallery.

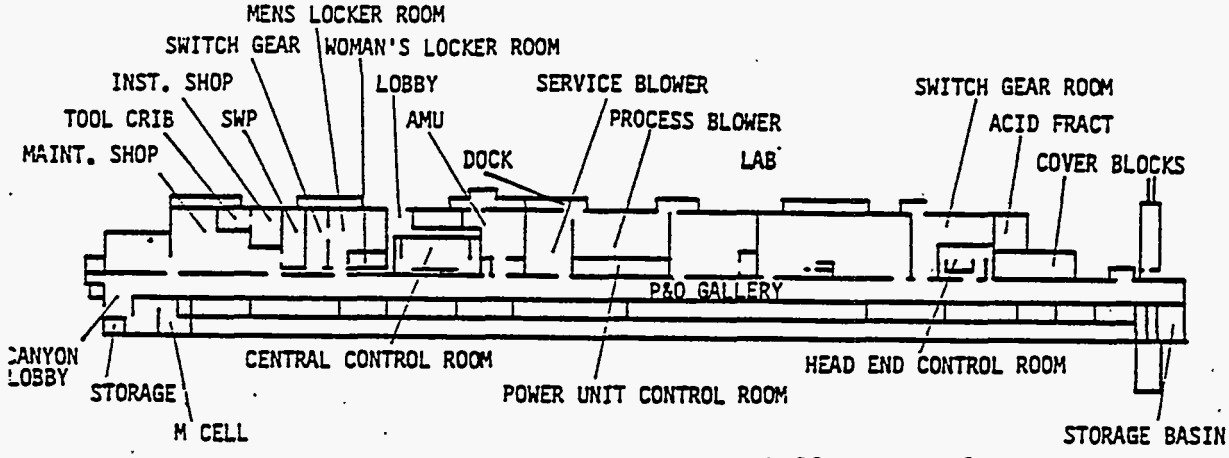

FIGURE 6-20. Pipe and Operating Gallery Level

The P & O Gallery level extends the full length of the building. The majority of cold piping and services to cell equipment originates in the P & O Gallery and terminates at various levels in the cells. The following operating equipment is located in the Gallery:

- Centrifuge bowl spray pumps
- Organic blend tank
- Dissolver drown water tanks.

A high-pressure steam reducing station is located at the east end of the Gallery in a ventilated area and outside the west end.

Crane Cab Gallery

The Crane Cab Gallery (see Figure 6-21) is located above the P & O Gallery. A parapet wall, between the Gallery and upper Canyon, provides a shielded area so that the operator entering or leaving the cab is protected from direct radiation coming from the Canyon. The cabway extends the full length of the Crane Cab Gallery.

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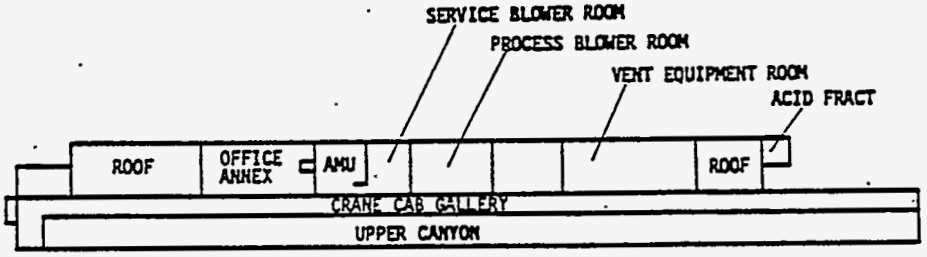

FIGURE 6-21. Crane Cab Gallery Level

SERVICE ANNEX

Bordering the galleries on the north side is the third main structural component of Purex - the Service Annex.

The Service Annex consists of two separate annexes called "East Annex" and "West Annex."

East Annex

The East Annex is a two-level structure (see Figure 6-22) which contains the:

- Analytical Laboratory
- Switchgear Room
- Head-End Control Room.

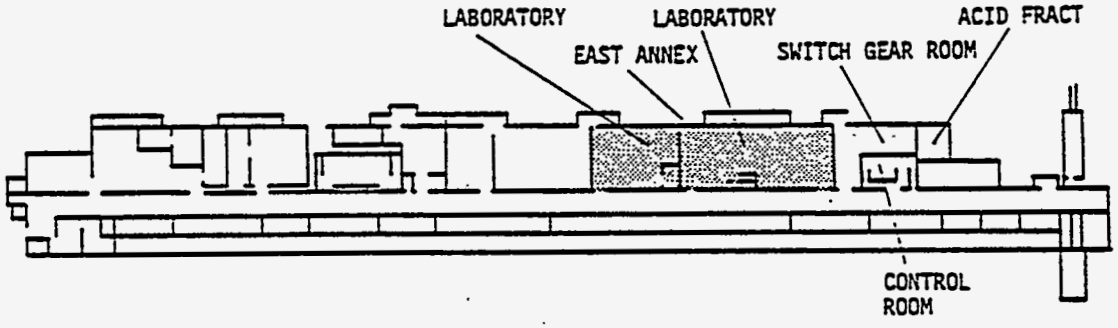

FIGURE 6-22. East Service Annex

Analytical Laboratory. The Analytical Laboratory, adjacent to E and F Cells, is a two-story structure. The first floor of the laboratory contains the glass and instrument repair shops, change rooms, lunchroom and analytical equipment. The upper floor houses the heating and ventilation equipment.

The Analytical Laboratory has a complete ventilation system separate from the rest of the Purex Building. The separate ventilation system reduces the hazards involved in handling radioactive materials in open hoods. It also allows the laboratory to continue operations during periods of shutdown in the main building.

Electrical Switchgear Room

Switchgear for the electrical distribution system is located in the 2400/480-V switchgear room next to the Head-End Control Room (see Figure 6-23). Another 480-volt switchgear room is near the Maintenance Shop in the West Annex. Both switchgear rooms are located at the P & O Gallery level.

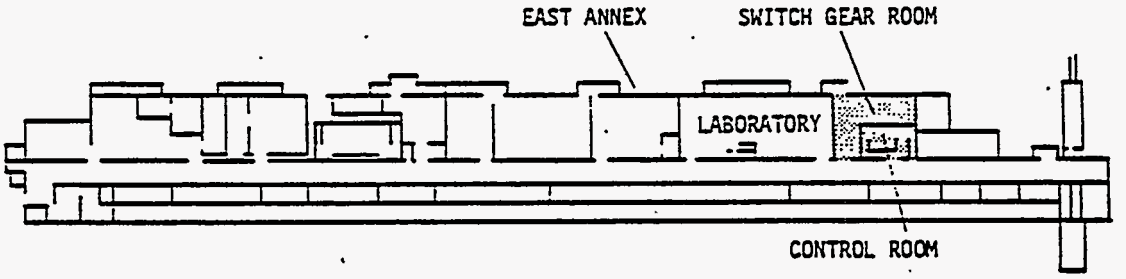

FIGURE 6-23. East Service Annex

Head-End Control Room

The Head-End Control Room is discussed in a later section of this manual on control rooms. Now let's look at the West Annex.

Questions

West Annex

The West Annex is a five-level structure (see Figure 6-24) which contains:

- Maintenance Shop
- Electrical Switchgear Room
- Locker Room and Change Room
- SWP Lobby
- Offices
- Lunchroom
- Central Control Room
- Aqueous Make-up Facility (AMU)
- Service and Process Blower Rooms
- Compressor Room.

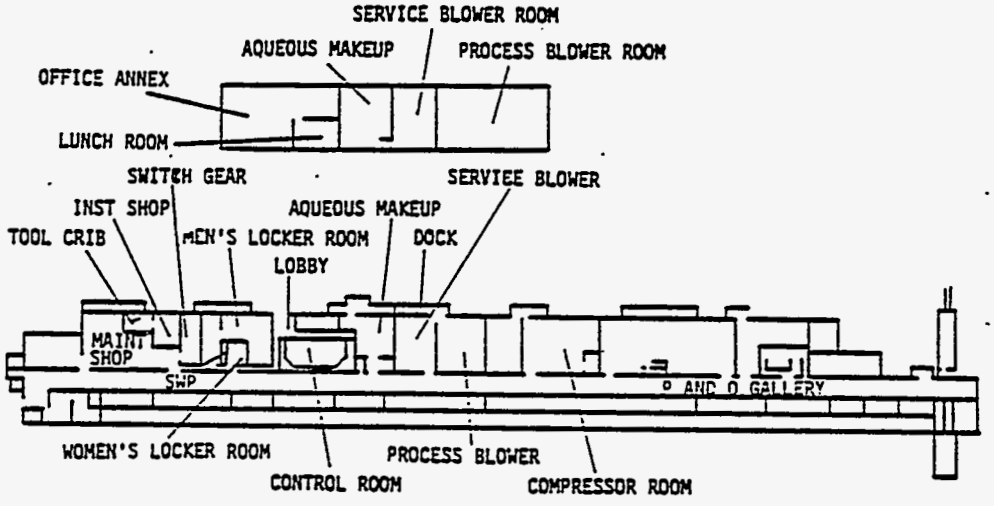

FIGURE 6-24. West Service Annex

Maintenance Shop. A centralized industrial shop, located at the P & O Gallery level at the west end of the service area, is adjacent to the Instrument Shop and Switchgear Room. It is equipped to handle all normal building maintenance. A central tool crib and clerical office are provided for this area.

Electrical Switchgear Room. Switchgear for the electrical distributor system is located in the 480-V switchgear room near the Maintenance Shop portion of the Service Building. The room is on the P & O Gallery level.

Question 14

1.0 INTRODUCTION

This updated PUREX* Technical Manual documents the technical bases of the current PUREX process and provides a physical description of the plant, equipment, and process at the Hanford Site. Included are process, facility, and equipment changes that have occurred since the original PUREX Technical Manual (HW-31000) was published in March 1955 and the revised versions as published in March 1980 and September 1983. The manual is intended for use in training and educating personnel unfamiliar with the process and as a reference handbook for personnel responsible for the startup and operation of the plant.

1.1 ARRANGEMENT AND CONTENT

Chapter 1.0 contains a summary of general information about the manual, plant, and process. It is written to provide the reader with a synoptic description of the process and as an aid in using the manual.

Chapter 2.0 describes the site, plant, and supporting facilities.

Chapter 3.0 describes the equipment currently used in the plant, and some of the reasons for equipment changes since plant startup; it also references blueprints describing the equipment in detail.

Chapter 4.0 describes the process, process control techniques, and methods for correcting typical off-standard conditions.

Chapter 5.0 discusses the technology involved in fuel element decladding, uranium dissolution, and feed preparation.

Chapter 6.0 discusses the solvent extraction technology used in providing the separation of uranium, plutonium, neptunium, and fission products.

Chapter 7.0 discusses the technology associated with the concentration of uranium and plutonium aqueous solutions.

Chapter 8.0 discusses the technology associated with concentrating aqueous neptunium nitrate, final purification of neptunium using ion exchange, and safety aspects involved with the ion exchange resin.

Chapter 9.0 discusses the technology for the recovery of nitric acid and oxides of nitrogen (NO_x) from off-gases, concentration of dilute acids into higher strength acid for reuse in the plant, and treatment of gaseous, aqueous, and solid wastes.

Chapter 10.0 presents basic information concerning nuclear criticality, and radiation and chemical handling safety applicable to the PUREX Plant.

Addendum I is the technical manual for the Plutonium Oxide Production and Rework Facilities. The addendum describes the facilities, location, equipment, and process technology and its relationship to the PUREX Process.

*Plutonium uranium extraction process developed at Oak Ridge National Laboratories.

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1.2 PUREX PLANT FUNCTION

The PUREX Plant, located in the 200 East Area of the Hanford Site, was designed and constructed to provide supplemental fuel reprocessing capability to separate plutonium and uranium products from irradiated fuel. The PUREX process, developed at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee, is an improvement over the reduction oxidation (REDOX) process since it uses a recoverable salting agent, which results in substantial reductions in unit costs and waste volumes. The PUREX Plant and process were designed to reprocess aluminum-clad uranium metal fuel to recover weapons-grade plutonium and depleted uranium, but have been modified to reprocess zirconium alloy (zircaloy) clad fuel from N Reactor to recover fuels-grade plutonium, slightly enriched uranium, and neptunium. The plant is operated by Westinghouse Hanford Company (Westinghouse Hanford) under the direction of the U.S. Department of Energy (DOE). A cross section of the PUREX Plant is shown in Figure 1-1.

Since the PUREX Plant began operations in 1956, a variety of fuels have been reprocessed. The fuel enrichments have varied from 0.72% to 2.1% ^{235}U; fuel exposures have varied from 300 to ~3,000 MWd/t U (megawatt days per ton of uranium); and cooling times have varied from 120 d to 7 yr. Aluminum-clad and zirconium-clad fuels have been processed at PUREX. Types of fuels processed include uranium metal, uranium and plutonium oxides, and thoria targets. During operations, improvements were made to increase production rates, provide diverse capability to handle various fuels, provide higher quality products, decrease environmental releases, and improve the safety of the operation. Additional changes were made while the plant was on standby from September 1972 to October 1983, and more are being developed and implemented.

The PUREX Plant is operated to reprocess the inventory of stored N Reactor fuel to provide plutonium for research, reactor development, safety programs, and weapons for United States defense programs; plus, provide slightly enriched uranium for fuel in reactors generating electricity and plutonium.

1.2.1 Feed Material

The current supply of feed material to the PUREX Plant is N Reactor fuel elements made of uranium metal with zircaloy cladding. The fuel elements, consisting of tube-in-tube design, are of two enrichments: (1) both inner and outer tubes 0.947% ^{235}U (Mark IV), and (2) the inner tube 0.947% ^{235}U and the outer tube 1.25% ^{235}U (Mark IA or "spike fuel"). The outer element assembly is 2.4 in. in diameter and from ~15 to 26 in. in length (most being ~26 in.). The fuel elements are black due to the formation of zirconium oxide on the surface during fabrication and irradiation in the reactor. After exposure of ~1,000 to 3,000 MWd/t, the fuel is discharged from N Reactor; stored in the N Reactor, K-East, or K-West Basins; cooled 180 d or longer; and shipped in cask cars to PUREX for processing.

About 18 tons of pressurized water reactor (PWR) fuel elements with zircaloy cladding are scheduled to be processed also. A new headend flowsheet will be required for processing this fuel at PUREX. In addition, ~3.2 tons of aluminum-clad uranium metal fuel elements, stored in four buckets in the PUREX fuel storage basin since 1972, will be processed. This material is highly depleted uranium (0.2% to 0.3% ^{235}U) containing 8.7 kg of plutonium with an approximate 26% ^{240}Pu content. Modifications to the headend of the plant are also being considered to permit the reprocessing of the 300 fuel assemblies from the Fast Flux Test Facility (FFTF).

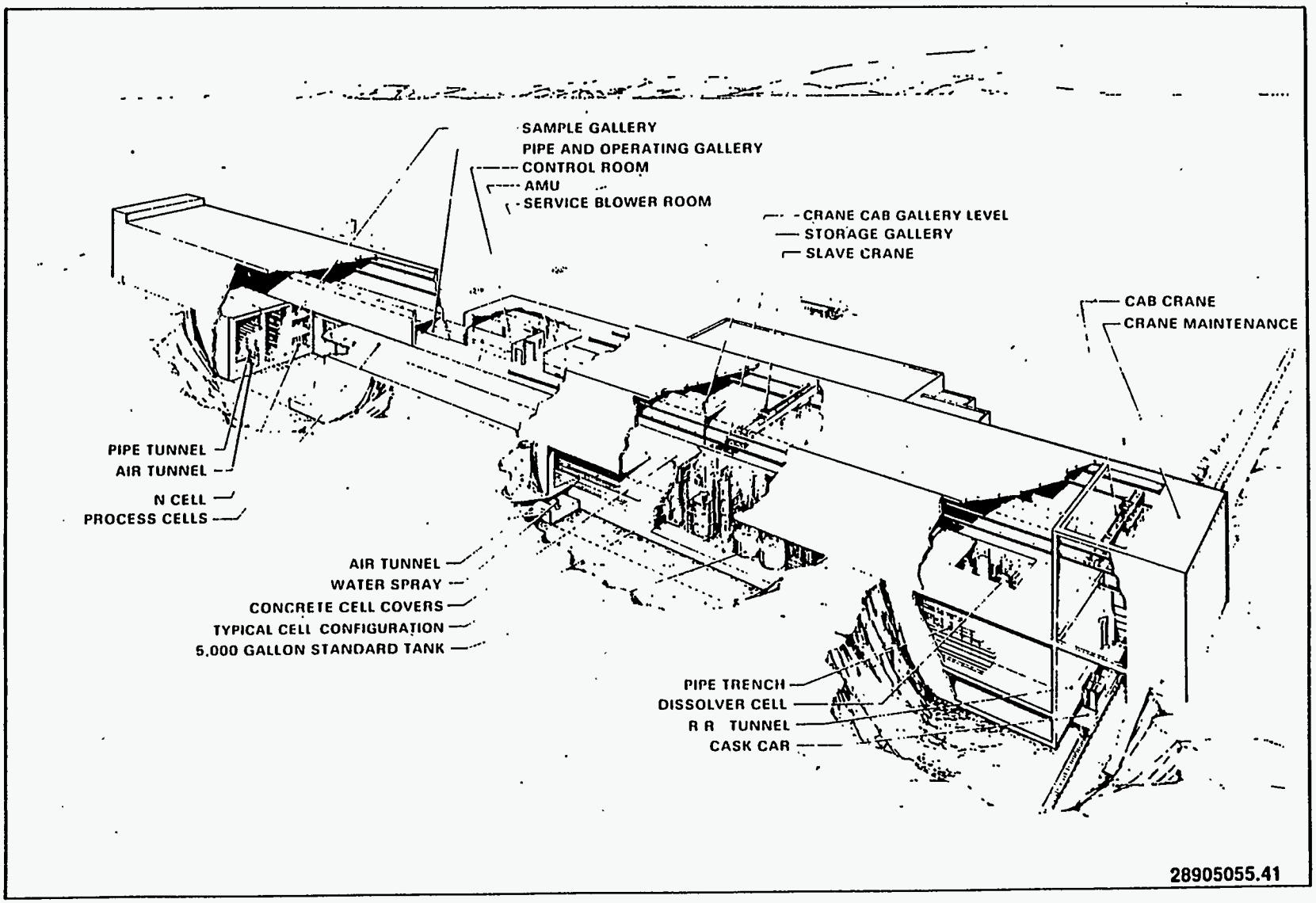

Figure 1-1. PUREX Plant Cross-Section.

Question 14

1.2.2 Plutonium Product

The plutonium product of the PUREX Plant can be a nitrate solution containing ~350 g Pu/L and ~7M HNO_3. The uranium content is <2,000 parts per million parts (ppmp) plutonium. Other plutonium product specifications are listed in Section 7.2. The plutonium, depending on its isotopic composition, is used to make breeder reactor fuel or weapons. As described in the Addendum it can also be PuO_2.

1.2.3 Uranium Product

The uranium product of the PUREX Plant is a concentrated uranyl nitrate solution containing ~4.2 lb U/gal and <0.1 lb HNO_3/gal. The plutonium content is <10 parts per billion parts (ppbp) uranium. The maximum allowable fission product concentrations are as follows:

^{95}Zr-Nb	10 µCi/lb U
^{103}Ru and ^{106}Ru-Rh	20 µCi/lb U
All others, excluding ^{99}Tc	20 µCi/lb U

The maximum allowable concentrations of other impurities are:

iron	40 ppmp U
chromium	16 ppmp U
nickel	12 ppmp U
sodium	20 ppmp U
organic	Nondetectable

The uranium product solution is shipped to the 244-U Building in the 200 West Area for calcination to uranium trioxide. This product is then shipped offsite for enrichment with ^{235}U and reuse as nuclear fuel.

1.2.4 Neptunium Product

The PUREX Plant neptunium product is a nitrate solution containing ~40 g Np/L, and >0.3M HNO_3. At these conditions, the neptunium valence is stabilized at the +5 state. Maximum allowable actinide concentrations are:

plutonium	1.0 wt% Np
uranium	1.0 wt% Np
thorium	3.0 wt% Np
^{234}Th	25 µCi/g Np

Allowable ^{95}Zr-Nb and ruthenium total concentration is 25 µCi/g neptunium. Neptunium was originally shipped to Savannah River, where it was used to produce ^{238}Pu. While awaiting shipment, the neptunium solution is stored in canyon vessel TK-J2. This tank holds ~1,200 gal, which is equivalent to the total volume of neptunium produced during many years of PUREX operation.

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1.2.5 Plant Processing Rate

The PUREX Plant processes N Reactor fuel at a nominal rate of 10 tons of uranium per day through the solvent extraction system on a campaign basis. The limiting parts of the process are the coating removal and coating waste treatment steps in the headend. During a campaign, the batch-operated head-end is started to build up a feed inventory of ~35 tons of uranium as UNH solution in the solvent extraction feed tanks. The solvent extraction system is then started while the headend is operated to provide a continuous feed supply. The solvent extraction system, consisting of 14 pulse columns, various feed tanks, pumps, concentrators, and associated equipment, operates as a continuous process. The plutonium and neptunium processing rates are dependent on the uranium processing rate and on the plutonium and neptunium concentrations in irradiated fuel elements. The plutonium and neptunium concentrations depend on irradiation history of the fuel elements. The neptunium content in the fuel is also dependent on the ^{236}U content of the uranium used in making the fuel elements. Approximate plutonium and neptunium processing rates at various irradiation levels (MWd/t) of N Reactor fuel, corresponding to a uranium processing rate of 10 tons per day, are tabulated in Table 1-1 for 0.947% and 1.15% ^{235}U enriched fuel.

Table 1-1. Approximate Plutonium and Neptunium Processing Rates.

N Reactor irradiation level (MWd/t)	^{240}Pu (%)[a]	Neptunium (g)[b]	Plutonium (kg)[b]
0.947% ^{235}U enriched 2,435	12	~300	18.3
1,670	9	~220	13.5
1,030	6	~140	9.0
1.15% ^{235}U enriched 2,950[c]	12	~280	16.0
2,030	9	~240	14.4
1,280	6	~150	9.8

PST89-3131-1-1

[a]In total plutonium.

[b]Processed per day at 10 tons of uranium per day.

[c]Decontaminated uranium solution is blended with this fuel to meet criticality specifications for solvent extraction processing.

1.3 BASIC CHEMICAL PRINCIPLES OF THE PUREX PROCESS

The PUREX process is designed for individual separation of uranium, plutonium, neptunium, and fission products which are combined in irradiated fuel elements. The desired components are separated and purified in this solvent extraction process by controlling their relative phase distributions between aqueous solutions and an immiscible organic solvent comprised of tributyl phosphate (TBP) dissolved in a hydrocarbon diluent, normal paraffin hydrocarbon (NPH). In the following subsections, the basic principles of the process are briefly described and the process is outlined. This section is intended only as an introduction to the process. More complete information is contained in Chapter 4.0.

Questions

1.3.1 Properties of Uranium of Process Importance

The PUREX process utilizes the preferential extractability of uranyl nitrate by TBP to separate uranium from plutonium and the fission product elements.

Metallic uranium is soluble in nitric acid forming an aqueous solution of $UO_2(NO_3)_2 \cdot XH_2O$.

The salts of uranium consist chiefly of two classes: the uranous uranium at a valence state of +4 (green color), and the uranyl (UO_2^{2-}) (yellow in color with a strong greenish fluorescence). Uranium may exist in other valence states, but only the tetravalent and hexavalent forms are comparatively stable in aqueous solutions. Uranium(+4) is a strong reducing agent, and is not normally present in PUREX process solutions since it is difficult to reduce UO_2^{2+} to uranium(+4). The product of uranium metal dissolution in nitric acid, $UO_2(NO_3)_2 \cdot XH_2O$, is very soluble in aqueous solutions, and in TBP. When aqueous solutions of uranyl nitrate are contacted with TBP, the uranium will distribute preferentially into the organic phase* if sufficient nitric acid is present as a salting agent in the aqueous phase. The uranium forms a complex compound [$UO_2(NO_3)_2 \cdot (TBP)_2$] in the organic phase. Advantage is taken of this preferential distribution and the relative nonreducibility of UO_2^{2+} in accomplishing the separation of uranium from plutonium and fission products in the PUREX process.

1.3.2 Properties of Plutonium of Process Importance

The PUREX process utilizes the preferential extractability of the plutonium(+4) and plutonium(+6) nitrates by TBP, and the virtual nonextractability of plutonium(+3) nitrate to separate plutonium from uranium and the associated fission products.

The dissolution of irradiated uranium fuel elements in nitric acid results in a solution in which the plutonium is chiefly in the +4 valence state.

Solutions of trivalent (blue-violet), tetravalent (brown-green), pentavalent (colorless), and hexavalent (pink-orange) plutonium have been produced. Plutonium(+5) is unstable, and soon disappears by disproportionation to other valence states. Plutonium(+3) is more stable than plutonium(+5), but in the presence of mild oxidants is converted to plutonium(+4). Both plutonium(+4) and plutonium(+6) nitrates can be made to distribute preferentially from an aqueous solution salted with nitric acid into TBP in the same manner as uranyl nitrate, while the plutonium(+3) nitrate always favors the aqueous phase. Plutonium(+4) and plutonium(+6) form complex compounds in solution with 2 molecules of TBP. Plutonium(+6) acts as a plutonyl ion (PuO_2^{+2}) and forms a complex with 2 molecules of TBP similar to that formed by uranium. The solvent extractability of the +4 and +6 valence states makes possible the separation of plutonium from the fission products, while the relatively easy reduction of plutonium to the virtually nonextractable +3 valence state makes possible the separation of plutonium from uranium in the PUREX process.

*The organic phase is often referred to as the solvent or extractant phase, as required for clarification of the text. Some aqueous streams, however, are used as solvents or extractants of specific constituents. Supportive text of these terms should clarify the meaning.

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1.3.3 Properties of Neptunium of Process Importance

The PUREX process utilizes the preferential extractability of the neptunium(+4) and neptunium(+6) nitrates by TBP, and the nonextractability of neptunium(+5) to separate neptunium from plutonium, uranium, and the majority of the fission products. Further separation from fission products and thorium is attained by preferential sorption of neptunium(+6) on Amberlite IRA-99, or equivalent, ion exchange resin.

The dissolution of irradiated fuel elements in nitric acid results in a solution in which the neptunium is chiefly in the +5 valence state.

Neptunium(+5) is the most stable valence state with a nitrate solution that is emerald green in color.

1.3.4 Properties of Fission Products of Process Importance

Fission products such as ^{131}I, ^{129}I, ^{85}Kr, ^{14}C, and ^{131m}Xe are volatilized from the dissolver during uranium metal dissolution. A silver reactor and acid absorbers collect part of these fission products, while the remainder are released to the atmosphere. Iodine-131 and ^{131}Xe have such short half-lives that they decay to negligible quantities prior to processing. Ruthenium-103 and -106, tritium, and ^{125}Sb are partially volatilized, and except for ^{125}Sb, are nearly completely removed from the off-gases prior to release. Part of the ^{125}Sb is collected in the silver reactor, part in the acid absorption columns, and an unknown amount is released to the atmosphere.

The fission products remaining in the metal solution are, in general, relatively inextractable into TBP, even when the aqueous phase contains a salting agent, and thus largely remain in the aqueous phase at the conditions under which plutonium and uranium are extracted. The presence of residual fluoride from the coating removal process in the uranium feed increases ^{95}Zr-Nb decontamination in the first cycle of the solvent extraction system. Most of the iodine remaining in the feed is extracted into the organic stream and is later removed with the carbonate-permanganate wash.

1.3.5 Decontamination

The gamma-emitting fission products associated with irradiated uranium fuel elements are reduced by factors of 1×10^7 in the uranium product, $>1 \times 10^8$ in the plutonium product, and $>1 \times 10^8$ in the neptunium product. Uranium is separated from the plutonium product by a factor of $>1 \times 10^7$. Plutonium is separated from uranium product by a factor of $>4 \times 10^4$.

The factor by which the concentration of radioactive contaminants is reduced is termed the decontamination factor (DF), which can be expressed mathematically as follows:

$$DF = \frac{\textit{Contaminant radioactivity initially present}}{\textit{Contaminant radioactivity present at step in consideration}}$$

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Either the beta or gamma radiations may be used as an index of the fission product radioactivity present, and the decontamination thus determined is called the beta dF or gamma dF. A logarithmic method of expressing df is also used, and is expressed as follows:

$$dF = log_{10}(DF)$$

Therefore, a DF of 10^5 is equivalent to a dF of 5; a DF of 20 equals a dF of 1.3; etc.

1.4 PUREX PROCESS DESCRIPTION

Figure 1-2 is a process flow diagram of the PUREX Process, including feed preparation, solvent extraction, solvent treatment, acid recovery, and waste handling steps. Individual parts of the process are discussed in the following subsections.

This flow diagram shows the code letters usually used to identify the main process streams in the PUREX Process. For example, the HAF stream is the uranium-plutonium feed stream to the HA Column, the first solvent extraction column in the process. The first two letters (or numeral plus one or two letters) of this code identify the equipment piece or cycle (the HA Column in the preceding example). The last letter (or two-letter group) identifies the stream. Influent stream abbreviations end in F, X, R, S, or IS, which stand for feed (uranium, plutonium, or neptunium), extractant, recycle, scrub, and intermediate scrub, respectively. Effluent stream abbreviations end in P, U, N, W, D, A, or C, which stand for plutonium (or product), uranium, neptunium, waste, distillate, acid, and concentrate, respectively. Effluent streams containing uranium, plutonium, and neptunium end only in P. Thus, the HAP is the effluent stream from the HA Column containing uranium, plutonium, and neptunium.

1.4.1 Feed Preparation

The purpose of the feed preparation process is to prepare a solution from the irradiated fuel elements that is suitable as a feed to the solvent extraction battery. The feed preparation process includes the following steps.

- The Zircaloy jackets are removed by dissolution in a boiling solution of 5.5M NH_4F and 0.5M NH_4NO_3. The resulting jacket removal waste is processed through a centrifuge to recover small amounts of uranium and plutonium that react with the fluoride during jacket removal. The waste is then treated with caustic to remove ammonia and sent to the 242-A Evaporator for concentration to a slurry acceptable for storage in underground double-shell tanks.

- The slurried centrifuge cake and the declad fuel elements are contacted with potassium hydroxide to convert the fluoride compounds to oxide compounds (metathesis). Most of the fluoride is transferred in the waste from this operation as soluble potassium fluoride, thus minimizing the corrosion rate during cake or uranium metal dissolution and subsequent processing operations.

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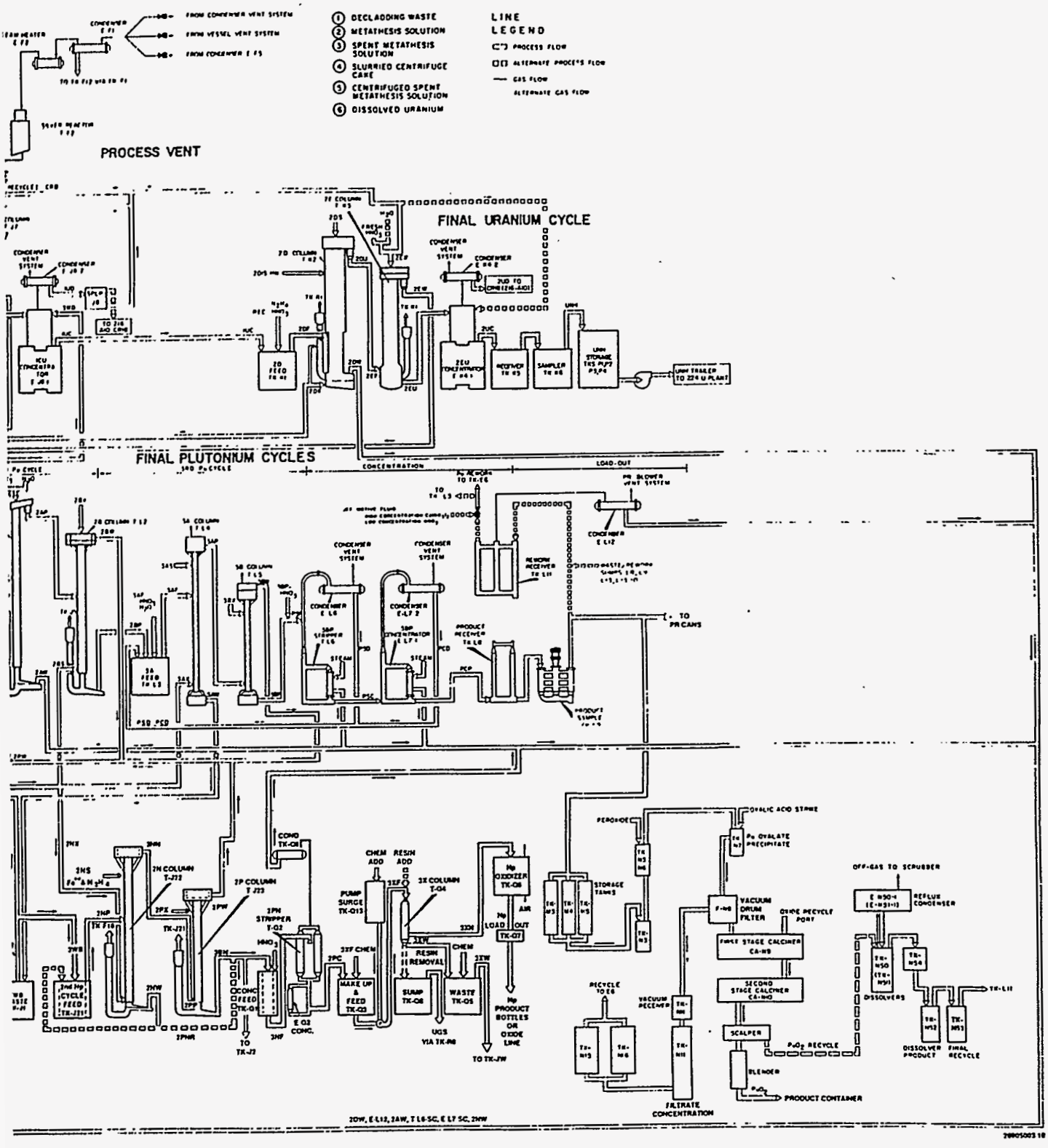
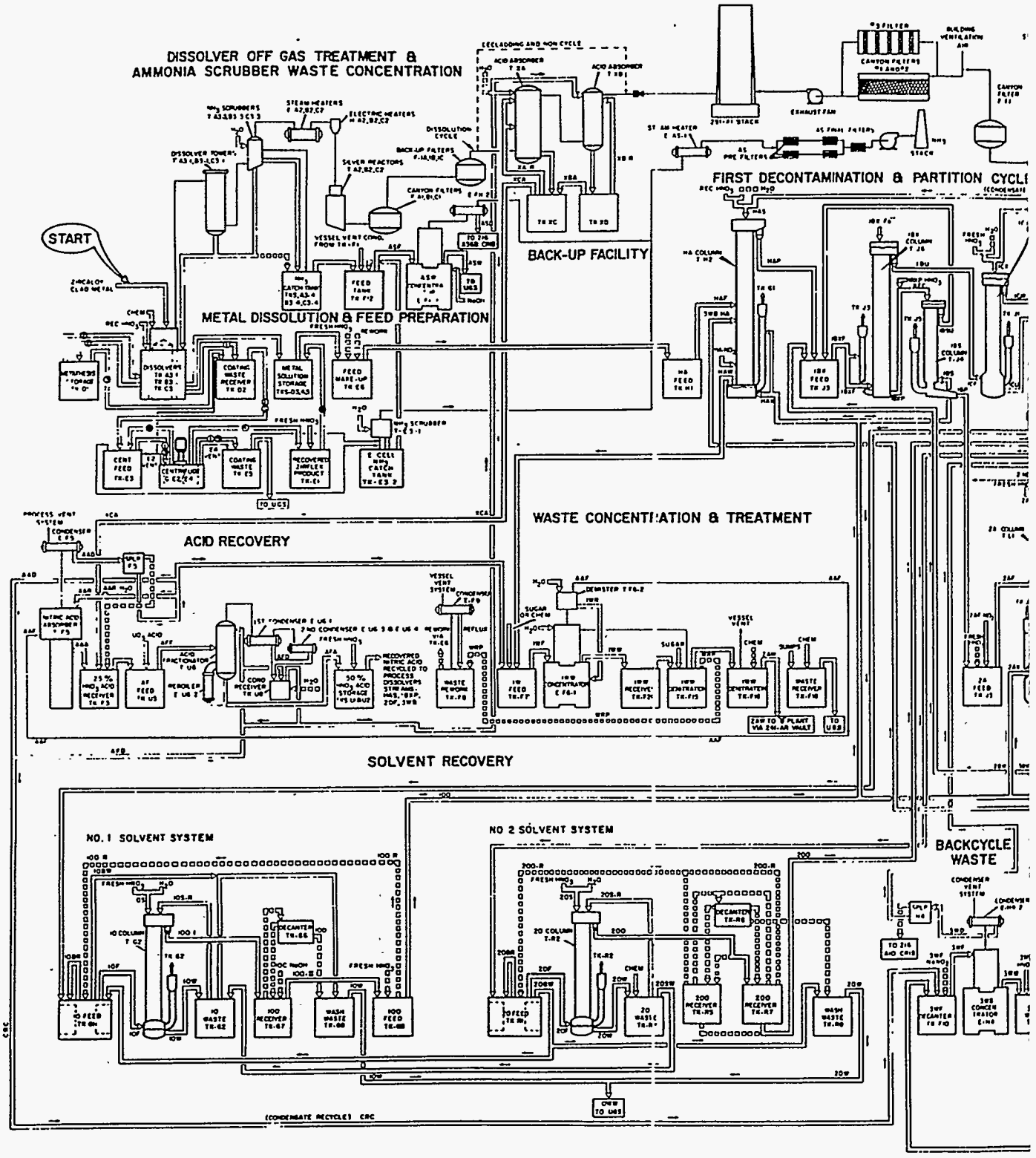


Figure 1-2. PUREX Process Flow Diagram.


DISSOLVER OFF GAS TREATMENT & AMMONIA SCRUBBER WASTE CONCENTRATION
START
METAL DISSOLUTION & FEED PREPARATION
BACK-UP FACILITY
FIRST DECONTAMINATION & PARTITION CYCLE
ACID RECOVERY
WASTE CONCENTRATION & TREATMENT
SOLVENT RECOVERY
NO. 1 SOLVENT SYSTEM
NO 2 SOLVENT SYSTEM
BACKCYCLE WASTE

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- The remaining uranium metal and the centrifuge cake containing plutonium, neptunium, and fission products are dissolved in 10.4M and 12.2M HNO_3, respectively, with sufficient aluminum nitrate to complex any residual fluoride remaining from the metathesis step.

- The dissolver solution is moved to feed tanks where it is sampled for product accountability. Any high exposure spike fuel is blended with decontaminated uranium solution to meet criticality specifications for processing in the solvent extraction system.

1.4.2 Solvent Extraction

Pulsed solvent extraction columns are employed in the PUREX process to effect the decontamination necessary to produce acceptable products. A number of cycles make up the total solvent extraction process as described below.

1.4.2.1 Codecontamination and Partition Cycle. The Codecontamination and Partition Cycle separates the feed into a fission product-containing aqueous stream (HAW), a uranium and neptunium aqueous stream (1CU), and a plutonium aqueous stream (1BP).

The feed solution (HAF) from the feed preparation section is continuously fed to the intermediate feed point of the HA Column. This feed contains uranium, plutonium, neptunium, fission products, and nitric acid as a salting agent. A countercurrent flow of TBP in a hydrocarbon diluent (HAX) rises through the aqueous phase in the column, and extracts the uranium, plutonium, and neptunium into the solvent phase, but leaves the majority of the radioactive fission products in the aqueous phase. A backcycle waste stream (3WB), containing some product from other column waste streams and nitric acid, is added to the HA Column just below the feed point to provide most of the salting strength in the column. An aqueous scrub stream (HAS), introduced at the top of the column, further decontaminates the uranium, plutonium, and neptunium by washing fission products back from the solvent phase to the aqueous phase. Uranium is in the +6 valence state, and plutonium is chiefly in the +4 valence state in the HA Column. A small stream of sodium nitrite is added near the bottom of the column to oxidize neptunium to the +6 valence state to effect a more complete extraction into the organic. The organic stream (HAP) containing the uranium, plutonium, and neptunium overflows to the feed tank of the Partition Cycle.

This organic stream is mixed with four organic recycle streams (1BSU, 2BW, 3BW, 2PW) to form the 1BXF feed stream, which is pumped to the bottom of the partitioning column (1BX). An aqueous stream, containing ferrous sulfamate reductant added to the top of the 1BX Column to reduce plutonium to the inextractable +3 valence state, descends through the column and carries the plutonium from the bottom of the 1BX Column to the top of the 1BS Column in the 1BXP stream. The small amount of uranium in this stream is scrubbed out by contacting with organic flowing up through the 1BS Column. The aqueous plutonium stream (1BP) leaves the bottom of the column, then goes to the Second Plutonium Cycle. The organic stream (1BSU) leaving the 1BS Column goes back to the 1BX Column feed tank.

The uranium and neptunium leave the top of the 1BX Column in the organic stream, and go to the bottom of the 1C Column where they are countercurrently stripped into a dilute acid scrub stream (1CX), which is then fed to the 1CU Concentrator where it is concentrated as feed (1UC) for the Final Uranium Cycle.

1.4.2.2 Final Uranium Cycle. The Final Uranium Cycle completes the decontamination of uranium from neptunium, residual traces of radioactive fission products, and plutonium with uranium from the partition cycle.

Nitric acid and hydrazine are added to the 1UC stream to increase the salting strength and provide a holding reductant (to react with nitrous acid) in the feed (2DF) to the 2D Column. Organic, added at the bottom of the column, extracts uranium from the feed as the organic moves up through the 2D Column, and overflows (2DU) to the 2E Column. A scrub stream (2DIS) containing hydroxylamine nitrate as a reductant, is added to the top of the 2D Column to reduce any plutonium to the inextractable +3 valence state. The column is operated at a high aqueous-to-organic ratio (A/O) to keep the organic saturated with uranium, thus forcing fission products, neptunium, and plutonium to leave in the aqueous 2DW stream enroute to the Backcycle Waste System.

The uranium in the 2DU stream is stripped by a dilute acid aqueous scrub stream (2EX) in the 2E Column, and is then concentrated in the 2EU Concentrator to form the UNH product that is stored in the 203A Tanks prior to shipment to 224-UA Building (UO_3 Plant) for calcination.

1.4.2.3 Final Plutonium Cycles. The Final Plutonium Cycles, which are composed of the second and third cycles, complete the decontamination of the plutonium. The aqueous product stream from the 1B scrub column (1BP) contains plutonium in the +3 valence state. This plutonium is oxidized to the +4 valence state in TK-J5 (2AF) by the addition of sodium nitrite and sometimes, nitric acid. The oxidized solution (2AF) is fed to the center feed point of the 2A Column. In the bottom section of the column, the plutonium is extracted into a TBP-NPH solution (2AX). In the upper portion of the column, the organic stream is contacted with nitric acid solution (2AS), which is fed to the top of the column to scrub fission products from the plutonium. The organic solution cascades to the bottom of the 2B Column where the plutonium is transferred back into the aqueous phase by countercurrent extraction with an aqueous strip solution (2BX) containing hydroxylamine nitrate and hydrazine as a reductant and holding reductant, respectively. A second organic stream (2BS) is added near the bottom of the column to provide additional uranium decontamination.

The aqueous plutonium product from the 2B Column (2BP) flows to the 3A Column feed tank (TK-L3) where additional nitric acid is added to form the (3AF) feed stream, which is introduced to the midpoint of the 3A Column. Organic is added at the bottom, and extracts plutonium from the feed as it moves up through the 3A Column to form the product stream (3AP). A scrub stream (3AS) is added to the top of the column to scrub fission products from the organic, and flows countercurrently to form the 3AW stream.

The 3AP stream containing the plutonium goes to the bottom of the 3B Column, where it is stripped back into an aqueous dilute nitric scrub stream (3BX). The plutonium nitrate leaves the bottom of the 3B Column as the 3BP stream. Organic wastes from the Final Plutonium Cycles (2BW, 3BW) are recycled to the 1BX feed tank.

The 3BP stream is butted with nitric acid to prevent plutonium polymerization during subsequent process steps. The plutonium nitrate is then stripped of organic in the 3BP Stripper and concentrated to its PUREX product form in the 3BP Concentrator. Process condensates from the 3BP Stripper-Concentrator are routed to the Third Plutonium Cycle feed tank for rework.

1.4.2.4 Final Neptunium Cycle. Neptunium is collected from the Backcycle Waste System on a batch basis and decontaminated in two solvent extraction columns and an ion exchange column. Collection of neptunium (operating Phase I) is started by diverting part of the backcycle waste concentrate (3WB) to the midpoint of the 2N Column. A scrub stream (2NS) containing ferrous sulfamate reductant is then introduced at the top of the column and an organic stream (2NX) is introduced at the bottom. These streams flow countercurrently through the column while the neptunium is reduced to the extractable +4 valence state and the plutonium is reduced to the inextractable +3 valence state.

The neptunium leaves the top of the 2N Column in the organic 2NP stream, enters the 2P Column where it is stripped back into dilute nitric acid and returned as 2PN-R to the 2N Column feed tank. The major portion of the plutonium and fission products exit the 2N Column in 2NW, which is routed to the Backcycle Waste System.

When a batch of neptunium (2,000 g) is collected, the feed from the backcycle waste to the 2PN feed tank is replaced with nitric acid and the two columns are operated as Phase II for neptunium decontamination. The 2NS and 2PX scrub stream flow rates are increased minimally, and the columns are operated until the fission product and plutonium content of the 2PN-R is reduced to an acceptable intermediate level. Most of the uranium exits the system in the organic stream leaving the 2P Column (2PW) to the 1BX feed tank during Phases I and II.

When the collected neptunium is sufficiently decontaminated, Phase III is started to remove neptunium. During Phase III, the scrub stream flow rates are reduced to a minimum, nitric acid is used as feed to the 2N Column, and the 2PN-R is routed either to TK-J2 or to Q Cell as 2PN. In TK-J2, the 2PN neptunium solution can be concentrated and stored awaiting final disposition. In Q Cell, the 2PN is concentrated and loaded onto an ion exchange column that contains Amberlite IRA-99 ion exchange resin. The column is scrubbed with several streams to attain final fission product and plutonium decontamination and is eluted with dilute nitric acid giving a product solution containing 40 g Np/L. Loading and scrub waste streams are collected, sampled, and routed to the Backcycle Waste System or to underground storage (UGS), depending on product content. The forecut and aftercut from the elution step are recycled to the 2PN Stripper-Concentrator.

1.4.3 Solvent Treatment

The solvent treatment section of the plant reclaims the combined TBP and NPH for recycle to the process. Two solvent treatment systems are employed. Solvent Treatment System No. 1 (Solvent System 1) processes the solvent from all of the solvent extraction cycles, except for the Final Uranium Cycle, which is processed by Solvent Treatment System No. 2 (Solvent System 2).

Solvent System 1 receives organic (1CW) from the 1C Column. The organic is contacted by passing through packing in TK-G1 concurrent with a solution of sodium carbonate and potassium permanganate to remove fission products and degraded organic. The organic is then scrubbed with dilute nitric acid in the 1O Column and returned to the process as HAX, 1BS, 2AX, 2BS, 3AX, and 2NX. The spent carbonate-permanganate solution is sent to UGS.

Solvent System 2 receives organic (2EW) from the 2E Column. This liquid is treated similarly as in Solvent System 1 and returned to the process as 2DX. Since there are fewer fission products and degradation products associated with this solvent, the spent aqueous wash solutions from this system are usually transferred to Solvent System 1 for reuse.

1.4.4 Backcycle Waste System

Aqueous waste streams containing nitric acid, uranium, plutonium, neptunium, fission products from various columns in the plant, and condensates from some plant condensers, are collected and concentrated in the Backcycle Waste System. Streams entering the Backcycle Waste System include: 2DW, 2AW, 3AW, and 2NW; T-L6 and E-L7-1 tube bundle steam condensates; and condensates from Condensers E-F5, E-U6, E-L12, and E-Q9. The 3AW stream is fed to the backcycle waste concentrator receiver tank, while all other streams are fed to the concentrator feed tank. Most of the concentrated waste (3WB) containing high acid concentration is fed to the HA Column to provide salting strength and for product recovery. The remaining 3WB is fed to the Final Neptunium Cycle for collection of neptunium.

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1.4.5 Acid Recovery and Waste Treatment

The principal aqueous process wastes from the PUREX Plant receive the following treatment:

- Highly radioactive waste (HAW) containing nitric acid is concentrated, with simultaneous recovery of the acid. The concentrate is denitrated with sugar with partial recovery of the NO_x gases produced. The denitrated solution is treated with caustic and sodium nitrite and sent to UGS

- Spent organic wash solution and sump wastes are made alkaline and transferred to UGS

- Ammonia scrubber waste collected during coating dissolution and coating waste treatment is transferred to UGS

- Process condensates from high-level waste concentration, backcycle waste concentration, acid fractionation, and partition cycle concentration are recycled as scrub streams to various columns instead of being discharged to cribs (covered, rock-filled trenches). Condensate from the Final Uranium Cycle is sent to UGS.

- Recovery of nitric acid from dissolver off-gas NO_x is accomplished by two acid absorbers (T-XA and T-XB). This dilute nitric stream is routed to the vacuum fractionator (T-U6) with the dilute acid recovered from the high-level radioactive waste. These streams plus nitric acid recovered at the UO_3 Plant are processed in the vacuum fractionator to produce a 10.4M acid, which is then reused in the plant.

4.0 PROCESS DESCRIPTION

This chapter gives a detailed description of the PUREX process including fuel dissolution, solvent extraction separations, product concentration and loadout, waste treatment and disposal, and solvent and acid recovery. Figure 4-1 is a schematic diagram showing the entire PUREX process. Also included in the chapter is a section devoted to descriptions of the methods used in laboratory analysis of the various PUREX process stream samples.

Chapters 5.0 to 9.0 are devoted to discussions of the technological bases associated with each major element of the PUREX process.

4.1 TRANSPORT OF FUEL ELEMENTS

Reactor fuel elements are delivered to PUREX in heavily shielded railroad cars on a regular schedule during plant operating periods. A shipment may require up to six cars, but generally includes only enough to provide one dissolver charge at a time. The N Reactor fuel is transported to PUREX in several different types of canisters and two different kinds of casks, depending on which 100 Area fuel storage basin it is delivered from. The handling equipment of the KE and KW Basins requires that the fuel be shipped in short canisters and casks. Fuel stored at the N Basin, however, can be shipped to PUREX in the original tall N Production Reactor (NPR) casks, which accommodate either short or tall canisters. The N Basin is also capable of handling the short cask used at KE and KW Basins. However, this would require modification in the N Basin. A detailed discussion of the shipping and transport equipment can be found in Chapter 3.0, Section 3.2.

The responsibilities for shipping fuel between 100 N Operations and PUREX Operations are clearly defined to achieve safe handling and positive identification of the fuel. Positive identification also contributes to the safe operation of the PUREX Plant, as this information is required to plan dissolver charge sizes and other operating criteria. The information describing the fuels in reactor basin storage is required in advance of any shipment to PUREX, and includes the following:

- Enrichment level
- Date of discharge from the reactor
- Basin storage position
- Number of fuel elements per canister
- Uranium content of each piece
- Net weight of each canister
- Total exposure of the fuels
- Reactor power level.

Plant input accountability is provided by this information, and is used as a check against the dissolver TK-D5 solution analysis.

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Zircaloy-clad Mark IV fuels (0.947% ^{235}U enriched) are handled differently than "spike," Mark IA fuel elements (0.947% and 1.25% ^{235}U enriched). Descriptions of the fuel elements processed in the PUREX Plant are given in Chapter 5.0. In the past, most Mark IA fuel elements were transported in tall canisters and casks, although some spike fuel was loaded in short canisters with hexagonal tops.

4.1.1 Fuel Element Shipping

This section describes the shipping and handling of the casks containing fuel between the reactor storage basins and PUREX, and within the PUREX canyon.

4.1.1.1 Shipping and Handling Containers at Basins. Modified short canisters and casks, described in detail in Chapter 3.0, Section 3.2, are used at the KE and KW Basins. The casks are handled and loaded in a similar manner at both the K and N Area basins. A cask is removed from the cask car with a bridge crane. The lid is unlatched, and the cask is lowered into a water-filled loading pit. An underwater mechanism has been devised to remove the cask lid as the cask is lowered. Under ~20 ft of water, the cask is moved out from under the lid and is rested on the bottom of the pit. The cask is loaded with canisters in the prescribed manner, then the lid is replaced as the cask is raised. After the lid is latched, the cask is placed on a cask car for shipment to PUREX.

Zircaloy-clad fuels from N Reactor are of tube-in-tube configuration, and are received in two types of two-barrel canisters. Short, 28-in.-tall canisters normally contain fourteen, 0.947% enriched fuel elements in a single layer of vertical elements, while taller canisters (71 in.) contain up to four layers of fuel elements. Usually only 0.947% and 1.25% enriched spike fuel elements are transported in the tall canisters. Short canisters containing spike fuel elements are identified with octagonal lids. Positive identification by the crane operator of the fuel element type in each canister is not possible due to the distance and optics involved.

Nuclear criticality prevention during fuel transit is provided by the canisters and casks, whose design configuration physically limits the spacing of the accumulated fuel elements. Administrative controls are required after charging fuels to the dissolvers to prevent nuclear criticality.

4.1.1.2 Rail Car Description. The canisters filled with fuel elements are transported in massive casks. The casks are enclosed in water-filled tanks or wells installed on special railroad cars. The water provides cooling and additional shielding. The tank covers are hinged and are opened with gear box and chain and sprocket mechanisms operated with a hand wheel. This system of containers is designed to effectively shield the large amounts of radiation emitted by the irradiated metal during the time it is contained in the car. Typically, the metal remains in a car ~20 h before it is charged to a dissolver.

A thermometer is provided to monitor the cask tank water temperature so that, if necessary, evaporated water can be replaced before the elements overheat (liquid level measurement is not yet available in the tanks). Over-heating of the fuel elements could result in cladding rupture and contamination of the water. Continued loss of the water coolant by evaporation could also create a potential for a uranium fire. However, since the fuels to be processed are previously stored in water-filled basins for a minimum of 180 d following discharge from the reactor, overheating of fuel in the cask tank is not expected.

4.1.1.3 Rail Car Handling. The PUREX dispatcher regulates train entry into the railroad cut and tunnel by means of electric locks on the gate and the tunnel outside door. When a load of fuel reaches the PUREX Plant, the dispatcher is contacted by the train crew for permission to enter the railroad cut, located outside the northeast end of the 202-A Building. A member of Patrol is required to open

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the gate, while an operating supervisor, an operator, and an RPT are required to receive the shipment. After the train enters the tunnel, the tunnel door control is activated by the dispatcher. The operator confirms that the cask cars are positioned for unloading, and the crane operator verifies that the canyon overhead ventilation door is closed. The cask cars (as many as three) are pushed into the tunnel by the train crew. The engine is disconnected, and a car puller is hooked to the cars nearest the tunnel door (north end). This enables the crane operator, who does not have a view of the door-end of the tunnel, to position the cars in the tunnel after the door is closed. With the car puller hooked to the north car, the crane operator cannot accidentally push a car through the door.

The cask car tank covers are opened with hand wheels on the tank by an operator before the tunnel door is closed. A visual inspection of the dissolver by the crane operator precedes the charging operation. Following the charge, empty canisters are returned to the casks. The overhead door is closed and the dispatcher is notified. When the tunnel door is opened, the tank covers are closed and the cars are disconnected from the car puller.

The cars must meet contamination release limits before they can be turned over to the train crew. This means that portions of the cars that the train crew may contact, such as couplers, levers, handrails, and footrails, are cleaned to "nonsmearable" condition. The cask car decks, tanks, and running gear (axles, shafts, etc.) have less restrictive release limits.

4.1.2 Fuel Handling and Dissolver Charging Procedures

Charging fuels of 0.947% ^{235}U enrichment or 0.947% and 1.25% enriched spike fuels to one of three identically designed dissolvers is the first step in the coating removal process described in Section 4.2. Zircaloy-clad fuels are charged into a solution of AFAN for coating removal.

4.1.2.1 Fuel Identification and Radiation Monitoring. A visual inspection is made to identify the fuel elements before unloading to control the amount of fissile material in dissolver charges. Some fuel assemblies (0.947% and 1.25% enriched spike fuel) are fabricated with different ^{235}U enrichments in the outer and inner tube. For criticality control, only complete assemblies are charged, unless special specifications are involved.

A radiation detection chamber, which activates a red light in the crane cab when radiation levels exceed the limit, is installed in the railroad tunnel to monitor the canisters during removal from the casks. This radiation signal is transmitted and recorded in the dispatcher's office and the Central Control Room. The alarm level is set to detect the radiation equivalent to that of fuel cooled for 180 d. Insufficiently aged fuels are prevented from being charged by this "green slug" monitoring system, as dissolution of these fuels would liberate large quantities of radioiodine that would vent to the atmosphere, thus exceeding release limits. If the alarm sounds in the Central Control Room, the Crane Cab, or the Dispatcher's Office, the canister containing inadequately aged fuel is returned to the cask for shipment to storage in the reactor basin.

Shift operating supervision, the crane operator, and dispatcher must coordinate their activities to ensure that proper fuel is charged to the dissolvers and the charge limits are observed. The shift supervisor determines from a written, bucket-loading summary, which of the available canisters to unload and charge to stay within the charging limit. The information contained in the bucket or metal-loading summary is listed at the beginning of Section 4.1.

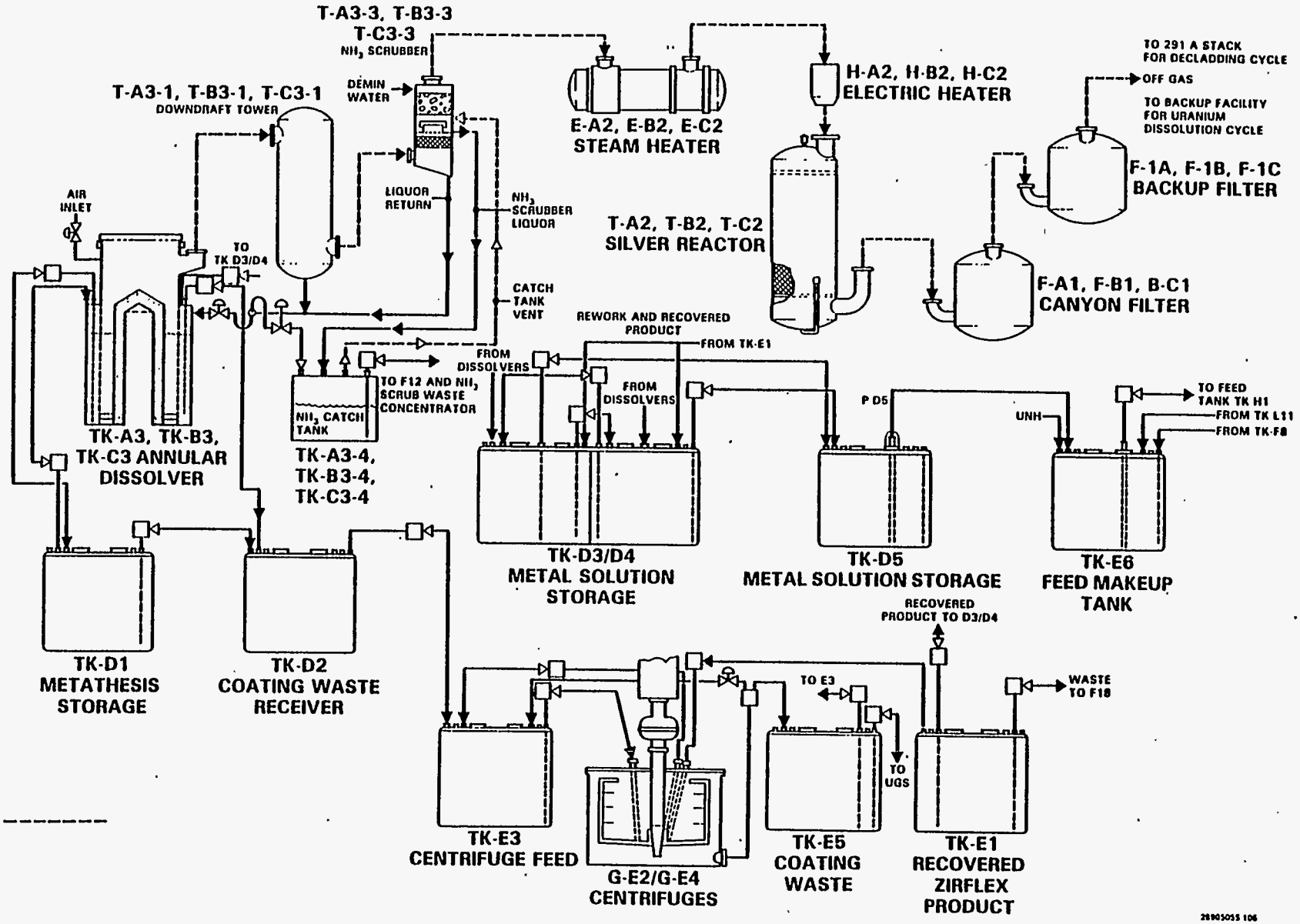

Figure 4-4. Coating Removal and Uranium Dissolution Process Flow Diagram.

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Table 4-1. Zirflex Decladding Streams.

Stream	Composition		Function	Volume or flow
Dilution water	H_2O		Dilute Zirflex solution to desired concentration	5,299 L
Zirflex solution	NH_4F NH_4NO_3	11.2M 1.0M	Dissolve Zircaloy cladding	5,299 L
Charge	U Zircaloy-2 Pu* Np*	22,500 lb 1,580 lb 20,531 g 340 g	N Reactor fuel elements for processing	
Dissolver air bleed	Air		Dilute hydrogen in off-gas during decladding	400 ft^3/min at 25 °C
Steam sparge	H_2O		Remove NH_3 to maintain desired pH	1,633 kg/h for 7 h
Water makeup	H_2O		Maintain constant liquid level in dissolver during decladding	3,825 L
Dilution water	H_2O		Dilute decladding waste prior to cooling and jetting to reduce solids precipitation	4,542 L
Decladding waste	$(NH_4)_2ZrF_6$ NH_4F NH_4NO_3 U Pu U as entrained $(NH_4)_2UF_6$	0.50 M 0.038M 0.07M 0.68 g/L 4.9 E – 04 g/L 1 02 kg	Removed dissolved zirconium fluoride ion and solids from dissolver	15,516 L
Water rinse	H_2O		Remove additional fluoride ion and solids from dissolver	1,893 L
Dissolver off-gas	H_2 NH_3 H_2O Air	0.1% 4.0% 78.2% 71.7%	Gaseous effluent from dissolver during decladding	2,828 ft^3/min at 100 °C
Condensate	NH_4OH	2.14M	Condensate from downdraft condenser during decladding which is routed to catch tanks	3,896 gal
Downdraft condenser off-gas	H_2 NH_3 H_2O Air	0.5% 5.7% 4.2% 89.6%	Off-gas from downdraft condenser routed to ammonia scrubber	454 ft^3/min at 30 °C
Ammonia scrub water	H_2O		Remove ammonia from off-gas	76 L/min for 8 h (36,890 L)
Ammonia scrubber off-gas	H_2 NH_3 H_2O Air	0.5% 0.1% 4.2% 95.2%	Treated off-gas to main stack via the Back-Up Facility for residual ammonia removal	427 ft^3/min at 30 °C
Spent ammonia scrub water	NH_4OH	0.27M	Waste from ammonia scrubber	45,210 L

NOTE: For processing of 0.947% ^{235}U enriched Mark IV fuel from N Reactor.
*Assumes fuel exposure of 2,435 MWd/t; 12% ^{240}Pu content; 1,825 q Pu/MTU.

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Table 4-2. Metathesis Streams.

Stream	Composition		Function	Volume or flow
KOH Makeup	KOH	7.0M	Metathesis solution makeup	2,460 L
Metathesis solution	K^+ OH^- F^-	5.9 M 5.43M 0.47M	Converts UF_4 and $(NH_4)_2UF_6$ remaining in dissolver to $UO_2 \cdot 2H_2O$	4,848 L
Water	H_2O		Maintain liquid level during metathesis digest	2,475 L
Recycled metathesis solution	K^+ OH^- F^-	5.68M 4.79M 0.89M	Partially used metathesis solution returned to TK-D1 for use in next metathesis in dissolver or E Cell	5,990 L
Heel dilution water/solution	K^+ OH^- F^-	1.00M 0.85M 0.15M	Remove additional metathesis solution to TK-D1	390 L
Air bleed	Air		Dilute off-gas	150 ft^3/min
Air sparge	Air		Suspend solids during digest	60 ft^3/min for 4 h
Metathesis rinse water solution	KOH KF U Pu U as $UO_2 \cdot 2H_2O$	0.007M 0.002M Trace Trace 8.55 kg	Remove spent metathesis solution	5,848 L
Heel dilution water/solution	KOH KF U Pu	1.1 E – 03 3.5 E – 04 Trace Trace	Dilute and remove additional rinse solution	390 L
Metathesis spent scrub water and condensate from downdraft condenser	NH_4OH	Trace	Feed to ammonia waste concentrator	11,858 L
Ammonia scrub water	H_2O		Remove ammonia from off-gas	30.24 L/min for 2 h 11.34 L/min for 4 h 6.350 L
Ammonia scrubber off-gas	NH_3	Trace	Disposal via the Back-Up Facility to the main stack	223 ft^3/min

NOTE: For processing of 0.947% ^{235}U enriched Mark IV fuel from N Reactor. PST89-3131-4-2

Table 4-3. Headend Waste Disposal Streams.

Stream	Composition		Function	Volume or flow
Sodium hydroxide	NaOH	19.0M	React with decladding waste and rinse from centrifuge that are added to the NaOH to drive off ammonia	2,830 L
Scrub water	H_2O		Remove ammonia from gases evolved from TK-E5 when wastes are added to NaOH solution	95 L/min for 12 h 68,400 L
Decladding waste and rinse	$(NH_4)_2ZrF_6$ NH_4F NH_4NO_3 U Pu U as $(NH_4)_2UF_6$	0.43M 0.33M 0.06M 7.6kg 5.0 g 51.0 kg	Feed to centrifuge	12,865 L
Rare earth nitrate	REN $(NO_3)_3$ 2.5 M		To coprecipitate plutonium	359 L
Decladding waste and rinse	Same as above except $(NH_4)2UF_6$ is removed		Waste from centrifuge for disposal via TK-E5	12,865 L
TK-E5 off-gas	NH_3 H_2O Air	20.2% 9.5% 70.3%	Remove ammonia generated in TK-E5 during reaction with NaOH	208 ft^3/min at 45 °C
Ammonia scrubber off-gas (E Cell)	NH_3 H_2O Air	0.1% 5.6% 94.3%	Route off-gas to ammonia stack	208 ft^3/min at 35 °C
Spent ammonia scrub water	NH_4OH ^{106}Ru-Rh	0.32M	Route waste to ammonia waste concentrator	69,864 L
Decladding waste and rinse	$ZrO_2 \cdot 2H_2O$ NaF $NaNO_3$ U Pu pH ^{106}Ru-Rh solids	0.34M 2.36M 0.05M 7.6 kg 5.0 g 14.0 50% by volume	Route waste to UGS tank	16,113 L
Water rinse	H_2O		Flush TK-E5 and line to underground storage tank	1,393 L
Sodium hydroxide	NaOH	19M	React with decladding waste and rinse mixed with metathesis rinse	1,121 L
Decladding waste and rinse mixed with metathesis rinse	$(NH_4)_2ZrF_6$ NH_4F NH_4NO_3 KF U Pu U as $(NH_4)_2UF_6$ U as $UO_2 \cdot 2H_2O$	0.19 M 0.15M 0.03 Trace 3.0 kg 2.0 g 53.9 kg 8.55 kg	Feed to centrifuge	11,547 L
Decladding waste and rinse mixed with metathesis rinse	Same as above except uranium is removed		Waste from centrifuge for disposal via TK-E5	11,547 L
Reacted decladding wastes and dissolver rinses	$ZrO_2 \cdot 2H_2O$ NaF $NaNO_3$ NaOH U Pu ^{106}Ru-Rh solids	0.15M 1.01M 0.02M 0.37M 3.0 kg 2.0 g 20% by volume	Routed waste to UGS tank	15,026 L

NOTE: For processing of 0.947% ^{235}U enriched Mark IV fuel from N Reactor.

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Table 4-4. Centrifuged Uranium Metathesis and Dissolution Streams.

Stream	Composition		Function	Volume or flow (L)
Water rinse	H_2O		Rinse of centrifuge feed tank TK-E3 and centrifuge routed to TK-E5 for disposal and flush of line to UGS tank	1,893 L
Centrifuge cake removal slurry water	H_2O		Remove centrifuge cake to TK-E3 for metathesis	908
Slurried centrifuge cake	U as $(NH_4)_2UF_6$ U as $UO_2 \cdot 2H_2O$	104.91 kg 8.55 kg	Route uranium solids to TK-E3	935
Spent metathesis solution to TK-E3	KOH KF	4.29M 0.80M	Metathesize $(NH_4)_2UF_6$ in cake slurry	3,373
Spent metathesis solution from TK-E3	KOH KF U Pu U as $UO_2 \cdot 2H_2O$	2.68M 1.21M Trace Trace 112.36 kg	Feed to centrifuge for recovery of $UO_2 \cdot 2H_2O$	4,417
Centrifuged spent metathesis solution	Same as above except $UO_2 \cdot 2H_2O$ is removed		Route waste to TK-E5 and then to UGS tank	4,417
Water rinse	H_2O		Rinse TK-E3, centrifuge TK-E5 line to UGS tank	1,893
Centrifuge cake removal slurry solution	$Al(NO_3)_3$	0.48M	Slurry $UO_2 \cdot 2H_2O$ centrifuge cake to TK-E1 and complex fluoride	606
Slurried centrifuge cake	$Al(NO_3)_3$ U as $UO_2 \cdot 2H_2O$	0.48M 112.36 kg	Transfer cake slurry to tank	624
Nitric acid	HNO_3	12.2M	Dissolve uranium oxide in TK-E1	189
Dissolved uranium	$UO_2(NO_3)_2$ $Al(NO_3)_2$ F^- HNO_3 Pu	0.54M 0.33M Trace 0.97M 0.25 g/L	Feed addition to TK-D4	885

NOTE: For processing of 0.94% ^{235}U enriched Mark IV fuel from N Reactor.

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Table 4-5. Ammonia Scrubber Water and Ventilation System Steam Condensate Concentration and Disposal Streams.[c]

Stream	Composition		Function	Volume or flow
Decladding condensate and spent ammonia scrub water from dissolver cells	NH_4OH ^{106}Ru-Rh[a]	0.71M	Feed to concentrator	61,756 L
Metathesis spent ammonia scrub water	NH_4OH	Trace	Feed to concentrator	11,858 L
E Cell spent ammonia scrub water	NH_4OH ^{106}Ru-Rh[a]	0.32M	Feed to concentrator	69,864 L
PUREX vessel and condenser vent jet steam condensate	H_2O HNO_3	Trace	Feed to concentrator	81,756 L/d
NaOH add	NaOH	19.0M	Prevent formation of NH_4NO_3 from reaction of NH_4OH with trace quantities of HNO_3 in jet condensates	~5 L
ASD condensate	NH_4OH ^{106}Ru-Rh[a,b]	0.25M	Route condensate with most of the ammonia to 216-A-36-B underground disposal trench or crib	265,231 L
Condenser off-gas	NH_3 H_2O Air	1.0% 5.6% 93.4%	Route off-gas to ammonia stack	130 ft^3/min at 35 °C
ASW	^{106}Ru-Rh[a]		Route concentrated waste to UGS tank	6,813 L/batch as required

NOTE: For processing of 0.947% ^{235}U enriched Mark IV uranium fuel from N Reactor. PST89-3131-4-5

[a]Values not available at this time.

[b]^{106}Ru-Rh value based on processing 180-d cooled fuel. Value is 0.5 µCi/gal for 5-yr cooled fuel.

[c]The feed stream is currently being adjusted to pH 12 and routed to UGS via TK-G7.

The coating removal reaction is controlled by maintaining an optimum zirconium-to-fluoride mole ratio (4:1), maintaining an optimum hexafluorozirconate concentration to preclude precipitation, and removing ammonia generated in the reaction by steam stripping the coating removal solution.

Basic controls during the coating removal process are as follows:

- Maintaining hydrogen in the off-gas at <4 vol% (6% is the safety limit)
- Maintaining steam sparge flow and makeup water addition
- Maintaining boiling temperatures
- Maintaining constant liquid volume in the dissolver.

Key controls for the potassium hydroxide metathesis of uranium and plutonium fluorides are as follows:

- Assurance of excess potassium hydroxide

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Table 4-7. Uranium Dissolution, Feed Preparation, and Dissolver Off-Gas Treatment Streams.

Stream	Composition		Function	Volume or flow
Air bleed	Air		Dilute and increase volume/velocity of off-gas	150 ft^3/min
Aluminum nitrate	$Al(NO_3)_3$	1.6M	Complex residual fluoride in first cut	1,985 L
Nitric acid	HNO_3	10.4M	Dissolve uranium metal in first cut	9,463 L
Air sparge	Air		Circulate solution; dilute and increase volume/ velocity of off-gas	60ft^3/min for 8 h on 1st cut 10 h on 2nd cut
Downdraft condenser off-gas	NO_x	23%	Route off-gas to treatment facilities (silver reactor, filters, Back-up Facility) for 12 h reaction time	278 ft^3/min at 30 °C
First Cut	$UO_2(NO_3)_2$ $Al(NO_3)_3$ F^- HNO_3 Pu	2.05M 0.29M 0.07M 0.43M 0.98g/L	Route product dissolver solution to TK-D3/D4 storage	11,880 L
Aluminum nitrate	$Al(NO_3)_2$	1.6M	Complex residual fluoride in second cut	530 L
Nitric acid	HNO_3	10.4M	Dissolve uranium metal in second cut	7,116 L
Second cut	$UO_2(NO_3)_2$ $Al(NO_3)_3$ F^- HNO_3 Pu	2.34M 0.11M Trace 0.70M 1.12g/L	Route product dissolver solution to TK-D3/D4 storage	7,688 L
First rinse	H_2O		Dilute jet heel and transfer addition product from dissolver to TK-D3/D4	379 L
Second rinse	H_2O		Same as first rinse	757 L
Dissolved uranium from centrifuge cake	$UO_2(NO_3)_2$ $Al(NO_3)_3$ F^- HNO_3 Pu	0.54M 0.33M Trace 0.97M 0.26g/L	Feed addition to TK-D4	885 L
Uranyl nitrate solution	$UO_2(NO_3)_2$ $Al(NO_3)_3$ F^- HNO_3 Pu	1.87M 0.20M 0.04M 0.50M 3.3 g/L	Feed addition to TK-E6	22,914 L
XA absorber water	H_2O		Absorb NO_x in XA tower of Back-up Facility	29 L/min
XA hydrogen peroxide	H_2O_2	50 wt%	Increase absorber efficiency	2 L/min

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Table 4-7. Uranium Dissolution, Feed Preparation, and Dissolver Off-Gas Treatment Streams. (cont.)

Stream	Composition		Function	Volume or flow
XA reflux	HNO_3	2.0M	Cool tower to increase efficiency and absorb NO_x	1,022 L/min
XCA	HNO_3	2.0M	Route Back-up Facility acid to TK-F3 for transfer to fractionator	23.3 L/min
XB absorber water*	H_2O		Absorb NO_x in XB tower of Back-up Facility	1 L/min
XB hydrogen peroxide	H_2O_2	50 wt%	Increase absorber efficiency	0.2 L/min
XB reflux	HNO_3	2.0M	Cool tower and absorb NO_x	303 L/min
XBA	HNO_3	2.0M	Route T-XB product from TK-XD to TK-XC for use in T-XA reflux and transfer to TK-F3	1.1 L/min
Back-up Facility off-gas	NO_x	0.7% for 12-h reaction time in dissolvers	Route off-gas to main stack	697 ft^3/min at 40 °C

NOTE: For processing of 0.947% ^{235}U enriched Mark IV fuel from N Reactor. PST89-3131-4-7
*Recycled AFD condensate from the acid fractionator may be used for these streams.

4.3.1 Headend Process Flow Diagram

A process flow diagram of the uranium dissolution process and equipment is given in Figure 4-4. The figure shows the major pieces of equipment (excluding the off-gas Back-Up Facility), process routes, and some instrumentation and control equipment. The uranium dissolution system consists of three independent annular dissolvers with parallel off-gas systems also used for coating removal, a feed makeup tank, and three storage tanks. The off-gas systems include the downdraft condensers (dissolver towers), steam and electric heaters, silver reactors, and two off-gas filters per system. The filters are described in Section 4.14, and the off-gas Back-Up Facility (see Figure 4-1) is described in this section and in Chapter 3.0, Sections 3.4 and 3.13.

The dissolvers discharge to metal solution lag storage TK-D3 and -D4, a two-compartment, oval-shaped vessel with a capacity of 7,700 gal in each side. The tanks are equipped with jets for transferring between compartments and to TK-D5, where solution samples are taken for product accountability. Tank D5 contains a pump, that recirculates solution through the sample pot and transfers the solution to TK-E6 for feed preparation. The volume of solution transferred is determined from TK-D5 measurements. The two-stage sampler, shown schematically in Figure 4-5, involves pumping solution to a first-stage sample pot and second-stage air-lift circulation of the solution to the Sample Gallery. The first-stage sampling is operated from the Headend Control Room. The solution is then pumped to TK-E6 for final feed makeup. Tank E6 has provisions for adding demineralized water, nitric acid from three sources, and rework material from four sources.

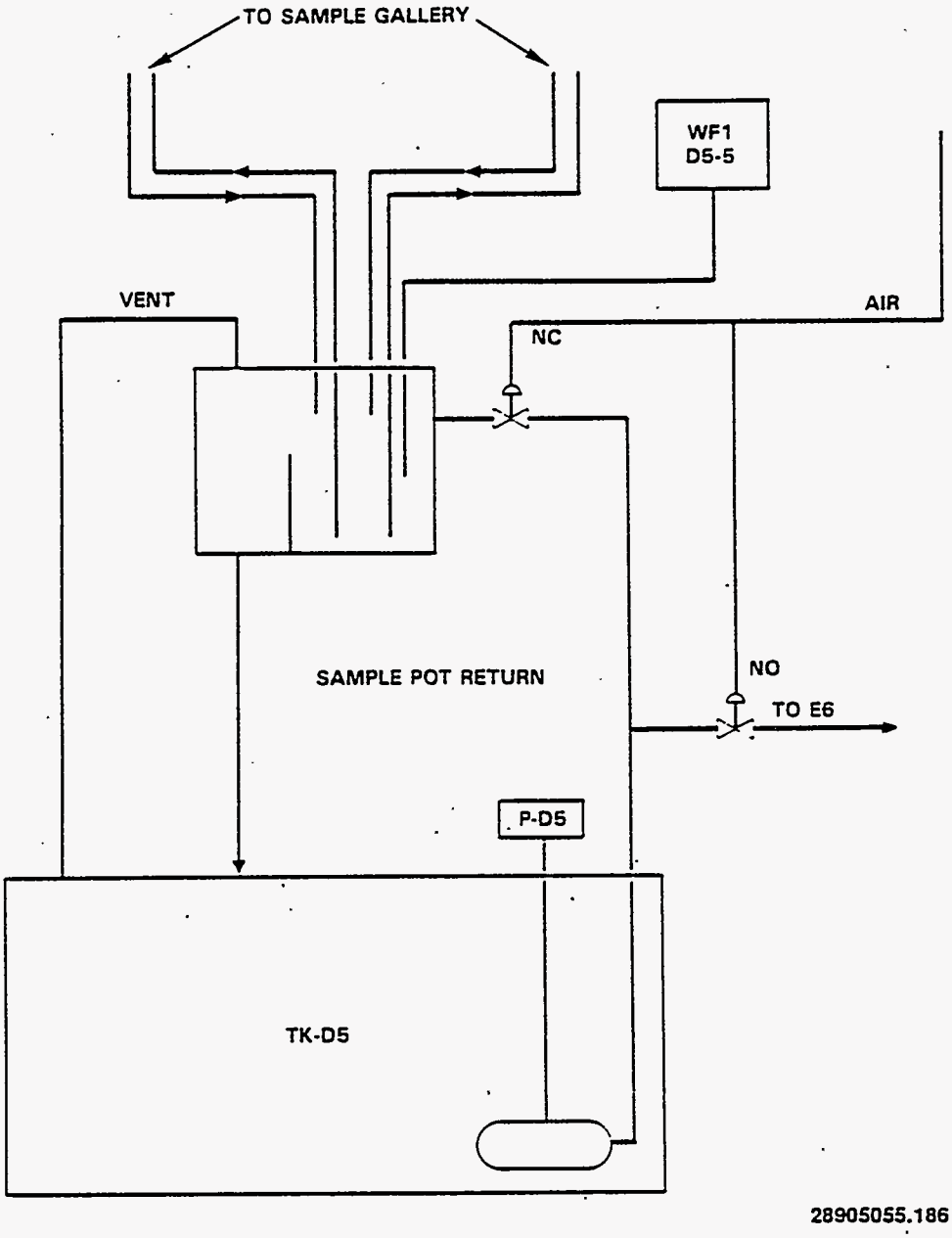

Figure 4-5. Sampling System for TK-D5.

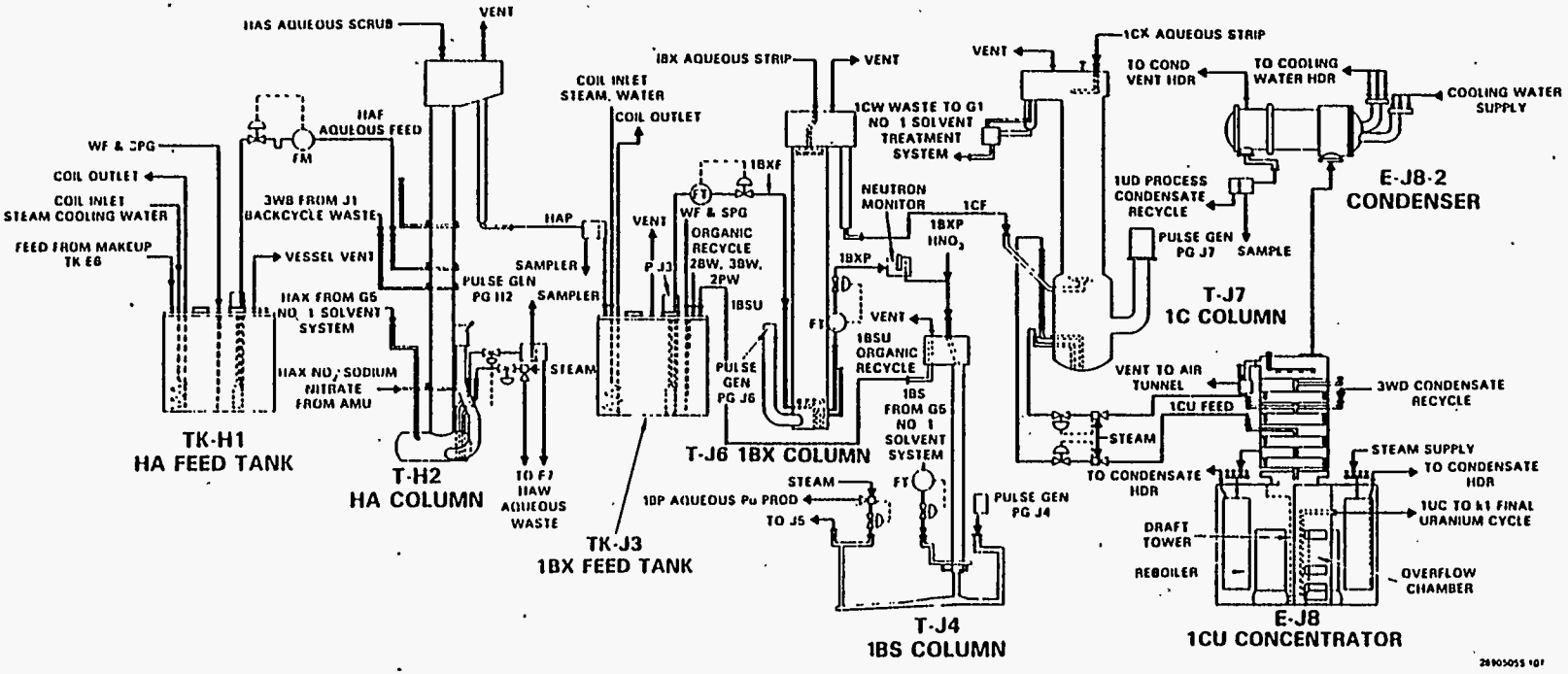

Figure 4-6. Codecontamination and Partition Cycle Process Flow Diagram.

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Table 4-10. Codecontamination and Partition Cycle Streams.

Stream	Composition		Function	Flow* (L/min)
HAF	U HNO_3 $Al(NO_3)_3$ F^- Pu Np	433 g/L 0.50M 0.2M 0.04M 0.899 g/L 0.01 g/L	HA Column feed solution	13.0
HAX	TBP NPH HNO_3	25% 75% 0.01M	HA Column extractant (organic)	85.0
HAW	HNO_3 Al F^- U Pu	3.03M 0.07M 0.02M 3.4 E-03 g/L 4.8 E-05 g/L	HA Column aqueous waste	32.9
3WB	HNO_3 U Pu Np	7.3M 8.8 g/L 0.04 g/L variable	Aqueous backcycle-additional salting strength for extraction section	12.0
HA-NO_2	$NaNO_2$	0.77M	Neptunium valence adjustment to +6 to ensure extractability.	0.049
HAS	HNO_3	2.0M	HA Column acidic scrub solution to remove fission products from organic	15.0
HAP	U HNO_3 Pu Np	65.6 g/L 0.14M 0.14 g/L variable	HA Column product stream containing extracted plutonium, uranium, and neptunium	87.7
1BXF	U HNO_3 Pu	52 g/L 0.16M 0.10 g/L	1BX Column feed stream containing extracted plutonium, uranium, and neptunium, and 1BSU, 2BW, 2PW, and 3BW recycle streams	115.3
1BX	HNO_3 Fe^{+2} NH_2SO_3	0.30M 0.028M 0.1M	1BX Column plutonium partition stream--Fe^{+2} reduces plutonium valence from +4 to +3, plutonium is stripped into 1BX, SA kills NO_2	6.5
1BU	U HNO_3 Pu Np	50.8 g/L 0.08M 0.52 E-6 g/L variable	1BX Column uranium and neptunium product stream, organic	114.9
1BXP	U HNO_3 Pu	15.9 g/L 1.5M 1.7 g/L	1BX Column plutonium product stream	6.8
1BXP-HNO_3	HNO_3	10.4M	Recovered acid to increase 1BP acidity	2.9

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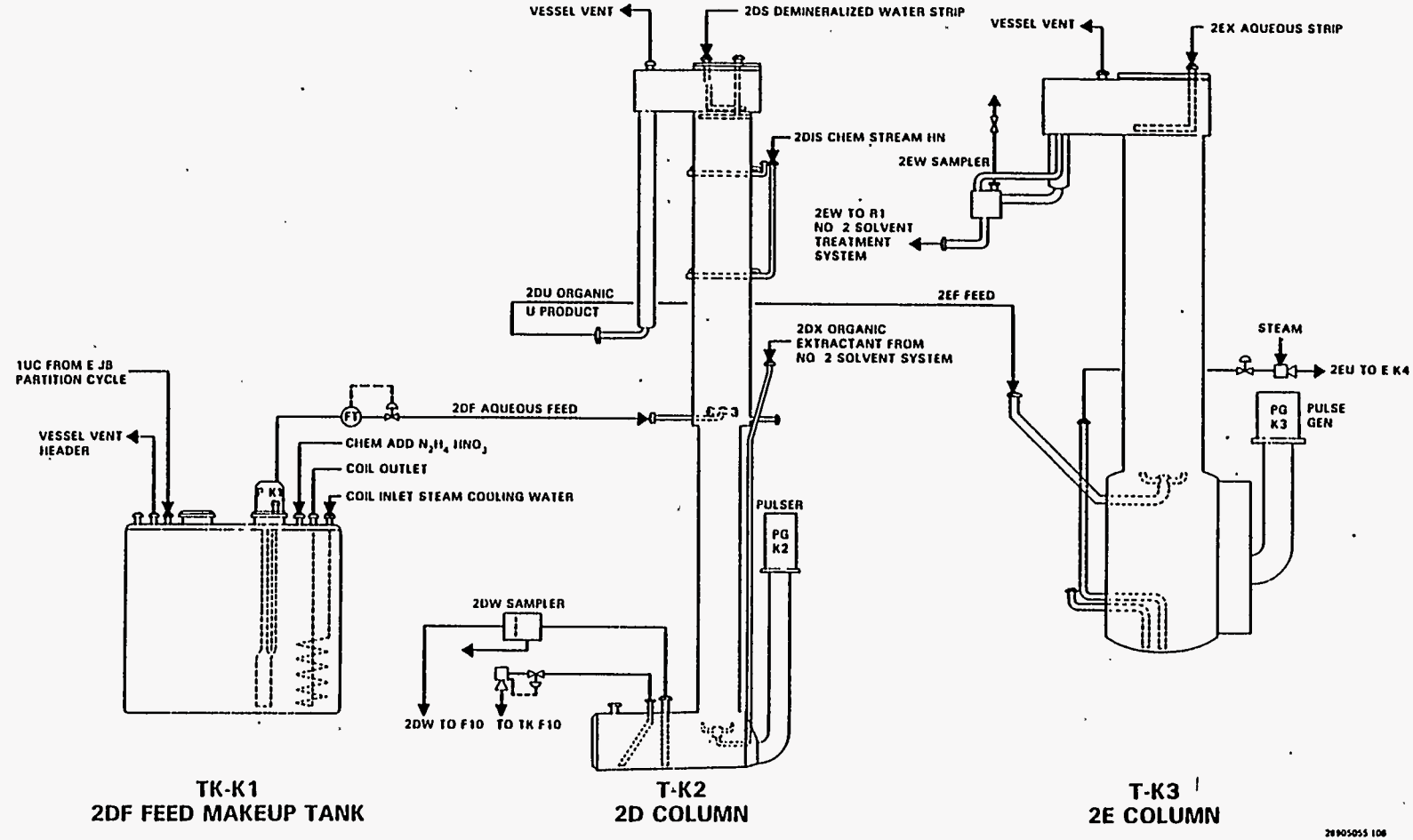

Figure 4-7. Final Uranium Cycle Process Flow Diagram.

Table 4-11. Final Uranium Cycle Process Streams.

Stream	Composition		Function	Flow* (L/min)
2DF-HNO_3	HNO_3	10.4M	2D Column feed nitric butt stream, to increase salting strength	0.55
2DF-N_2H_4	N_2H_4	11.3M	Reduce nitrite (NO^-_2) with hydrazine	0.0052
2DF	HNO_3 U Np Pu	1.5M 469.5 g/L Variable 4.8 E – 5 g/L	2D Column uranium-neptunium aqueous feed, from TK-K1 (2DF)	12.4
2DX	TBP NPH HNO_3	25% 75% 0.01M	2D Column organic stream, extracts uranium, leaves neptunium, plutonium, and fission products	80.0
2DIS	HN HNO_3	0.024M 0.01M	Reductant stream (HN) to reduce plutonium to valence +3	2.44
2DS	H_2O		2D Column scrub water to strip HNO_3 and fission product organic	7.08
2DW	U HNO_3 Pu Np	8.8 g/L 0.94M 2.5 E – 5 g/L variable	2D Column aqueous waste backcycled to HA column via backcycle waste concentrator system	20.2
2DU (2EF)	U HNO_3	68.9 g/L 0.006M	2D Column organic uranium product feed to 2E Column	82.2
2EX	HNO_3	0.01M	2E Column aqueous strip (very dilute HNO_3), strips uranium	88.2
2EW	TBP NPH HNO_3 U	25% 75% Trace Trace	2E Column organic waste to Solvent System 2	80.0
2EU	U HNO_3	62.9 g/L 0.015M	2E Column aqueous uranium product to 2EU Concentrator	90.0

*Based on processing rate of 8.1 metric tons of U/day, no neptunium recovery. PST89-3131-4-11

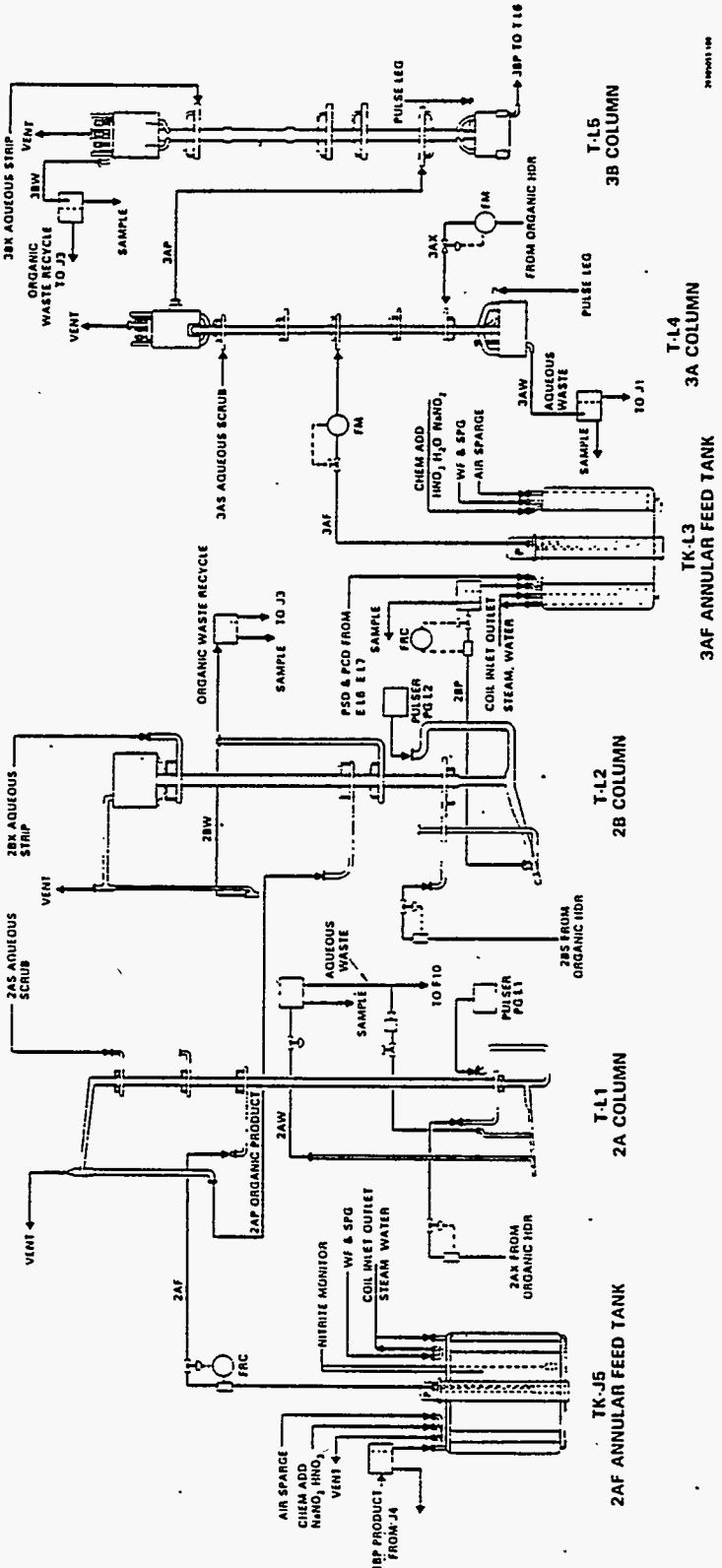

Figure 4-8. Final Plutonium Solvent Extraction Cycles Process Flow Diagram.

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Table 4-12. Third Plutonium Cycle Process Streams.

Stream	Composition		Function	Flow*(L/min)
2AF-NO_2	$NaNO_2$	0.77M	Nitrite stream to oxidize Pu^{+3} to Pu^{+4}	1.17
2AF	HNO_3 NO_2 Pu	3.15M 0.002M 1.07 g/L	2A Column feed stream, Pu^{+4}	10.7
2AX	TBP NPH HNO_3	25% 75% 0.01M	2A Column extractant, organic	3.5
2AS	HNO_3	0.75M	2A Column scrub. Dilute HNO_3 removes fission products from plutonium-bearing organic	3.09
2AW	HNO_3 Pu	2.6M 0.03 g/L	2A Column aqueous waste to Backcycle Waste System	13.8
2AP	HNO_3 Pu	0.123M 3.24 g/L	2A Column plutonium product stream to 2B column	3.57
2BX	HNO_3 HN N_2H_4	0.3M 0.1M 0.05M	2B Column stripping solution reduces Pu^{+4} to Pu^{+3} and kills nitrite	1.6
2BS	TBP NPH HNO_3	25% 75% 0.01M	2B Column uranium scrub stream, organic	0.34
2BW	HNO_3 Pu	0.05M 0.009 g/L	2B Column organic waste recycled to 1BX feed tank	5.01
2BP	HNO_3 Pu	0.50M 7.17 g/L	2B Column plutonium product to 3A column feed makeup	1.61
3AF-NO_2	$NaNO_2$	0.77M	Nitrite stream to oxidize Pu^{+3} to Pu^{+4}. Used only if necessary	0.06
3AF-HNO_3	HNO_3	12.2M	Increases 3AF acidity	0.86
3AF-D1L	HNO_3	1.2M	Dilute HNO_3 stream to increase 3AF volume and flowrate. Used only during recycle of concentrated $Pu(NO_3)_4$ solutions	0.593
3AF	HNO_3 Pu	3.3M 3.3 g/L	3A Column feed stream, Pu^{+4}	3.5
3AS	HNO_3	1.2M	3A Column scrub, dilute HNO_3 removes fission products from plutonium-loaded organic	0.43
3AX	TBP NPH HNO_3	25% 75% 0.01M	3A Column extractant (organic)	0.85
3AW	HNO_3 Pu	3.05M 0.004 g/L	3A Column aqueous waste routed to Backcycle Waste System	3.88

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Table 4-12. Third Plutonium Cycle Process Streams. (cont.)

Stream	Composition		Function	Flow*(L/min)
3AP	HNO_3 Pu	0.18M 13.3 g/L	3A Column plutonium product, to 3B Column	0.86
3BX	HNO_3	0.15M	3B Column strip solution dilute HNO_3 to remove Pu^{+4}	0.55
3BW	HNO_3 Pu	0.07 0.3 E – 3 g/gal	3B Column organic waste recycled to TK-J3 (1BX)	0.85
3BP	HNO_3 Pu	0.42 20.5 g/L	3B Column plutonium product	0.56
3BP	HNO_3	12.2M	3BP HNO_3 butt	0.04

*Based on 8.1 metric tons U/day, no neptunium recovery. PST89-3131-4-12

As the aqueous phase descends through the extraction section, the plutonium(+4) and 50% or more of the nitrite ion entering in the 2AF are extracted into the organic. The organic containing the extracted plutonium moves up the column past the feed point into the scrub section, where it contacts the dilute nitric (0.75M) aqueous scrub solution, 2AS (2A Column scrub stream). The 2AS strips or scrubs most of the extracted fission products out of the organic phase. The scrubbed organic rises and accumulates in the top disengaging section, and becomes the 2AP (2A Column plutonium product stream), which overflows from the top of the 2A Column to the bottom of the 2B Column.

The descending aqueous droplets coalesce in the bottom disengaging section of the 2A Column to form the 2AW (2A Column waste stream). The 2AW, which contains ~0.7% of the entering plutonium plus the scrubbed and nonextracted fission products, is ultimately returned to the HA Column via the backcycle waste concentrator.

4.4.3.3 2B Column. The aqueous-continuous 2B Column functions like a combined 1BX-1BS Column. Plutonium is partitioned from the uranium and fission products present in the 2AP by the aqueous 2BX stream. The 2BX stream contains hydroxylamine nitrate as a reductant, and hydrazine as a holding reductant similar to the ferrous sulfamate and sulfamic acid in the 1BX Column.

The organic 2AP bearing the plutonium product enters the 2B Column via an external distribution ring equipped with nozzles extending through the column wall one-third of the way up the column. As the organic and aqueous streams are intimately contacted in the 2B Column, the plutonium is stripped from the organic to the aqueous phase where it is reduced by the 2BX from the +4 valence state to the nearly inextractable +3 state. The nitrite present in the organic also reacts with the 2BX reductant. An excessive quantity of nitrite could thus consume all the reductant and force the plutonium out the 2BW waste stream for recycle back to the 1BX Column.

The plutonium-bearing aqueous stream continues down the column and is contacted by an organic stream (2BS) from Solvent System 1 to scrub uranium from the aqueous. This 2BS stream enters the column via an external distributor ring just below the plate section. The organic streams rise and coalesce into an organic layer at the top of the column. This organic stream, containing uranium, fission products, and only 0.04% of the entering plutonium, is the 2BW (2B Column waste stream). It overflows from the 2B Column and is recycled by gravity flow to the 1BX Column feed tank (TK-J3). The plutonium-bearing aqueous stream, 2BP (2B Column product), overflows into TK-L3 (3AF), the feed tank for the Third Plutonium Cycle.

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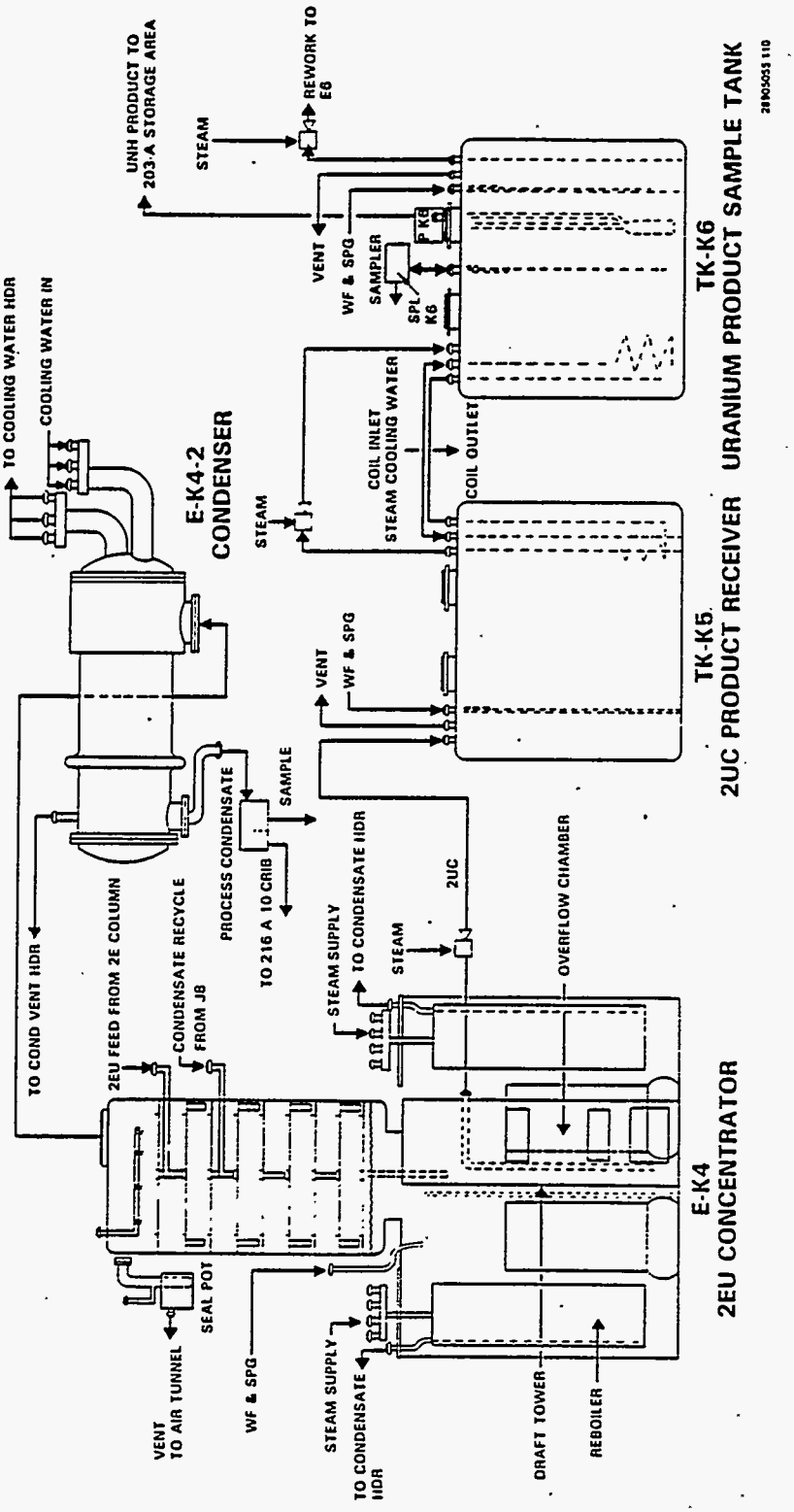

Figure 4-9. Uranium Concentration Process Flow Diagram.

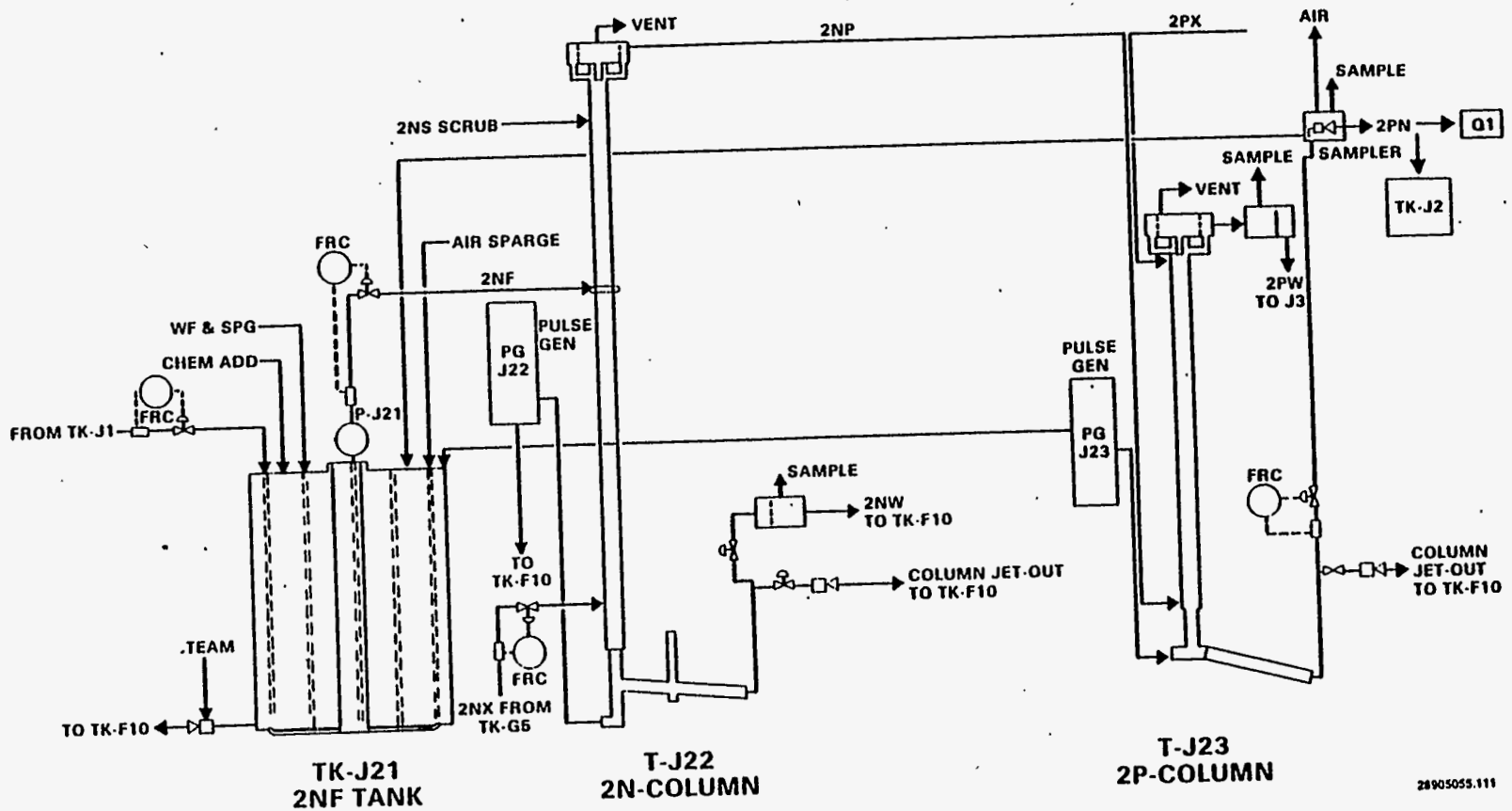

Figure 4-11. Second Neptunium Cycle Process Flow Diagram.

Table 4-22. Second Neptunium Cycle Process Streams--Phase I.

Stream	Composition*		Function	Flow (L/min)
3WB	HNO_3 U Pu Np	7.7M 16.7 g/L 9.25 E-03 g/L variable	Neptunium feed stream to TK-J21 from Backcycle Waste System	10.2
2NF (I)	HNO_3 U Pu Np	5.9M 16.7 g/L 0.007 g/L increasing	2N Column feed stream made up of 3WB and 2PNR	14.0
2NS	HNO_3 Fe^{+2} N_2H_4 NH_2SO_3	2M 0.025M 0.05M 0.05M	2N Column scrub stream--reducing agents for Pu+3 and Np+4 valence adjustments	2.5
2NX	TBP HNO_3	30% 0.01M	2N Column extractant stream from organic header 1	12.9
2NW	HNO_3 Pu Np Fe^{+2} SO_4	5.0M 0.006 g/L 5.3 E-05 g/L 0.004M 0.008M	2N Column waste stream routed to backcycle waste collection tank (TK-F10)	16.3
2NN (2PF)	TBP HNO_3 Pu U Np	30% 0.4M 0.001 g/L 19.0 g/L increasing	2N Column neptunium stream; 2P Column feed stream	12.9
2PX	HNO_3	0.01M	2P Column aqueous strip stream	3.8
2PNR	HNO_3 U Pu Np	1.3M 19.0 g/L 0.002 g/L increasing	2P Column neptunium product stream (recycled to TK-J21)	3.8
2PW	TBP U Np	30% 11.9 g/L 0.003 g/L	2P Column organic waste stream routed to 1BX Column feed tank (TK-J3)	12.9

*The neptunium concentration increases in feed and product streams to a maximum of ~3.7 g/L in the 2PNR due to recycle. The 3WB neptunium concentration also varies depending on the amount of neptunium in the fuel, length of processing campaign, and other factors, but is commonly ~0.016 g/L. Process streams also contain fission products (primarily ^{95}Zr-Nb and ^{106}Ru-Rh at concentrations ≤0.026 Ci/L. These quantities are not listed in this or subsequent tables, as 1 Ci/gal of ^{106}Ru-Rh represents only 7.9×10^{-5} g/L.

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Decontamination accomplished by this mode of operation (Phase I) is not sufficient to allow the neptunium product solution to be routed to the neptunium ion exchange unit for further processing. Therefore, Phase I operation is continued until a specified amount (usually 1,800 to 2,000 g) of neptunium is accumulated in the system; then a decontamination process (Phase II) is initiated.

4.6.1.2.2 Phase II. Phase II operation is very similar to Phase I, except the 3WB flow (the source of new plutonium, uranium, neptunium, and fission products) to the 2N Column feed tank (TK-J21) is discontinued and replaced by a lower volume 57 wt% HNO_3 stream. As Phase II progresses, the amount of plutonium, uranium, and fission products associated with the recycled product solution (2PNR) gradually decreases. The required duration of Phase II operation (generally 12 to 24 h), is determined by the 2PNR uranium concentration, which should be <6 g/L prior to transfer to the neptunium ion exchange unit. During this period, the plutonium concentration also decreases to the desired value of <1 g Pu/1,000 g Np. When this point is reached, Phase II ends and Phase III operation begins.

Table 4-23. Second Neptunium Cycle Process Streams--Phase II.

Stream	Composition*		Function	Flow (L/min)
Syn 3WB-II	HNO_3	12.2M	Nitric acid solution to take place of 3WB during Phase II	3.5
2NF	Np U, Pu, and fission products HNO_3	1.9 g/L decreasing 5.4M	2N Column feed stream made up of 2PNR (recycled neptunium product stream) and Syn 3WB	8.6
2NS	HNO_3 Fe^{+2} N_2H_4 NH_2SO_3	1.27M 0.017M 0.04M 0.032M	2N Column scrub stream--reducing agents for Pu^{+3} and Np^{+4} valence state	3.3
2NX	TBP HNO_3	30% 0.01M	2N Column extractant stream from organic header 1	9.8
2NW	Pu HNO_3 Np Fe^{+2} SO_4^{-2}	decreasing 4.0M 0.0002 g/L 0.005M 0.001M	2N Column waste stream routed to backcycle waste collection tank (TK-F10)	11.8
2NN (2PF)	TBP Np U, Pu, and fission products HNO_3	30% 1.7 g/L decreasing 0.3M	2N Column neptunium stream; 2N Column feed stream	9.9
2PX	HNO_3	0.01 g/L	2P Column aqueous strip stream	4.9
2PNR	Np U, Pu, and fission products HNO_3	3.3 g/L decreasing 0.6M	2P Column neptunium product stream (recycled to TK-J21)	5.0
2PW	TBP U Np	30% decreasing 0.001 g/L	2P Column organic waste stream routed to 1BX Column feed tank (TK-J3)	9.8

*During Phase II, the columns are operated to give essentially 100% neptunium recycle resulting in essentially constant neptunium concentrations. However, the concentrations of uranium, plutonium, and fission products decrease due to desired losses via the 2PW and 2NW streams. PST89-3131-4-23

4.6.1.3.2 Phase II to Phase III Transition. If the Phase III product is to be routed to the neptunium purification unit (Q Cell), transition to Phase III is not initiated until the unit is ready to receive the 2PN product stream and the 2PN analyses are satisfactory. The Q Cell concentrator must be operating in a satisfactory manner, and TK-Q1 and TK-Q3 must be available to receive the 2PN stream. Phase II to Phase III transition is also a gradual change (~45 min for total flow changes). The following sequential steps are required:

- The flowrate adjustments to the 2NF-H_2O, 2NF-HNO_3, 2NF, 2NS, 2NX, 2PX, and 2PN are begun
- Flow ratios are maintained as indicated on the flowrate sheet by stepwise flow changes
- Time elapsed for total rate changes is ~45 min
- Following the rate adjustments, run the system at these reduced rates for ~30 min before proceeding

Table 4-24. Second Neptunium Cycle Process Streams--Phase III.

Stream	Composition*		Function	Flow (L/min)
SYN 3WB-III	HNO_3	5.6M	Nitric acid solution to take place of 3WB during Phase III	6.8
2NF (III)	Np HNO_3	decreasing 5.6M	2N Column feed stream made up of Syn 3WB and 2NF-II heel in TK-J21	6.8
2NS	HNO_3 Fe^{+2} N_2H_4 NH_2SO_3	1.27M 0.017M 0.017M 0.034M	2N Column scrub stream--reducing agents for Pu+3 and Np+4 valence adjustments	1.2
2NX	TBP HNO_3	30% 0.01M	2N Column waste stream routed to organic header 1	4.2
2NW	HNO_3 Fe^{+2} Np SO_4^{-2}	4.8M 0.003M 0.0002 g/L 0.005M	2N Column waste stream routed to backcycle waste collection tank (TK-F10)	7.9
2NN (2PF)	TBP Np	30% decreasing	2N Column neptunium stream 2P Column feed stream	4.2
2PX	HNO_3	0.01M	2P Column aqueous strip stream	1.9
2PN	HNO_3 Np	0.7M decreasing	2P Column neptunium product stream to TK-Q1	1.9
2PW	TBP Np	30% 0.001 g/L	2P Column organic waste stream routed to 1BX column feed tank (TK-J3)	4.2

*The feed (2NF) is continuously diluted with synthetic 3WB resulting in a decreasing neptunium concentration.

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- Confirm that the plutonium content of the 2PN stream is $<2.6 \times 10^8$ cpm/L (2.64×10^{-3} g/L)
- Purge the supply air to the 2PN jet to the cell atmosphere for ~60 s to remove any buildup of solids in the air line that may plug the 2PN jet
- Open the air to the 2PN jet to Q Cell or TK-J2 to its maximum pressure by increasing the air pressure with the controller. If the 2PN is to go to Q Cell, the time elapsed between turning on the 2PN jet and the arrival of the 2PN in TK-Q1 is ~45 min
- Make necessary adjustments to the 2PN flow to Q Cell to avoid overloading the Q Cell concentrator. Adjust the 2PN flowrate to Q Cell by adjusting the 2PX flow controller, not by changing the 2PN jet air pressure.

4.6.1.3.3 Phase III to Phase I Transition. At the completion of Phase III, the J Cell package has been stripped of ~90% of the neptunium. At this time, the J Cell package can be shut down, or, if more neptunium is available in the backcycle, the flowrates of the package can be adjusted back to Phase I rates, and accumulation of neptunium can be resumed.

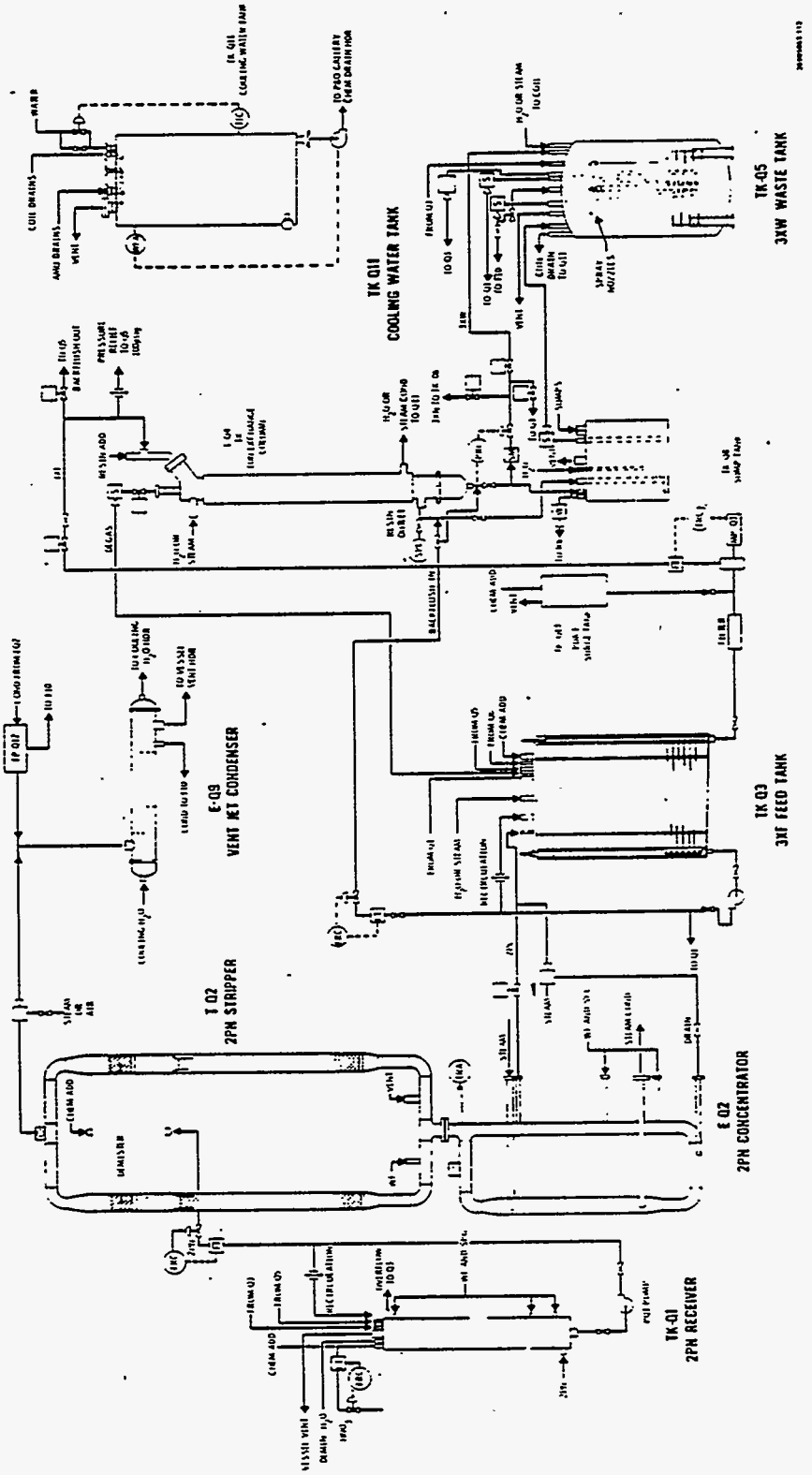

Figure 4-13. Neptunium Purification Process Flow Diagram.

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Table 4-26. Neptunium Concentration and Purification--Q Cell Streams. (Sheet 1 of 2)

Stream	Composition		Function	Flow rate and/or volume/batch
2NP	Np HNO_3 Small amount U, Pu, fission products	2 g/L 0.7M	Neptunium product solution accumulated in TK-Q1 (concentrator feed tank) from 2P Column-Phase III. Routed to the E-Q2 Stripper-Concentrator	1.9L/min ~910 L
2PN-HNO_3	HNO_3	57 wt% (12.2M)	Nitric acid butt to adjust acidity of 2PN prior to concentration	(As required, used only if recycle concentrate is not available)
2PC	Np HNO_3 U, Pu, fission products	~9 g/L 3.1M	Concentrated neptunium product solution accumulated in TK-Q3 (makeup and feed tank - 3XF)	200 L
3XPT	HNO_3 N_2H_4	6.0M 0.1M	Resin pretreatment wash solution (routed to top of 3X column) to prepare resin for neptunium loading	0.46 L/min 90 L
3XW-PT	HNO_3 N_2H_4	~2.9M <0.1M	Pretreatment waste routed from bottom of 3X Column to 3XW combined waste tank (TK-Q5)	90 L
3XF-HNO_3	HNO_3	12.2M	Nitric acid butt to adjust 2PC acidity	138 L
3XF-N_2H_4	H_2H_4	11.3M	Hydrazine (reducing agent) addition to 2PC-3XF solution in TK-Q3 to adjust the neptunium valence to the +4 state	2.8 L
Recycle concentrate	Np HNO_3	~4.8 g/L 7.25M	Neptunium solution from previous purification run to be reprocessed as part of 3XF	40 L
3XF	Np HNO_3 N_2H_4 U,Pu, fission products	~6 g/L 6.3M 0.1M	Adjusted neptunium feed solution to 3X ion exchange column. Neptunium loaded on resin along with trace fission products and uranium	~0.120 L/min 335 L
3XW	Np, U, Pu, fission products HNO_3 N_2H_4	6.3M ~0.1M	Loading waste routed from bottom of 3X column to combined waste tank (TK-Q5)	~0.120 L/min 335 L
3XS-Pu	HNO_3 Fe^{+2} N_2H_4 NH_2SO_3	6.7M 0.1M 0.1M 0.2M	Wash solution--strong HNO_3 and reducing agents to remove plutonium from resin. Not routinely used	0.46 L/min 225 L
3XW-Pu	Pu HNO_3 Fe^{+2} NH_2SO_3 N_2H_4	 6.7M 0.1M 0.2M ~0.1M	Waste plutonium wash solution from 3X column to TK-Q5. Not routinely used	0.46 L/min 225 L
3XS-FP	HNO_3 N_2H_4 NaF	7.0M 0.05M 0.01M	Wash solution (strong HNO_3-NaF) to remove fission products from resin	0.46 L/min 450 L

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Table 4-26. Neptunium Concentration and Purification–Q Cell Streams. (Sheet 2 of 2)

Stream	Composition		Function	Flow rate and/or volume/batch
3XW-FP	Fission products HNO_3 F^-	 7.0M <0.01M	Waste fission products wash solution from 3X Column to TK-Q5	0.46 L/min 450 L
3XS-FS	HNO_3 N_2H_4	8.0M 0.1M	Wash solution (strong nitric acid) to remove residual fluoride from resin prior to neptunium elution	0.46 L/min 225 L
3XW-F	F^- HNO_3 N_2H_4	<0.005M 8.0M <1M	Waste fluoride wash solution from 3X Column to TK-Q5	0.46 L/min 225 L
3XE	HNO_3	0.35M	3X Column eluent (dilute HNO_3) to remove neptunium from resin	0.23 L/min 140 L
Forecut 3XF-FC	HNO_3 Np	~5.0M 1.2 g/L	Displacement of residual strong HNO_3 from fluoride wash with 3XE solution. Recycled from the 3X Column to TK-Q3 (3XF) to be concentrated, then combined with feed solution for the next run.	0.23 L/min ~55 L
3XN	Np HNO_3	40 g/L 0.35M	Neptunium product elution stream routed to the neptunium oxidizer tank (TK-Q6)	40 L
Product strip-aftercut 3XF-AC	Np HNO_3	2.8 g/L 0.35M	Final neptunium strip of resin with 3XE solution. Final strip waste stream routed to TK-Q3 and combined with forecut wastes for concentration and recycle	0.23 L/min 45 L
3XW-ANN	$Al(NO_3)_3$ Al/F Mole ratio	1.6M ≥3	ANN addition to waste in TK-Q5 to complex fluoride prior to backcycle of waste to TK-F10	12 L
3XW-$NaNO_2$	$NaNO_2$	0.77M	Nitrite addition to react with N_2H_4 prior to recycle of 3XW to TK-F10	240 L
3XW*	U, Pu, fission products Np HNO_3	 ~0.15 g/L 5.4M	Combined Q Cell waste in TK-Q5 normally routed to the backcycle waste system but nay be routed to UGS if the neptunium content is low (<0.02 g/L)	~1,350 L

*3XW-$NaNO_2$ and 3XW volumes listed are for normal runs where 3XS-Pu stream is not used. The respective volumes are 306 L and 1,650 L when it is used. Composition of 3XW also changes with 3XWS-Pu use, but is not shown.

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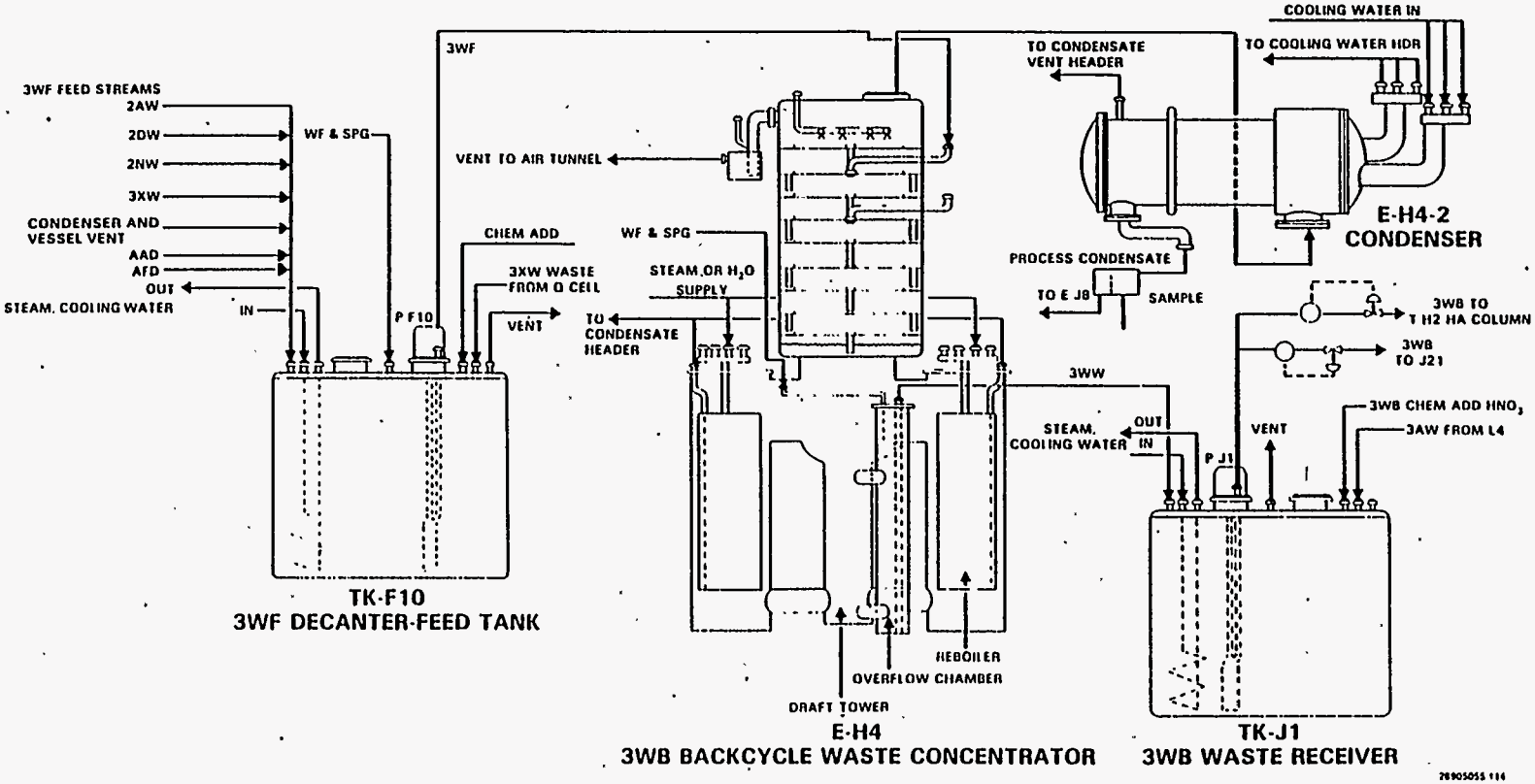

Figure 4-14. Backcycle Waste Process Flow Diagram.

Upstream 1.

Table 4-27. Backcycle Waste System Process Streams--Phase I.

Stream	Composition	Function	Flow (L/min)
2NW	HNO_3 5.0M Pu 0.006 g/L Np (No stream when neptunium is not recovered.) 0.0002 g/L	Aqueous waste from 2N Column	16.5
2DW	HNO_3 1.15 U 16.8 g/L Np variable	Aqueous waste from 2N Column	23.4
2AW	HNO_3 2.9M Pu 0.004 g/L	Aqueous waste from 2N Column	24.1
AAD	HNO_3 0.1M	Acid absorber process condensate (E-F5)	12.45
AFD	HNO_3 0.005M	Acid fractionator process condensate	18.09
3XW	HNO_3 5.1M Np 0.14 g/L (No stream when neptunium is not recovered.)	Aqueous wastes from Q cell neptunium anion exchange process	0.03 (avg.) (~375 gal in 3 batches over 10-d period)
3WF	HNO_3 1.15M U 2.54 g/L Pu 0.001	Backcycle feed	153.8
3WW	HNO_3 8.3M U 18.84 g/L Pu 0.009 g/L	Concentrated backcycle waste	20.7
3AW	HNO_3 3.0M Pu 0.01 g/L	Aqueous waste from 3A Column	3.05
3WB	HNO_3 7.6M U 16.4 g/L Pu 0.009 g/L Np variable	Backcycle waste to TK-J21 and T-H2	23.75
3WB-2N	Same as 3WB (Used only during neptunium recovery)	3WB to TK-J21	10.21
3WB-HA	Same as 3WB	3WB to the HA Column (T-H2)	13.54

NOTE: Neptunium concentrations are highly variable, depending on feed and upstream process conditions.

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Table 4-28. Backcycle Waste System Process Streams--Phases II, III.

Stream	Composition		Function	Flow (L/min)
2DW, 2AW AAD, AFD, 3AW	Same as Phase I		Same as Phase I	Same as Phase I
2NW-II*	HNO_3 Np	4.0M 0.0002 g/L	Aqueous waste 2N Column Phase II	11.8
2NW-III*	HNO_3 Np	4.80M 0.0002 g/L	2N waste, Phase III	8.05
3WF	HNO_3 U Np	0.93M 0.012M 0.0006 g/L	Backcycle feed	147
3WW	HNO_3 U Np	8.4M 0.1M 0.006 g/L	Concentrated backcycle waste	15.7
3WB	HNO_3 U Pu	7.5M 0.1M 0.009 g/L	Composite backcycle waste to T-H2 (HA Column)	18.8

*Neptunium concentrations are variable.

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The concentrator functions the same as other PUREX concentrators. Feed solution is introduced into the stripping column to remove organic, then enters the concentrator reboiler where it mixes with the concentrated solution as it is recirculated through the two vertical tube bundles, and leaves the concentrator via the stilling chamber. Thermal recirculation of the solution through the vertical tube bundles results from the boiling action in the steam-heated tubes.

Liquid droplets entrained in the vapor jetting from the reboiler tubes are partially removed by being deflected by the impingement plate above the tubes, with the rest being removed by passing through the stripping section of the concentrator tower, where the flooded bubble-cap trays provide effective deentrainment. Droplets of concentrator feed solution entrained at the feed plate are removed from the vapors by passage through the one-to-three bubble-cap trays above the feed plate and the wire mesh pad in the top of the concentrator tower.

4.6.3.2 Startup and Shutdown of Backcycle Concentration. Startup and operation of E-H4-1 involves the following major steps:

- Establish the proper vacuum on the condenser and concentrator
- Fill E-H4-1 to a minimum volume of 2,500 gal with seal pot water
- Air blow the tube bundle steam chests to remove water
- Slowly heat the concentrator to boiling (30 min) with steam on both tube bundles while starting cooling water to the condenser (E-H4-2)
- Maintain the volume at 2,500 (±100 gal) by addition of seal pot water

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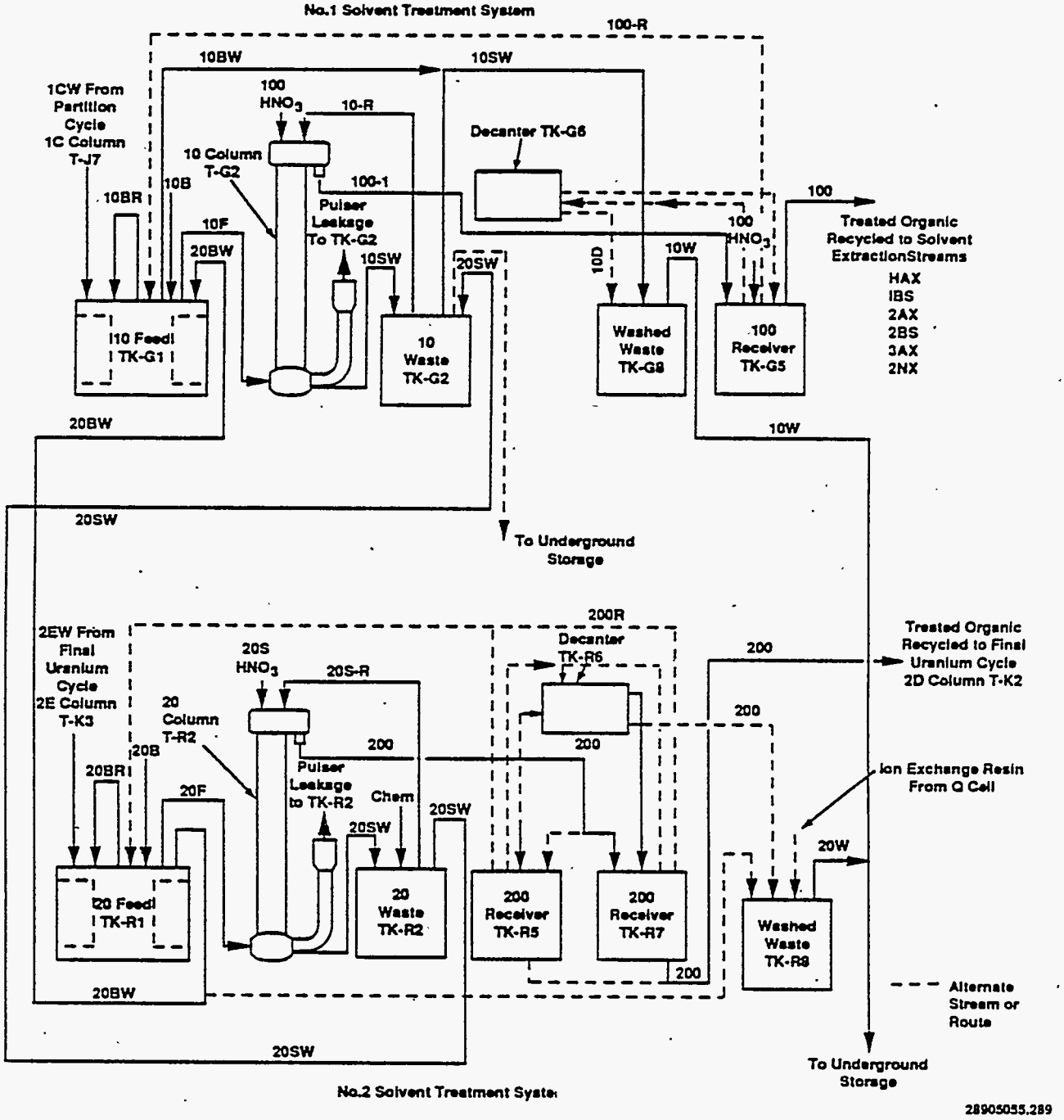

Figure 4-15. Solvent Recovery System--Process Flow Diagrams.

Table 4-29. Solvent System Streams.

Stream	Composition	Function	Flow (L/min)
1CW	TBP 25% NPH 75% U trace fission products, other impurities	Organic waste stream from 1C Column to the semibatch wash tank (TK-G1)	112.3
1OB (Batch makeup)	Na_2CO_3 0.24M $KMnO_4$ 0.006M	Alkaline-permanganate wash, added to TK-G1 to remove fission products and impurities from solvent	2.2 (avg.)
1OBR	Na_2CO_3 $KMnO_4$ Composition variable between 1OB and 1OBW	Recycled alkaline-permanganate wash solution in TK-G1	757.1
1OBW	Na_2CO_3 0.21M Na_2CO_3 0.06M $KMnO_4$ Trace MnO_2 0.5 g/L U 0.2 g/L fission products	Depleted alkaline-permanganate wash solution routed to TK-G8 for disposal	2.2
1OF	Na_2CO_3 trace TBP 30% NPH 70%	Washed-disengaged organic--1O Column feed	123.6
1OSR	HNO_3 0.04M	Dilute HNO_3 scrub to top of column to decontaminate 1OF organic stream. Alternated between fresh makeup and recycle from TK-G2	13.7
1OW	Na_2CO_3 0.12M $NaNO_3$ 0.05M MnO_2 0.29 g/L	Aqueous waste from 1O Column and TK-G1 to TK-G8 (batch transfer to UGS)	3.9
1OS HNO_3	HNO_3 12.2M	Concentrated HNO_3 added to the 1OS stream to maintain 1OSR acidity	2.3 E – 02
1OSW	HNO3 0.04M Impurities	Contaminated scrub solution in TK-G2 sent to wash waste collection tank (TK-G8)	7.8 (avg.)
1OO	TBP 25% NPH 75% ^{95}Zr-Nb 18.5 µCi/L ^{106}Ru 50.2 µCi/L HNO_3 0.01M	Washed solvent from T-G2, transferred to solvent receiver tank 1 (TK-G5)	112.3
2EW	U trace HNO_3 0.0001M Fission products, other impurities	Organic waste stream from the 2E column [(final uranium cycle to semibatch wash tank (TK-R1)]	75.7
Fresh solvent	TBP 50% NPH 50% (May be varied as needed to adjust TBP concentration of solvent.)	Fresh solvent added to TK-R1 from solvent blend tank (TK-R1A) on a batch basis to replenish process inventory	0.3 (avg.)
2OB (Batch makeup)	Na_2CO_3 0.24M $KMnO_4$ 0.024M to 0.006M	Alkaline-permanganate wash added to TK-R1 to remove fission products and impurities from solvent	2.2 (avg.)
2OBR	Na_2CO_3 $KMnO_4$ Composition variable between 2OB and 2OBW	Recycled alkaline-permanganate wash solution in TK-R1	757

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Table 4-29. Solvent System Streams. (cont.)

Stream	Composition		Function	Flow (L/min)
2OBW	Na_2CO_3 $KMnO_4$ $NaCO_3$ MnO_2	0.23M 0.026M 0.02M 0.002 g/L	Semidepleted alkaline-permanganate wash solution routed to TK-G1 for further use, or to the wash waste collection tank (TK-R8) for disposal	2.2 (avg.)
2OF	Na_2CO_3 TBP NPH	trace 30% 70%	Washed disengaged organic 2O Column feed stream	75.7
2OSR	HNO_3	0.04M	Dilute HNO_3 scrub solution to top of 2O Column to decontaminate 2OF organic stream. Alternated between fresh makeup and recycle from TK-R2	19.7
2OS HNO_3	HNO_3	12.2M	Concentrated HNO_3 added to the 2OS stream to maintain 2OSR acidity	1.9 E – 02
2OSW	HNO_3	0.04M	Partially contaminated scrub solution normally transferred to TK-G2 for further use	1.4 (avg.)
2OS	HNO_3	0.064M	Fresh dilute HNO_3 scrub solution batch makeup	1.8 (avg.)
2OO	TBP NPH ^{95}Zr-Nb ^{106}Ru HNO_3	30% 70% 0.1 µCi/L 0.2 µCi/L 0.01M	Washed solvent transferred to TK-R7	75.7

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As shown in Figure 4-15, the R Cell nitric wash process is similar to that of G Cell, involving the 2O Column for solvent scrubbing, collection of waste in TK-R2, and recycle of the 2OSR stream as solvent scrub solution. R Cell scrub waste (2OSW) is also routinely transferred to TK-G2 to be re-used as chemical makeup for the 1OSR stream used to scrub the solvent of Solvent System 1.

The dilute nitric acid scrub (1OSR) in TK-G2 must also be changed periodically to remove accumulated fission products and to replace the nitric acid destroyed by reaction with the sodium carbonate entrained in the solvent. The spent solution is jetted to TK-G8 while maintaining normal operation in G Cell, and is replaced by increasing the 1OS water and nitric acid flow rates, or by transfer of used dilute nitric acid scrub (2OSW) from TK-R2.

Spent nitric acid in TK-R2 is replaced after jetting the used solution (2OSW) to TK-G2 for reuse in Solvent System 1, or to TK-R8 for disposal to UGS in the tank farms. Tank R2 is refilled with water and nitric acid to make fresh 2OS.

4.7.2.3 Startup and Shutdown of Solvent Systems. The purpose of the startup procedures is to bring G or R Cell on-line by systematically starting the process stream flows, until steady-state conditions are reached.

The G Cell solvent system is started by establishing an internal recycle (spinning) of solvent by routing the solvent output from TK-G5 back to TK-G1. As the plant is started up, the organic streams to the various cycles are started as needed, and the recycling of solvent is discontinued.

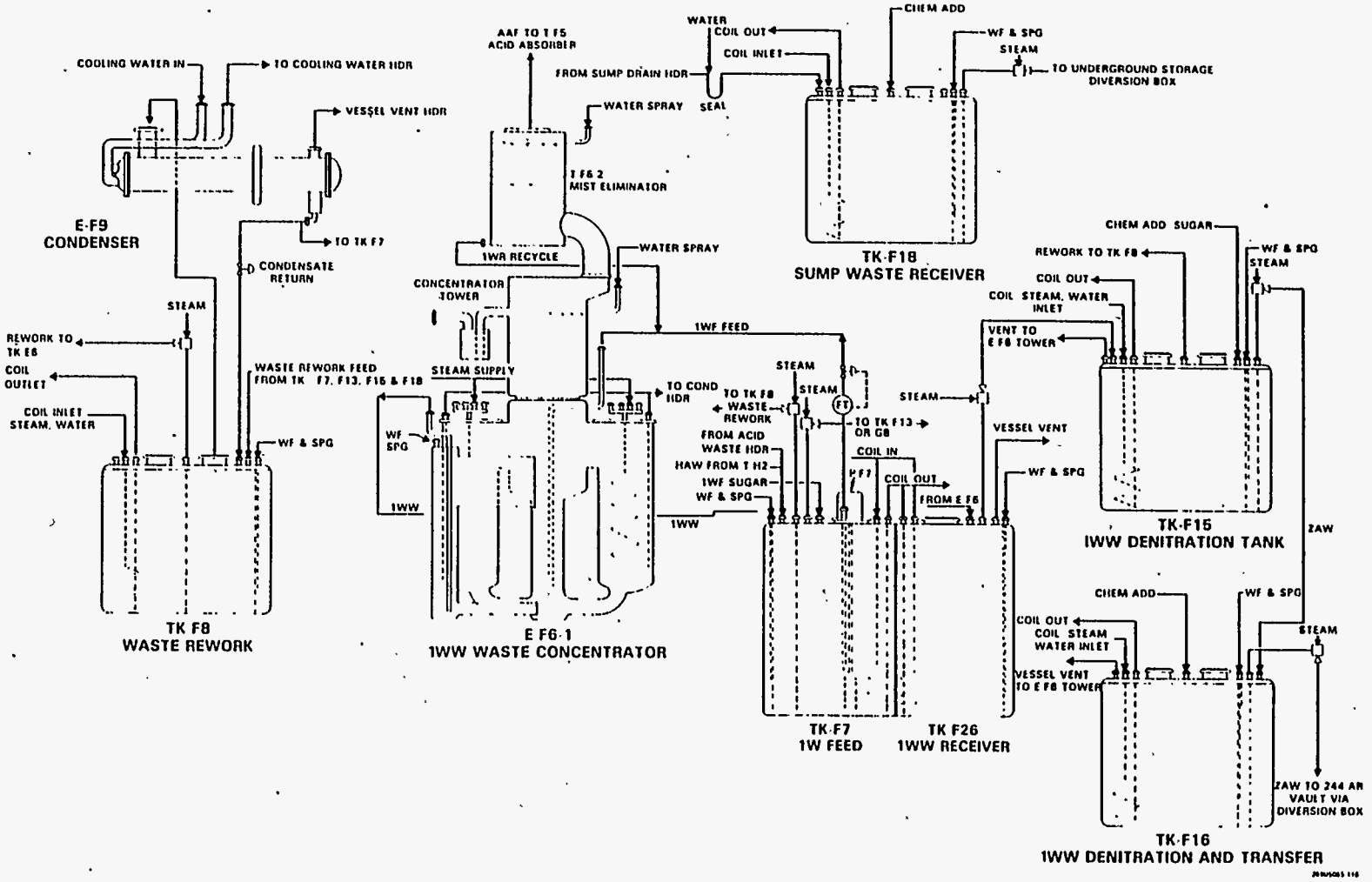

Figure 4-16. Waste Concentration and Handling Flow Diagram.

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Table 4-33. High-Level Waste Concentration and Sugar Denitration Streams.

Stream	Composition		Function	Flow (L/min)
HAW	U HNO_3 Al F- Pu	3.4 E-03 g/L 3.03M 0.07M 0.0075M 5 E-05 g/L	HA column waste stream	37.9
1WF H_2O	HNO_3 ADD, Recycled E-F5 condensate	0.1M	Demineralized H_2O alternate added to dilute HAW in TK-F7 to allow more efficient concentrator operation resulting in better acid recovery	75.1
1WF sugar	Sugar NaOH	0.7M 0.005M	Feed treatment in TK-F7 to suppress ruthenium volatilization from acid waste. Sodium hydroxide added to prevent mold	0.13
1WF	U HNO_3 Al F- Pu	trace 1.08M 0.002M 0.007M trace	Feed to E-F6-1 waste concentrator	113.0
1WW	U HNO_3 Al F- Pu	3.2 E-02 g/L 6.7M 0.55M 0.06M 4.4 E-04 g/L	Concentrated waste overflow from concentrator	4.71
Denitration sugar	Sugar NaOH	0.7M 0.005M	Denitrate 1WW	0.78
ZAW	Fission products U NHO_3 Al F- Pu	>1,000 Ci/L 2.5 E-02 g/L 0.77M 0.67M 0.06M 3.8 E-04 g/L	Sugar-treated zirflex acid waste to 244-AR vault	5.35

*Based on PUREX processing rate of 8.1 MTU/day.

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To improve the nitric acid recovery from the high-level waste, 1WF dilution water (normally recycled condensate from the E-F5 Condenser) is added to the concentrator feed tank (TK-F7). The concentrator is generally operated at full capacity, so the volume of dilution water added varies with the HAW flowrate. Sugar solution is also continuously added to TK-F7 to suppress ruthenium volatilization from the concentrator. The sugar reacts with nitric acid to form nitrite, which prevents ruthenium oxidation to volatile ruthenium tetroxide (RuO_4).

The vapors (water and nitric acid) from the boiling waste in the concentrator pass upward through a mist eliminator located in the deentrainment tower, and another mist eliminator (T-F6-2) in the tower off-gas line, before going on to the nitric acid recovery equipment. This off-gas stream is called the AAF. The condensate (1WR) formed in the upper mist eliminator is returned to the solution section of the concentrator.

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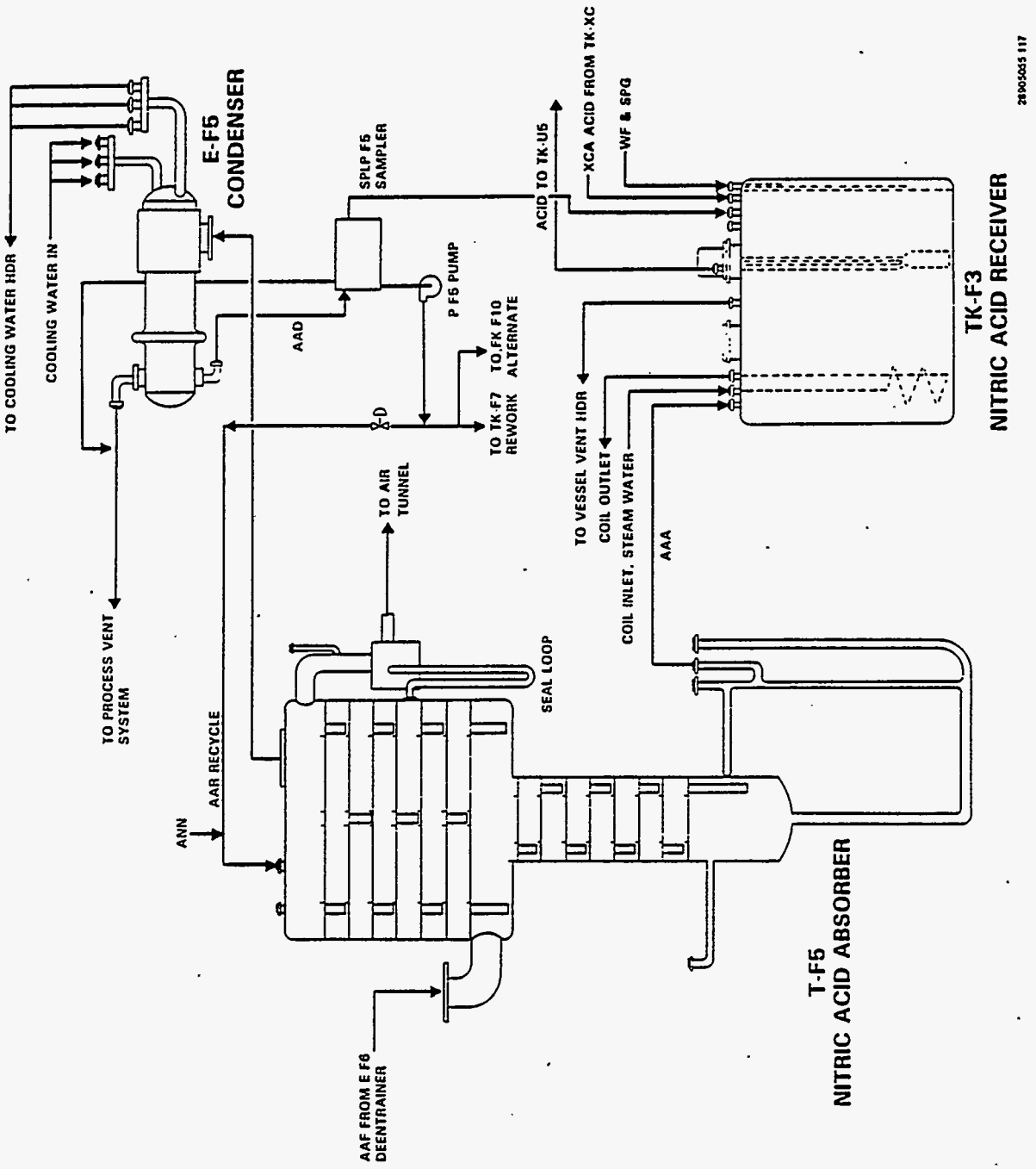

Figure 4-17. Nitric Acid Absorber Flow Diagram.

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Table 4-35. Nitric Acid Absorption Streams.

Stream	Composition	Function	Flow (L/min)
AAF	Vapor HNO_3 1.1M	Acid absorber feed stream--vapor from waste concentrator (E-F6-1)	112.0
AAR	Recycled AAD; alternate demineralized H_2O	Acid absorber water to T-F5	25.7
AAA	HNO_3 4.10M	18% HNO_3 solution product from T-F5 routed to TK-F3	25.7
XCA	HNO_3 2.0M	HNO_3 recovered from DOG by Back-Up Facility routed to TK-F3	23.4
AAD	HNO_3 0.1M	Acid absorber condensate from E-F5 routed to AAR, TK-F7, and TK-F10	115.9
ANN	ANN 1.68M	ANN solution added to T-F5 to complex fluoride reducing corrosion	0.3

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4.9.1.3.1 **Acid Absorber Operation and Process Control.** The acid absorber is started as follows:

- The T-F5/E-F6 Condenser vent system is operated on steam to give >40 in. of water vacuum
- The T-F5/E-F6 vacuum jet is operated on steam to supply the desired vacuum
- Water is added to T-F5 as necessary to increase the liquid level to 100 in.
- The T-F5 Condenser cooling water is turned on to maintain a water outlet temperature of ≤55°C
- The E-F6 Concentrator is started as described in Subsection 4.8.1.1.1
- The T-F5 condensate recycle pump is started with the flow to T-F5 (AAR) set at 25% of the rate sheet value. The flow is increased to the rate sheet value as the T-F5 specific gravity increases
- The condensate flows to TK-F7 and TK-F10 are adjusted.

The T-F5 bottoms specific gravity is controlled during operation to ensure efficient nitric acid recovery by adjusting the AAR flowrate.

The T-F5 Acid Absorber is shut down by turning off the condensate recycle pump after the HAW flow is stopped. The TK-F7 inventory is reduced and E-F6 Concentrator feed and steam flows are reduced.

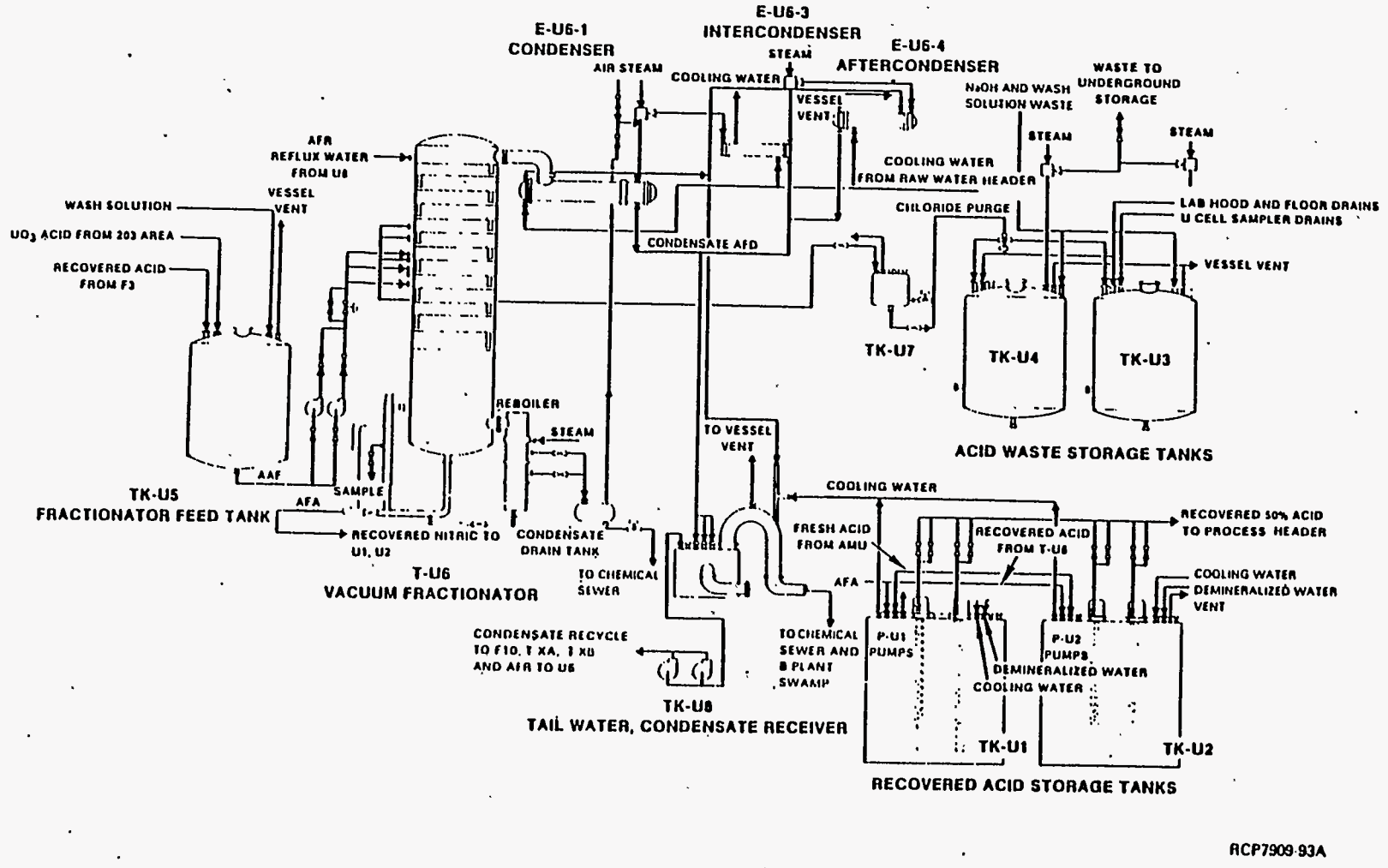

Figure 4-18. Vacuum Fractionator and U Cell System Flow Diagram.

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Table 4-37. Vacuum Fractionator Streams.

Stream	Composition	Function	Flow (L/min)*
UO_3 Plant Acid	HNO_3 10.4M	UO_3 Plant recovered acid	4.9
AFF	HNO_3 3.76M NH_4NO_3 0.01M	Acid Fractionator feed pumped from TK-U5. Mixture of AAA, XCA, and UO_3 acid	54.0
AFR	Demineralized H_2O (alternate) HNO_3 0.005M AFD recycle	Reflux added to fractionator (T-U6)	10.8
AFA	HNO_3 10.4M	50% HNO_3 solution from fractionator, routed to storage tanks (TK-U1 and -U2)	19.6
AFD XA, XB	HNO_3 0.005M	Fractionator condensate routed to Back-Up Facility as absorber water	47.0
AFD-F10	HNO_3 0.005M	Excess AFD routed to Backcycle Waste System	18.5

*Based on PUREX Plant processing rate of 10 MTU/day. PST89-3131-4-37

The following guidelines govern steady-state operation of the vacuum fractionator.

- The tower vacuum is maintained at 100 mm Hg (absolute pressure).
- The bottoms concentration is maintained at 50 wt% HNO_3 by adjusting the steam flow to the reboiler.
- The E-U6-1 Condenser cooling water outlet temperature is maintained at somewhat $<40\,^{\circ}C$ by adjusting the cooling water flow.
- The acid from the fractionator is routed between TK-U1 and -U2 as necessary.
- Tanks U1 and -U2 liquid temperatures are maintained between 20 °C and 30 °C by adjusting water flow to the coils.
- The feed to the fractionator (AFF) is maintained at a rate that keeps low liquid inventories in TK-F3, -XC, -XD, and -U5.
- The desired reflux rate (AFR) for the current feed rate (AFF) is determined and the AFR flowmeter is set.

Table 4-55. Physical Measurements.

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Specific gravity	Sp. gr.	Determination of specific gravity of liquid samples	All	Density meter	The sample is introduced via a vacuum flow sampler into a U-shaped glass tube that is vibrated electromagnetically. Density is calculated from the deviation in resonant frequency, using a digital processor	Solids, gassing	0.7 mL	2 mL	NE	NE	1/2 h	--
Isotopic	IA (1)	Determination of isotopic distribution of uranium in UNH product	K6	Mass spectrometry	An aliquot of sample is added to dilute HNO_3. A very small quantity of solution containing <1 µg of metal is mounted on a special filament and the isotopic ratios of the uranium are determined by high resolution mass spectrometry	Other metals with the same mass numbers as uranium; relatively nonvolatile organics	25 µL	250 µL	~0.1	Bias free	4 d	234-5
	(2)	Determination of isotopic distribution of plutonium in $Pu(NO_3)_4$ product	L9	Mass spectrometry	Same as for uranium, except the diluted sample is decontaminated of uranium by ion exchange, to avoid interference of ^{238}U with ^{238}Pu	Relatively nonvolatile organics; ions with the same mass numbers as plutonium (the worst potential interference, ^{238}U, is removed in the method)	20 µL	250 µL	~0.1	Bias free	3 d	234-5
	(3)	Determination of isotopic distribution of plutonium in $Pu(NO_3)_4$ product	L9	Gamma Energy Analysis ("Solution Counter")	Sample is diluted with HNO_3 in a vial. The vial is capped, sealed, placed inside another vial, and counted using a special Ge(Li) detector designed for low-energy gammas	^{241}Am, FP	1.5 mL	1.5 mL	±5.0	100	1/2 h	

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Table 4-56. Chemical Measurements. (Sheet 1 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Carbonate	CO_3	Determination of carbonate in "cold" organic wash solution	Na_2CO_3-$KMnO_4$ wash	Acid-base titration	Total carbonate is determined by adding an excess of standard H_2SO_4, heating, and back-titrating the unreacted H_2SO_4 with standardized base to a potentiometric end point	Anions of weak volatile acids (e.g., nitrite)	100 µL	50 mL	±5	99	1	--
Caustic ratio	C/R	Empirical determination of "caustic demand" for various acidic waste samples	F18, G8, R8	Acid base titration	A sample of process waste material is titrated with standardized NaOH to the desired pH (12.00). From the volume required to titrate the sample, the amount of 50% NaOH needed to neutralize the process waste material is calculated	Not really applicable, since this is an empirical method	25 to 100 µL	1 mL	(Empirical)	(Empirical)	1/2	--
Fluoride	F^-	Determination of total fluoride ion in aqueous process samples	D2, D5, E1, E3, E5, F15, (F26), K6, L9, Sumps, U1/U2, F3, IBP, AFAN, 3XS-FP	Specific ion electrode	An aliquot of sample is added to a special mixture of buffer and complexant. By the method of standard addition, the sample fluoride concentration is calculated	Excess free acid (>0.4 meq) base (>1.0 meq) or polyvalent metal ions (>0.4m<u>M</u> per sample)	25 µL to 1 mL	1 mL	±10	100	1	--
Free acid	H^+ (1)	Determination of acidity in aqueous samples essentially free of hydrolyzable cations (<0.1%)	U1/U2, F3, F5, 2NW, 3WD, 1UD, 2AW, 2AS, 1.6/1.7, HAS, 1CX, 2BX, 2EX, XCX, 2PX, 3AS, 3BX, 3XE, 3XPT, 3XS-FP, 3XS-FS	Acid-base titration	An aliquot of sample is diluted into water and titrated with standard base. The end point is determined either potentiometrically using a pH electrode, or a colorimetric indicator	Hydrolyzable metal ions, such as Fe^{+3}, Al^{+3}, UO_2^{+2}, etc.; colored solutions; anions with equilibria involving H^+ (e.g., $Cr_2O_7^{-2}$)	10 µL to 50 mL	50 mL	±3	97	1/2	--
	(2)	Determination of free acid in aqueous samples containing hydrolyzable cations	F8, F15, F18, F28, Sumps, L9, L10, RW, L11, R8, 2PC, 3XF, 3XW, 3EW, Q8, 3WF, HAW, J1 (3WB), 2NS, $Cd(NO_3)_2$, 2PN, 2NF, 1BP, 2AF, 2BP, 3BP, 1BX, 3AF, 3XS-Pu	Acid base titration with complexant	The metal ions are complexed with excess potassium oxalate, and the solution is then titrated with standard base to a potentiometric end point	Ions that have interspecies equilibria involving hydrogen ion interfere with the analysis (such as phosphate and dichromate)	20 µL to 3 mL	50 mL	±12	84	1	--

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Table 4-56. Chemical Measurements. (Sheet 2 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (If not PUREX)
							Nominal	Maximum				
Free acid (cont.)	(3)	Determination of free acid in aqueous samples with high uranium content	D5, E1, E6, R6, P8, P-TKs, 2DW	Acid-base titration with complexants	Same as (2) except KF is used along with the oxalate, and the solution is titrated to a preset pH	Anions such as listed in (2)	10 to 15 µL	1 mL	±10	91	1/2	--
	(4)	Determination of total acid in organic samples essentially free of hydrolyzable cations (<0.1%)	C5, R7	Acid-base titration	An aliquot of sample is contacted with water and the aqueous solution is titrated with standard base to a potentiometric end point	Hydrolyzed TBP; hydrolyzable metal ions as listed in (1)	2 mL	2 mL	NE	NE	1/2	--
	(5)	Determination of strippable acid in organic samples with high metal content	HAP, J3, (HBXF)	Stripping and titration with complexants	An aliquot of sample is emulsified with oxalate water. The aqueous phase is then treated with complexing solution and then titrated with standard base to a preset pH	Hydrolyzed TBP; anions or species having equilibria as described in (2)	500 µL	500 µL	NE	NE	1	--
Aluminum	Al	Process solutions	ANN TK205, D-4, D-5, E-1, F-15, F-28, F-3-AAA, L-11, N-19, N-53, U-1, U-2	Spectrophotometry	Samples are stripped, buffered, and aluminum is complexed with 8-Hydroxyquinoline, absorbance is read on a spectrometer	Other metals, e.g., Fe, Zr, Pu, U, Ni, Cr	100 µL	1 mL	±23	100	2 h	--
Cadmium	Cd	Assay of clean solutions	XCX	Complexometric titration	Titrate with EDTA at pH = 10 using color of Mg EDTA with Eriochrome Black T to determine endpoint	Other metals which are complexed by EDTA at same pH, e.g., Fe	25 µL	7.5 mL	±10	100	1 h	--
Hydrazine	N_2H_4	Determination of hydrazine in "cold" AMU samples	2HX, 2NS, N_2H_4, 3XF-F, 3XS-Pu, 3XS-FP, 3XS-FS	Absorption spectrophotometry	Hydrazine reacts with p dimethylaminobenzaldehyde (p-DAB) to form a rearrangement compound that is an intense yellow color. The intensity of the color is then measured spectrophotometrically and the concentration of hydrazine is determined from a calibration curve	Other amines that can form compounds with p-DAB	50 to 100 µL	1 mL	±8	93	1/2	--
Hydroxide	OH^-	Determination of total hydroxide ion in "cold" AMU samples and those free of hydrolyzable anions (CO_3^{-2}, PO_4^{-3}, etc.)	KOH	Acid base titration (potentiometric)	The sample is titrated with standard acid to a potentiometric end point. The break is calculated as hydroxide	Anions of weak acids such as CO_3^{-2}, PO_4^{-3}, etc.; aluminate (to some extent); CrO_4^{-2}	50 µL	5 mL	±1	99-100	1/2	--

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Table 4-56. Chemical Measurements. (Sheet 3 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Hydroxylamine nitrate	HN	Determination of total hydroxylamine in "cold" AMU samples	2BX, HN	REDOX titration	Ferric ammonium sulfate is added to the complexed hydroxylamine sample, which reacts to reduce the Fe^{+3}. The resultant Fe^{+2} is titrated with standard permanganate solution. From the stoichiometric permanganate titration, the hydroxylamine concentration is calculated	Fe^{+2} initially in the sample; any other compound that will reduce Fe^{+3}	100 µL to 1 mL	10 mL	±5	99	1	--
Iron(+2)	Fe^{+2} (1)	Determination of Fe^{+2} in aqueous samples with low concentrations of other colored species	1BP	Absorption spectrophotometry	An aliquot of sample is mixed with a special complexant (batho-phenanthroline) in an acetate buffer. The Fe^{+2} reacts with the complexant at a pH of 3.5 to 3.7 to form a red-colored complex. The intensity of the color produced is then measured spectrophotometrically and the concentration of Fe^{+2} is determined from a calibration curve	Be, Sn, Dy, Mo, Hg, Zn, (pH > 4)	10 µL	500 µL	5	94	1/2	--
	(2)	Determination of Fe^{+2} in "cold" AMU samples	1BX, 2NS, $Fe(SAl)_2$, 3XS-Pu	REDOX titration	The sample containing Fe^{+2} is titrated with standard permanganate solution to a colorimetric end point	N_2H_4, NH_2OH, other reductants oxidized by permanganate	250 µL to 10 mL	10 mL	7	91	1/2	--
Iron (total)	Fe (1)	Determination of total iron in aqueous samples with low concentration of other colored species	D5, F15, U1/U2, F3, I.9	Reduction/ absorption spectrophotometry	All the iron in the sample is reduced to Fe^{+2} with hydroxylamine hydrochloride. The Fe^{+2} is then complexed with batho-phenanthroline and determined as described above for Iron(+2) method No. 1	Be, Sn, Dy, Mo, Hg, Zn, Pu^{+4}.. color of ion interferes in high concentrations (e.g., I.9)	25 to 100 µL	1/2 mL (500 µL)	±5	94	1/2	--
Metals	Al, B, Cd, Fe(g), Ca, Cr, K, Ni, Na, Mn, Mo, Pb, Si, Ta, Tb, Ti, Zr, Fe, I'	Determination of most trace metals in aqueous solutions	All aqueous sample points	Inductively coupled plasma (ICP)	The analysis is dependent on the sample matrix		2 mL	10 mL	±10	100	4	--

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Table 4-56. Chemical Measurements. (Sheet 4 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Neptunium valence	Np Val	Determination of neptunium valence state ratios in Q Cell samples	Q3, Q4, Q8	Absorption spectrophotometry	The sample is diluted into HNO_3 of the same concentration as that in the sample. The dilute sample is then scanned on an extended-range double-beam spectrophotometer. By comparing the spectrum obtained with the spectra of pure valence states (+4, +5, and +8) and also knowing the free acid concentration, the percentage of each valence state in the sample is calculated	Species that absorb in the same region as neptunium ions; changes in acidity will change ratio of valence states; thus acidity must be known	100 µL	5 mL	±5	NE	1/2	--
Neptunium (total)	Np	Determination of neptunium at g/L level	J2	Absorption spectrophotometry	Neptunium is oxidized quantitatively to Np(VI) with dichromate at fixed HNO_3 concentration. Absorption peak at 7nm is compared with calibration curve	Species that absorb at same wavelength as Np(VI)	100 µL	4 mL	±5	±5	1	--
Ammonia	NH_3	Determination of NH_3 in most aqueous samples	F18	Distillation acid-base titration	The sample is made strongly basic with NaOH and heated. The ammonia thus formed is distilled and trapped in boric acid, which is titrated with standardized HCl using bromcresol green indicator	Other volatile bases	NE	1 mL	±10	90	1/2	--
Nitrite (nitrous acid)	NO_2 (1)	Determination of nitrite in aqueous samples with low Fe+3 content	3XW (Q5), 3AF, $NaNO_2$, 2AF	Absorption spectrophotometry	An aliquot of sample is introduced into a solution of sulfanilic acid in acetic acid. The nitrous acid in the sample forms a diazonium salt that is then combined with 1-naphthylamine-7-sulfonic acid to form a pink azo dye. The intensity of this dye is then measured spectrophotometrically and the concentration of NO_2^- determined using a calibration curve	Fe^{+3}, but can be corrected for; plutonium at very high levels (Pu: NO_2 > 120); Nd	10 to 50 µL	1 mL	±10	90	1	222-S
	(2)	Determination of HNO_2 in organic samples	HAP, HXF, HBSU, 2BW, 3BW	Aqueous stripping Absorption spectrophotometry	An aliquot of organic sample is contacted with dilute carbonate solution to strip the nitrous acid into the aqueous phase. The aqueous is acidified and buffered. Sulfanilic acid is added and the mixture is then analyzed as in method No. 1	Same as (1)	NE	NE	NE	NE	1 1/2	--
Nitrate	NO_3	Determination of nitrate in aqueous samples	$NaNO_3$	Raman spectrometry	The sample is introduced into a capillary tube and scanned on a Raman spectrometer. The concentration of nitrate is determined by means of a calibration curve and perchlorate as an internal standard	Carbonate	250 L	2 mL	±5	100	1	222-S

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Table 4-56. Chemical Measurements. (Sheet 5 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Nitrate (cont.)	NO_3	Determination of nitrate in aqueous solutions	F-16	Specific ion electrode	The sample is diluted, chemically adjusted, and analyzed by the method of standard addition	NO_2^-, SO_4^-	100 µL	100 mL	15	100	2	--
Nickel	Ni	Aqueous solutions	D-4, D-5, E-1, F-15	Spectrophotometry	The sample is complexed with DEDTC, extracted into N-butanol, and read on a spectrophotometer	Other metals which will complex with DEDTC, e.g., Zr, Pu	100 µL	1 mL	±22	100	1	--
Oxalate	Ox	Determination of residual oxalate in process solutions; verify make up of AMU solutions	E-6, N-35, N-36, N-21, N-22, N-53, L-11, N-13, N-15, N-16, N-30	Redox titration	Plutonium is extracted, if necessary, to remove color. Sample is heated, then titrated with standard permanganate to first persistent pink color	Any other reductants	1 mL	5 mL	± 10	103	1	--
Total reducing agent	RedA	Determination of residual reducing normality in process solutions	Amu-overflow, 12B 2DP	Redox titration	Sample is titrated with $KMnO_4$ in acid solution to first persistent pink color	--	100 µL	5 mL	±4	102	1/2	--
pH	pH	Determination of pH in any aqueous sample	All	Specific ion electrode	The pH of undiluted sample is measured by use of a pH meter and combination electrode	Sodium at pH > 12. Possibly other alkali metal ions	250 µL	None	±0.2 pH	>99	1/4	--
Plutonium	Pu (I)	Accountability measurement for plutonium in dissolver solution	D5	SX/IX/mass spectrometry	Accurately known amounts of sample and spike solution (known standard solution of pure ^{240}Pu or ^{242}Pu) are combined in 1M HNO_3 and allowed to equilibrate. Valence adjustments and a TTA extraction are then performed as described in plutonium radiochemical method No. 1. After the organic is scrubbed 2 to 3 times with 0.75M HNO_3, Pu^{+4} is stripped into 8M HNO_3, and a final cleanup from uranium is made with an anion exchange column, to assure thorough decontamination from ^{238}U. An isotopic analysis is then made by high-resolution mass spectrometry. From knowing the isotopic distributions in the sample, spike, and sample plus spike, along with the spike concentration, the sample concentration is calculated	Relatively nonvolatile organics; metals with same mass numbers as plutonium (^{238}U and ^{241}Am are removed in this method)	No	0.05 mL	NE	NE	NE	234-5

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Table 4-56. Chemical Measurements. (Sheet 6 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CI.) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Plutonium (cont.)	(2)	Accountability measurement in plutonium product	1.9	REDOX titration	The plutonium in the sample is quantitatively oxidized to Pu^{+6} by heating with AgO. It is then reduced to Pu^{+3} with a known excess of Fe^{+2} and the excess Fe^{+2} and Pu^{+3} are titrated with standard dichromate ($Cr_2O_7^{-2}$) to an amperometric end point	Americium (>0.1% by wt.) Cr, Mn (>100 ppm)	1 mL	1 mL	±0.1	>99	10	234-5
Sulfamate	SA	Determination of total sulfamate in "cold" AMU samples containing Fe^{+2}	1BX	Redox titration	Total sulfamate concentration is determined by adding the sample to a warm sulfuric-nitric acid mixture. A pretitration with permanganate is done first to oxidize Fe^{+2} to Fe^{+3}. Then standard $NaNO_2$ solution is added to the mixture. Sodium nitrite reacts with hydrogen ion from the acid solution to yield nitrous acid. At an elevated temperature, the nitrous acid reacts rapidly with SA. The excess nitrous acid is titrated with standard permanganate and the amount of sulfamic acid is determined stoichiometrically	N_2H_4, NH_3OH, or any other reductant that reduces nitrous acid. Ferrous ion interferes, but is oxidized in the preliminary titration	3 mL	10 mL	±5	99	1/2	--
Trace metallic impurities	TMI	Determination of trace metals in product samples	Q8	Emission spectroscopy	The sample is placed in a suitable matrix and excited with a DC arc source. Characteristic emission lines from each trace element in the sample are identified. Through comparison with suitable standards, the intensity of each line is used to calculate the amount of impurity present in the sample	Many element interferences; rare earths	NE	1 g	±100 to 50	NE	7	234-5
			1.9	ICP	The sample is diluted with 1M HNO_3. The plutonium is then extracted from the aqueous with TTOA. The aqueous is analyzed by ICP		500 µL	2 mL	±10	100	4	--

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Table 4-56. Chemical Measurements. (Sheet 7 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Trace, metallic impurities (cont.)			R6, P8		The sample is diluted in a 2M HNO_3 matrix. The uranium is then extracted from the aqueous by TOPO. The aqueous is analyzed by ICP		2 mL	2 mL	±10	100	4	--
Thorium in plutonium product	Th		I-9		Plutonium is extracted from an adjusted sample by TIOA. The thorium is extracted into TOPO and stripped with 0.2M H_2SO_4. The aqueous is analyzed by ICP	Pu	1 mL	1 mL	±10	100	4	--
Tributyl phosphate	TBP	Determination of TBP in plant solvent	G5, R7	Acid/base titration	TBP in sample is stripped of any metals, then saturated with HNO_3 and titrated with standard NaOH	Other acidic substances in sample (e.g., DBP)	1 mL	1 mL	±4	99	1/2	--
Uranium	(1)	Determination of high-level uranium (>0.05M) in aqueous or organic samples and accountability measurement of uranium in feed and product	D5, E1, E8, HAF, J1(3W8), 2NF, 2PW, 2PN, 1BSU (J2), 1BXF (J3), 1CU (J8), 2DW (K2), K6	REDOX titration	Uranium is reduced to U^{+4} in concentrated phosphoric acid with Fe^{+2}. The excess Fe^{+2} is then oxidized to Fe^{+3} with HNO_3 and a molybdenum catalyst. The U^{+4} is then amperometrically titrated with standard dichromate	H_2O (large amounts); various metal ions: M M:U Tc >1/1000 Mn >1/10 V >1/10 Mo (in presence of high nitrate content)	50 µL to 1 mL	1 mL	±0.2	Essentially 100	4	--
	(2)	Determination of low-level uranium in aqueous solutions	K2, P2, P4	Energy dispersive x-ray fluorescence	Uranium is diluted with HNO_3 and run on an energy dispersive x-ray instrument against a yttrium standard	Minimal	100 µL	1 mL	±10	100	2	--
	(3)	Determination of low-level uranium in aqueous solutions	2EW	Energy dispersive x-ray fluorescence	Uranium is diluted with 25% TBP in NPH and run on an energy dispersive x-ray instrument against a yttrium standard	Minimal	100 µL	1 mL	±10	100	2	--

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Table 4-56. Chemical Measurements. (Sheet 8 of 8)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time (h)	Labs (if not PUREX)
							Nominal	Maximum				
Uranium (cont.)	(4)	Determination of low-level uranium in aqueous samples	D3, E5, E2, E4, F13, F18, F8, E1-low, H2-HAW, PDD weekly, R1-low, SA, SB, SC, SCD weekly, SD, Se, SFA, SEB, SG, SJ, SK, SLK, SMB, SPA through SPE, G8, U4, D-2, D2E3, F15, F18, F26, P5, R8, U1, U2, and U3	Laser fluorimetry	Dilute on direct analysis by laser fluorimetry	Minimal	100 µL	1 mL	±25	100	1	--
	(5)	Determination of low-level uranium in organious solutions	G100, J7-1CW, K3-2EW, R1-200	Laser fluorimetry	The sample is contacted with the fluoride reagent and analyzed by a method of standard addition and laser fluorimetry	Minimal	100 µL	1 mL	±25	100	1	--
	(6)	Determination of low-level uranium in plutonium containing solutions	J5A-1BP, 1.11, 1.9, 1.2-2BP, 1.SB-PSF	Laser fluorimetry	The uranium is extracted into TBP after the sample is treated with ferrous sulfamate and hydroxylamine to reduce the plutonium to the +3 valence state. The uranium is back extracted into water as in No. 4	Minimal	100 µL	1 mL	±25	100	2	--
	(7)	Determination of all levels of uranium by bromo-PADAP	Same as 4, 5, 6		Back-up procedures exist for those used as 4, 5, and 6		100 µL	1 mL	±20	100	2	--
Zirconium	Zr	Determination of Zr in most process solutions	CRW, D-2, D-5, E-1, E-3, E 5, E-2/E-4	Spectrophotometry	Samples are (1) extracted with TDPD, (2) thiocyanate added to complex Fe, U, (3) hydroxylamine HCl added to reduce Pu, (4) Zr complexed with xylenol orange, (5) read on visible spectrometer	Mo, Ti, Hf	100 µL	2 mL	±19	103	2	--

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Table 4-57. Radiochemical Measurements. (Sheet 1 of 6)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Total alpha	AT	Determination of total alpha activity in aqueous samples with a relatively high ratio of alpha activity to total dissolved salt content and determination of alpha activity in organic samples	D-3, D-5, E-6, F-10-3WF, J1-3WB, J22-2NW(I), JSA-1BP, L3-3AF, L4-3AW, L5B-PSF, L6-1.7, L-9 L-0, L1-2AW, L2B-2BF, L3-3AF, M3, 4, 5, 6, Load Out, N-13, N30, N-50, N-51, N-53, N20, P-N32, SA, SB, SC, SD, SE, SFA, SFB, SG, SJ, SK, SLD, SLK, SMB, SN, SNA, SPL-C-1, N-15, N-18, N-21, N-22, P-5, H3-11AP, J3-1BXF, J4-1BSU, J7-1CW, L2A-2BW, L5A-3BW, R-5, N-16, N-30	Evaporation and radio-assay	An aliquot of an aqueous sample or dilute sample is evaporated to dryness on a stainless steel disc and counted on an ASP. Dilutions are made with dilute HNO_3. For organic samples dilutions are made with xylene or high-quality kerosene.	100 µg of solids on the disc will cause low results; high beta activity (>1 rad) may cause high results.	20 to 500 µL	1 mL	aqueous samples ±3 organic sample ±5	100.6 99	1/2 1/2	
Alpha energy analysis	AEA	Determination of individual alpha emitters (Np, Pu, Am) in samples containing more than one alpha count percent of each emitter	2PC, 3XF, 3EW, 3XW, (Q4), 3XW (Q5), Sumps, 3WB (J1), 2PN, 2NF, J1A, 2BW (I, II, III), J21-2NF (I, II, III), L11, F15, H2-11AW	Evaporation and radio-assay	An aliquot of sample is mounted on a disc as described for AT determination. The disc is then counted with a semiconductor detector in a light-tight vacuum chamber. The detector is connected to a pulse height analyzer that produces an alpha energy spectrum. The percentage contribution of each alpha emmitter with differing alpha energies is then calculated	Solids on the disc broaden the spectral peaks and invalidate the analysis. Several isotopes have energies too close to be separated and are thus counted together. Two common pairs are: $^{239,240}Pu$ and $^{238}Pu/^{241}Am$	20 to 500 µL	1 mL	NE	NE	Depends on counting time, 1 to 8 h	

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Table 4-57. Radiochemical Measurements. (Sheet 2 of 6)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Total alpha and beta	AT, TB, (2)	Determination of total activity of high and low-level samples, waste, and effluents	ASD, PPP, SCD (grab, weekly) alpha only; F-18/P5	Evaporation and radio-assay	An aliquot sample (5 to 10 mL) is mounted on a 2-in. dish and evaporated to dryness. The activity is measured with a combination alpha and beta detector. If >10 mL of sample is needed, multiple aliquots are added, evaporating each time	Nonvolatile residue or dissolved salt can cause self-absorption on the mounts	10 mL	50 mL	+10	101	2	
Gamma energy analysis	(1)	Determination of gamma emitter concentrations in aqueous samples with high alpha content	D2, D3, D5, D2/E3, E5, E2/E4, F15(1WW), F18, F26, F10(SWF), F3(AAA), F5(AAD), G5(100), H3(HAP), H43WB), J1A(2PK-1,II), J21 (2WFFEB), J5A(1BP, J7(1CU), J8A (1CU) K6, K2(2DW), K3(2EW), K42EU), P1, P2, P3, P4, P5, P8, P-TK, R-8, R7(200), SX3 sump; U-1, Comp, U5, U2 Comp, UN11	Absorbed liquid and radio-assay	An aliquot of sample is diluted to 1 mL with dilute HNO_3 in a small polystyrene T-vial. A cotton dental roll is then added and the vial is capped and sealed. This mount is placed in an aluminum holder and counted.	High concentrations of pure beta emitters (e.g., ^{90}Sr) or very high beta-gamma ratios can mask gamma peaks on the low end (<0.3 MeV)	25 to 100 µL	NE	NE	NE	1/2	
	(2)	Determination of emitters in Pu product	1.9	Liquid-filled vial and radio-assay	An aliquot of sample is added to a plastic vial and filled with dilute HNO_3. The vial is then capped, sealed, placed in another vial, sealed, and counted directly on top of the Ge(Li) detector.		10 to 50 mL	100 mL	NE	NE	NE	
	(3)	Determination of gamma emitters in ICC and ICS	ICC, ICS	Plastic jar	An aliquot is added to a 125 mL plastic jar. The jar is capped and sealed with tape. Counting is done as described above		125 mL	125 mL	NE	NE	1 1/2	

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Table 4-57. Radiochemical Measurements. (Sheet 3 of 6)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Americium	Am	Determination of Am in process waste streams	E5, D2, E3	Solvent extraction/ radioassay	Am is separated from Pu by extraction with HDEHP. Ce(IV) is removed by TTA extraction. Am is extracted into HDEHP after acid adjustment. Am stripped into 1M HNO_3 mounted and counted by AEA	Cm, Fe(III), F^-, $C_2O_4^{2-}$, fission products	2 mL	2 mL	±20	84	2	--
Neptunium	Np (1)	Determination of neptunium in aqueous samples with >10 alpha percent neptunium	3WB*, 2NF*	Solvent extraction/ radioassay (α)	Neptunium (+5) is reduced to Np^{+4} with $Fe(NH_2SO_3)_2$ and NH_2OH HCl in 0.75M HNO_3 which also reduces plutonium to the inextractable Pu^{+3} state. The Np^{+4} state is then extracted with 0.5M TTA, in xylene and the organic phase is scrubbed with fresh 0.75M HNO_3 and $Fe(NH_2SO_3)_2$. An aliquot of the organic phase is mounted on the ASP for AT and; if necessary, AEA	High concentrations of uranium, plutonium, or other alpha emitters or extractable salts (e.g., Fe^{+3}, complexants (e.g., F^-, $C_2O_4^{2-}$; or caustic samples	100 µL	1 mL	±40	82	1	
	(2)	Determination of neptunium in aqueous samples with high uranium content	K8, 2DW	Solvent extraction/ radioassay (α)	Same as 10	Very high plutonium content; complexants; caustic samples	1 mL	1 mL	±14	88	1	
	(3)	Determination of neptunium in aqueous samples with high beta-gamma levels	F8, F13, F16, F28, HAW, 2NW, D5, F15	Solvent extraction/ radioassay (α)	Neptunium (+5) is reduced to Np^{+4} in 3M to 5M HNO_3 with $Fe(NH_2SO_3)_2$. The Np^{+4} is then extracted into 10% TIOA in xylene and the organic is scrubbed with fresh 5M HNO_3 and Fe^{+2} to scrub out Pu^{+3}. The TIOA is then diluted to ~3% with xylene, and the Np^{+4} is stripped into 1M HCl. More Fe^{+2} is added to reduce any Np^{+5} formed by the low acidity, and the Np^{+4} is extracted into 0.5M TTA in xylene. The organic is then mounted and counted	High uranium; complexants; caustic samples	100 µL to 2 mL	2 mL	±30	89	2	

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Table 4-57. Radiochemical Measurements. (Sheet 4 of 6)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Neptunium (cont.)	(4)	Determination of neptunium in $Pu(NO_3)_4$ product	L9	Solvent extraction/ radioassay (α)	An aliquot of sample is added to 1M HCl and Fe^{+2}, which reduces the neptunium plus plutonium to Np^{+4} and Pu^{+3}, respectively. The neptunium is then extracted into 0.5M TTA in xylene and stripped into 8M HNO_3. The aqueous phase is adjusted to 5M HNO_3, more Fe^{+2} is added, and the Np^{+4} is extracted into 10% TIOA in xylene. The organic phase is then diluted to 3% TIOA and the Np^{+4} is stripped into 1M HCl. More Fe^{+2} is added and the Np+4 is again extracted into 0.5M TTA in xylene. The TTA organic phase is then mounted and counted as described in No. 1	High uranium concentration; complexants, caustic samples	500 µL	1 mL	NE	NE	4	
Neptunium (cont.)	(5)	Determination of neptunium in waste organic samples	2PW	Solvent extraction/ radioassay (α)	An aliquot of sample is contacted with dilute HNO_3, $NaNO_2$, and ferric nitrate. After stripping the neptunium as Np^{+5}, excess nitrite is destroyed with hydroxylamine and the Np^{+5} reduced to Np+4 with $Fe(NH_2SO_3)_2$. After an acid adjustment, the Np^{+4} is extracted into 0.5M TTA in xylene and the organic is mounted and counted as described previously in No. 1	High plutonium and uranium; N_2H_4 HN_3 or other substances that consume nitrite	500 µL	1 mL	NE	NE	2	
	(6)	Input accountability measurement of neptunium	D5, F15	Solvent extraction/ radioassay (γ + α)	An aliquot of sample is adjusted to 1M to 5M and a spike of ^{239}Np is added. (This is used to correct for losses through the method.) The method is the same as described for samples with high beta gamma except that the organic mount is counted for AT, AEA, and GEA (the ^{239}Np) to calculate the concentration of ^{237}Np in the sample	Free complexants; caustic samples	500 µL	1 mL	±6	100	8	

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Table 4-57. Radiochemical Measurements. (Sheet 5 of 6)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Neptunium (cont.)	(7)	Product accountability measurement of neptunium	Q6	Radioassay (γ)	An aliquot of neptunium product is added to a T-vial and counted on a Ge(Li) detector GEA system as described for vial mounts in GEA method No. 2. The 86 keV gamma ray of the ^{237}Np is measured and compared to appropriate standards for accountability	None	NE	1 mL	NE	NE	NE	
Plutonium	Pu(1)	Determination of plutonium in aqueous samples with high beta-gamma levels and/or high dissolved salt content (except uranium)	D2, E1, E3, F8, F15, F16, F26, F18, U3/U4, HAW	Solvent extraction/ radioassay (α)	The sample is first heated with 3M HNO_3, hydroxylamine and iron to reduce all the plutonium to Pu^{+3} and destroy any polymeric forms of plutonium. An acid adjustment to 10.9M HNO_3 is made. Sodium nitrite is added to oxidize the Pu^{+3} to Pu^{+4}, which is then separated from other alpha emitters and fission products by extracting into a solution of TTA in xylene. An aliquot of the organic is mounted on a disk and the plutonium is measured by alpha counting	High concentrations of complexants, such as SO_4^{-2}, PO_4^{-3}, $C_2O_4^{-2}$, and EDTA; high uranium; caustic samples (>1M)	25 µL to 1 mL	1 mL	±10	92	1	
Plutonium	(2)	Determination of plutonium in aqueous samples with high uranium content	1CU, 2EU, K6, P-TKs	Solvent extraction/ radioassay (α)	Same as method No. 1, except that the organic is scrubbed with 0.75M HNO_3 to remove uranium prior to mounting	Complexants; caustic samples	100 µL to 1 mL	1 mL	±20	97	1	
	(3)	Determination of plutonium in neptunium product	Q8	Solvent extraction/ radioassay (α)	The sample is treated with $NaNO_2$ in dilute acid to oxidize the alpha emitters to Np^{+5} and Pu^{+4}, respectively. The Pu^{+4} is then extracted with 0.5M TTA in xylene, and an aliquot of the organic is mounted and counted as described above in method No. 1	Complexants; caustic samples; high uranium	500 µL	1 mL	NE	NE	3	

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Table 4-57. Radiochemical Measurements. (Sheet 6 of 6)

Determination	Symbol	Application	Sample points	Method	Description	Interferences	Sample size		Precision (95% CL) (%)	Accuracy (%)	Analysis time	Labs (if not PUREX)
							Nominal	Maximum				
Plutonium retention	Rot (PRN)	Determination of the plutonium retention number on treated solvent extraction organic	G5, R7	Solvent extraction/ radioassay (G)	An aliquot of organic is contacted with standard plutonium solution (~0.3 g/l. Pu, 3M HNO_3). The organic is then stripped three successive times with fresh aliquots of 0.01M HNO_3. An aliquot of the organic is then mounted and counted	Not really applicable, as this is an empirical method	5 mL	5 mL	Not applicable	NA	1.5	

NOTE: The precisions and accuracies (where given) are for an average sample. Both are dependent on the amount of activity in the sample and/or the specific material being measured. PST89-3131-4-57

18. MAIN MATERIAL DESCRIPTION	FEED	PU PRODUCT (1)
i) Main types of accountability units to be handled in the facility	1. Fuel assembly. Assemblies charged to dissolver which becomes the S/R point for measurement and basis for accountability further in the porcess	2. a) Pu Nitrate L-11 Tank ~ 100 l Loaded to MK IV and MK V cans (~8 l/can) b) Pu Oxide 1.5 l slip lid oxide cans 3. UNH K-6 Tank

18.		INPUT	PRODUCT
ii)	Chemical and Physical Form (for feed include types of fuel element/assemblies, including nuclear material content and enrichment). Attach drawing(s)	1. Per specification sheet (attached)	2. a) Pu Nitrate solution loaded into MK IV and MK V Pr cans <350 g Pu/l 1.4 M HNO_3 b) Pu Oxide in slip lid cans Pu Oxide Powder of stoichiometric proportions ~1800 g/l 3. UNH stored in P Tanks (~103,00 gal) <500 g/l Uranium ~0.4 M HNO_3

Supplim 18.11

MARK IV AND MARK IA FUEL ELEMENT DESCRIPTION

	MARK IV				MARK IA		
reirradiation enrichment of uranium-235	0.947% Enriched				1.25 - 0.947% Enriched "Spike"		
Type	E	S	A	C	M	T	F
ngth (inches)	26.1	24.6	23.2	17.4	20.9	19.6	14.9
ameter of element (inches)							
Outer of outer element	2.42	2.42	2.42	2.42	2.40	2.40	2.40
Inner of outer element	1.70	1.70	1.70	1.70	1.77	1.77	1.77
Outer of inner element	1.28	1.28	1.28	1.28	1.25	1.25	1.25
Inner of inner element	0.48	0.48	0.48	0.48	0.44	0.44	0.44
ladding Thickness (mils)							
- Outer of outer element	17-22	17-22	17-22	17-22	18-24	18-24	18-24
- Inner of outer element	12-18	12-18	12-18	12-18	18-24	18-24	18-24
- Outer of inner element	23-30	23-30	23-30	23-30	33-40	33-40	33-40
- Inner of inner element	13-20	13-20	13-20	13-20	18-24	18-24	18-24
eight of uranium in outer (lbs)							
- (0.947% U-235)	35.2	33.1	31.2	23.1			
- (1.25% U-235)					24.4	22.9	17.3
eight of uranium in inner (lbs)							
0.947% U-235	16.5	15.5	14.6	10.9	12.1	11.3	8.6
eighted Average of uranium in element (lbs)	50.3				36.1		
atio of Zircalloy-2 to uranium (lbs/ton)	139.8	141.5	143.3	153.4	170.4	172.2	181.1
	140.5				170.8		
of Processing load of each	88	7	1	4	88	10	2
	80				20		
isplacement Volume gal/ton uranium	16	16	16	16	16	16	16

18.	FEED	PRODUCT
iii) Throughout Enrichment Ranges and Pu contents	1. 10.2 MTU/day (~one dissolver charge. Spike fuel limited to ~8.4 MTU) enrichment is between 0.9% ^{235}U and 1.25% ^{235}U ~0.2% Pu content ~20 Kg Pu/day	2. Purified Plutonium as PuO_2 or Plutonium nitrate in the same ratios as feed (20 Kgs Pu/day) 3. UNH solution with an enrichment of between 0.9% ^{235}U and 1.25% ^{235}U ~10.2 MT/day

RECEIVE AND HANDLE CASK DATA SHEET

CASK CAR NO.					CASK CAR NO.				
DATE	TIME	LIQUID LEVEL		OPERATOR'S INITIALS	DATE	TIME	LIQUID LEVEL		OPERATOR'S INITIALS
		OK	WATER ADDED				OK	WATER ADDED	
CASK CAR NO.					CASK CAR NO.				
CASK CAR NO.					CASK CAR NO.				

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Question 18-IV

DISSOLVER CHARGING FORM

The first five columns must be completed and approved prior to starting any dissolver charge. Mark IV (0.94) fuel charging limit is 10.4 MTU tons (22,932 pounds) of uranium. A larger amount of NPR fuel will result in unacceptably large zirconium heels.
Mark IA (spike) fuel charging limit is 8.6 MTU including heel. Prestart conditions met _____
DISSOLVER _____ CHARGE NUMBER _____

CAR NO.	CASK POSITION	CANISTER LOCATION	KEY NUMBER	TONS URANIUM	DATE/SHIFT CANISTER LOADED	VERIFY EMPTY CANISTER

TOTAL _____

* METAL HEEL INCHES _____ POUNDS _____ $\left(\frac{\text{500 lb U}}{\text{in. H20}}\right)$

TOTAL CHARGE _____

CASK CAR LAYOUT

A	1	2	3	A
B	1	2	3	B
C	1	2	3	C

PREPARED BY _____
APPROVED BY _____
(Shift or Shift Support Mgr.)
_____
(Shift Engineer)

*If 1.25 (spike) heel is >2.5 in. over grate, fuel additions to dissolver must be adjusted below flowsheet. Top of grate is 9 in. of liquid in A3 and 11 in. in B3 and C3. Estimate metal heel at 500 lb uranium per inch of liquid (above the grate) required to cover heel. Heel is calculated by PO-230-010.

Question 18.IV

UNC NUCLEAR INDUSTRIES

IRRADIATED NUCLEAR MATERIAL TRANSFER FORM

PRELIMINARY INFORMATION ONLY (NOT DECAY CORRECTED)

1 _____ CLASSIFICATION

2 TRANSFER FORM NO. _____

LOAD NO. _____ CAR NO _____

3 BASIS: ☐ K-East ☐ K-West ☐ N ☐ PUREX return to UNC

4 WELL	5 POSITION	6 SUPV. VERF	7 KEY NUMBER	8 UNIRRADIATED ENRICHMENT	9 CANISTER LOCATION (Basin Code & No.)	10 NO. OF ASSEMBLIES	11A NO. OF INNERS	11B NO. OF OUTERS	12 U AFTER BURN OUT	13 U Element Wt.	14 Pu BUILD UP	15 Wt. % U-235	16 Wt. % Pu 240	17 MWD/T
A	1													
	2													
	3													
B	1													
	2													
	3													
C	1													
	2													
	3													

For Information Only

20 Loading At _____	21 Date	22 Time first canister removed from bay	23 Signature
24 Well Car Received By Train Crew	25 Date	26	Signature
27 Well Car Received At _____	29 Date		31 Signature
32 Unloading	33 Date	34 Time last canister unloaded	35 Supervisor Signature

36 Well Car To Be Unloaded By:

_____ Date _____ Time

If car cannot be unloaded by date and time shown, it must be returned to point of origin for unloading provided date and time is not exceeded, or provision for cooling of wells must be made by receiver.

37 Remarks:

Well car drained, flushed and refilled. ☐ Yes ☐ No

38 UNC Nuclear Material Custodian: _____

Rockwell Nuclear Material Custodian: _____

39 Safeguards Information:

Preliminary Data Only – not decay-corrected

Basis of shipping quantities: ☐ Old conversion ratio ☐ New conversion ratio

DOE/NRC Form 741: HXA/HRA No. _____

Rockwell Form No. M _____

40 UNC SHIPPER'S DISTRIBUTION

Goldenrod - Train Crew
Pink - Shipper (retain)
Canary - UNC NMC&A (3717 Bldg.)
All Others To PUREX
Photocopy of Original - UNC 100N Fuel Accountability (1705N Bldg.)
Photocopy of Original - UNC 100N Production Accounting (1101 N Bldg.)

ROCKWELL RECEIVER'S DISTRIBUTION

Green - Receiver (retain)
Blue - Rockwell NMC (27042 Bldg.)
White - UNC NMC&A (3717 Bldg.)

41 _____ CLASSIFICATION 41 _____ CLASSIFIED BY 41 _____ DATE

SC 5300 282 (2 83)

IRRADIATED NUCLEAR MATERIAL TRANSFER FORM

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A-6400-183.2 (N-4-82)

18.	FEED	PRODUCT
iv) Batch Size/Flow Rate and Campaign Period, Means of Batch Identification	1. ~450 fuel assemblies per day (1 dissolver charge) Operation consists of 3-6 month campaign intervals with shutdowns or outages (inventories performed in these periods) Feed is tracked by Basket ID# and piece count (Procedure PU-219-001) 2. a) Pu Nitrate Solution collected in M Cell Tank (M3, M4, M5 or M6) after completion of solvent extraction. ~250 l/tank b) Pu Nitrate is loaded to product cans (10 liter capacity (nominal 8 liter per can)	3. Pu Oxide Process until blender is full (15-17 Kg Pu) Sample blender for process control and accountability then load powder load to oxide cans 1.6 Kg/can with 10 cans filled per blender batch. identification by can ID 4. Uranium collected in K6 Tank 5000 gallon tank. Solution sampled for accountability and transferred to P tanks for storage. Tracked by K6 Tank batch identification #
(1) For example Uranium and Plutonium		

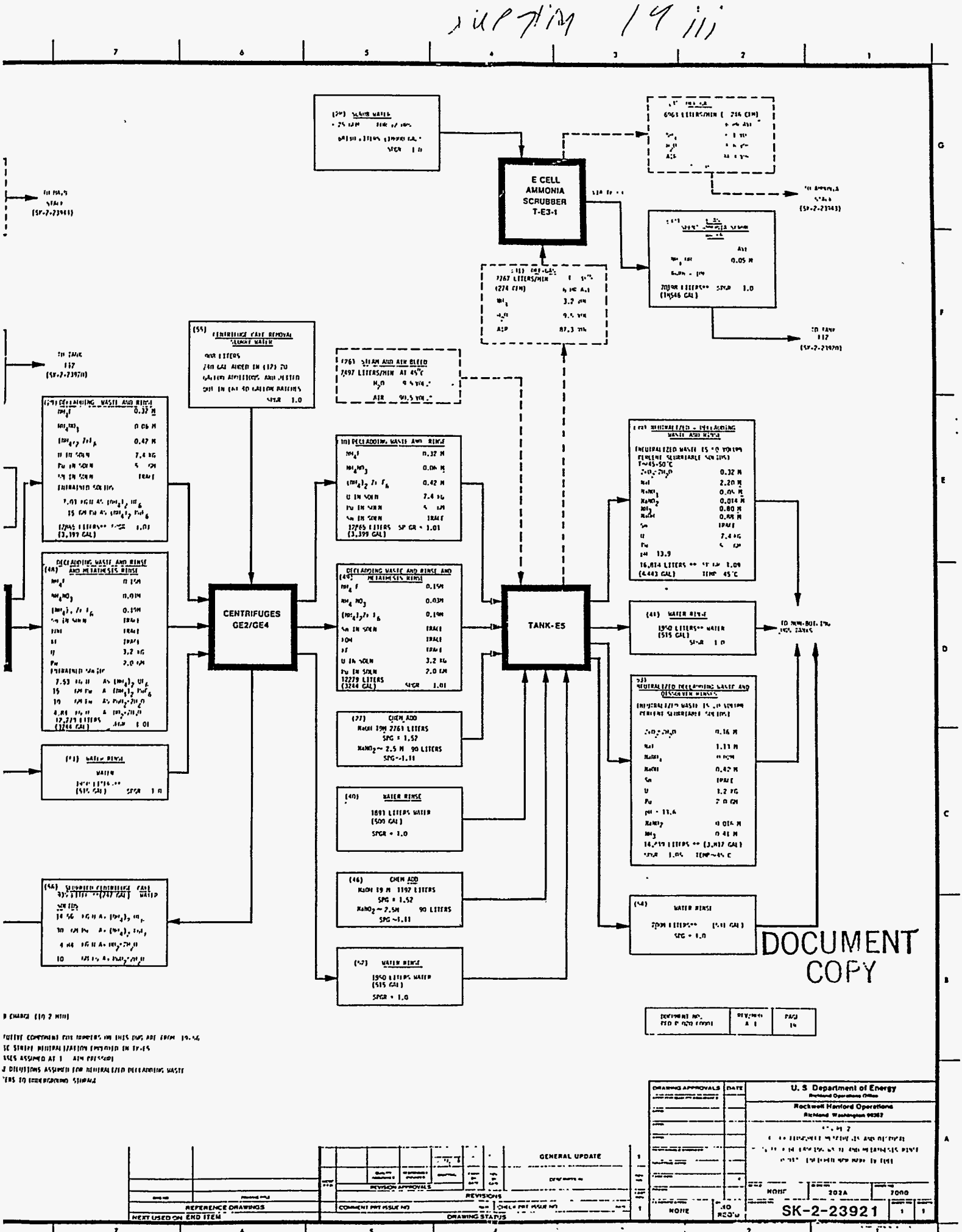
MAIN MATERIAL DESCRIPTION CONTINUED	FEED	PRODUCT (1)
18. v) Storage and Plant Inventory (Indicating any change with throughput)	1. No on site storage. Fuel assemblies received daily in rail cars.	2. a) Pu Nitrate PR cans stored in corridor prior to transfer to Z plant for storage or further processing. Maximum of ~15 cans (interim) storage. b) Pu Oxide 2 cans per DOT 6M container. ~12 DOT 6M containers storage awaiting shipment to Z Plant. 3. Uranium Nitrate P2, P3, P4 Tanks. 103,000 gallon tanks. Transferred on as needed basis by tanker truck to UO_3 Plant.

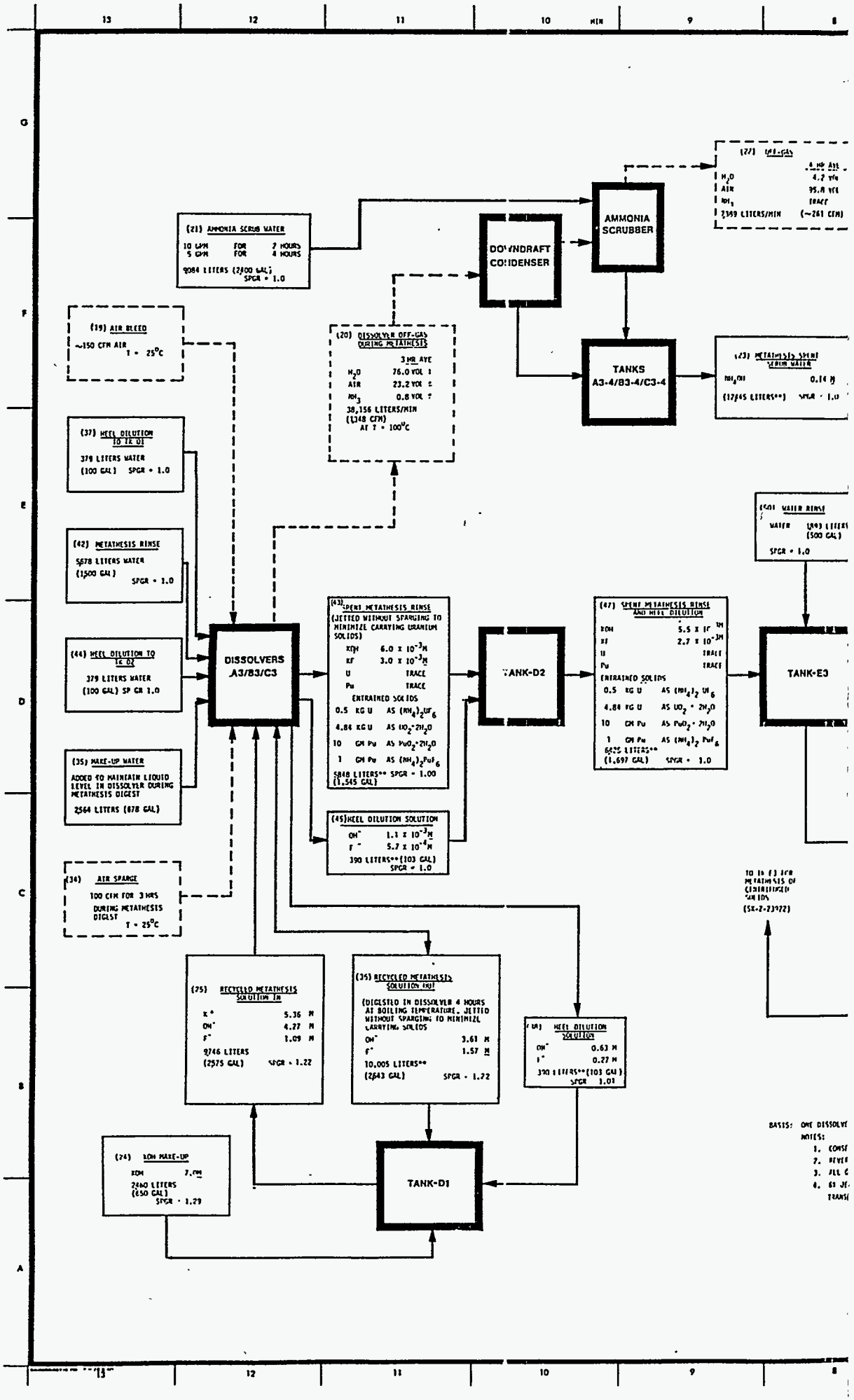
18.	FEED	PRODUCT
vi) Frequency of Receipt or Shipment (batches/units per month)	1. Nominal 1 dissolver batch/day processed through to solvent extraction. - ~6 rail cans per day - ~450 assemblies per day Nominal operation of 30 days/month during campaigns	2. a) Pu Nitrate Sampling 1 tank/4 days (30 cans) - best of ~10 cans/day loadout - 1 can/2 hours b) Pu Oxide - Fill blender ~1 day 1 blender sampled/day - Load out ~10 cans in ~8 hours 3. UNH - 1 tank per day - 1 sample/day - 1 bulk measurement/day

19. Waste Material (Including contaminated equipment, measured discards and retained waste) Describe for each waste stream: i) Major contributions (sources)	1. Zirflex (E5) cladding waste. Waste from decladding of fuel in dissolvers using caustic. 2. Ammonia Declad waste (gasses). Waste from the scrubbing out of ammonia solutions from off-gasses created during the decladding of fuel in the dissolvers. 3. F16 & F18 high level waste. F16 wastes are from sugar denitration of wastes generated during fuel dissolution in the dissolvers. Waste is denitrated for recovery of acid for reuse. F18 collects wastes from the ammonia scrubber, sump wastes, and miscellaneous wastes which can contain high levels of contaminants. 4. U3 & U4 lab wastes 5. R8 & G8 solvent cleaning waste 6. Low level wastes/cribs. Includes steam condensate, cooling water, ammonia scrubber and process condensates (from concentrators), and chemical sewer (miscellaneous low level wastes) 7. Gaseous (off gas). Includes HVAC exhaust stacks, ammonia off-gas stack. 8. Solid wastes (process solid wastes)

19. iii) Chemical and physical form (liquid, solid, etc.)	SK-2-23921 Declad waste in TK-E5 1. Zirflex liquid PH~12 2. Ammonia liquid (Scrubber solutions) 3. F16 & F18 high level waste liquid 4. U3 & U4 lab wastes liquid 5. R8 & G8 solvent cleaning wastes liquid 6. Low level wastes/cribs liquid 7. Gaseous (off gas) gas 8. Solid waste solid process trash principally from N cell

19. ii) Type of waste	Cladding waste solutions SK-2-23944 & 45 - everything but declad wastes Same as 19. i)


E CELL AMMONIA SCRUBBER T-E3-1
CENTRIFUGES GE2/GE4
TANK-E5
(55) CENTRIFUGE CAKE REMOVAL SLURRY WATER
(41) WATER RINSE
(40) WATER RINSE
(46) CHEM ADD
(47) WATER RINSE
(44) WATER RINSE
DOCUMENT COPY


(21) AMMONIA SCRUB WATER
10 GPM FOR 2 HOURS
5 GPM FOR 4 HOURS
9084 LITERS (2400 GAL)
SPGR = 1.0
DOWNDRAFT CONDENSER
AMMONIA SCRUBBER
(27) OFF-GAS
4 HR AVE
H_2O 4.2 VOL %
AIR 95.8 VOL %
NH_3 TRACE
2369 LITERS/MIN (~261 CFM)
(19) AIR BLEED
~150 CFM AIR
T = 25°C
(20) DISSOLVER OFF-GAS DURING METATHESIS
3 HR AVE
H_2O 76.0 VOL %
AIR 23.2 VOL %
NH_3 0.8 VOL %
38,156 LITERS/MIN
(1348 CFM)
AT T = 100°C
TANKS A3-4/B3-4/C3-4
(23) METATHESIS SPENT STREAM WATER
NH_4OH 0.14 M
(17,645 LITERS**) SPGR = 1.0
(37) HEEL DILUTION TO TK D1
379 LITERS WATER
(100 GAL) SPGR = 1.0
(42) METATHESIS RINSE
5678 LITERS WATER
(1500 GAL)
SPGR = 1.0
(44) HEEL DILUTION TO TK D2
379 LITERS WATER
(100 GAL) SP GR 1.0
(35) MAKE-UP WATER
ADDED TO MAINTAIN LIQUID LEVEL IN DISSOLVER DURING METATHESIS DIGEST
2564 LITERS (678 GAL)
(34) AIR SPARGE
100 CFM FOR 3 HRS
DURING METATHESIS DIGEST
T = 25°C
DISSOLVERS A3/B3/C3
(43) SPENT METATHESIS RINSE
(JETTED WITHOUT SPARGING TO MINIMIZE CARRYING URANIUM SOLIDS)
KOH 6.0 x 10⁻³ M
KF 3.0 x 10⁻³ M
U TRACE
Pu TRACE
ENTRAINED SOLIDS
0.5 KG U AS $(NH_4)_2UF_6$
4.88 KG U AS $UO_2 \cdot 2H_2O$
10 GM Pu AS $PuO_2 \cdot 2H_2O$
1 GM Pu AS $(NH_4)_2PuF_6$
5848 LITERS** SPGR = 1.00
(1,545 GAL)
TANK-D2
(47) SPENT METATHESIS RINSE AND HEEL DILUTION
KOH 5.5 x 10⁻³ M
KF 2.7 x 10⁻³ M
U TRACE
Pu TRACE
ENTRAINED SOLIDS
0.5 KG U AS $(NH_4)_2UF_6$
4.88 KG U AS $UO_2 \cdot 2H_2O$
10 GM Pu AS $PuO_2 \cdot 2H_2O$
1 GM Pu AS $(NH_4)_2PuF_6$
6425 LITERS**
(1,697 GAL) SPGR = 1.0
(50) WATER RINSE
WATER (1893 LITERS (500 GAL)
SPGR = 1.0
TANK-E3
(45) HEEL DILUTION SOLUTION
OH^- 1.1 x 10⁻³ M
F^- 5.7 x 10⁻⁴ M
390 LITERS** (103 GAL)
SPGR = 1.0
TO TK E3 FOR METATHESIS OF CENTRIFUGED SOLIDS
(SK-2-23922)
(75) RECYCLED METATHESIS SOLUTION IN
K^+ 5.36 M
OH^- 4.27 M
F^- 1.09 M
9746 LITERS
(2575 GAL) SPGR = 1.22
(35) RECYCLED METATHESIS SOLUTION OUT
(DIGESTED IN DISSOLVER 4 HOURS AT BOILING TEMPERATURE, JETTED WITHOUT SPARGING TO MINIMIZE CARRYING SOLIDS
OH^- 3.61 M
F^- 1.57 M
10,005 LITERS**
(2643 GAL) SPGR = 1.22
(48) HEEL DILUTION SOLUTION
OH^- 0.63 M
F^- 0.27 M
390 LITERS** (103 GAL)
SPGR 1.01
(74) KOH MAKE-UP
KOH 7.0M
2460 LITERS
(650 GAL)
SPGR = 1.29
TANK-D1
BASIS: ONE DISSOLVE
NOTES:
1. CONSE
2. REVER
3. FILL C
4. 65 JE
TRANS

Question 19

MONIA SCRUBBER
ASTE CONCENTRATION

FISSION PRODUCT
WASTE CONCENTRATION

DIGESTION TANK F-16

ZAM

VOLUME	865 ℓ /MTU
U	* 5x10^{-} g/ℓ
Pu	3.0x10^{-3} g/ℓ
Al	0.60 M
F^{-}	0.11 M
OH^{-}	1.0 M
NO_3^{-}+NO_2^{-}	2.5 M
SPG	1.17
BATCH VOLUME	15,000 ℓ
BATCH FREQUENCY	0.058/MTU

TO UNDERGROUND STORAGE

CANYON CELL
SUMP WASTE

SUMP WASTE RECEIVER F-18

VOLUME	475 ℓ /MTU
U	~ 2.1 g/ℓ
Pu	~ 3.0 x10^{-3} g/ℓ
OH^{-}	0.01 M
NO_2^{-}	0.011 M
SPG	1.02
BATCH VOLUME	15,000 ℓ
BATCH FREQUENCY	~ 0.03/MTU

TO UNDERGROUND STORAGE

ACID RECOVERY
CELL SUMP WASTE

U CELL SUMP WASTES U3&4

VOLUME	800 ℓ /MTU
U	3.8x10^{-3} g/ℓ
Pu	4.8 x10^{-6} g/ℓ
OH^{-}	0.01 M
SPG	1.02
NO_2^{-}	0.011 M
BATCH VOLUME	25,000
BATCH FREQUENCY	0.032/MTU

TO UNDERGROUND STORAGE

AQUEOUS EFFLUENT DISCHARGES

COOLING WATER

VOLUME	9.0 x 10^{6} LITERS/MTU

CHEMICAL SEWER

VOLUME	9.0 x 10^{5} LITERS/MTU
**BORAX	3.6x10^{-6} M
NaOH	1.9x10^{-5}
NH_4NO_3	5.3x10^{-5}
Fe $(NH_2SO_3)_2$	6.0x10^{-6}
NH_2SO_3H	2.0x10^{-6}
SUGAR	1.6x10^{-5}
NaOH	8.0x10^{-5}
$NaFO_3$	9.6x10^{-5}
Al $(NO_3)_3$ $9H_2O$	1.0x10^{-4}

STEAM CONDENSATE

VOLUME	1.2x10^{5} LITERS/MTU
U	7.5x10^{-6} g/ℓ
Pu	9.4x10^{-9} g/ℓ
Ru-Rh-106	7.6x10^{-3} μCi/ℓ
Sr-90 Y-90	2.0x10^{-3} μCi/ℓ
Cs-137	5.6x10^{-3} μCi/ℓ

PROCESS CONDENSATE

ASDP (F-FIX CONDENSATE)

VOLUME	30,960 ℓ /MTU
NH_4OH	0.23 M
Ru-Rh-106 ***	0.0094 Ci/MTU

Z1D (F-R4 CONDENSATE)

VOLUME	9,120 ℓ /MTU
TRITIUM	2,700 μCi/ℓ
HNO_3	TRACE

FLOWSHEET BASES: 1 METRIC TON URANIUM PROCESSED, 33 MWD/T BU 20 MWD/T BU.

*CONCENTRATION AND ION CALCULATIONS BASED ON 33 MWD/T BU AND 20 MWD/T BU MIXTURE

** BASED ON ESTIMATED LOSS OF ONE PERCENT OF CHEMICALS USED IN PUREX.

*** FISSION PRODUCT RELEASES ARE BASED ON 150 DAY COOLED FUEL. A DF OF 1.0x10^{3} IS EXPECTED

DOCUMENT COPY

DOCUMENT NO.	REV/MOD	PAGE
PFD-P-020-00001	A-2	42

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
RICHLAND OPERATIONS OFFICE
Atlantic Richfield Hanford Company
Richland, Washington 99352

FIGURE 25
PUREX LIQUID WASTE & EFFLUENTS
MATERIAL BALANCES

NONE	202A
NOT REQ'D	SK-2-23944

GENERAL UPDATE 2
GENERAL UPDATE 1

REVISION APPROVALS | REVISIONS | DESCRIPTION

REFERENCE DRAWINGS | NEXT USED ON END ITEM | COMMENT PREVIOUS NO | COMMENT THIS NO | DRAWING STATUS

HEADEND

COATING WASTE E-5

VOLUME	* ~ 4,427 ℓ/MTU
U	7.18 g/ℓ
Pu	1.3×10^{-3} g/ℓ
$ZrO_2 \cdot 2H_2O$	0.18 M
NaF	1.21 M
$NaNO_3$	0.324 M
Sn	0.0014 M
NaOH	0.4 M
KOH	0.32 M
KF	0.15 M
NO_2^-	0.011 M
SPG	1.07
BATCH VOLUME	15,000
BATCH FREQUENCY	0.29/MTU

TO UNDERGROUND STORAGE

SOLVENT RECOVERY WASTE

NUMBER 1 SOLVENT SYSTEM G-8

NUMBER 2 SOLVENT SYSTEM R-8

10M

VOLUME	622 ℓ/MTU
U	5.5×10^{-1} g/ℓ
Pu	2.6×10^{-6} g/ℓ
Na_2CO_3	0.12 M
$NaNO_3$	0.03 M
$NaNO_2$	0.006 M
OH^-	0.01 M
NO_2^-	0.011 M
SPG	1.02
BATCH VOLUME	15,000
BATCH FREQUENCY	0.041/MTU

20M

NORMALLY WASTE RECYCLED TO G CF 1

WASTE VOLUME DISCARDED (NEGLIGIBLE)

TO UNDERGROUND STORAGE

AMI
W

CONDENSER

ASW CONCENTRATOR E-F11

TO 21

FINAL URANIUM CYCLE

CONDENSER

URANIUM PRODUCT CONCENTRATOR E-K4

TO 7

Question 14 iii

Notes: (1) All flows [illegible] Kg/MTU

(2) Flows are based on a processing rate of 9.08 MTU/day

(3) ASSUMED 80% OF THE FUEL PROCESSED IS MARK IV & 20% MARK 1[illegible]

(4) FLOWS BASED ON 100% NITRIC ACID

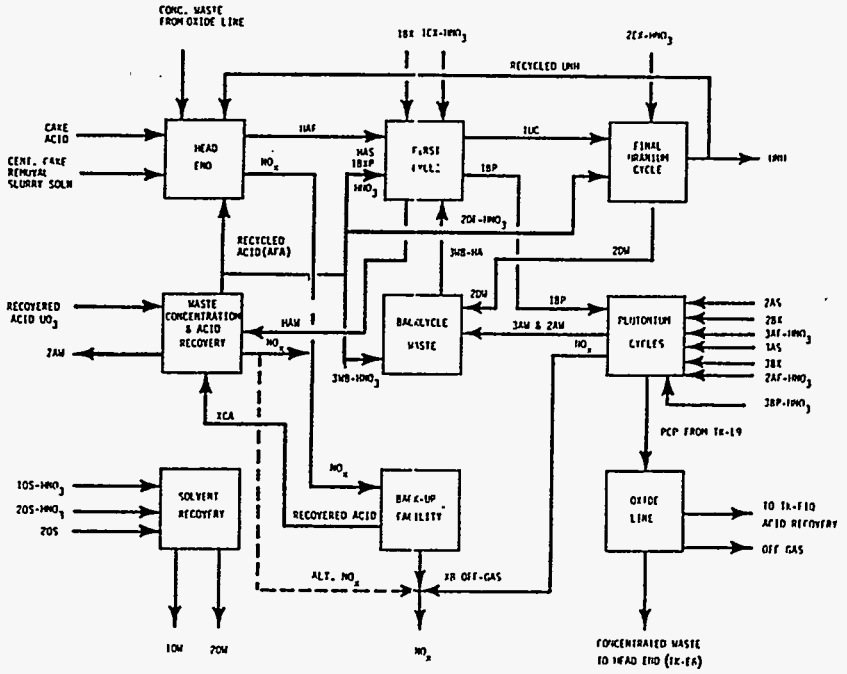
• AFA NITRIC SUPPLEMENT - AMOUNT OF FRESH NITRIC ACID REQUIRED TO BALANCE PLANT LOSSES

DOCUMENT COPY

DOCUMENT NO.	REV/MOD	PAGE
PFD-P-020-00001	A-1	43

						GENERAL UPDATE	1
		QUALITY ASSURANCE	ENGINEERING			DESCRIPTION	
	REVISION APPROVALS						
	REVISIONS						
REFERENCE DRAWINGS	COMMENT PRT ISSUE NO		CHECK PRT ISSUE NO				1
NEXT USED ON / END ITEM	DRAWING STATUS						

DRAWING APPROVALS	DATE	
		U. S. Department of Energy Richland Operations Office
		Rockwell Hanford Operations Richland, Washington 99352
		FIGURE 26 PUREX NITRIC ACID BALANCE [illegible]
		NONE | 202A | [illegible]
NONE	NOT REQ'D	SK-2-23945 | 1



OVERALL NITRIC ACID BALANCE

	12%Pu^{240}				9%Pu^{240}			
SECTION	STREAMS IN	FLOW	STREAMS OUT	FLOW	STREAMS IN	FLOW	STREAMS OUT	FLOW
Head End	Cake Acid	17.4	NH_4NO_3	1.4	Cake Acid	17.4	NH_4NO_3	1.4
	Cake 2nd Flush Slurry	3.5			Cake 2nd Flush Slurry	3.5		
1st Decon	1BX	43.0	UNH Product	537	1BX	30.6	UNH Product	537
Part Cycle & 2nd U Cycle	CONDENSATE RECYCLE 1CX, 2EX	18.3			CONDENSATE RECYCLE 1CX,2EX	18.3		
	2AS	26.5			2AS	19.0		
	2BX	4.5			2BX	3.2		
2nd & 3rd Pu Cycles & Pu Conc.	2AF-HNO_3	variable			2AF-HNO_3	variable		
	3AF-HNO_3	71.9			3AF-HNO_3	51.7		
	3AS	5.9			3AS	4.2		
	3BX	0.6			3BX	0.5		
	3BP-HNO_3	3.4			3BP-HNO_3	2.4		
Waste Conc. Acid Recovery	*AFA NITRIC SUPPLEMENT	0	F1B HEEL	6.3	* AFA NITRIC SUPPLEMENT	37.1	F1B HEEL	6.3
	UO_3 Acid	511.2	2AM	40.6	UO_3 Acid	511.2	2AM	40.7
			NO_x(E-F5	85.3			NO_x(E-F5)	81.1
	10S HNO_3	3.0	10SM	0.7	10S-HNO_3	3.0	10SM	0 *
Solvent Treatment	20S-HNO_3	2.3			20S-HNO_3	2.3		
	20S BATCH	1.1			20S BATCH	1.1		
Oxide Line			Heated Proc. Off Gas	0.3			Heated Process Off Gas	0.2
Back Up Facility			XR Off Gas	38.1			XR Off Gas	38.1
TOTALS		712.6		709.7		705.5		705.5

19. iv) Estimated enrichment ranges, and uranium/plutonium content	a) U 0.9 ^{235}U to 1.25% ^{235}U 1. zirflex waste 0.18 l/lU 1.3 X 10^{-3} g Pu/l 2. Ammonia ~0 3. F16 & F18 5 X 10^{-1} g U/l 3 X 10^{-3} g Pu/l 4. U3 & U4 analytical 4 X 10^{-3} g U/l 5 X 10^{-6} g Pu/l 5. R8 & G8 Solvent treatment 5 X 10^{-1} g U/l 3 X 10^{-4} g Pu/l 6. Low level wastes levels ~0 7. Gaseous ~0 8. Solid wastes <40 g Pu/drum
(1) For example uranium and plutonium.	

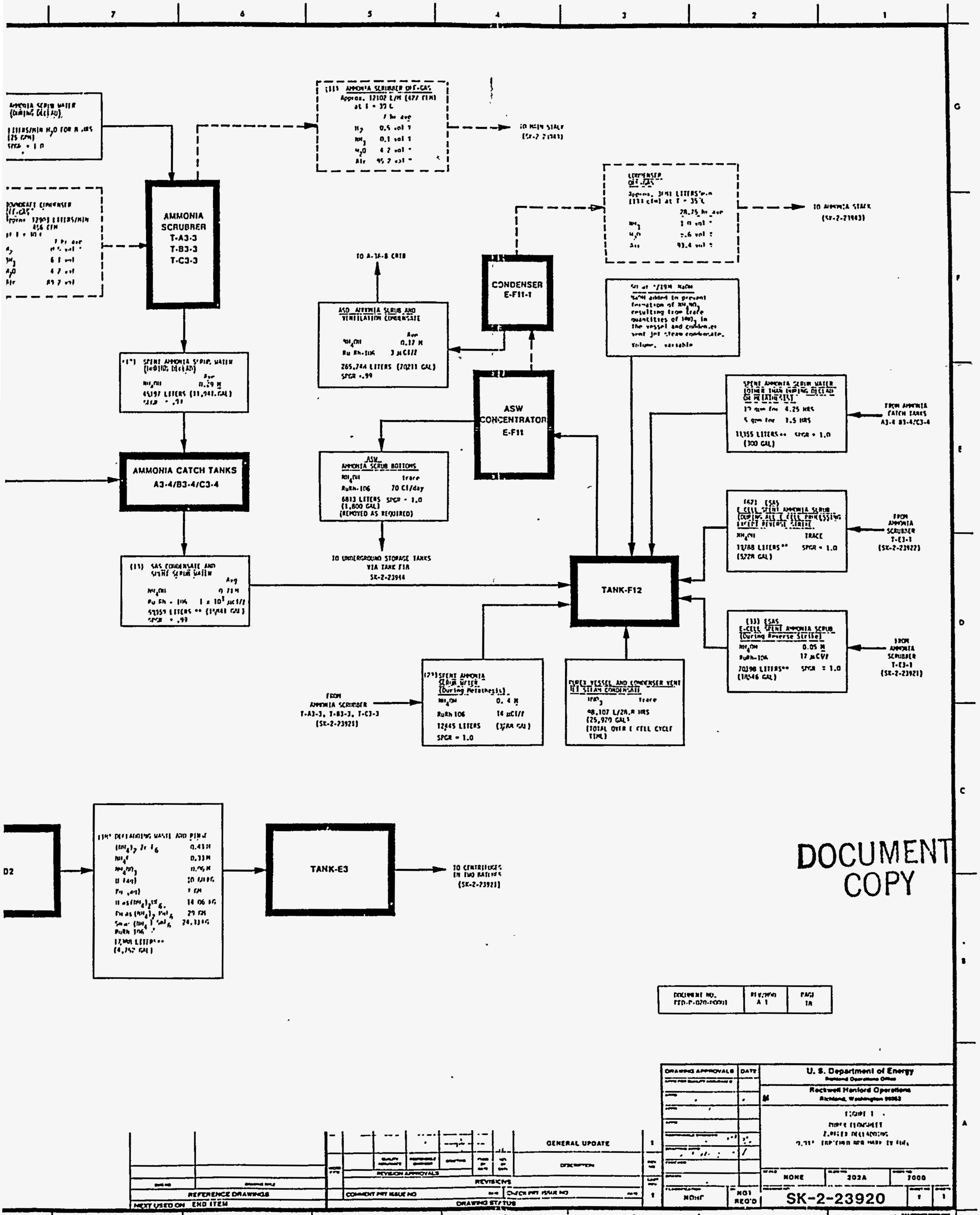
Waste Material (Continued) 19. v) Estimated quantities per year, period of storing	10-2 MTU/day 20 KgPu/day 250 operating days per year 1. cladding waste 0.01% of throughput 2.5 MT U 1.2 Kg Pu 2. Ammonia 0 3. F16 & F18 (high level waste) (0.2% of throughput) 51 Kg U 24 Kg Pu 4. Analytical waste (250,000 liters) <Kg U <1 g Pu 5. Solvent treatment <5 Kg U <10 g Pu 6. Low level wastes ~0 7. Gaseous ~0 8. Solid waste U ~0 Pu ~2 Kg/l

19. vi) Waste generated rates (as of input/throughput quantities per month)	1. Zirflex (cladding) 0.1% U & Pu 2. Ammonia ~0 3. High level waste 0.2% U & Pu 4. Analytical waste ~0% 5. Solvent treatment ~0% 6. Low level waste ~0% 7. Gaseous ~0% 8. Solid waste U=0% Pu=.04%

19. vii)	Store inventory range and maximum capacity	none No on-site (within MBA)

19. viii)	Method and frequency of recovery/disposal	Reference Technical Manual Sections

20. Waste treatment system	Diagram(s) attached under Ref. No 1. Flowsheets are found in PFD-P-020-00001, an old Rockwell document. - Referral flow sheet and acid recovery - Solvent treatment - HLW concentration


AMMONIA SCRUBBER T-A3-3 T-B3-3 T-C3-3
AMMONIA CATCH TANKS A3-4/B3-4/C3-4
CONDENSER E-F11-1
ASW CONCENTRATOR E-F11
TANK-F12
TANK-E3
TO A-16-B CRIB
TO UNDERGROUND STORAGE TANKS VIA TANK F18
TO AMMONIA STACK
TO CENTRIFUGES IN TWO BATCHES
DOCUMENT COPY
U. S. Department of Energy
Rockwell Hanford Operations
GENERAL UPDATE
REFERENCE DRAWINGS
DRAWING STATUS
SK-2-23920

Liquation 20

BASIS: ONE DISSOLVER CHARGE

NOTES:

1. CONSECUTIVE COMPONENT BOX NUMBERS ON THIS DRAWING ARE FROM 1-18
2. ESTIMATED E CELL CYCLE TIME = 28.8 HRS
3. ALL GASES ASSUMED AT 1 ATM PRESSURE

* ADJUST NH_4F SOLUTION ADDITION ON EACH CHARGE TO MAINTAIN F/ZR MOLE RATIO AT APPROXIMATELY 7.8

** INCLUDES 3% JET TRANSFER DILUTION

*** FUEL CONTENT IS BASED UPON AN EXPOSURE OF OF 2,435 MWD/T WITH A 12% Pu^{240} COMPOSITION. SOME FUEL TO BE PROCESSED HAS BEEN EXPOSED TO ONLY ABOUT 1,700 MWD/T & WILL HAVE ABOUT 1300 GM Pu/SHORT TON U AT A 9% Pu^{240} COMPOSITION.

4* FISSION PRODUCT CONTENT BASED ON 180 DAY COOLED FUEL (REF. UNI-436.)

5* A 20 GALLON DISSOLVER JET HEEL WAS ASSUMED EXCEPT WHERE NOTED OTHERWISE.

DOWNDRAFT CONDENSER
T-A3-1
T-B3-1
T-C3-1

(8) DISSOLVER OFF-GAS
Approx. 84083 liters/min (2878 cfm)
T = 100°C

	7 hr ave
H_2	0.1 vol%
NH_3	4.0 vol%
H_2O	78.2 vol%
Air	17.7 vol%

(10) CONDENSATES
Avg
NH_4OH 2.07 M
14760 LITERS SPGR = 0.98
(3900 GAL)

(1) DISSOLVER AIR BLEED
Approx. 11326 LITERS/min
(400 cfm)
Temp. 25°C

(2) DILUTION WATER
Temp. Ambient
5299 LITERS, SPGR = 1.0
(1400 gal.)

(3) ZIRFLEX SOLUTION*
NH_4F 11.2 M, 7.07 mole HF/mole Zr
NH_4NO_3 1.0 M, .68 mole NH_4NO_3/mole Zr
5299 LITERS
(1400 gal) SPGR = 1.125

(4) CHARGE***
Uranium: 10,205.93 Kg
(10.2 metric tons)
22,500 lbs.
(448 elements,
32 canisters)
Zircaloy-2: 716.68 kg (1580 lbs)
Composition 98.5% Zr
1.5% Sn
Plutonium (12% Pu^{240}): 1825 gms/short ton
20531 gms/charge
RuRh-106[4*] 2.87×10^{3} Ci/MT:
I-129[4*] 2.29×10^{-3} Ci/MT

(7) WATER MAKE-UP
Water added as necessary to maintain dissolver liquid level approx. 3825 LITERS
(1010 GAL)

(14) DILUTION WATER
4542 LITERS
(1200 gal) SPGR = 1.0

(16) RINSE WATER
1893 LITERS
(500 gal) SPGR = 1.0

DISSOLVERS 5*
A3/B3/C3

(6) STEAM SPARGE
Approx. 1633 kg/hr steam for 7 hours
(3600 PPH)

(15) DECLADDING WASTE

$(NH_4)_2 ZrF_6$	0.50 M
NH_4F	0.38 M
NH_4NO_3	0.07 M

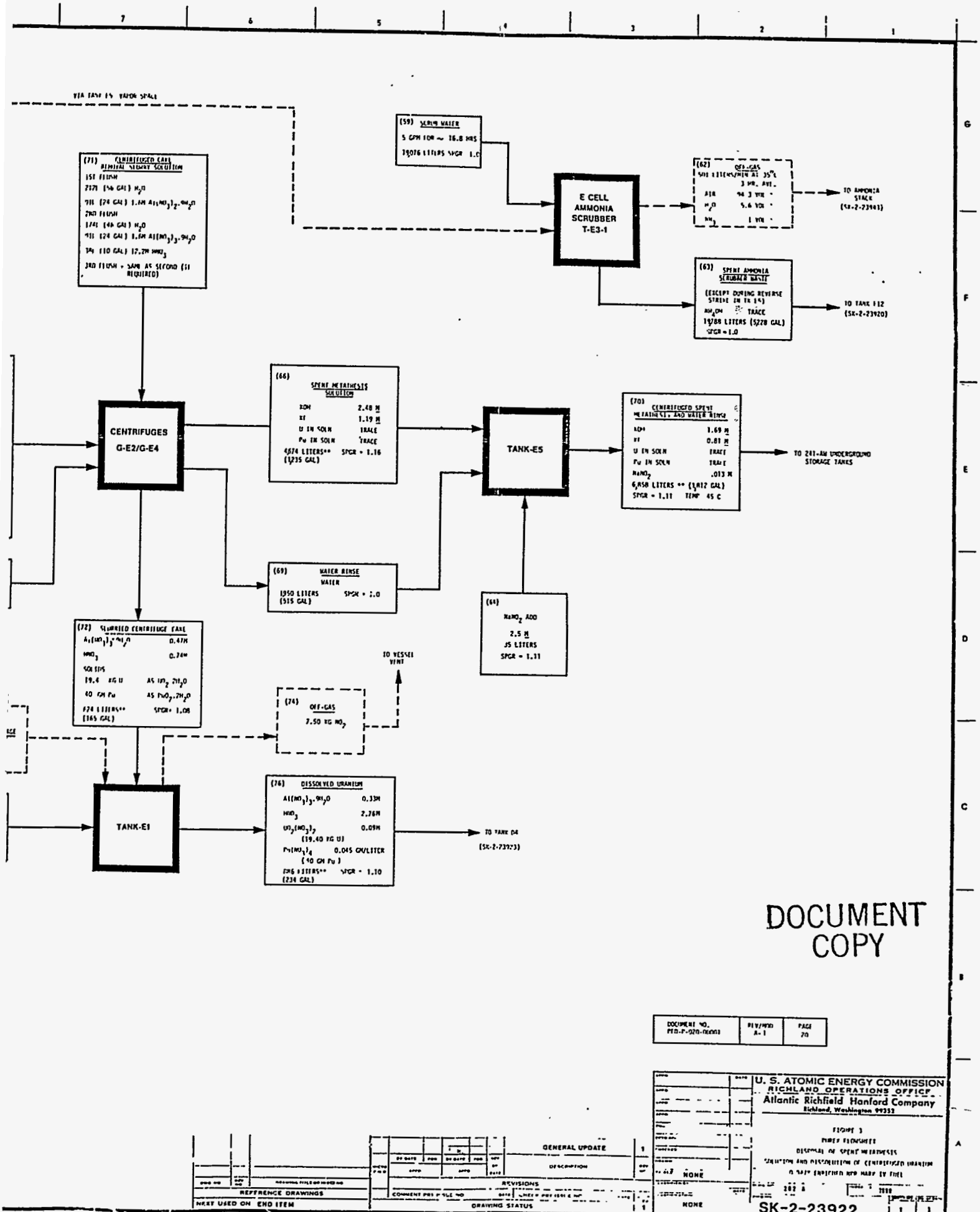
U(IN SOLN) 10.60 KG/BATCH (0.68 GM/L)
Pu(IN SOLN) 7 GM/BATCH (4.9 x 10^{-6} GM/L)
Sn(IN SOLN) 10.75 KG/BATCH
U (CARRIED AS ENTRAINED $(NH_4)_2 UF_6$) = 14.06 KG
Pu (CARRIED AS ENTRAINED $(NH_4)_2 PuF_6$) = 29 GM
RuRh-106
15516 LITERS** (4099 GAL)
SPGR = 1.03

(17) WATER RINSE

$(NH_4)_2 ZrF_6$	0.07 M
NH_4F	0.02 M
NH_4NO_3	trace

RuRh-106
1949 LITERS** SPGR = 1.0
(515 GAL)

TANK-



DOCUMENT COPY

DOCUMENT NO. HW-P-020-00003	REV/MOD A-1	PAGE 70

U. S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE
Atlantic Richfield Hanford Company
Richland, Washington 99352

FIGURE 3
PUREX FLOWSHEET
DISPOSAL OF SPENT METATHESIS SOLUTION AND DISSOLUTION OF CENTRIFUGED URANIUM 0.947% ENRICHED AND HARD BY FUEL

SK-2-23922

GENERAL UPDATE

REVISIONS

REFERENCE DRAWINGS

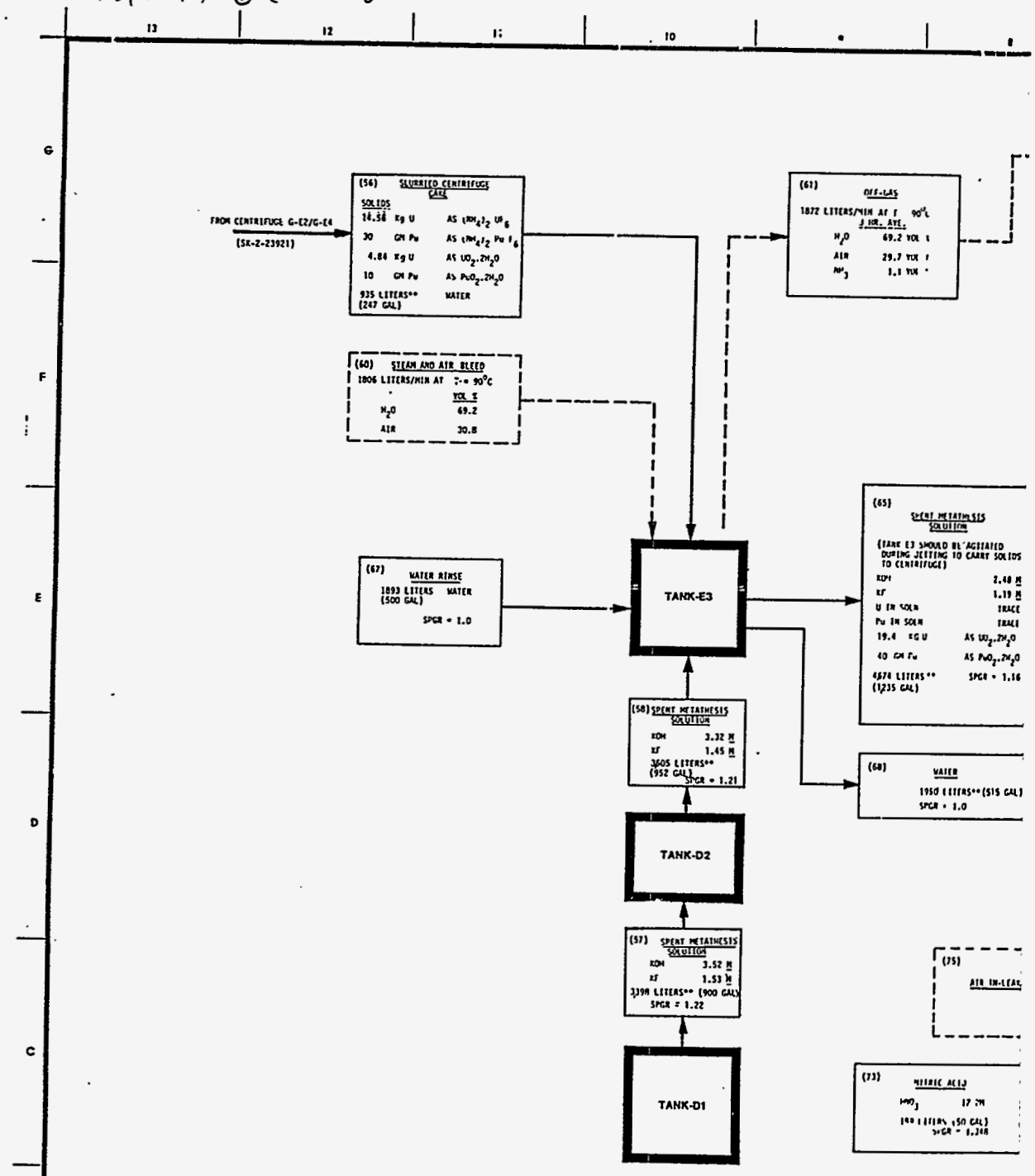
NEXT USED ON END ITEM

DRAWING STATUS

NONE

NONE

QUESTION 20

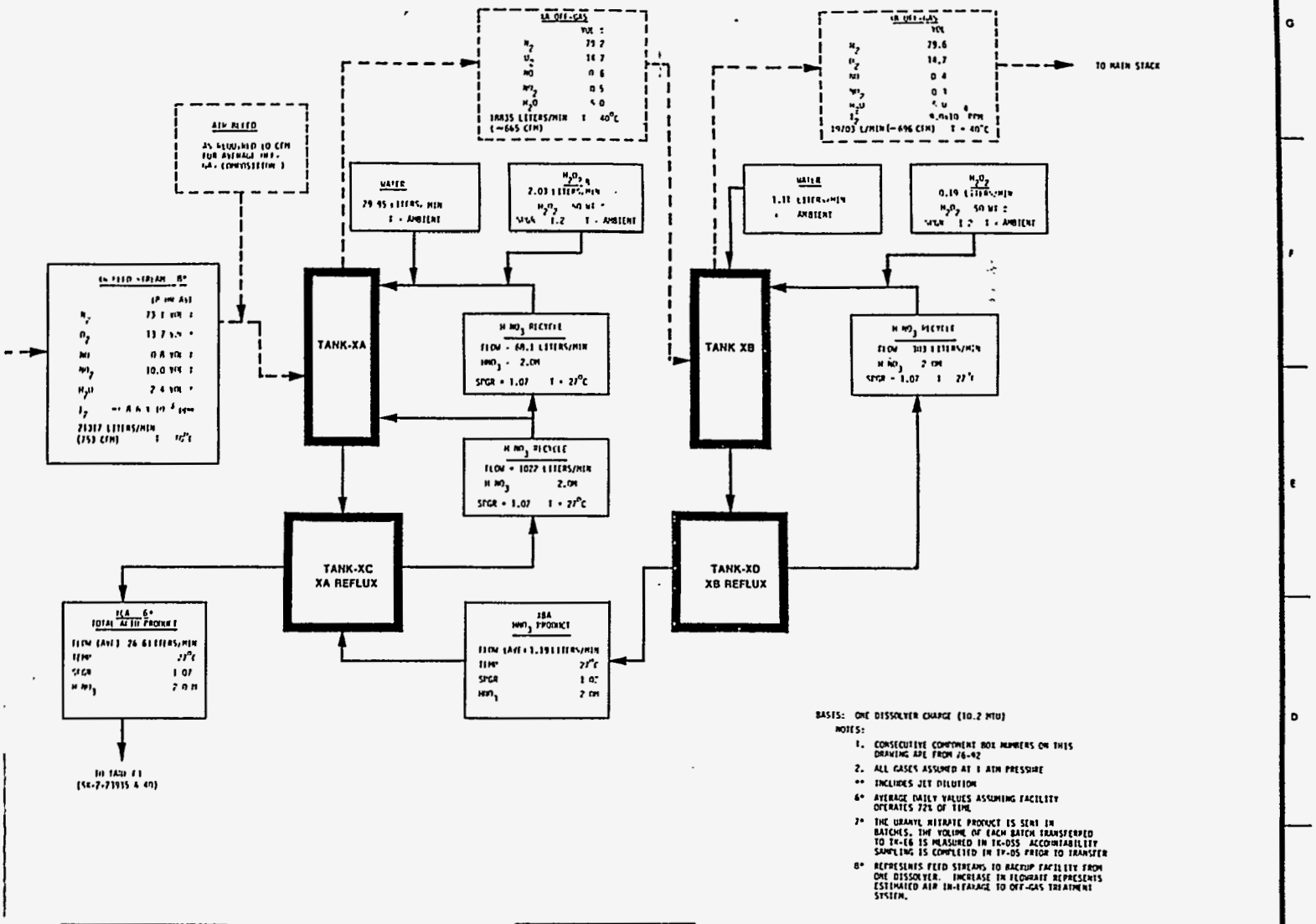


BASIS: ONE DISSOLVER CHARGE (10.2 MTU)

NOTES:

1. CONSECUTIVE COMPONENT BOX NUMBERS ON THIS DRAWING ARE 56-76
2. ALL GASES ASSUMED AT 1 ATM PRESSURE

** INCLUDES JET DILUTIONS



BASIS: ONE DISSOLVER CHARGE (10.2 MTU)

NOTES:

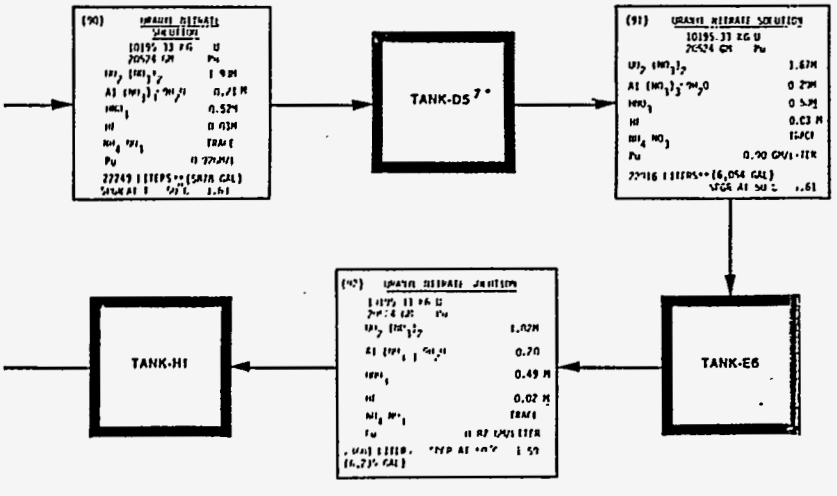
1. CONSECUTIVE COMPONENT BOX NUMBERS ON THIS DRAWING ARE FROM 76-92
2. ALL GASES ASSUMED AT 1 ATM PRESSURE

** INCLUDES JET DILUTION

6* AVERAGE DAILY VALUES ASSUMING FACILITY OPERATES 72% OF TIME

7* THE URANYL NITRATE PRODUCT IS SENT IN BATCHES. THE VOLUME OF EACH BATCH TRANSFERRED TO TK-E6 IS MEASURED IN TK-D5S ACCOUNTABILITY SAMPLING IS COMPLETED IN TP-D5 PRIOR TO TRANSFER

8* REPRESENTS FEED STREAMS TO BACKUP FACILITY FROM ONE DISSOLVER. INCREASE IN FLOWRATE REPRESENTS ESTIMATED AIR IN-LEAKAGE TO OFF-GAS TREATMENT SYSTEM.



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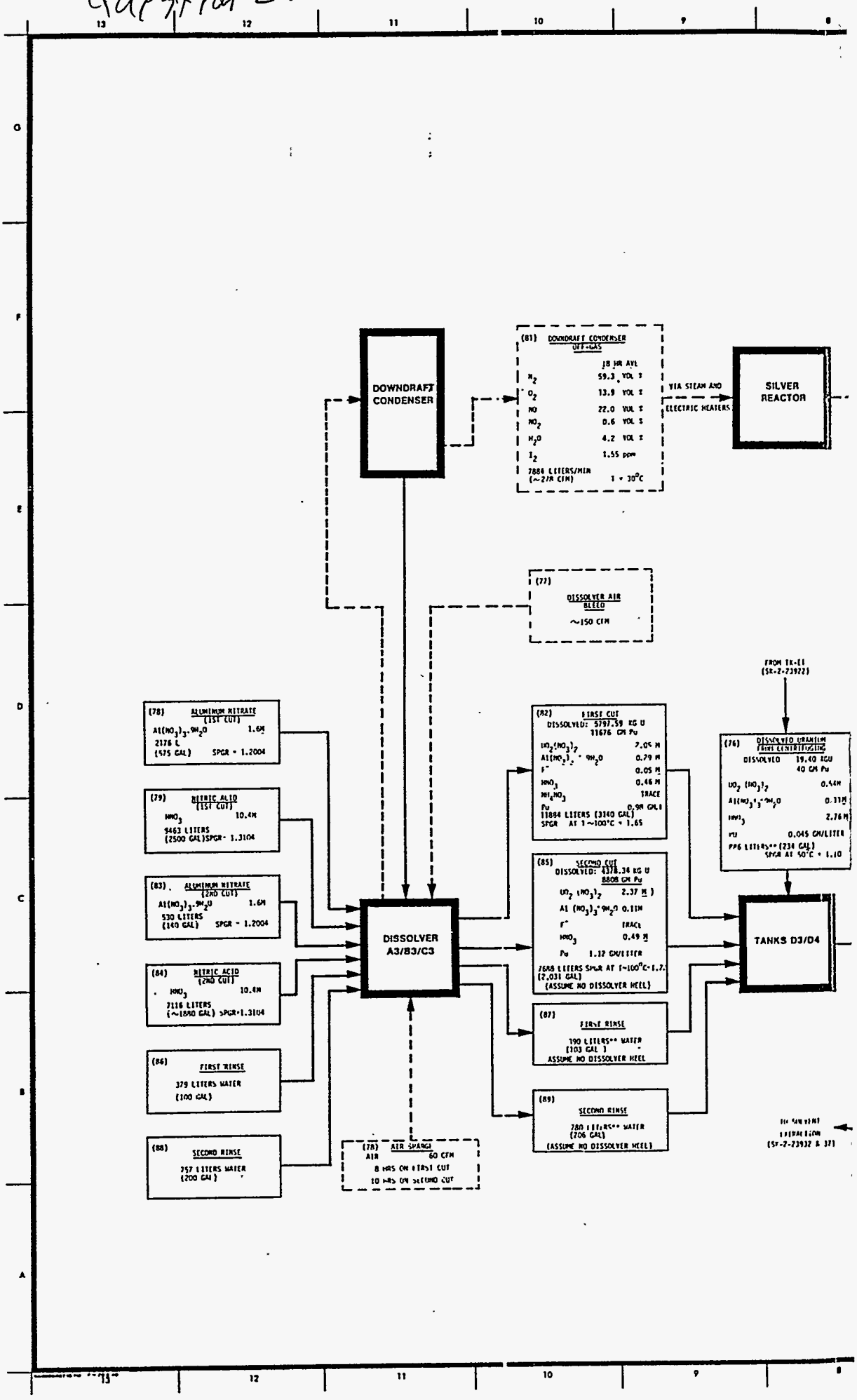
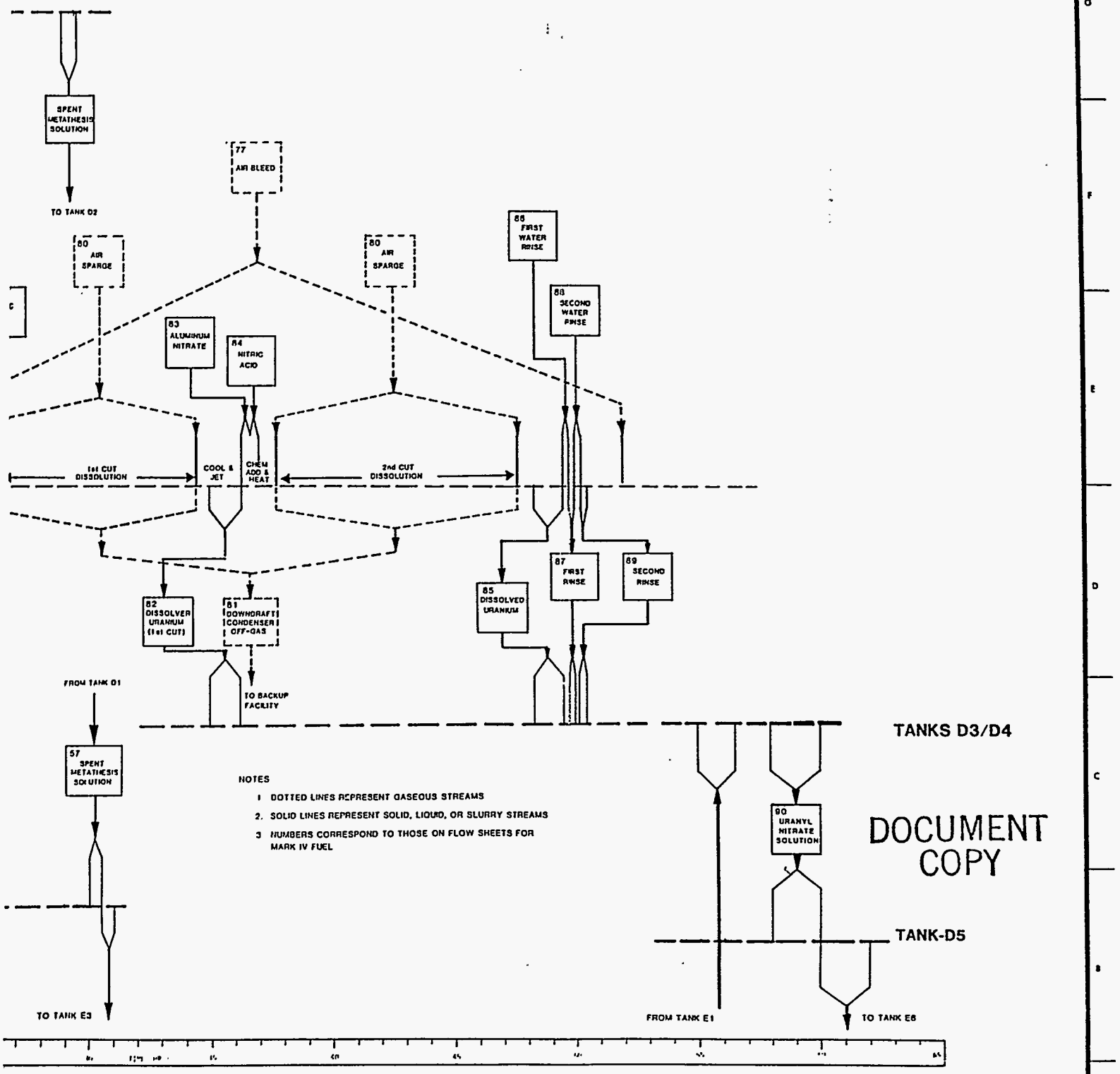
NONE | 202A | 7000

SK-2-23923 | 1

REVISIONS
GENERAL UPDATE
COMMENT PRT ISSUE NO | CHECK PRT ISSUE NO
DRAWING STATUS
NONE | NOT REQ'D
REFERENCE DRAWINGS
NEXT USED ON END ITEM

Option 20


DOWNDRAFT CONDENSER
(81) DOWNDRAFT CONDENSER OFF-GAS
18 HR AVE
H_2 59.3 VOL %
O_2 13.9 VOL %
NO 22.0 VOL %
NO_2 0.6 VOL %
H_2O 4.2 VOL %
I_2 1.55 ppm
7884 LITERS/MIN (~278 CFM) T = 30°C
VIA STEAM AND ELECTRIC HEATERS
SILVER REACTOR
(77) DISSOLVER AIR BLEED ~150 CFM
FROM TK-E1 (SK-2-23922)
(78) ALUMINUM NITRATE (1ST CUT)
$Al(NO_3)_3 \cdot 9H_2O$ 1.6M
2178 L (575 GAL) SPGR = 1.2004
(79) NITRIC ACID (1ST CUT)
HNO_3 10.4M
9463 LITERS (2500 GAL) SPGR = 1.3104
(83) ALUMINUM NITRATE (2ND CUT)
$Al(NO_3)_3 \cdot 9H_2O$ 1.6M
530 LITERS (140 GAL) SPGR = 1.2004
(84) NITRIC ACID (2ND CUT)
HNO_3 10.4M
7116 LITERS (~1880 GAL) SPGR=1.3104
(86) FIRST RINSE
379 LITERS WATER (100 GAL)
(88) SECOND RINSE
757 LITERS WATER (200 GAL)
DISSOLVER A3/B3/C3
(78) AIR SPARGE
AIR 60 CFM
8 HRS ON FIRST CUT
10 HRS ON SECOND CUT
(82) RINSE CUT
DISSOLVED: 5797.59 KG U
11676 GM Pu
$UO_2(NO_3)_2$ 7.05 M
$Al(NO_3)_3 \cdot 9H_2O$ 0.79 M
F^- 0.05 M
HNO_3 0.46 M
NH_4NO_3 TRACE
Pu 0.98 GM/L
11884 LITERS (3140 GAL)
SPGR AT T=100°C = 1.65
(85) SECOND CUT
DISSOLVED: 4378.34 KG U
8808 GM Pu
$UO_2(NO_3)_2$ 2.37 M
$Al(NO_3)_3 \cdot 9H_2O$ 0.11M
F^- TRACE
HNO_3 0.49 M
Pu 1.12 GM/LITER
7568 LITERS SPGR AT T=100°C=1.7
(2,031 GAL)
(ASSUME NO DISSOLVER HEEL)
(87) FIRST RINSE
190 LITERS** WATER (103 GAL)
ASSUME NO DISSOLVER HEEL
(89) SECOND RINSE
780 LITERS** WATER (206 GAL)
(ASSUME NO DISSOLVER HEEL)
(76) DISSOLVED URANIUM FROM CENTRIFUGING
DISSOLVED 19.40 KGU
40 GM Pu
$UO_2(NO_3)_2$ 0.44M
$Al(NO_3)_3 \cdot 9H_2O$ 0.11M
HNO_3 2.76M
Pu 0.045 GM/LITER
996 LITERS** (234 GAL)
SPGR AT 50°C = 1.10
TANKS D3/D4
TO SOLVENT EXTRACTION (SK-2-23932 & 37)



NOTES

1. DOTTED LINES REPRESENT GASEOUS STREAMS
2. SOLID LINES REPRESENT SOLID, LIQUID, OR SLURRY STREAMS
3. NUMBERS CORRESPOND TO THOSE ON FLOW SHEETS FOR MARK IV FUEL

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Rockwell Hanford Operations
Richland, Washington 99352

FIGURE 5
TYPICAL HEAVY METAL FUEL REPROCESSING
FLOW SHEET FOR MARK IV FUEL

REVISION APPROVALS							REVISIONS
							GENERAL UPDATE

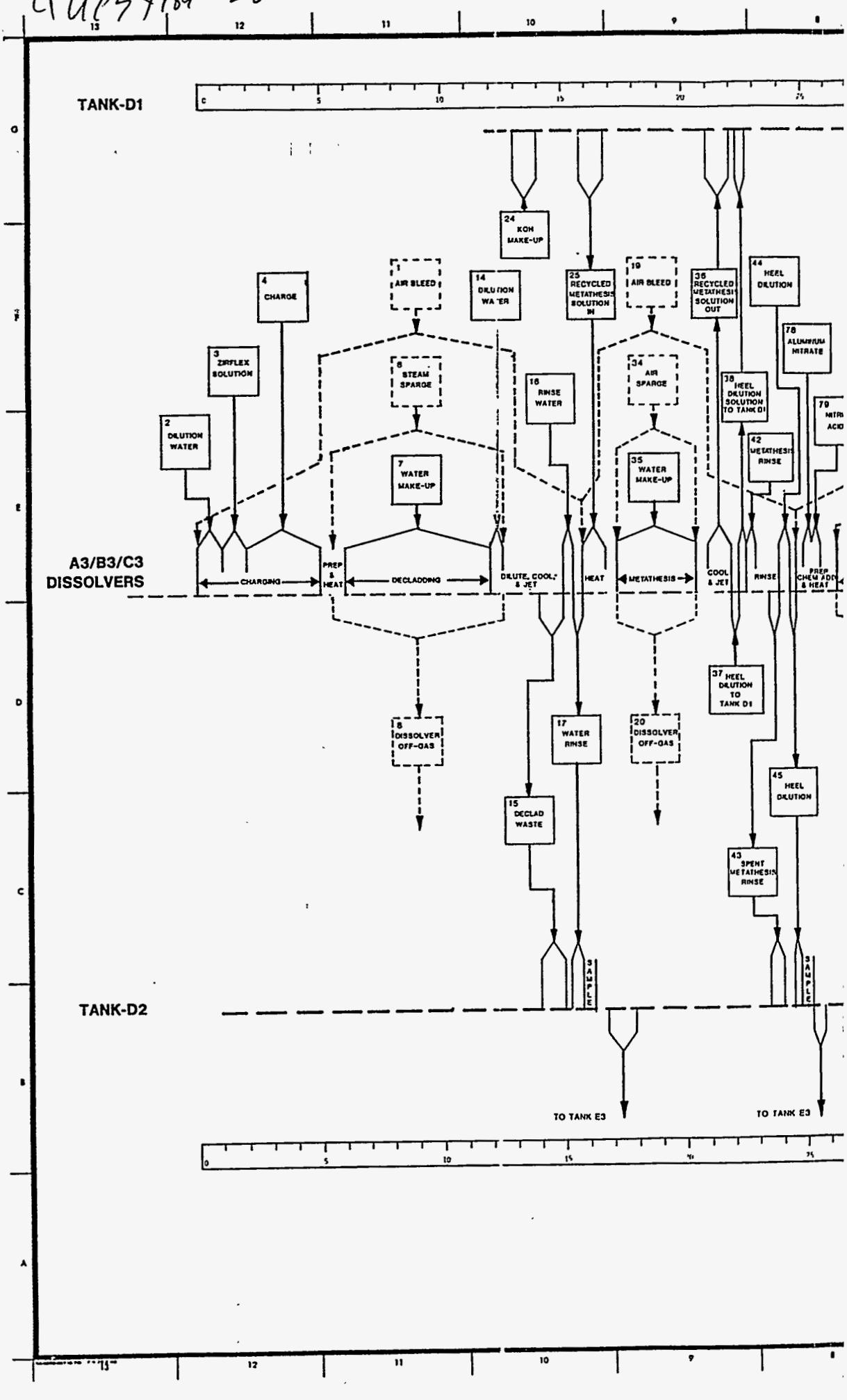
REFERENCE DRAWINGS	COMMENT PRT ISSUE NO	CHECK PRT ISSUE NO
NEXT USED ON END ITEM	DRAWING STATUS	

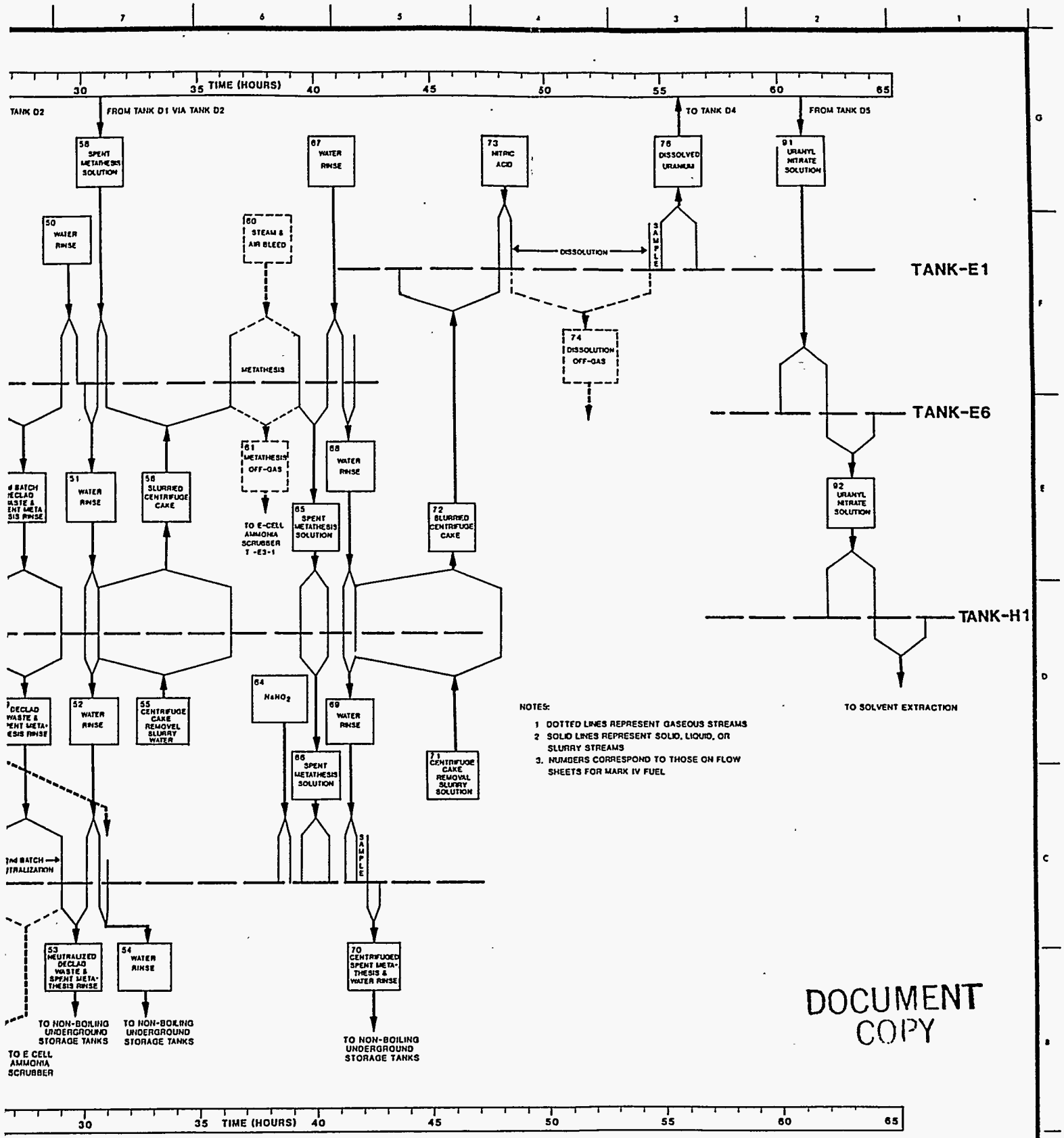
NONE	NOT REQ'D

NONE	202A	T000

SK-2-23924

Question 20


TANK-D1
A3/B3/C3
DISSOLVERS
TANK-D2
1 AIR BLEED
2 DILUTION WATER
3 ZIRFLEX SOLUTION
4 CHARGE
6 STEAM SPARGE
7 WATER MAKE-UP
8 DISSOLVER OFF-GAS
10 AIR BLEED
14 DILUTION WATER
15 DECLAD WASTE
16 RINSE WATER
17 WATER RINSE
20 DISSOLVER OFF-GAS
24 KOH MAKE-UP
25 RECYCLED METATHESIS SOLUTION IN
34 AIR SPARGE
35 WATER MAKE-UP
36 RECYCLED METATHESIS SOLUTION OUT
37 HEEL DILUTION TO TANK D1
38 HEEL DILUTION SOLUTION TO TANK D1
42 METATHESIS RINSE
43 SPENT METATHESIS RINSE
44 HEEL DILUTION
45 HEEL DILUTION
78 ALUMINUM NITRATE
79 NITRIC ACID
CHARGING
PREP & HEAT
DECLADDING
DILUTE, COOL & JET
HEAT
METATHESIS
COOL & JET
RINSE
SAMPLE
SAMPLE
TO TANK E3
TO TANK E3



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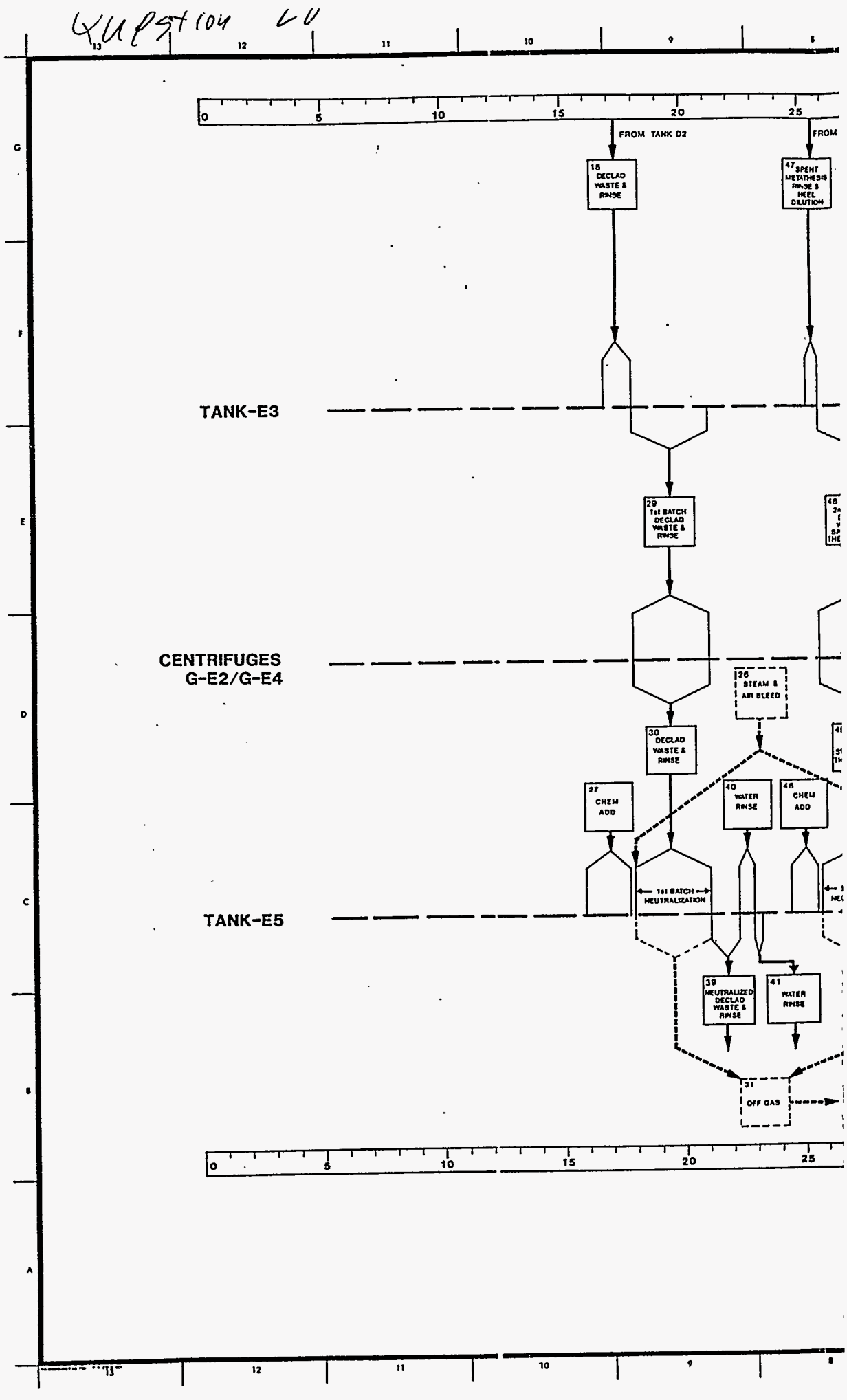
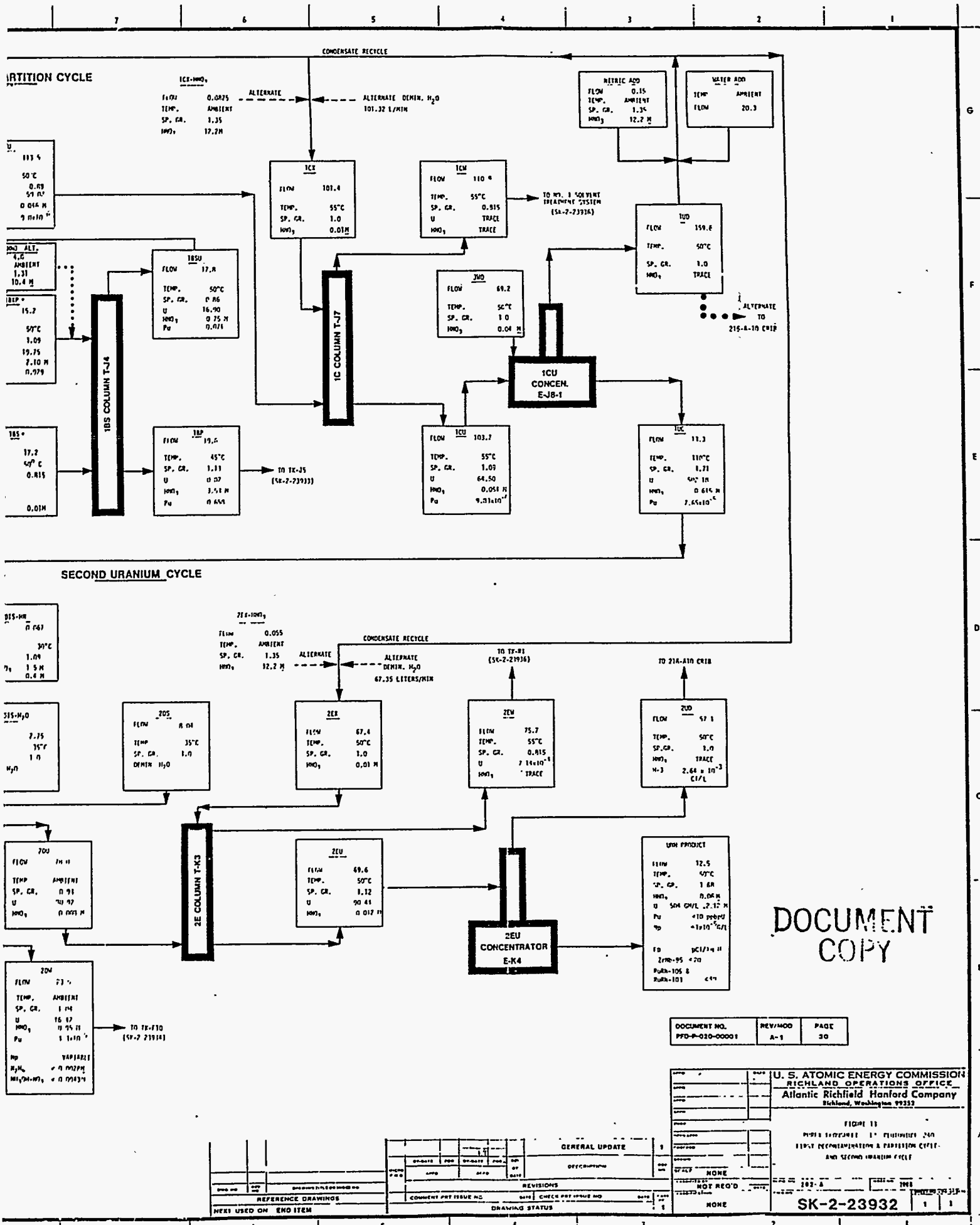
U. S Department of Energy
Rockwell Hanford Operations

FIGURE 6
PUREX HEAD-END CYCLE TIMES FOR PROCESSING 0.947% ENRICHED NPR MARK IV FUEL

SK-2-23925


FROM TANK D2
FROM
18 DECLAD WASTE & RINSE
47 SPENT METATHESIS PHASE & HEEL DILUTION
TANK-E3
29 1st BATCH DECLAD WASTE & RINSE
CENTRIFUGES G-E2/G-E4
26 STEAM & AIR BLEED
30 DECLAD WASTE & RINSE
27 CHEM ADD
40 WATER RINSE
46 CHEM ADD
1st BATCH NEUTRALIZATION
TANK-E5
39 NEUTRALIZED DECLAD WASTE & RINSE
41 WATER RINSE
31 OFF GAS



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Richland, Washington 99352

FIGURE 11
PUREX DECONTAMINATION & PARTITION CYCLE-
AND SECOND URANIUM CYCLE

SK-2-23932

GENERAL UPDATE

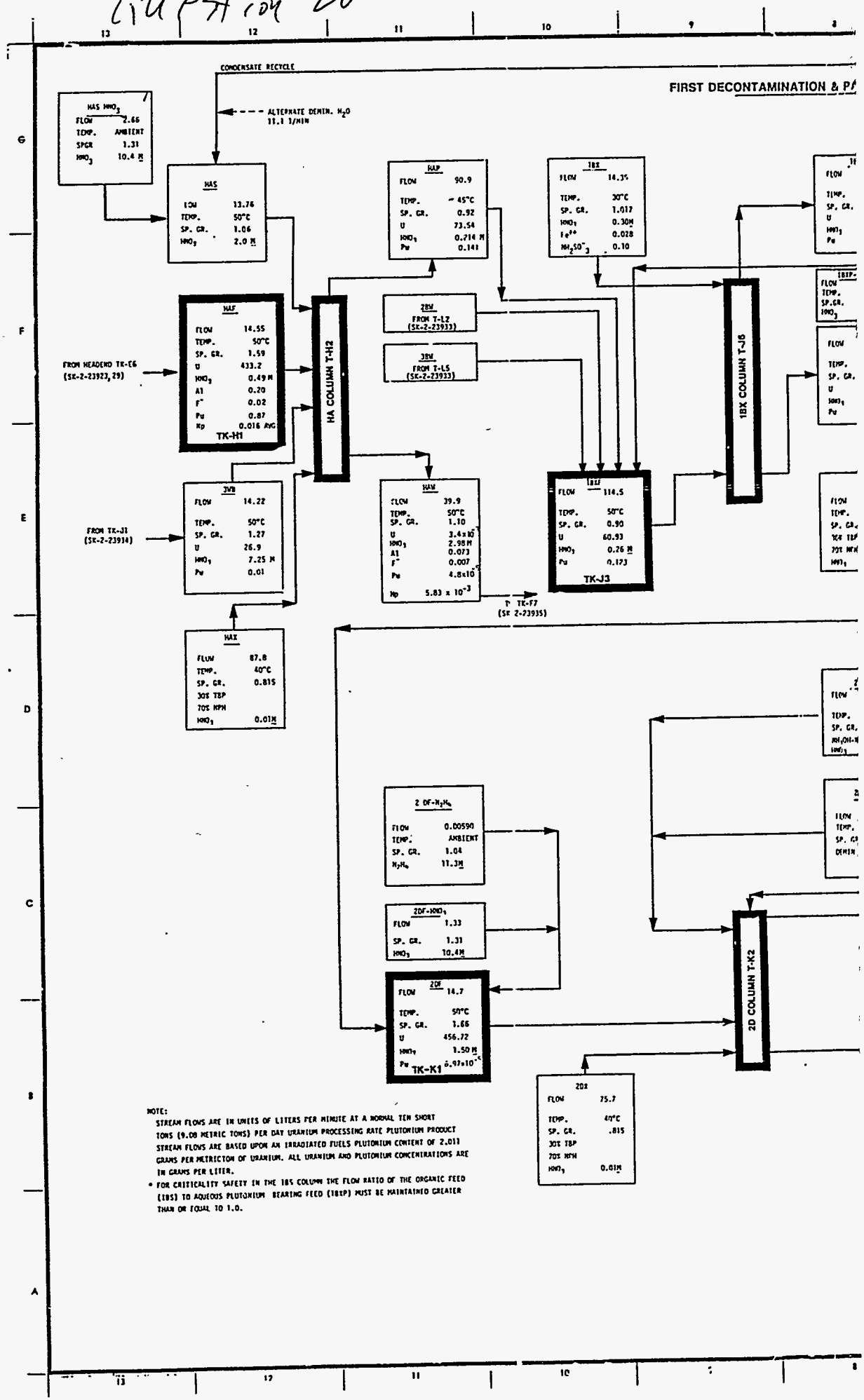
REVISIONS

DRAWING STATUS

REFERENCE DRAWINGS

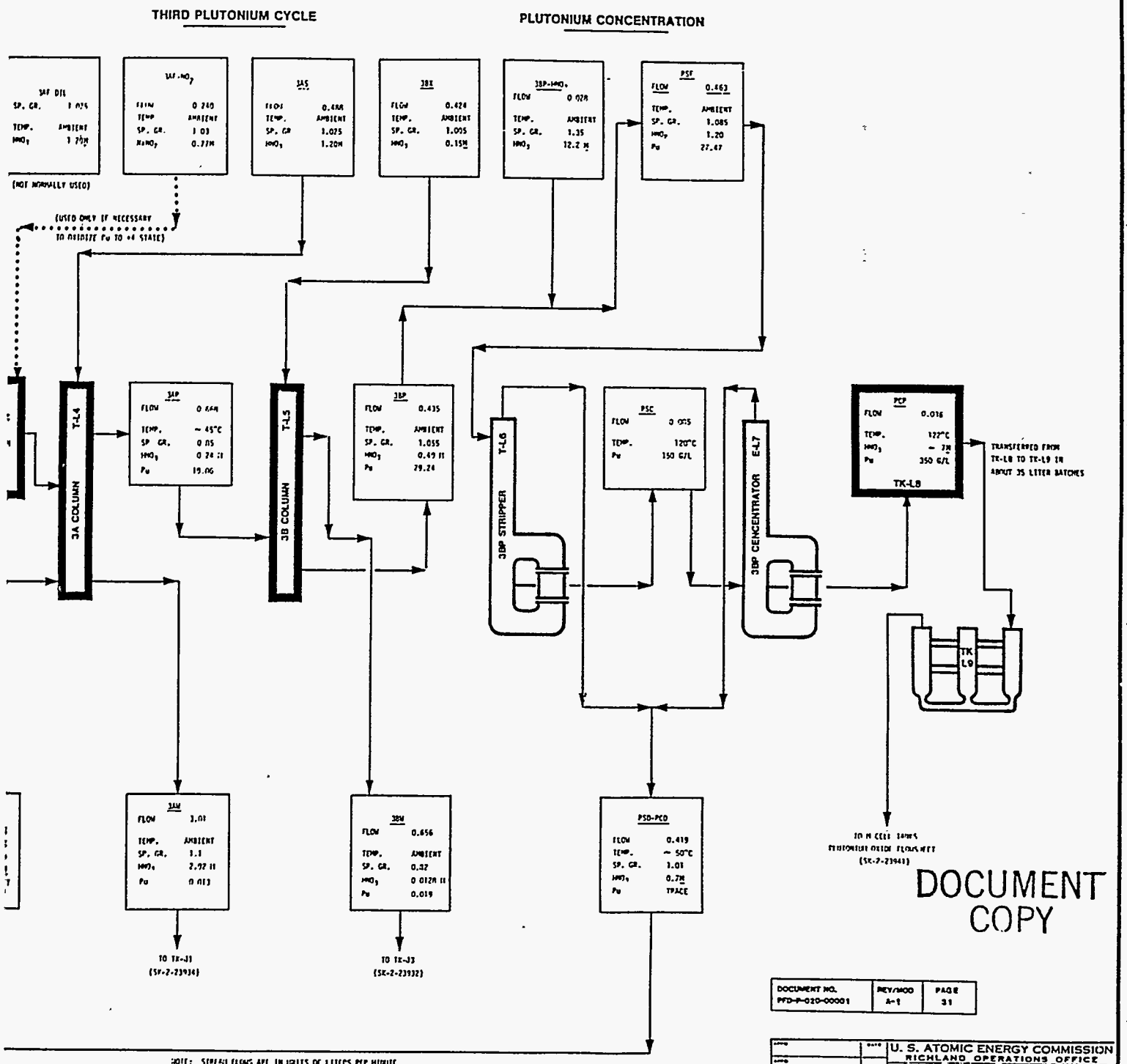
NEXT USED ON END ITEM

Question 20



NOTE:
STREAM FLOWS ARE IN UNITS OF LITERS PER MINUTE AT A NORMAL TEN SHORT TONS (9.08 METRIC TONS) PER DAY URANIUM PROCESSING RATE PLUTONIUM PRODUCT STREAM FLOWS ARE BASED UPON AN IRRADIATED FUELS PLUTONIUM CONTENT OF 2.011 GRAMS PER METRICTON OF URANIUM. ALL URANIUM AND PLUTONIUM CONCENTRATIONS ARE IN GRAMS PER LITER.

* FOR CRITICALITY SAFETY IN THE 1BS COLUMN THE FLOW RATIO OF THE ORGANIC FEED (1BS) TO AQUEOUS PLUTONIUM BEARING FEED (1BXP) MUST BE MAINTAINED GREATER THAN OR EQUAL TO 1.0.



DOCUMENT COPY

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NOTE: STREAM FLOWS ARE IN LITERS OF LITERS PER MINUTE AT A NORMAL TEN SHORT TONS (9.07 METRIC TONS) PER DAY URANIUM PROCESSING RATE PLUTONIUM PRODUCT STREAM FLOWS ARE BASED UPON AN IRRADIATED FUEL CONTENT OF 1,574 G/SHORT TON OR 2,011 G/METRIC TON URANIUM AND PLUTONIUM CONCENTRATIONS ARE IN GRAMS PER LITER

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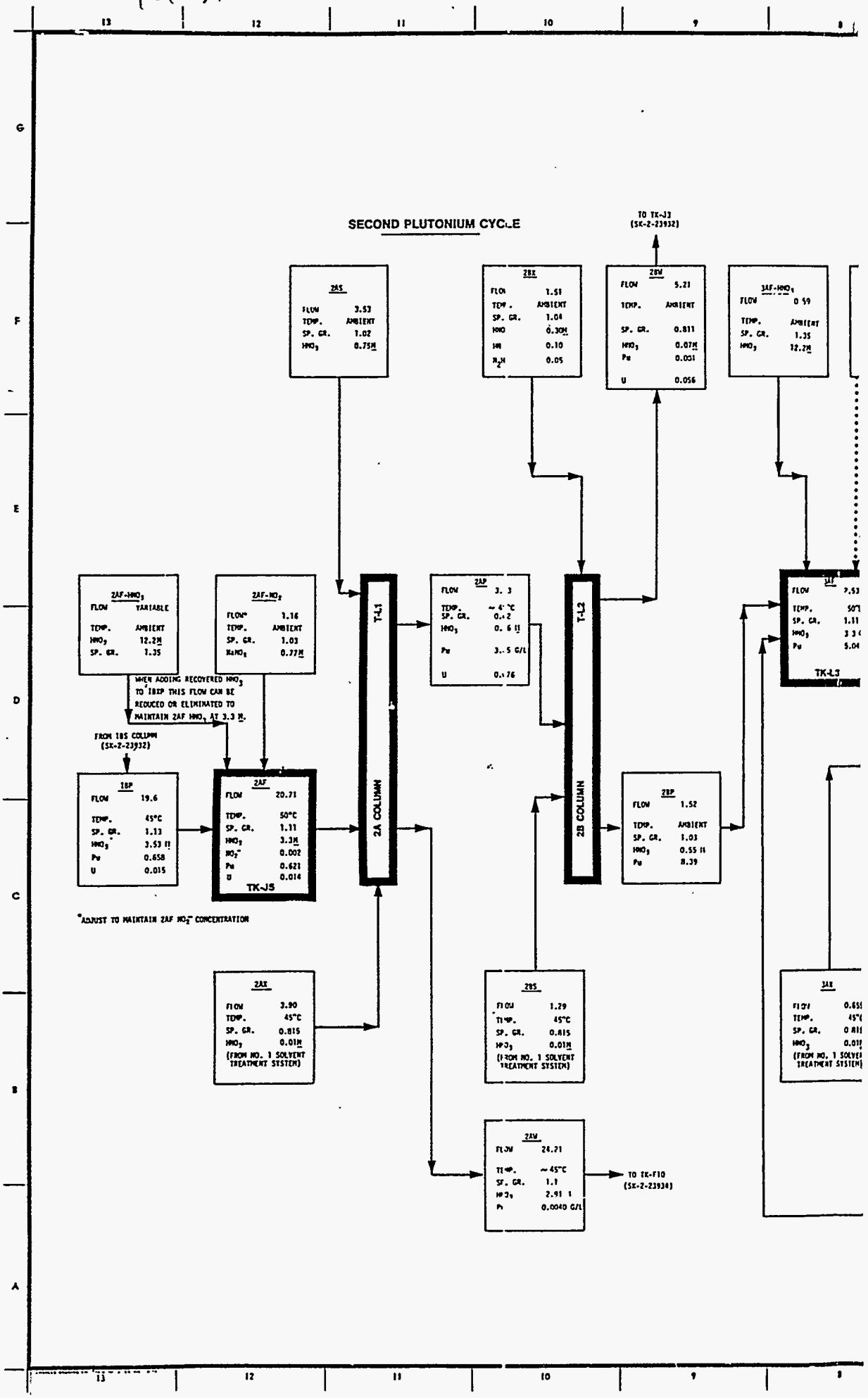
Richland, Washington 99352

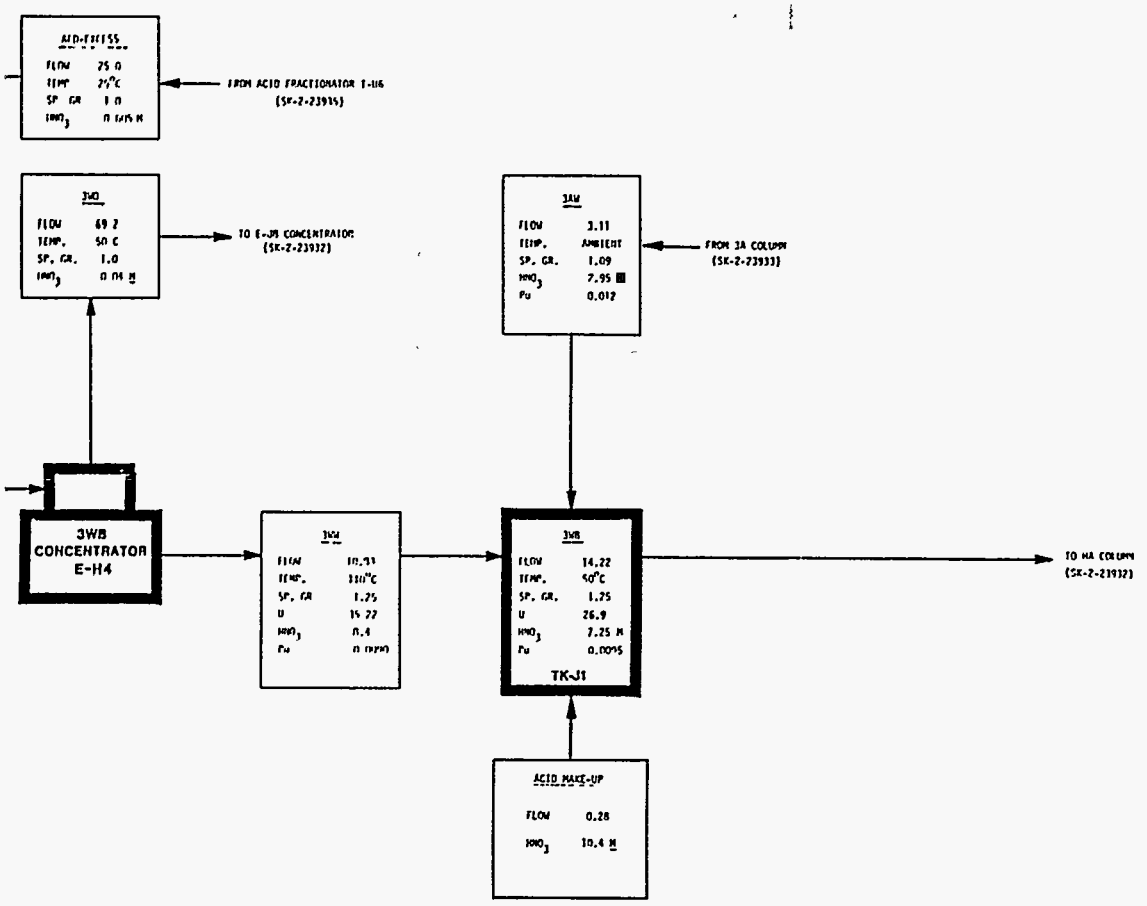
FIGURE 18
PUREX FLOWSHEET - 12 METRIC TON PER DAY SECOND PLUTONIUM CYCLE, THIRD PLUTONIUM CYCLE, AND PLUTONIUM CONCENTRATION

SCALE NONE
NOT REQ'D
NONE
282-A
SK-2-23933

GENERAL UPDATE
REVISIONS
REFERENCE DRAWINGS
NEXT USED ON END ITEM
DRAWING STATUS

Question 20


SECOND PLUTONIUM CYCLE
TO TK-J3 (SK-2-23932)
2AS
FLOW 3.53
TEMP. AMBIENT
SP. GR. 1.02
HNO3 8.75M
2BX
FLOW 1.51
TEMP. AMBIENT
SP. GR. 1.04
HNO 0.30M
HN 0.10
N2H 0.05
2BW
FLOW 5.21
TEMP. AMBIENT
SP. GR. 0.811
HNO3 0.07M
Pu 0.001
U 0.056
3AF-HNO3
FLOW 0.59
TEMP. AMBIENT
SP. GR. 1.35
HNO3 12.2M
2AF-HNO3
FLOW VARIABLE
TEMP. AMBIENT
HNO3 12.2M
SP. GR. 1.35
2AF-NO2
FLOW* 1.16
TEMP. AMBIENT
SP. GR. 1.03
NaNO2 0.77M
WHEN ADDING RECOVERED HNO3 TO 1BXP THIS FLOW CAN BE REDUCED OR ELIMINATED TO MAINTAIN 2AF HNO3 AT 3.3 M.
FROM 1BS COLUMN (SK-2-23932)
1BP
FLOW 19.6
TEMP. 45°C
SP. GR. 1.13
HNO3 3.53 M
Pu 0.658
U 0.015
2AF
FLOW 20.71
TEMP. 50°C
SP. GR. 1.11
HNO3 3.3M
NO2- 0.002
Pu 0.621
U 0.014
TK-J5
T-L1
2A COLUMN
2AP
FLOW 3.3
TEMP. ~ 4° °C
SP. GR. 0.82
HNO3 0.6 M
Pu 3.5 G/L
U 0.176
T-L2
2B COLUMN
2BP
FLOW 1.52
TEMP. AMBIENT
SP. GR. 1.03
HNO3 0.55 M
Pu 8.39
3AF
FLOW 9.53
TEMP. 50°C
SP. GR. 1.11
HNO3 3.3 M
Pu 5.04
TK-L3
*ADJUST TO MAINTAIN 2AF NO2- CONCENTRATION
2AX
FLOW 3.90
TEMP. 45°C
SP. GR. 0.815
HNO3 0.01M
(FROM NO. 1 SOLVENT TREATMENT SYSTEM)
2BS
FLOW 1.29
TEMP. 45°C
SP. GR. 0.815
HNO3 0.01M
(FROM NO. 1 SOLVENT TREATMENT SYSTEM)
2AV
FLOW 24.21
TEMP. ~ 45°C
SP. GR. 1.1
HNO3 2.91 M
Pu 0.0040 G/L
TO TK-F10 (SK-2-23934)
3AX
FLOW 0.65
TEMP. 45°C
SP. GR. 0.81
HNO3 0.01M
(FROM NO. 1 SOLVENT TREATMENT SYSTEM)



NOTE: STREAM FLOWS ARE IN LITERS PER MINUTE, URANIUM AND PLUTONIUM CONCENTRATIONS ARE IN GRAMS PER LITER.

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								GENERAL UPDATE	1
								DESCRIPTION	
REVISION APPROVALS								REVISIONS	
DRAWING NO.	DRAWING TITLE							COMMENT PER ISSUE NO	CHECK PRT ISSUE NO
REFERENCE DRAWINGS								DRAWING STATUS	
NEXT USED ON END ITEM									

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ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
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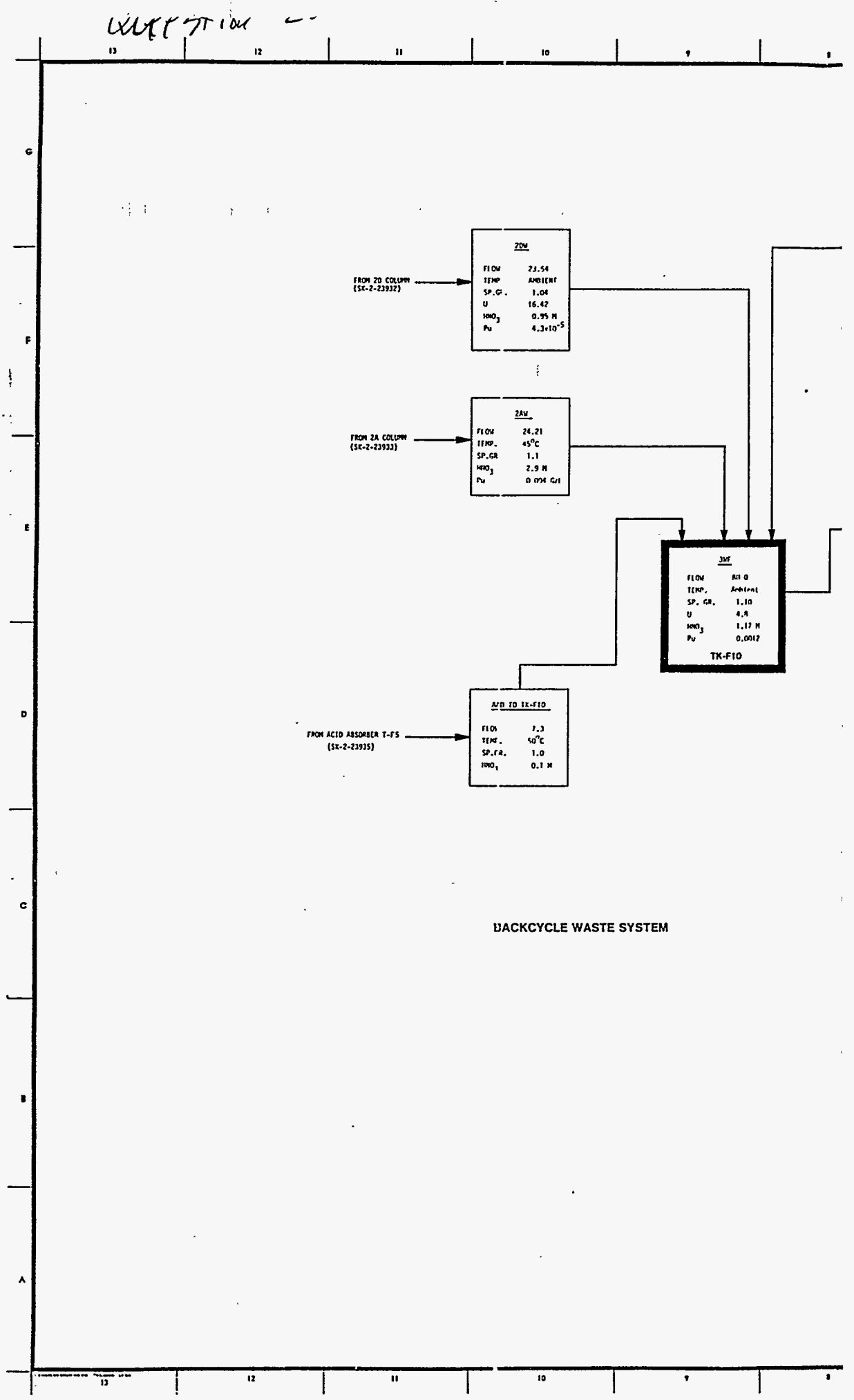
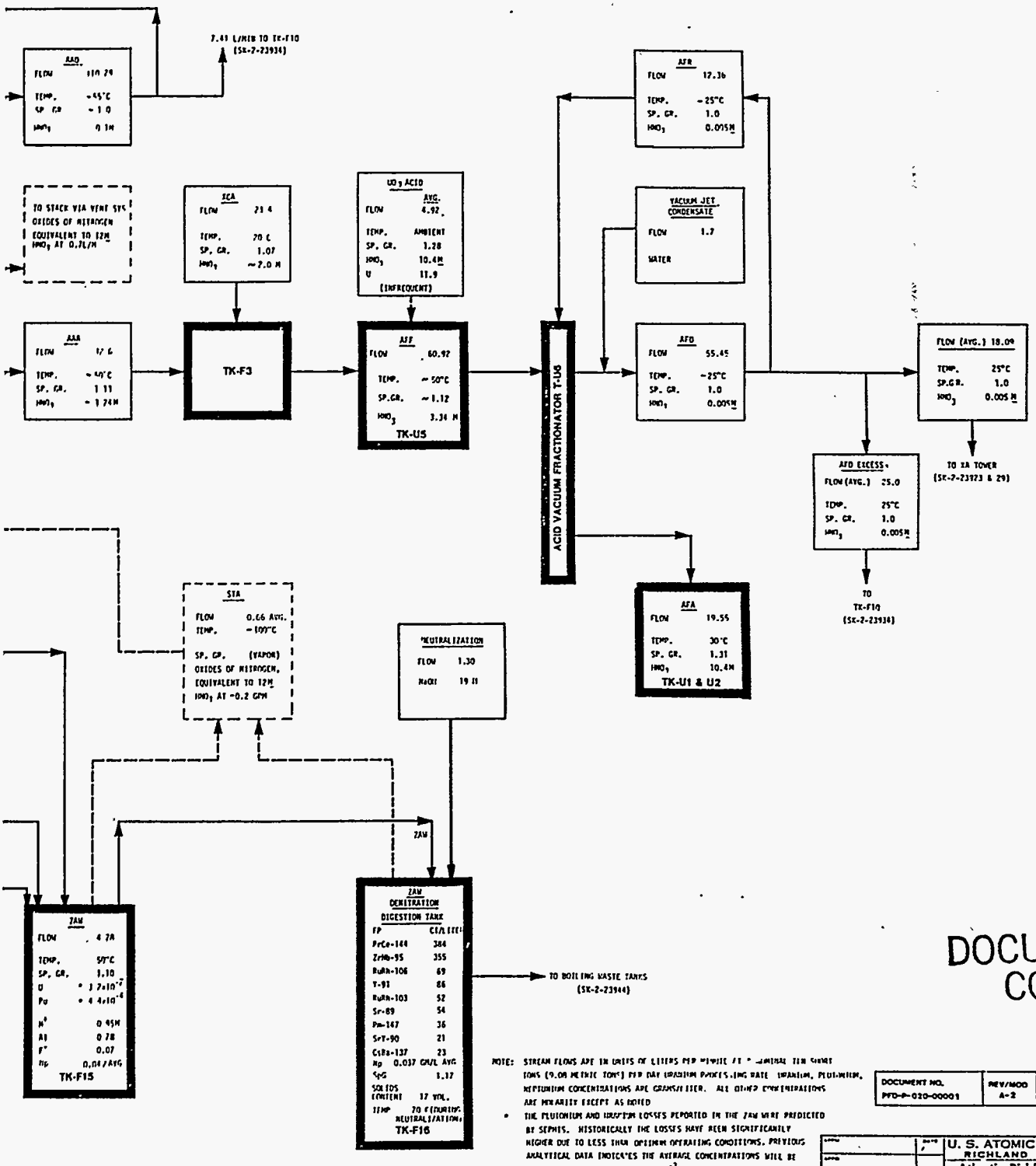
FIGURE 15
FUEL REPROCESSING - 1ST PARTITION CELL
RADIOACTIVE WASTE CONCENTRATION

NONE	202A	7000	
NONE	NOT REQ'D	SK-2-23934	1


FROM 2D COLUMN (SK-2-23932)
2DW
FLOW 23.54
TEMP AMBIENT
SP.GR. 1.04
U 16.42
HNO_3 0.95 M
Pu 4.3×10^{-5}
FROM 2A COLUMN (SK-2-23933)
2AW
FLOW 24.21
TEMP. 45°C
SP.GR 1.1
HNO_3 2.9 M
Pu 0.004 G/l
3WF
FLOW RUN
TEMP. Ambient
SP. GR. 1.10
U 4.9
HNO_3 1.17 M
Pu 0.0012
TK-F10
A/D TO TK-F10
FLOW 7.3
TEMP. 50°C
SP.GR. 1.0
HNO_3 0.1 M
FROM ACID ABSORBER T-F5 (SK-2-23935)
BACKCYCLE WASTE SYSTEM


AAD
FLOW 110 29
TEMP. ~45°C
SP. GR. ~1.0
HNO3 0.1M
7.41 L/MIN TO TK-F10 (SK-2-23934)
TO STACK VIA VENT SYS OXIDES OF NITROGEN EQUIVALENT TO 12M HNO3 AT 0.7L/H
SCA
FLOW 21.4
TEMP. 70 C
SP. GR. 1.07
HNO3 ~2.0 M
UO3 ACID
AVG.
FLOW 4.92
TEMP. AMBIENT
SP. GR. 1.28
HNO3 10.4M
U 11.9
(INFREQUENT)
AFR
FLOW 12.36
TEMP. ~25°C
SP. GR. 1.0
HNO3 0.005M
VACUUM JET CONDENSATE
FLOW 1.7
WATER
AAA
FLOW 17.6
TEMP. ~40°C
SP. GR. 1.11
HNO3 ~1.24M
TK-F3
AFF
FLOW 60.92
TEMP. ~50°C
SP.GR. ~1.12
HNO3 3.34 M
TK-U5
ACID VACUUM FRACTIONATOR T-U8
AFD
FLOW 55.45
TEMP. ~25°C
SP. GR. 1.0
HNO3 0.005M
FLOW (AVG.) 18.09
TEMP. 25°C
SP.GR. 1.0
HNO3 0.005 M
TO 2A TOWER (SK-2-23923 & 29)
AFD EXCESS
FLOW (AVG.) 25.0
TEMP. 25°C
SP. GR. 1.0
HNO3 0.005M
TO TK-F10 (SK-2-23934)
AFA
FLOW 19.55
TEMP. 30°C
SP. GR. 1.31
HNO3 10.4M
TK-U1 & U2
STA
FLOW 0.66 AVG.
TEMP. ~100°C
SP. GR. (VAPOR)
OXIDES OF NITROGEN, EQUIVALENT TO 12M HNO3 AT ~0.2 GPM
NEUTRALIZATION
FLOW 1.30
NaOH 19.11
ZAM
FLOW 4.28
TEMP. 50°C
SP. GR. 1.10
U ~3.7x10-2
Pu ~4.4x10-4
H+ 0.95M
Al 0.78
F- 0.07
Np 0.04 g/kg
TK-F15
ZAM CONCENTRATION DIGESTION TANK
FP CURIES/LITER
PrCe-144 384
ZrNb-95 355
RuRh-106 69
Y-91 86
RuRh-103 52
Sr-89 54
Pm-147 36
SrY-90 21
CsBa-137 23
Np 0.037 GM/L AVG
SpG 1.17
SOLIDS CONTENT 17 VOL.
TEMP 70 C (DURING NEUTRALIZATION)
TK-F16
TO BOILING WASTE TANKS (SK-2-23944)
DOCUMENT COPY
NOTE: STREAM FLOWS ARE IN UNITS OF LITERS PER MINUTE AT NOMINAL TEN DAY TONS (9.08 METRIC TONS) PER DAY URANIUM RATES. ING RATE URANIUM, PLUTONIUM, NEPTUNIUM CONCENTRATIONS ARE GRAMS/LITER. ALL OTHER CONCENTRATIONS ARE MOLARITY EXCEPT AS NOTED
* THE PLUTONIUM AND NEPTUNIUM LOSSES REPORTED IN THE ZAM WERE PREDICTED BY SEPHIS. HISTORICALLY THE LOSSES HAVE BEEN SIGNIFICANTLY HIGHER DUE TO LESS THAN OPTIMUM OPERATING CONDITIONS. PREVIOUS ANALYTICAL DATA INDICATES THE AVERAGE CONCENTRATIONS WILL BE CLOSER TO: U 1.1 g/ℓ Pu 4.4x10-3 g/ℓ
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U. S. ATOMIC ENERGY COMMISSION
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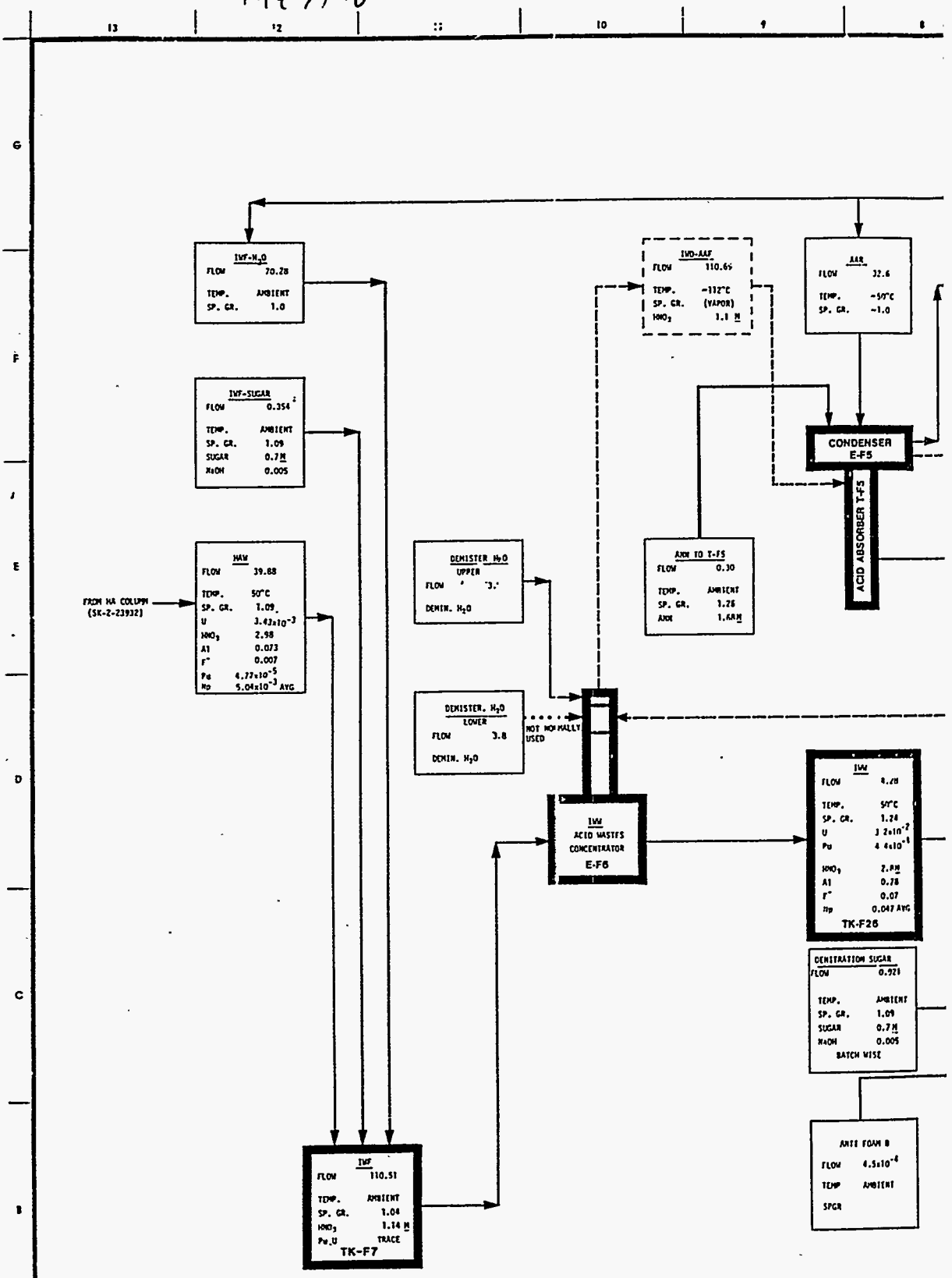
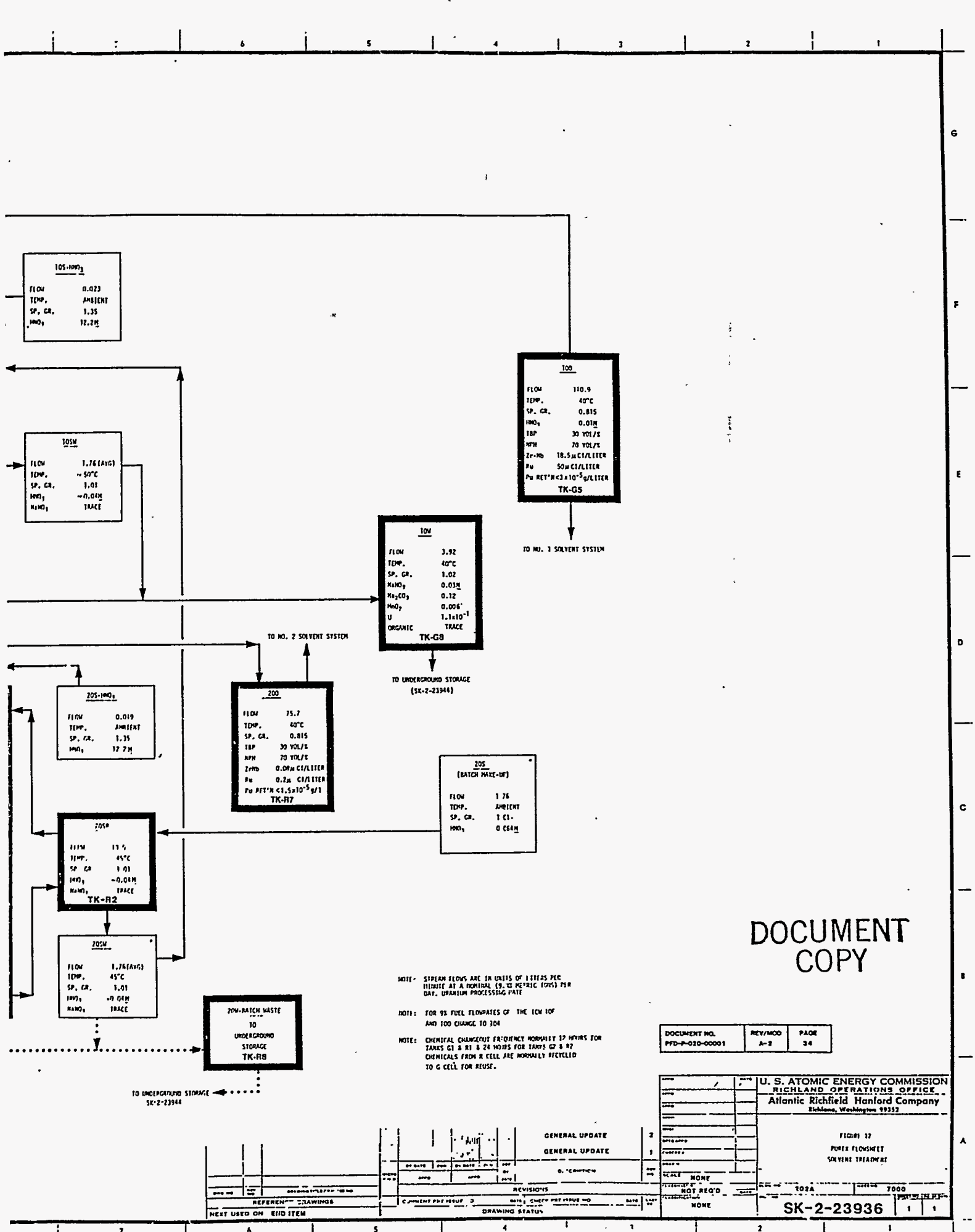
Atlantic Richfield Hanford Company
Richland, Washington 99352
FIGURE 16
PUREX FLOWSHEET -12% PLUTONIUM 240
WASTE CONCENTRATION & ACID RECOVERY
GENERAL UPDATE 2
GENERAL UPDATE
DESCRIPTION
REVISIONS
DRAWING STATUS
REFERENCE DRAWINGS
NEXT USED ON END ITEM
SCALE NONE
NOT REQ'D
NONE
202A
SK-2-23935

Question 20


IWF-H_2O
FLOW 70.28
TEMP. AMBIENT
SP. GR. 1.0
IWF-SUGAR
FLOW 0.354
TEMP. AMBIENT
SP. GR. 1.09
SUGAR 0.7 M
NaOH 0.005
HAW
FLOW 39.88
TEMP. 50°C
SP. GR. 1.09
U 3.43×10^{-3}
HNO_3 2.98
Al 0.073
F^- 0.007
Pu 4.77×10^{-5}
Np 5.04×10^{-3} AVG
FROM HA COLUMN (SK-2-23932)
IWD-AAF
FLOW 110.65
TEMP. ~112°C
SP. GR. (VAPOR)
HNO_3 1.1 M
AAR
FLOW 32.6
TEMP. ~50°C
SP. GR. ~1.0
CONDENSER E-F5
ACID ABSORBER T-F5
AAN TO T-F5
FLOW 0.30
TEMP. AMBIENT
SP. GR. 1.26
AAN 1.6 M
DEMISTER H_2O UPPER
FLOW
DEMIN. H_2O
DEMISTER H_2O LOWER
FLOW 3.8
DEMIN. H_2O
NOT NORMALLY USED
IWW ACID WASTES CONCENTRATOR E-F6
IWW
FLOW
TEMP. 50°C
SP. GR. 1.24
U 3.2×10^{-2}
Pu 4.4×10^{-5}
HNO_3 2.9 M
Al 0.78
F^- 0.07
Np 0.047 AVG
TK-F26
DENITRATION SUGAR
FLOW 0.921
TEMP. AMBIENT
SP. GR. 1.09
SUGAR 0.7 M
NaOH 0.005
BATCH WISE
ANTI FOAM B
FLOW 4.5×10^{-4}
TEMP AMBIENT
SPGR
IWF
FLOW 110.51
TEMP. AMBIENT
SP. GR. 1.04
HNO_3 1.14 M
Pu,U TRACE
TK-F7



DOCUMENT COPY

NOTE: STREAM FLOWS ARE IN UNITS OF LITERS PER MINUTE AT A NOMINAL (9.10 METRIC TONS) PER DAY, URANIUM PROCESSING RATE

NOTE: FOR 9% FUEL FLOWRATES OF THE 10W AND 10D CHANGE TO 10H

NOTE: CHEMICAL CHANGEOUT FREQUENCY NORMALLY 12 HOURS FOR TANKS G1 & R1 & 24 HOURS FOR TANKS G2 & R2 CHEMICALS FROM R CELL ARE NORMALLY RECYCLED TO G CELL FOR REUSE.

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U. S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE
Atlantic Richfield Hanford Company
Richland, Washington 99352

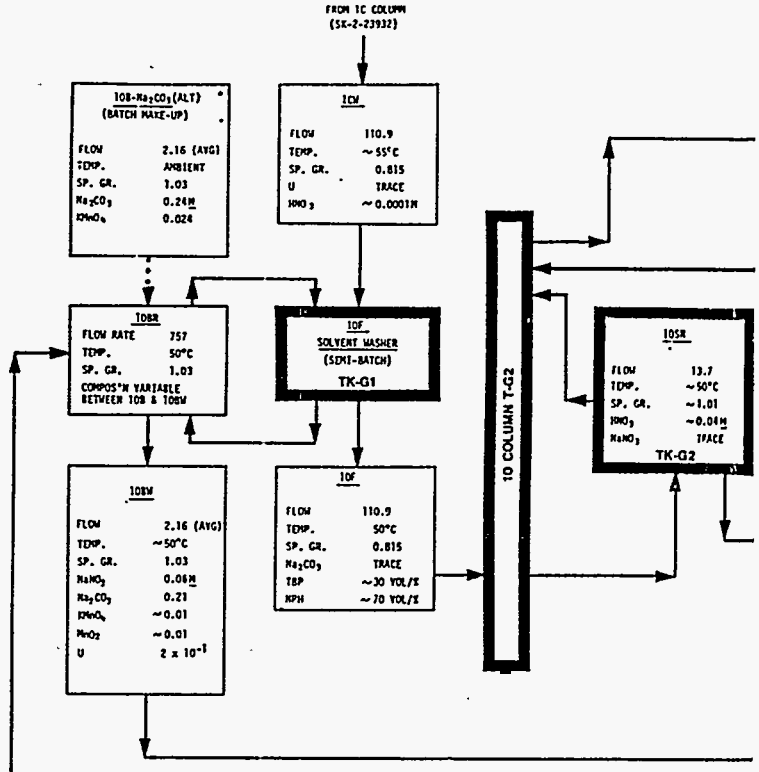
FIGURE 12
PUREX FLOWSHEET
SOLVENT TREATMENT

SCALE	NONE
NOT REQ'D	102A
NONE	SK-2-23936

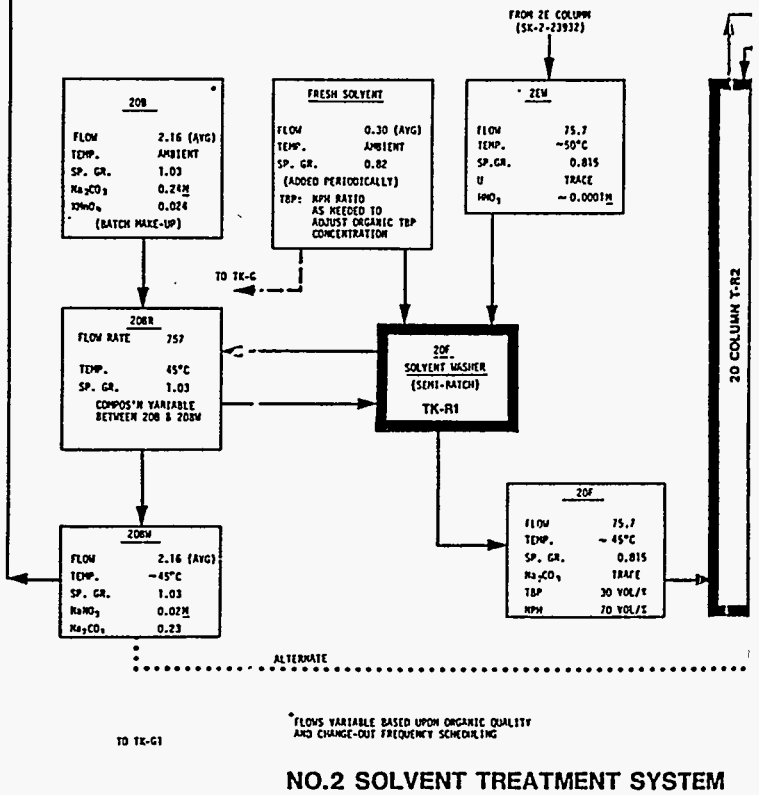
GENERAL UPDATE 2
GENERAL UPDATE 1

REVISIONS
REFERENCE DRAWINGS
NEXT USED ON E/D ITEM
DRAWING STATUS

Question 10



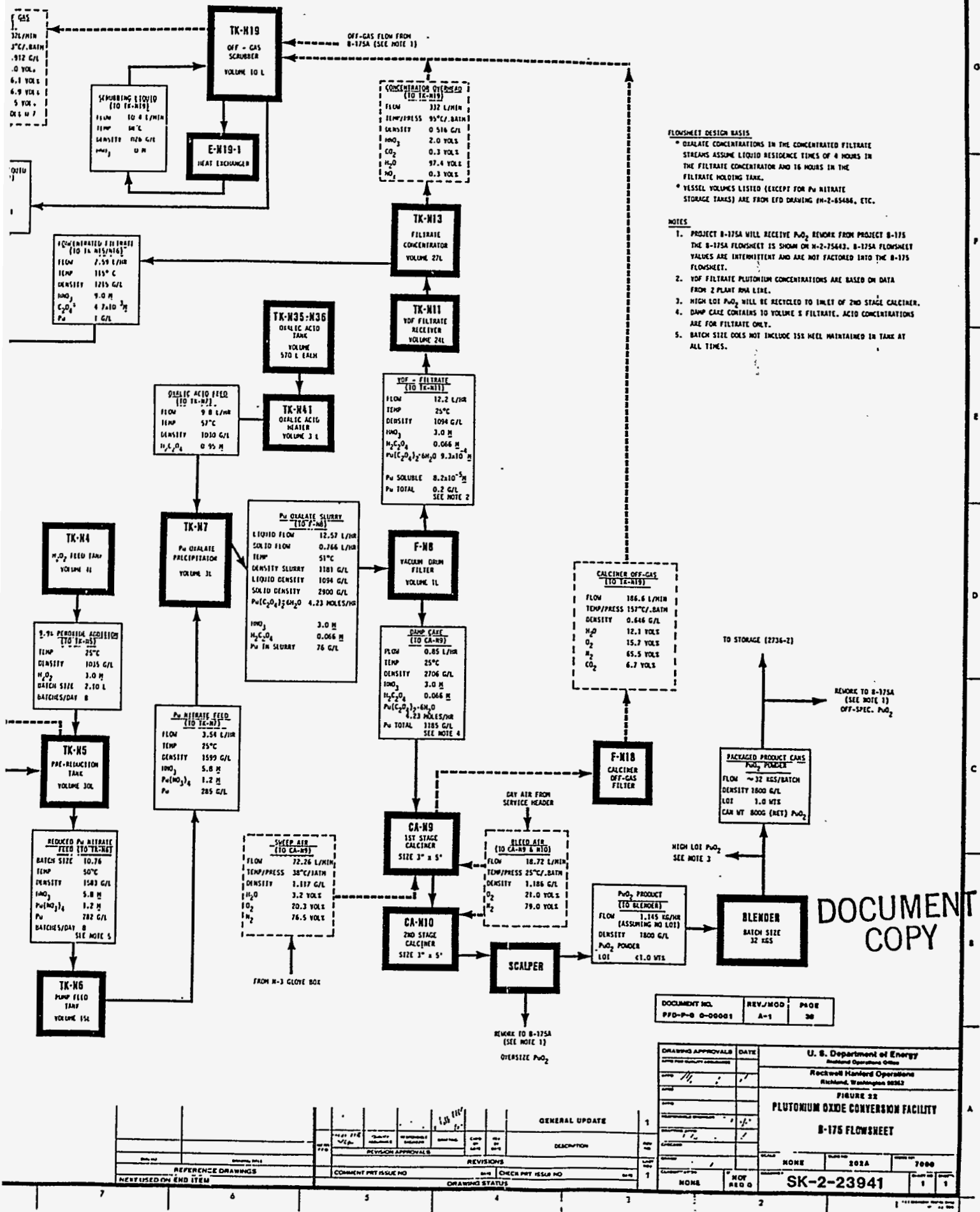
NO.1 SOLVENT TREATMENT SYSTEM



*FLOWS VARIABLE BASED UPON ORGANIC QUALITY AND CHANGE-OUT FREQUENCY SCHEDULING

NO.2 SOLVENT TREATMENT SYSTEM

NOTE: FRESH SOLVENT IS ADDED AS NEEDED TO ADJUST VOLUME & TBP CONCENTRATION



FLOWSHEET DESIGN BASIS

- OXALATE CONCENTRATIONS IN THE CONCENTRATED FILTRATE STREAMS ASSUME LIQUID RESIDENCE TIMES OF 4 HOURS IN THE FILTRATE CONCENTRATOR AND 16 HOURS IN THE FILTRATE HOLDING TANK.
- VESSEL VOLUMES LISTED (EXCEPT FOR Pu NITRATE STORAGE TANKS) ARE FROM EFD DRAWING H-2-65486, ETC.

NOTES

1. PROJECT B-175A WILL RECEIVE PuO_2 REWORK FROM PROJECT B-175 THE B-175A FLOWSHEET IS SHOWN ON H-2-75443. B-175A FLOWSHEET VALUES ARE INTERMITTENT AND ARE NOT FACTORED INTO THE B-175 FLOWSHEET.
2. VOF FILTRATE PLUTONIUM CONCENTRATIONS ARE BASED ON DATA FROM 2 PLANT RUN LINE.
3. HIGH LOI PuO_2 WILL BE RECYCLED TO INLET OF 2ND STAGE CALCINER.
4. DAMP CAKE CONTAINS 10 VOLUME % FILTRATE. ACID CONCENTRATIONS ARE FOR FILTRATE ONLY.
5. BATCH SIZE DOES NOT INCLUDE 15% HEEL MAINTAINED IN TANK AT ALL TIMES.

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DRAWING APPROVALS	DATE

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Richland Operations Office
Rockwell Hanford Operations
Richland, Washington 99352

FIGURE 22
PLUTONIUM OXIDE CONVERSION FACILITY
B-175 FLOWSHEET

SCALE	SIZE	DRAWING NO.
NONE	202A	7000

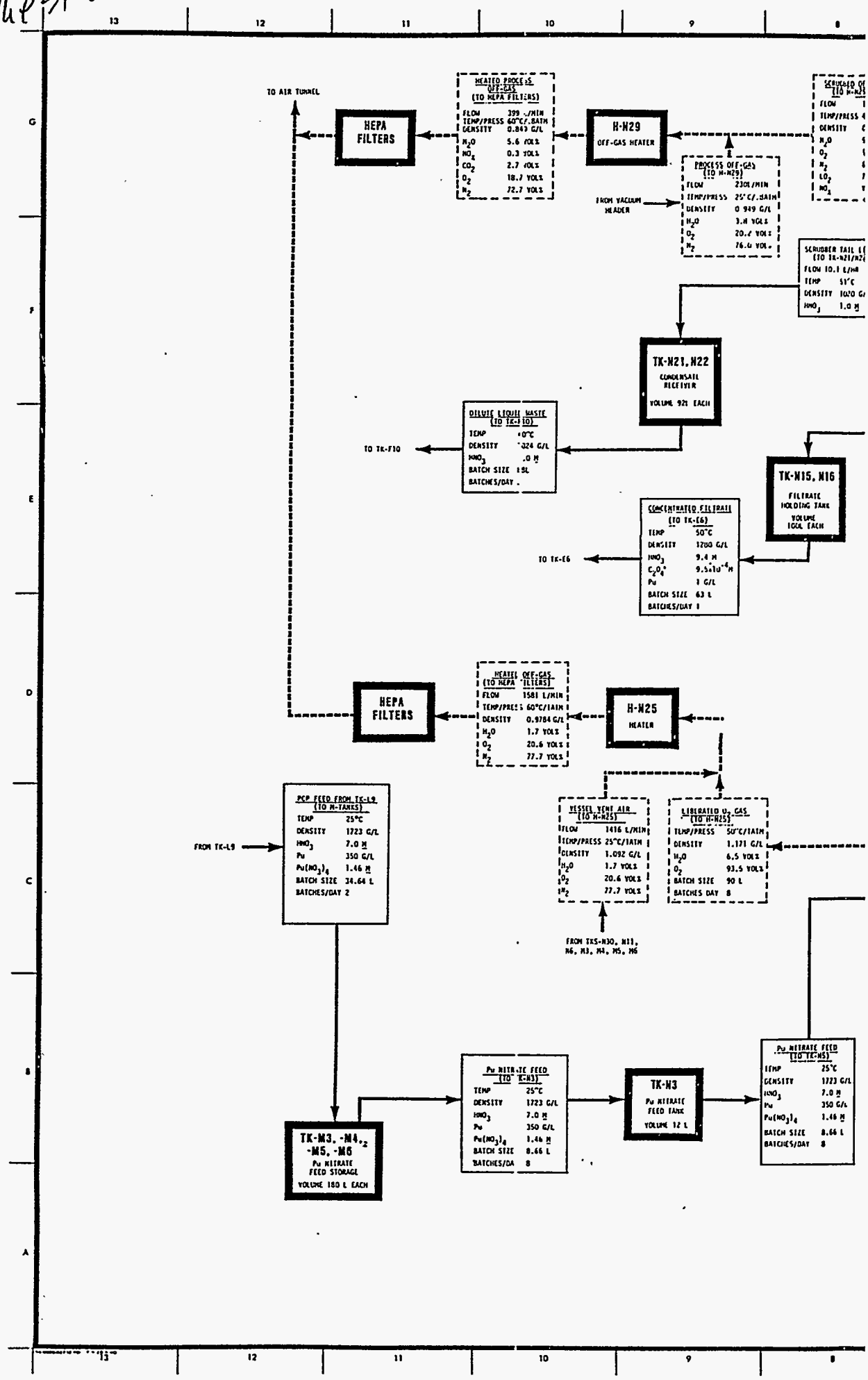
SK-2-23941

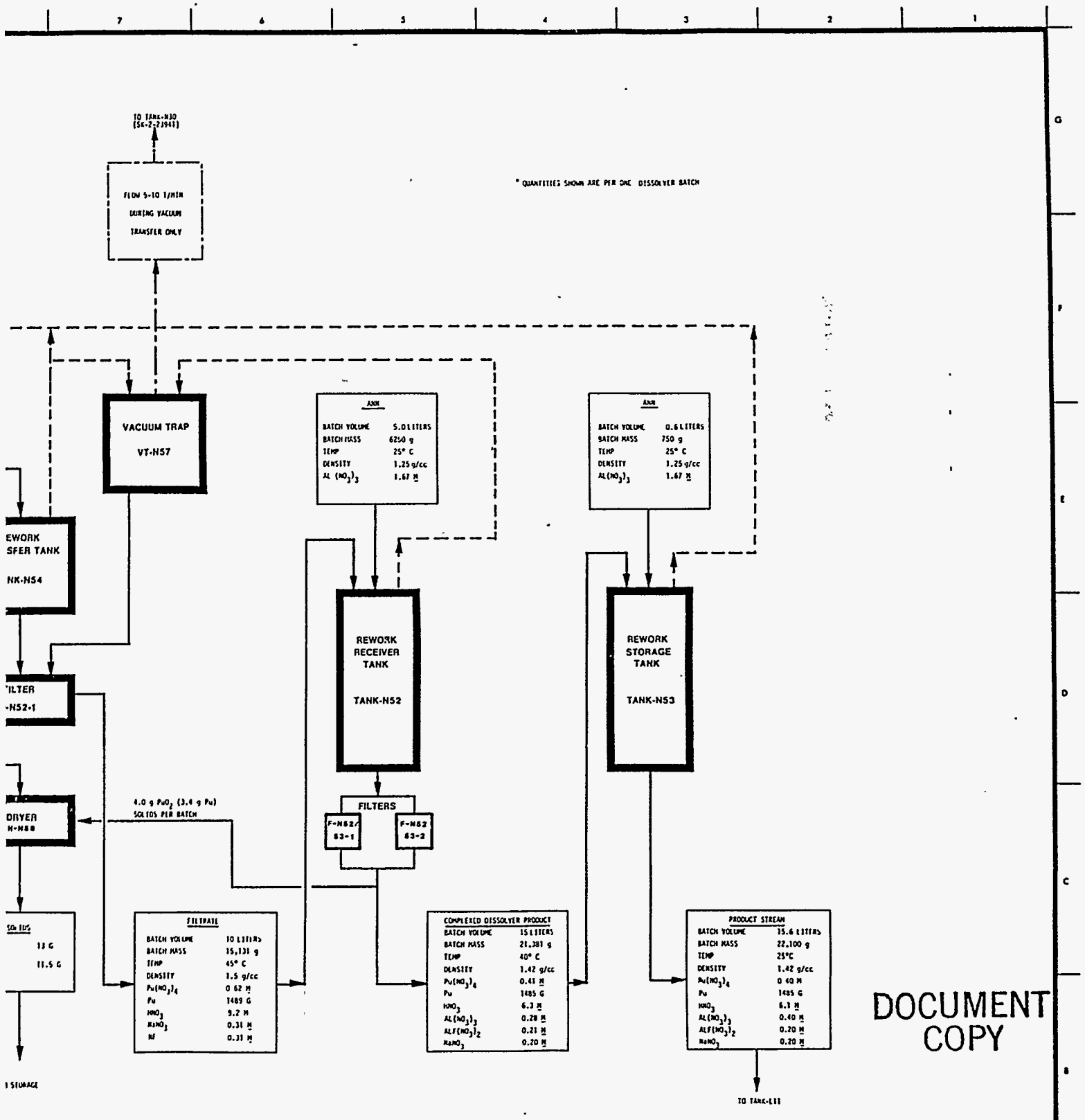
REVISION APPROVALS	REVISIONS		
	GENERAL UPDATE	1	
	DESCRIPTION	REV NO	

REFERENCE DRAWINGS
NEXT USED ON END ITEM
COMMENT PRT ISSUE NO
CHECK PRT ISSUE NO
DRAWING STATUS: 1

NONE | NOT REQ'D

Question 20


TO AIR TUNNEL
HEPA FILTERS
HEATED PROCESS OFF-GAS (TO HEPA FILTERS)
FLOW 399 L/MIN
TEMP/PRESS 60°C/.8ATM
DENSITY 0.849 G/L
H_2O 5.6 VOL%
NO_x 0.3 VOL%
CO_2 2.7 VOL%
O_2 18.7 VOL%
N_2 72.7 VOL%
H-N29
OFF-GAS HEATER
PROCESS OFF-GAS (TO H-N29)
FLOW 230L/MIN
TEMP/PRESS 25°C/.8ATM
DENSITY 0.949 G/L
H_2O 3.8 VOL%
O_2 20.4 VOL%
N_2 76.0 VOL%
FROM VACUUM HEADER
SCRUBBER TAIL (TO TK-N21/N22)
FLOW 10.1 L/HR
TEMP 51°C
DENSITY 1020 G/L
HNO_3 1.0 M
TK-N21, N22
CONDENSATE RECEIVER
VOLUME 92L EACH
DILUTE LIQUID WASTE (TO TK-F10)
TEMP 40°C
DENSITY 1024 G/L
HNO_3 .0 M
BATCH SIZE 15L
BATCHES/DAY
TO TK-F10
TK-N15, N16
FILTRATE HOLDING TANK
VOLUME 100L EACH
CONCENTRATED FILTRATE (TO TK-E6)
TEMP 50°C
DENSITY 1200 G/L
HNO_3 9.4 M
$C_2O_4^{=}$ 9.5×10^{-4} M
Pu 1 G/L
BATCH SIZE 63 L
BATCHES/DAY 1
TO TK-E6
HEPA FILTERS
HEATED OFF-GAS (TO HEPA FILTERS)
FLOW 1581 L/MIN
TEMP/PRESS 60°C/1ATM
DENSITY 0.9784 G/L
H_2O 1.7 VOL%
O_2 20.6 VOL%
N_2 77.7 VOL%
H-N25
HEATER
PCP FEED FROM TK-L9 (TO M-TANKS)
TEMP 25°C
DENSITY 1723 G/L
HNO_3 7.0 M
Pu 350 G/L
$Pu(NO_3)_4$ 1.46 M
BATCH SIZE 34.64 L
BATCHES/DAY 2
FROM TK-L9
VESSEL VENT AIR (TO H-N25)
FLOW 1416 L/MIN
TEMP/PRESS 25°C/1ATM
DENSITY 1.092 G/L
H_2O 1.7 VOL%
O_2 20.6 VOL%
N_2 77.7 VOL%
LIBERATED O_2 GAS (TO H-N25)
TEMP/PRESS 50°C/1ATM
DENSITY 1.171 G/L
H_2O 6.5 VOL%
O_2 93.5 VOL%
BATCH SIZE 90 L
BATCHES DAY 8
FROM TKS-N30, N11, N6, N3, N4, N5, N6
TK-M3, -M4, -M5, -M6
Pu NITRATE FEED STORAGE
VOLUME 180 L EACH
Pu NITRATE FEED (TO TK-N3)
TEMP 25°C
DENSITY 1723 G/L
HNO_3 7.0 M
Pu 350 G/L
$Pu(NO_3)_4$ 1.46 M
BATCH SIZE 8.66 L
BATCHES/DA 8
TK-N3
Pu NITRATE FEED TANK
VOLUME 12 L
Pu NITRATE FEED (TO TK-N5)
TEMP 25°C
DENSITY 1723 G/L
HNO_3 7.0 M
Pu 350 G/L
$Pu(NO_3)_4$ 1.46 M
BATCH SIZE 8.66 L
BATCHES/DAY 8



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DOCUMENT No.	REV/MOD	PAGE
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DRAWING APPROVALS	DATE
	/ /
	7/1

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Richland Operations Office
Rockwell Hanford Operations
Richland, Washington 99352

FIGURE 23
PUREX FLOWSHEET
PLUTONIUM OXIDE REMOVE

SCALE	DWG NO	REV NO
NONE	202A	7600

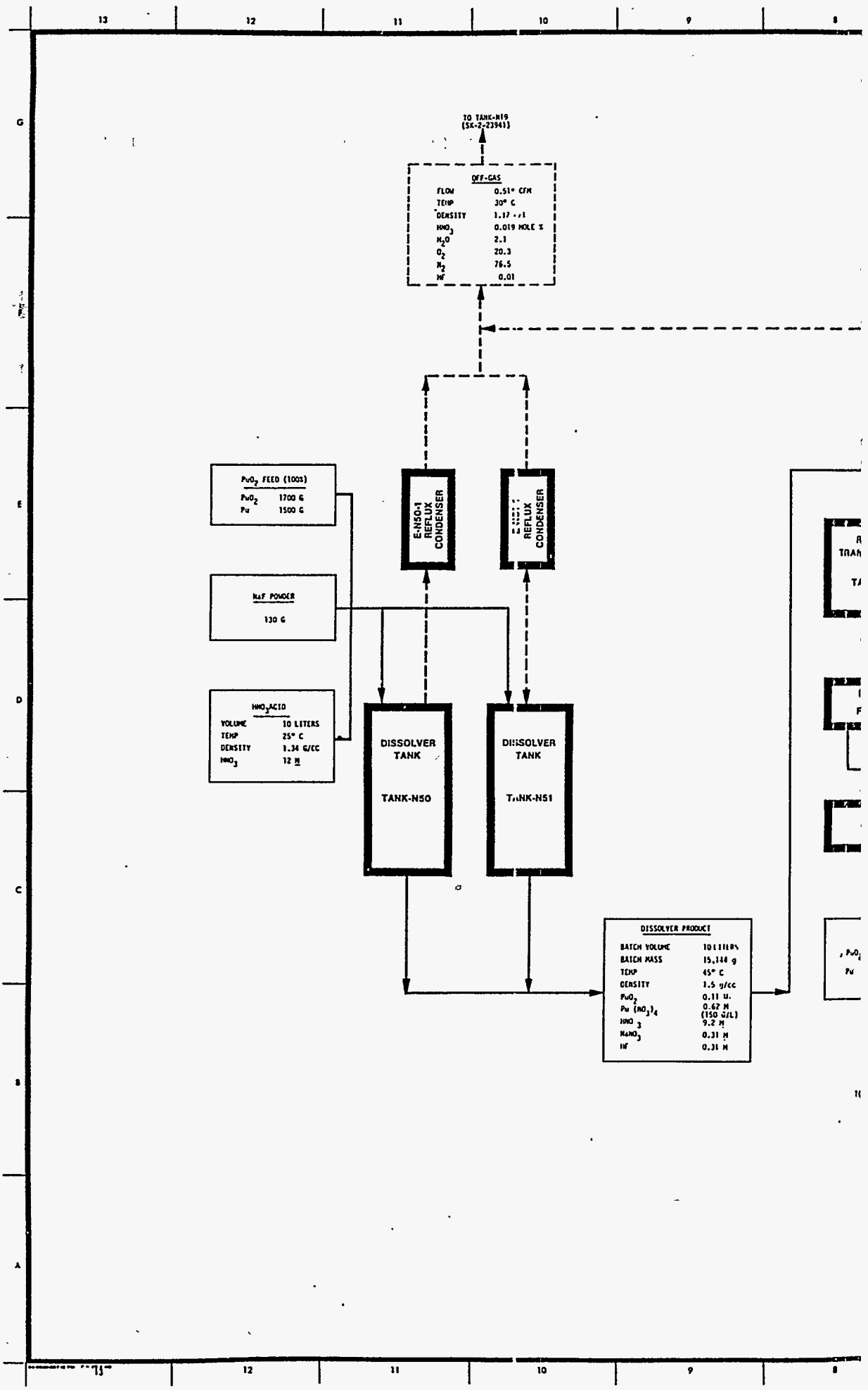
SK-2-23942 | 1

REVISIONS						
REVISION APPROVALS					DESCRIPTION	
					GENERAL UPDATE	1
COMMENT PRT ISSUE NO		CHECK PRT ISSUE NO			DRAWING STATUS	1

REFERENCE DRAWINGS	
NEXT USED ON END ITEM	

CONFIGURATION	QUALITY ASSURANCE
NONE	NOT REQ'D

Question 20


TO TANK-N19
(SK-2-23941)
OFF-GAS
FLOW 0.51* CFM
TEMP 30° C
DENSITY 1.17 g/l
HNO_3 0.019 MOLE %
H_2O 2.1
O_2 20.3
N_2 76.5
HF 0.01
PuO_2 FEED (100s)
PuO_2 1700 G
Pu 1500 G
NaF POWDER
130 G
HNO_3 ACID
VOLUME 10 LITERS
TEMP 25° C
DENSITY 1.34 G/CC
HNO_3 12 M
E-N50-1 REFLUX CONDENSER
REFLUX CONDENSER
DISSOLVER TANK
TANK-N50
DISSOLVER TANK
TANK-N51
DISSOLVER PRODUCT
BATCH VOLUME 10 LITERS
BATCH MASS 15,148 g
TEMP 45° C
DENSITY 1.5 g/cc
PuO_2 0.11 M
$Pu(NO_3)_4$ 0.62 M (150 G/L)
HNO_3 9.2 M
$NaNO_3$ 0.31 M
HF 0.31 M

21.	Other nuclear material in the facility and its location, if any	Drawing(s) attached under Ref. Nos. None (Np(stored in TK-J2 until processed or disposed of in some other manner such as sending to tank farm storage) See Question 14 for description of possible neptunium processing and related flow information.

22. Schematic flow sheet for nuclear material (identifying sampling points, flow and inventory measurement points, accountability areas, inventory locations, etc.)	Diagram(s) attached under Ref. Nos. from sample schedule. Inventory sample points determined by PO-020-019 and Nuclear Accountability procedures from WHC-CM-5-9. Description of sample points is contained in answer for question 14. Further sampling point data can be obtained from the PUREX Sample Schedule, FSS-P-080-00002. Flow: D2 Declad waste (rinse) E5 Cladding waste D5 Input Accountability Oxide to loadout (blender/can weight) Nitrate to loadout (M tanks/weighed cans) K6 Uranium Product F16 & F18 High level waste U3 & U4 lab waste R8 & G8 solvent cleaning waste Solid waste

Question 22

PLANT OPERATING PROCEDURE	PUREX Operation GENERAL System

SHUT DOWN SOLVENT EXTRACTION FOR INVENTORY

I. SYSTEM DESCRIPTION

This procedure provides instructions for shutting down the solvent extraction (SX) process for performing an accountability inventory. The PUREX solvent extraction process involves the separation of uranium, plutonium, and neptunium from radioactive fission products and nonradioactive chemical contaminants, as well as from each other. These separations are accomplished by controlling the relative solubilities of the various solutes in the organic solvent. Uranium, plutonium (+4) and neptunium are readily extracted by TBP from aqueous solutions rich in nitrate ion. Some fission products are also partially extracted by TBP, but to a much lesser extent than uranium, plutonium and neptunium. Thus, a high degree of separation may be obtained between fission products and the useful products.

The solvent extraction process must periodically be shut down for inventory. To do this, the Co-decontamination and Partition Cycle, the Second Uranium Cycle, the Second Plutonium Cycle and the Third Plutonium Cycle must be shut down. After shutdown, the tanks are sampled for accountability and the procedure PUREX PLANT NUCLEAR MATERIALS INVENTORY, PO-020-018, is performed at this time.

Included in this procedure are the directions for shutdown and preparation of the solvent extraction process along with the sampling requirements and record of shutdown activities.

Changes to this procedure, including PCAs require NMSD approval. NMSD

Question 22

I. SYSTEM DESCRIPTION (Cont.)

Equipment involved:

Feed Makeup Tank	(TK-E6)
HA Feed Tank	(TK-H1)
HA Column	(T-H2)
UNH Storage Tank	(TK-P2)
UNH Sampler Tank	(TK-K6)
2OF Rework Receiving Tank	(TK-K1)
1CU Concentrator	(E-J8-1)
2EU Concentrator	(E-K4-1)
2UC Receiver Tank	(TK-K5)
2E Column	(T-K3)
Plutonium Stripper	(T-L6)
Concentrator	(L7)
3WB Waste Concentrator	(E-H4-1)
3WB Waste Tank	(TK-J1)
3WF Decanter Tank	(TK-F10)
1W Tank	(TK-F7)
Organic Recovery Tank	(TK-F13).

II. PRESTART CONDITION

Head End operations has been shut down and vessels flushed per PO-230-110.

III. SAFETY

Do not transfer material between MBAs until plant is released for restart or permission is granted by Safeguards Department.

Criticality - Verify that the transfer of solution from TK-J1 to TK-F10 will not exceed Pu mass limits in TK-F10, E-H4, or TK- J1. If necessary, sample TK-J1 contents before transferring solution to TK-F10.

Pu mass limits:

TK-F10	15,000 g
E-H4	6,870 g
TK-J1	12,400 g.

Applicable Safety Documents - Provisions of Radiation Work Requirements and Permits Manual, WHC-CM-4-15, and Radiation Protection Manual, WHC-CM-4-10 apply to all work performed under this procedure. Observe all Master and PUREX Safety Rules.

Relevant Operational Safety Requirements are given in WHC-CM-5-24, Add I.

Question 22

IV. TOOLS AND SUPPLIES

PO-020-018, PUREX PLANT NUCLEAR MATERIALS INVENTORY
PO-080-032, SAMPLE WITH TYPE A SAMPLER
PO-080-034, SAMPLE WITH TYPE B SAMPLER
PO-080-035, SAMPLE WITH TYPE B SAMPLER, MODIFIED
PO-080-038, SAMPLE WITH TYPE C SAMPLER
PO-080-150, SAMPLE TK-L9 CONTENTS
PO-080-156, SAMPLE TK-L11
PO-080-190, RECIRCULATE AND SAMPLE UNH AND RECOVERED HNO_3
PO-230-019, PREPARE AND HANDLE FEED
PO-230-110, PERFORM HEAD END OPERATIONS FLUSH
PO-320-011, CHECK ORGANIC IN TK-F10
PO-320-030, SHUT DOWN F CELL
PO-330-004, PERFORM LONG-TERM SHUTDOWN OF G CELL
PO-330-014, PERFORM LONG-TERM SHUTDOWN OF R CELL
PO-340-003, OPERATE DECONTAMINATION CYCLE
PO-340-005, PERFORM LONG-TERM SHUTDOWN OF DECONTAMINATION CYCLE
PO-340-020, OPERATE E-H4 CONCENTRATOR
PO-350-005, PERFORM PARTITION CYCLE LONG-TERM SHUTDOWN
PO-350-200, OPERATE E-J8-1 CONCENTRATOR
PO-360-005, SHUT DOWN SECOND URANIUM CYCLE: LONG-TERM
PO-360-006, TRANSFER TK-K5 AND TK-K6 CONTENTS
PO-360-090, PERFORM AQUEOUS FLUSH OF T-K2 AND T-K3
PO-370-005, PERFORM LONG-TERM SHUTDOWN OF SECOND PLUTONIUM CYCLE
PO-370-013, SHUT DOWN THIRD PLUTONIUM CYCLE - SHORT- AND LONG-TERM
PO-370-025, EMPTY T-L6 AND E-L7
PO-600-120, OPERATE EFFLUENT DIVERSION SYSTEM

V. TABLE OF CONTENTS

Question 22

VI. PROCEDURE

DATE:_____ OPERATOR

A. SHUT DOWN SOLVENT EXTRACTION

1. If the HAF stream is shut down due to operating problems and with supervision direction, proceed to Step 7.

2. If supervision requests, make up cold feed in TK-E6.

   a. Transfer amount of cold feed as determined by supervision from TK-P1, TK-P2, TK-P3 or TK-P4 (tank to be determined by supervision) to TK-E6 per PO-230-019.

   b. Add amount of acid specified by supervision to TK-E6 per PO-230-019. _____

3. Request supervision to have HAF cutoff on TK-H1 bypassed. _____

4. Operate HA column per PO-340-003 until TK-H1 level is less than 5 divisions as indicated on WFR-H1. _____

5. Transfer an additional 15-20 chart divisions, as indicated on WFR-H1, from TK-E6 to TK-H1 per PO-230-019. _____

6. Repeat Steps 2-5 until TK-E6 is empty. _____

7. When TK-H1 level is at 5 chart divisions or less and TK-E6 is empty, shut down the co-decontamination cycle per PO-340-005. _____

8. Request supervision to remove HAF cutoff bypass. _____

9. Perform long-term shutdown of F Cell per PO-320-030. _____

10. Transfer amount of UNH specified by supervision from P Tank or TK-K6 to TK-E6.

    a. Transfer UNH from P Tank or TK-K6 per PO-230-019.

    b. Add 3-4 divisions (per 4000 gal UNH) of HNO_3 to TK-E6 per PO-230-019.

    c. If requested, add additional acid as specified by supervision per PO-230-019. _____

11. Shut down Partition Cycle per PO-350-005. _____

Question 22

A. SHUT DOWN SOLVENT EXTRACTION (Cont.)

DATE:_____ OPERATOR

12. Shut down K Cell per PO-360-005. _____

NOTE - TK-P2 level should be kept above 5 ft.

13. Transfer all uranium containing solutions in K Cell meeting product specification to P Tanks per PO-360-006. _____

14. Jet concentrator E-K4 contents to TK-K5.

    a. Ensure that TK-K5 can hold at least 4000 gal.

    b. When E-K4 temperature reaches 50-60 °C on TR-K4-1 (TI-K4-1 on MCS), turn E-K4 to TK-K5 jet controller JC-K4 on.

    c. When TK-K5 WF levels out on WFR-K5 (WI-K5 on MCS), turn JC-K4 off. _____

15. Perform acid flush of E-K4.

    a. Make up dilute HNO_3 flush solution per PO-360-090.

    b. Open valve K99-05 to add dilute HNO_3 flush solution until T-K3 static indicator has risen approximately 10 divisions (35 in.) then close valve.

    c. Jet contents of T-K3 to E-K4 using jet controller JC-K3-1 or JC-K3-2.

    d. Jet E-K4 contents to TK-K5 per Step 14.

    e. Jet TK-K5 contents to TK-K6 using jet controller JC-K5-2. _____

16. Shut down Second Pu Cycle per PO-370-005. _____

17. Shut down Third Pu Cycle per PO-370-013. _____

18. Empty out T-L6 and E-L7-1 per PO-370-025. _____

19. Shut down G and R Cells per PO-330-014 and PO-330-004. _____

Question 22

A. SHUT DOWN SOLVENT EXTRACTION (Cont.)

DATE:_____ OPERATOR

CAUTION

Do not ship organic in TK-F10 to E-H4.

NOTE - E-H4 cannot be sampled and should be empty before inventory is started.

20. Empty out E-H4 and TK-F10.

    a. Process TK-F10 contents through E-H4 per PO-340-020.

    b. As necessary, jet TK-J1 contents to TK-F10 using JC-J1-3.

    c. When TK-F10 specific gravity breaks, indicating organic, stop transfer.

    d. Shut down E-H4 per PO-340-020.

    e. After E-H4 shutdown is complete, jet the E-H4 bottoms to TK-J1 using controller JC-H4. _____

NOTE - When TK-J1 becomes full, it may be necessary to jet TK-J1 contents to TK-F10. This transfer requires supervision approval.

21. As necessary, jet TK-J1 contents to TK-F10.

CRITICALITY

VERIFY THAT THE TRANSFER OF SOLUTION FROM TK-J1 TO TK-F10 WILL NOT EXCEED Pu MASS LIMITS IN TK-F10, E-H4, OR TK-J1. IF NECESSARY, SAMPLE TK-J1 CONTENTS BEFORE TRANSFERRING SOLUTION TO TK-F10.

Pu MASS LIMITS:

- **TK-F10 15,000 g**
- **E-H4 6,870 g**
- **TK-J1 12,400 g.**

    a. Transfer TK-J1 contents to TK-F10 using JC-J1-3.

    b. When volume specified by supervision has been transferred, stop transfer using JC-J1-3. _____

Question 22

A. SHUT DOWN SOLVENT EXTRACTION (Cont.)

DATE:_____ OPERATOR

22. After condensate is no longer being routed from E-H4 to E-J8, shut down 1CU concentrator per PO-350-200. _____

23. After E-J8 is shut down and cooled, flush it.

a. Jet E-J8-1 contents to TK-K1 using jet controller JC-J8-1.

b. Add 200 gal of demineralized water to E-J8-1 by opening valve J-20-2.

c. Jet E-J8-1 contents to TK-K1 using jet controller JC-J8-1.

d. Repeat Steps b and c to flush with a second 200 gal of demineralized water. _____

24. Transfer TK-F10 and TK-F7 organic to TK-F13 per PO-320-011 and appropriate canyon change order routing._____

B. PERFORM ACCOUNTABILITY INVENTORY

DATE:_____ OPERATOR

NOTE - Material must not be transferred between MBAs until plant is released for restart or permission is granted by Safeguards Department.

- Procedure PO-020-018 will be done in conjunction with this task.

1. Request SNM specialists perform the following before sampling.

NOTE - Safeguards may witness this step.

a. Request supervision to contact Safeguards Department for witnessing sampling.

b. Record the WF, SpG, and temperature of every tank in the 202-A MBA as directed by supervision.

c. Apply inventory tags to WF/SpG instruments. _____

B. PERFORM ACCOUNTABILITY INVENTORY (Cont.)

DATE:_____ OPERATOR

2. Perform tank sampling.

NOTE - Safeguards will invite DOE to witness all samples.

- All samples must be taken in duplicate for accountability.

a. Agitate or recirculate tanks for 20-30 min or as specified in each sampling procedure.

b. Recirculate samplers for 20-30 min or as specified in each sampling procedure.

NOTE - P tanks must be recirculated for 24 hr before sampling if included in solvent extraction MBA.

c. Sample following tanks per appropriate procedure:

TANK	PROCEDURE
TK-E6	PO-080-032
TK-G5	PO-080-035
TK-F10	PO-080-035
TK-J1	PO-080-035
TK-U1	PO-080-038
TK-U2	PO-080-038
TK-R7	PO-080-038
TK-L9	PO-080-150
TK-P1/P2/ P3/P4/P5	PO-080-190

_____

B. PERFORM ACCOUNTABILITY INVENTORY (Cont.)

DATE:_____ OPERATOR

2. d. If there is indication on the WF indicator, sample the following tanks per appropriate procedure:

TANK	PROCEDURE
TK-F8	PO-080-032
TK-F15	PO-080-032
TK-F18	PO-080-032
TK-F13	PO-080-032
TK-F16	PO-080-032
TK-J3	PO-080-034
TK-J5	PO-080-034
TK-G8	PO-080-034
TK-L3	PO-080-034
TK-G7	PO-080-034
TK-K1	PO-080-035
TK-F3	PO-080-035
TK-K6	PO-080-038
TK-R5	PO-080-038
TK-R8	PO-080-038
TK-L11	PO-080-156

_____

e. Sample any other additional tanks as specified by supervision. List Tanks sampled below: _____

_____

_____

_____

WESTINGHOUSE HANFORD COMPANY	Manual _ Section Page	WHC-CM-5-9 4.7, REV 1* 1 of 8
$PUREX/UO_3$ PLANT ADMINISTRATION	Effective Date Organization	June 30, 1992 OPS/PUREX

TITLE:

PUREX NUCLEAR MATERIAL CONTROL

Approved by

J. C. Midgett, Manager
$PUREX/UO_3$ Plant

1.0 PURPOSE

This procedure establishes the methods and responsibilities for control of the movement of nuclear materials at the PUREX Plant in accordance with Department of Energy (DOE) order 5633.3.

2.0 SCOPE

This procedure applies to the PUREX Plant.

3.0 DEFINITIONS

Dedicated MBA Staff. Personnel who assist MBA Custodians by documenting the inventory, transfer or movement of Nuclear Material. Controls and issues tamper indicating devices and/or source data forms to Custodians.

Dissolution Process (DP) MBA 201. The processing equipment in the DP MBA which chemically removes the jackets from the irradiated fuel and prepares a metal (uranium/plutonium/fission product) solution for solvent extraction. The fuel elements, contained in canisters, are removed from the cask cars in FS-IA, carried by crane and dumped into the dissolvers (DP MBA). The fuel is received into the DP MBA at the shipper's stated value.

Material Balance Area (MBA). A physically defined location(s) wherein processing or laboratory work occurs. Materials are controlled as measured quantities and are accounted on a bulk quantity or discrete item basis.

Pu Conversion (PuC) MBA 203. The area where the Pu nitrate from the 202 MBA is converted to Pu oxide. The Pu oxide is carefully canned, sealed, and finally packaged in 6M shipping containers. The process wastes from this MBA are returned to the 202 MBA for rework or recycle.

*This is a complete rewrite, therefore, no revision bars are used to indicate changes.

PUREX Perpetual Inventory. A continuous accounting record of the quantities of NM transferred into and out of the PUREX complex and between the MBAs within the PUREX complex. Deliveries of NM to the PUREX Plant are debited to the PUREX Plant account and credited to the MBA receiving the shipment. Shipment of NM from the PUREX Plant are credited from the PUREX Plant accounted and debited from the MBA releasing the shipment. Transfers within the PUREX complex are debited to the releasing MBA. The accounting record will be maintained in such a way that the total throughput of each MBA and the PUREX Plant will be continuously tabulated.

Solvent Extraction (SX) MBA 202. The equipment in the SX MBA chemically decontaminates and partitions the metal solution into fission products, uranium nitrate, Pu nitrate, and Np nitrate. This MBA also includes the Waste Concentration and Treatment Cycle and Acid Recovery Cycle. Through the Waste Concentration and Treatment Cycle, the fission products, laboratory samples, and sump wastes are discharged to Tank Farms. This MBA also receives and stores recovered UO_3 acid and rework Uranyl Nitrate-Hexahydrate (UNH) from the UO_3 Plant.

Tamper-Indicating Device (TID). A Device used to seal and determine that the contents of a package of nuclear material have not been tampered with. Specifically the devices controlled by this procedure are pressure sensitive and cup-wire seals.

UNH Storage MBA 204. An area for receiving, storage, and shipping UNH from the 202 MBA.

4.0 RESPONSIBILITIES

1. The Custodial Manager appoints custodians and assures the proper control and documentation of Nuclear Material (NM).

2. The MBA primary custodian has overall responsibility for their MBAs and control and documentation of NM to, from, and within their MBA. Specific MBA custodians receive and are responsible for the custody of tamper indicating devices (TIDs).

3. The Primary/Alternate Custodian is responsible for:

   a. Operations and NM holdings and transfers of NM.

   b. Controlling NM source data forms and TIDs when received from dedicated MBA staff.

   c. Assuring correct entries on the plant operating procedure (POP) and laboratory operating (LO) procedure data sheets and source documents.

   d. Witnessing installation and removal of TIDs.

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e. Training employees in the correct method of TID installation and removal and documenting the training.

4. The Dedicated MBA Staff is responsible for:

a. Keeping records for the Primary/Alternate MBA Custodians

b. Transferring data to official source data forms (SDFs) and calculating results.

c. Maintaining, controlling, and issuing TIDs for the MBA Custodian.

d. Transferring data to perpetual inventory book from official SDFs.

5.0 PROCEDURE

Three types of transfers are involved at the PUREX Plant. These transfers are: (1) liquid tank to tank, (2) sample movement, and (3) solid waste disposal. This procedure gives a description of the accountability documentation required for the transfers (corrections to source data forms critical data fields require initials of both shipping and receiving custodians.)

5.1 TANK TO TANK TRANSFERS

NOTE: This section covers transfers through pipelines between tanks in different MBAs or to tanks out of the PUREX complex to the underground storage (UGS). A listing of the transfers is shown in Table 1.

ACTION BY		ACTION
Primary/Alternate Custodian	1.	Complete the board data and sample number on appropriate Plant Operating Procedure (POP) data sheet.
	2.	Record laboratory analysis data onto the POP data sheet. Release form, signed by custodian, to Dedicated MBA Staff.
Dedicated MBA Staff	3.	Complete PUREX/UO_3 NM Liquid Transfer Form (LTF) (BC-6800-062). Record control number of form in logbook. Return completed form to Primary/Alternate Custodian for action and signatures. NOTE: Transfers to underground storage require signature of shipping custodian only.

ACTION BY	ACTION
Dedicated MBA Staff	4. Enter the data into the PUREX Perpetual Inventory.
	5. Send copies of the transfer form to Safeguards Accounting within 48 hours after completion of the documented transaction form.
Primary/Alternate Custodians	6. Review form calculations and data, and sign (SDF) form.

5.2 SAMPLE MOVEMENT

NOTE: A Nuclear Material Item Transfer (NMIT) form (BC-6300-064) must be completed to document the transfer of reportable quantities of Pu (0.5g) and of enriched U (0.5g) between MBAs. The frequency of the completion of the form is determined by the origin and nature of the sample.

5.1 204 MBA and 201 MBA

NOTE: Complete one NMIT form for each MBA.

ACTION BY	ACTION
Dedicated MBA Staff	1. During inventory, compile the sample analysis. Determine the quantity of NM transferred to the PUREX Lab (202 MBA). Complete a NMIT form. Record the control number on the form in the logbook.
	2. Update the PUREX Perpetual Inventory by entering the transfer.
	3. Send copies of the completed NMIT form to Safeguards Accounting within 48 hours of completion of the documented transfer form.
Primary/Alternate Custodians	4. Sign the NMIT form as the shipping MBA custodian.
PUREX Lab	5. Sign the NMIT form as the receiving MBA custodian if from other than 202 MBA.

5.3 RECEIPT OF STANDARDS

ACTION BY	ACTION
PUREX Lab	1. Complete the NMIT form issued by shipper. Send copy to Dedicated MBA Staff.

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ACTION BY	ACTION
Dedicated MBA Staff	2. Update the receiving MBA and PUREX facility accounts of the PUREX Perpetual Inventory for the quantity of NM in the standard.
All other Samples:	
Shipping Custodian/ Dedicated MBA Staff	3. Determine the quantity of NM transferred to and from the PUREX Lab (202 MBA).
	4. Complete a NMIT form. Send records to receiver.
	5. Record the control number for the form in the logbook. Update the Perpetual Inventory by entering the transfer.
	6. Send copies of NMIT form to Safeguards Accounting within 48 hours after completion of the documented transfer form. Update inventory.

5.4 SOLID WASTE DISPOSAL

NOTE: A NMIT form must be completed whenever a waste container suspected of containing Transuranic (TRU) Waste equal to or greater than 0.5 g Pu, (0.05 g. to 0.49 Pu must be reported with an asterisk), crosses MBA boundaries (greater than 0.05 gram for transfers to tank farms.)

ACTION BY	ACTION
Operators and Primary/Alternate Custodians	1. Keep TRU waste for each MBA separate.
Operators	2. Fill waste containers per PO-100-100 or LO-100-224. Store within MBA until ready for Nondestructive Assay (NDA).
Dedicated MBA Staff	3. Release TIDs and Seals Application and Removal Forms (SARF) to Custodians as requested.
	4. Record in logbook the control number of TID seals and NMIT form control number.
Dedicated MBA Staff	5. Complete the NMIT form based upon the information obtained from the NDA and using U/Pu rations for that particular MBA.
	6. Update the PUREX Perpetual Inventory by entering the transfer from the PUREX facility account and the original MBA waste was generated in.

ACTION BY	ACTION
TRU Waste Shipment	7. Complete (NMIT) for TRU Waste Shipment.
Dedicated MBA Staff	8. Sign the completed NMIT form.
	9. Ship the waste per procedure.
Receiver or Dedicated MBA Staff	10. Send copies of the NMIT form to Safeguards Accounting within 48 hours after completion of the documented transfer form.

5.5 SNM DAILY OPERATIONAL PROCEDURES

NOTE: Paragraphh 5.5 of this procedure expressly addresses the actual mechanics of documenting all material movement as well as supporting tasks to maintain control of SNM.

ACTION BY	ACTION
Dedicated MBA Staff	1. Complete Liquid Transfer form for cross-MBA transfers.
	2. Log and complete Nuclear Material Item Transfer Forms for TRU Waste.
	3. Post accountability records in the Perpetual Inventory Book.
Dedicated MBA Staff	4. Control and distribute forms and seals.

6.0 REFERENCES

DOE 5633.3, "Control and Accountability of Nuclear Materials."

LO-100-224, "Disposal of Transuranic and Solid Waste."

PO-100-100, "PUREX Burial and Waste Handling"

WHC-CM-4-34, "Nuclear Material Control and Accountability Manual."

WHC-CM-4-35, "Safeguards Material Control Manual."

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7.0 CONCURRENCES

L. L. Buckley
L. L. Buckley, Manager
Facility and Operational Assurance

6/22/92
Date

A. F. Dale for
T. F. Dale, Manager
PUREX Analytical Laboratory

6-22-92
Date

for B. R. Fitzpatrick
B. R. Fitzpatrick, Manager
Safeguards Material Control

6-23-92
Date

Table 1. Tank Transfer Accountability Points.

Source		Destination		Accountability		
MBA	Tank	MBA	Tank	Tank		Stream
DP Receipts						
SX	U1/U2	DP	A3/B3/C3	P13/P14	*2	Recovered nitric acid
DP Removals						
DP	D5	SX	E8	D5		Metal feed solution
DP	D2	Tank Farms**		D2		Dectad solution
DP	E5	Tank Farms**		E5		Metathesis solution
DP	Sumps	SX	F18	F18	*1	Headend sump solution
SX Receipts						
DP	D5	SX	E8	D5		Metal feed solution
UO3 Plant		SX	P13/P14	P13/P14		Recovered nitric acid
UO3 Plant		SX	P2	X38/C2		Rework UNH
UNH	P1/P3/P4	SX	E8/K1/K8	*3	*4	Rework UNH
PuC	N15/N16	SX	E8/L11	N15/N16	*4	Concentrated filtrate
PuC	N21/N22	SX	F10	N21/N22		Off-Gas condensate
PuC	N53	SX	L11	N53		Scrap recovery
PuC	N30	SX	L9	N30		Vacuum vessel
Np	J2	SX	J21/J22/J23	J2		Rework neptunium
DP	Sumps	SX	F18	F18	*1	Headend sump waste
UNH	Sumps	SX	F18	P5	*5	UNH sump waste
SX Removals						
SX	L9	PuC	M3/M4/M5/M6	L9		Plutonium nitrate
SX	K8	DP	P1/P3/P4	K8		UNH
SX	U1/U2	Tank Farms**	A3/B3/C3	U1/U2	*2	Recovered nitric acid
SX	F15	Tank Farms**		F15		Liquid Waste
SX	F18	Tank Farms**		F18		Liquid Waste
SX	G8	Tank Farms**		G8		Liquid Waste
SX	R8	Tank Farms**		R8		Liquid Waste
SX	U3/U4	Tank Farms**		U3/U4		Liquid Waste
SX	L14	110	PR Cans	PR Scale		Plutonium nitrate
UNH Receipts						
SX	K8	UNH	P1/P3/P4	K8		Product UNH
UO3 Plant	C2/X38	UNH	P6	C2/X38		Rework UNH
UNH Removals						
UNH	P1/P3/P4	UO3 Plant**	C1	C1		Rework UNH
UNH	P6	SX	E8	*3		Rework UNH
UNH	P5	SX	F18	P5		UNH sump
PUC Receipts						
SX	L9	PuC	M3/M4/M5/M6	L9		Plutonium Nitrate
PUC Removals						
PuC	N15/N16	SX	E8/L11	N15/N16	*4	Concentrated filtrate
PuC	N21/N22	SX	F10	N21/N22		Off-Gas condensate
PuC	N53	SX	L11	N53		Scrap recovery
PuC	N30	SX	L11	N30		Vacuum vessel
Np Receipts						
SX	J23	Np	J2	J2		Neptunium Storage
Np Removals						
Np	J2	SX	J21/J22/J23	J2		Rework neptunium

*1 The quantity of plutonium and uranium jetted is determined by the difference in weight factors between additions to F18 with sample results for the transfers.

*2 The quantity of uranium returned to Headend is determined by a specific uranium assay for each batch and an average volume sent the dissolvers.

*3 This is UNH Rework stored in the UNH MBA. The accountability information can be based upon samples taken from K8, K1, E6 or the P Tanks. The sample to be used will be decided upon between PUREX Operations, PUREX Process Control, and PUREX Production Control. Accountability weight factor data must be taken from an accountability tank. Tank K1 is not an accountability tank.

*4 Destination of stream determined by PUREX Process Control.

*5 Sump diverted to F18 only if P5 sample exceeds environmental release standards.

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PUREX/UO_3 PLANT ADMINISTRATION	Effective Date	April 19, 1991
	Organization	OPS/PUREX

TITLE:

PUREX NUCLEAR MATERIALS INVENTORY

Approved by

J. C. Midgett, Manager
PUREX/UO_3 Plants

1.0 PURPOSE

This procedure establishes the methods for conducting formal inventories of special nuclear materials (SNM) at the PUREX plant.

2.0 SCOPE

This procedure applies to all Material Balance Areas (MBA) within the PUREX plant.

3.0 DEFINITIONS

Altered Material Balance Area. A period of plant condition which moves the material balance area (MBA) 203 boundaries to encompass only the N3/N4 dry air hoods.

Inventory.

1. Book Inventory. The quantity of nuclear inventory present at a given time as reflected by accounting records.

2. Physical Inventory. The quantity of nuclear material which is determined to be on hand by physically ascertaining its presence using techniques that include sampling, weighing, and analyses.

NOTE: All types of inventories are to be considered to have equal status.

Item Area. A specific room/vault within a MBA wherein material is stored and controlled by discreet item identities.

Feed Storage. The railroad cut inside the PUREX perimeter fencing, the railroad tunnel, and the fuel storage basin. Nuclear materials in cask cars in transit to PUREX are accounted for as part of the feed storage. Nuclear materials in transit to the 100 areas are accounted for as part of a 100 area MBA.

Material Balance Area 201. The fuel elements contained in canisters are removed from the cask cars in the feed storage area (railroad cut), carried by remote crane into the PUREX canyon, and charged into the dissolvers for dissolution. The processing equipment in the dissolution process chemically removes the zirconium jackets and prepares a metal solution for solvent extraction. The material balance area (MBA) 201 includes dissolvers A3, B3, C3, tanks D1, D2, D3, D4, D5, E1, E3, E5, headend sumps, backup facility and the centrifuges G-E2, G-E4.

Material Balance Area 202. The metal feed from MBA 201, in TK-D5, is transferred into TK-E6, which is in the solvent extraction MBA 202. The equipment in MBA 202 chemically decontaminates and partitions the metal solution into Uranium nitrate, Plutonium nitrate, sensitive actinides, and fission product waste. The MBA 202 includes waste concentration and treatment, acid recovery, solvent recovery systems, backcycle waste, and receives recovered UO3 acid and rework UNH from the UO3 plant. The MBA 202 includes all the tanks located in the Central Control Room (CCR), TK-F18, fractionator, tanks U1, U2, U3, U4, P2, P13, P14, P15, all the CCR sumps, and the PUREX Analytical Laboratory. While the N-Cell area is in a long term shutdown mode and using the altered material balance area, the MBA 202 will include the N-Cell wet hoods (N1A, N1B, N2A, N2B, N2C, N6, N7). The PR room hoods will always remain in MBA 202. The PR corridor, sample gallery and canyon lobby drum storage areas are included in the MBA 202.

Material Balance Area 203. The Plutonium conversion (Oxide Line), converts Plutonium nitrate solution into Plutonium oxide powder. The Plutonium oxide is carefully canned, sealed, and packaged into department of transportation (DOT 6M) shipping containers. The process wastes from MBA 203 are returned/recycled to the MBA 202 for rework. When the altered material balance area is utilized, the MBA 203 includes the N3/N4 hoods only.

Material Balance Area 204. The Uranyl Nitrate Hexahydrate (UNH) storage area. The concentrated UNH product from the final Uranium cycle MBA 202 is batch transferred into the UNH storage, receiving and shipping MBA 204 area. The MBA 202 also transfers out of specification material to MBA 204 for future rework back into MBA 202. The MBA 204 includes tanks P1, P3, P4, P5, P6.

Material Balance Area 208. The material balance area 208 includes the Q-Cell package and Tk-J2.

Nuclear Material Custodians. Custodians responsible for controlling and authorizing the movement of nuclear materials within and across the boundaries of the established MBAs of the PUREX plant. They shall also ensure that individuals performing accountability actions are properly trained, and will assist in the taking and resolution of their MBAs inventory.

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PUREX Perpetual Inventory. The PUREX perpetual inventory is a continuous accounting record of the quantities of nuclear material transferred into and out of, and between the MBAs within the PUREX complex. Deliveries of nuclear material to the PUREX plant are debited to the PUREX plant account and credited to the MBA receiving the shipment. Shipments of nuclear material from the PUREX plant are credited from the PUREX plant account and debited from the MBA releasing the shipment. Transfers within the PUREX complex are debited to the releasing MBA. The accounting records will be maintained by MBA Dedicated Staff in such a way that the total throughout each MBA, and the PUREX plant, will be continuously tabulated.

4.0 RESPONSIBILITIES

4.1 CUSTODIAL MANAGER

The Custodial Manager will be the chairperson responsible for conducting the inventory. He/she will establish an inventory team with representatives from, but not limited to, Operations, Process Engineering, Dedicated Staff, Safeguards, Laboratory and will take the lead in inventory anomaly resolution. Representatives from the Department of Energy Richland (DOE-RL) will be invited to witness inventory actions of each MBA, and may be involved throughout the entire inventory.

4.2 SAFEGUARDS MATERIAL CONTROL

Safeguards Material Control is responsible for implementing a graded physical inventory program for nuclear materials. Safeguards Material Control will establish and monitor nuclear material control limits, and oversee nuclear material measurement control systems. Safeguards will ensure that WHC-CM-4-34, Nuclear Material Control and Accountability Manual, is followed and incorporated into the PUREX Administrative procedures contained in WHC-CM-5-9, PUREX/UO_3 Plant Administration. Safeguards will make all the notifications to DOE needed throughout the inventory, and has the authority to start or stop the inventory. Written authorization is required from the manager of Safeguards Material Control, or his delegate, and given to the managing custodian before beginning the inventory, and before resuming normal transfers after the inventory is completed. Once an inventory has begun in any MBA, no transfers into or out of that MBA are permitted unless written permission is obtained from Safeguards Material Control.

4.3 NUCLEAR MATERIAL CUSTODIAN

The nuclear material custodian (MBA custodian) is responsible for having updated, Safeguards-approved procedures for conducting, reconciling, and certifying both routine physical inventories and special physical inventories.

5.0 REQUIREMENTS

5.1 SAMPLING

For a list of sampling sizes and tank agitation/recirculation times, see Figure 2.

5.2 PREINVENTORY DOCUMENTATION CHECK SHEET

This check sheet (Figure 1) verifies all material transfer documentation has been transmitted to Safeguards Accounting prior to inventory.

5.3 PREINVENTORY

The PUREX process must be in a shutdown mode with reportable material moved to specified accountability tanks for sampling. NDA measurements are required for hoods N3/N4 unless stipulated in writing by Safeguards Material Control. Once an inventory has begun in any MBA, no transfers into or out of that MBA are permitted unless written permission is obtained from Safeguards Material Control. All scrap not sealed with an approved TID will be sampled for measurement and all waste drums will be sealed and measured unless otherwise stipulated.

5.4 ALTERNATE INVENTORY FREQUENCY & PHYSICAL INVENTORY FREQUENCY

Alternate inventory frequency requirements may be approved by Safeguards Material Control and the DOE-RL for inventories containing large numbers of items, items stored in high radiation fields, critical assemblies, and other situations where alternate control mechanisms provide assurance that unreported changes in inventories would be detected. Inventory values shall be determined in time to provide for computation and reconciliation of inventories and determination of inventory differences, consistent with established inventory practices and DOE reporting requirements.

Minimum physical inventory frequencies for material balance areas are provided in the following table.

Attractiveness	Category *			
Level	I	II	III	IV
C	Bimonthly	Bimonthly	Semiannually	Annually
D	-	Semiannually	Semiannually	Annually
E	-	-	-	Annually

5.5 SPECIFIC TYPES OF INVENTORIES

1. Process material undergoing processing and recovery operations, and which is inaccessible for measurements by sampling, should be accounted for by use of process data, vessel level and density measurements, and calculated concentration values. This dynamic monitoring, measurements, and specific action criteria, subject to the approval of DOE-RL, should be used routinely to track materials in process until operations permit a complete inventory. These Process inventories should be conducted on a schedule established by Safeguards Material Control and DOE, but no less frequently than annual.

2. Special physical nuclear material inventories will be conducted when needed, as a result of changes in custodial responsibilities, missing items, inventory, differences exceeding established control limits, abnormal occurrences, or emergency evacuations (criticality or at the request of authorized facility personnel or the DOE-RL.)

   Special nuclear material inventories will be based on measured values, and, where feasible, measurements or estimates of holdup shall be made so that holdup quantities can be used in determining the inventory difference. Sample Analyses times will follow guidelines established in Sample Schedule FSS-P-080-00002. Inventory values shall be calculated and reported within 15 days after the last measured value is received. All items meeting reporting requirements must be labeled with a unique item identification number.

3. Materials in containers with less than one-half reportable quantity need not be included on inventory documents reported to Safeguards Accounting Control, but must be listed on internal documentation that indicates their general location and amount of nuclear material.

5.6 ACCOUNTABILITY/SAMPLING

Accountability measurements shall not be performed when the measurement system does not demonstrate satisfactory performance through the use of measurement control standards, as determined be Safeguards-approved measurement control program.

Scales and balances used for accountability purposes shall be maintained in good working condition, recalibrated according to an established schedule, and checked for accuracy and linearity on each day that the scale or balance is used for accountability purposes.

Statistical sampling is not applicable to PUREX because of plant configuration.

5.7 AUTHORIZATION FOR INVENTORY

Written authorization is required from the manager of Safeguards Material Control, or his delegate, and given to the managing custodian before beginning the inventory, and before resuming normal transfers after the inventory is completed. Once an inventory has begun in any MBA, no transfers into or out of that MBA are permitted unless written permission is obtained from Safeguards Material Control. Inventory samples may be taken and moved to the laboratory without written permission.

6.0 PROCEDURE

6.1 PRE/PRE INVENTORY MEETING

Representatives from each of the following organizations should attend this meeting:

1. Managing Custodian (Chairperson).
2. All MBA Custodians.
3. Safeguards and Security.
4. Analytical Laboratory.
5. Statistics.
6. PUREX Work Control.
7. HPT management.
8. Operations management.
9. Engineering.

This meeting (chaired by the custodial manager) shall be utilized for the planning of a PUREX plant inventory. Decisions must be made at this time as to what process movements, cleanouts, holdup levels and what nuclear material needs to be moved prior to measuring, in order to put the plant into a ready to inventory mode. Each MBA custodian, with help from engineering, will be given the original PUREX Nuclear Material Inventory Report form(s) (Figure 3) to complete the inventory actions for their individual MBA, and returned to the managing custodian at or before the next Pre-inventory meeting. The inventory actions include the following codes.

1. INV ——— Measured by typical solution measurements.
2. ITEM ID —— Inventoried by item count and identification.
3. EST 1 ——— Estimated from available instrument data.
4. EST 2 ——— Estimated from flowsheet data.
5. EST 3 ——— Estimated from historical values.
6. NEG 1 ——— Declared negligible on basis of known cleanout conditions.
7. NEG 2 ——— Declared negligible on basis of known operating conditions.

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Each custodian must verify that all samplers within their MBA are in good working order. If repair is needed, it must be fixed immediately or decide upon an alternate sampling method. Each custodian must verify that all weight factors, specific gravity and temperature indicators have updated calibration and are in good working order. If repair is needed, it must be fixed immediately. The RUSKA systems located in the Headend Control room (HECR), Central Control room (CCR), and N-Cell Lower Control room (N-Cell LCR) must be in good working order. The Laboratory representative will determine a start, finish, and analytical result data for the Non Destructive Assay (NDA) of the N-Cell hoods. If the NDA equipment is unavailable, an alternate visual estimation method may be used (WHC-CM-5-9, Section 4.10 and Section 4.26) with Safeguards concurrence. The M/N-Cell pumps must be operational. The primary and secondary scales located at the N4 loadout hood, must be calibrated and checked for accuracy and linearity on the day of use.

6.2 PRE INVENTORY MEETING

Representatives from each of the following organizations should attend this meeting.

1. Managing Custodian (Chairperson)
2. All MBA Custodians.
3. Safeguards and Security.
4. Analytical Laboratory.
5. Statistics.
6. PUREX Work Control.
7. HPT management.
8. Operations management.
9. Engineering

The MBA custodians must bring the completed inventory report (which was given to them at the Pre/Pre inventory meeting) to the Pre inventory meeting. From this inventory report a list of all samples to be taken will be determined. This list of samples will be given to the laboratory manager.

Process engineering, along with the managing custodian will determine the analytical sampling requirements, and the approximate concentration ranges. The laboratory will determine the sample size required per requested sample analysis.

To ensure that all material transfer documentation has been transmitted to Safeguards Accounting prior to inventory, dedicated staff will be given the preinventory documentation checksheet (Figure 1) to be completed before inventory begins. Dedicated staff must complete a double check (two person) comparison of each PUREX MBA book with Safeguards Accounting computer generated bookings, and a perfect match must be found. If any discrepancies arise during this booking check, immediate action must follow to ensure accurate accountability book values prior to inventory.

At this time the official inventory start date must be determined. The managing custodian will request written authorization (WHC-CM-4-49, Appendix C, "Inventory Control Form") from the manager of Safeguards Material Control for each MBA before starting the inventory, requesting no transfers into or out those MBAs unless written permission (WHC-CM-4-49, Appendix C, "Inventory Control Form") is obtained from Safeguards Material Control.

The custodian and planner must work together to ensure the needed personnel are available at the time of inventory. Custodians must keep in frequent contact with the managing custodian to ensure proper communications and a smooth inventory process. Planning is to develop a visual day-by-day inventory schedule to be signed by all participating organizations.

The laboratory representative will give an estimated time frame for the NDA process and ensure personnel are available and ready to work on the day NDA is scheduled to begin. The laboratory will request the N-Cell manager to have the proper amount of liquid nitrogen available for the NDA equipment. An estimated completion date and analytical results date will be determined at this time. If NDA is not to be done, the managing custodian will ensure the visual estimators are currently qualified and certified prior to beginning hood estimation. Hood estimation will be done according to WHC-CM-5-9, Sect. 4.10.

To ensure no personnel are denied access into radiation zones on the day of the inventory, all personnel involved with the inventory process in a radiation zone, should go through the Westinghouse radiation area management (WRAM) system following this meeting, to ensure they are up to date with all PUREX requirements.

This meeting will be the last one before the inventory begins, unless other wise requested.

Following the Pre inventory meeting, the chair person will compile a formal list of tanks to be sampled and distribute a copy to all in attendance along with the meeting minutes.

6.3 WITNESSES

Throughout the inventory process Safeguards and DOE representative(s) must be invited to witness or verify all tank samples, oxide/oxalate sampling, hood estimations, and control room tagging of instrumentation readings.

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6.4 SAMPLING

The dedicated staff will use the inventory sampling list to request samples from the Dispatch operator. Samples may have to be submitted to both the PUREX and Plutonium Finishing Plant (PFP) laboratories. The dispatcher will assign sample tags containing the sample serial number, code number (source), the word "inventory" or "INV" in the run number spot, the date, and the time of day. Sample analyses "turn-around" times should adhere to the PUREX Sampling Schedule, FSS-080-00002. The 204-A area samples are to be obtained according to PUREX Plant Operating Procedure PO-080-190, "Recirculate and Sample UNH and Recovered HNO3."

All sample transfers from MBAs (except 202) into the analytical laboratory since previous inventory, must be documented 24 hours before a new inventory starts.

6.5 TAGS

Inventory tags are match-paired, brightly colored, sequentially prenumbered, self-adhering labels (available by request from Safeguards). The inventory process is a "wall-to-wall" tally and the use of inventory tags assures at a glance that all vessels, items, containers, standards and hoods, are inventoried, and nothing has been omitted from the actual inventory. When a tag has been affixed, it will remain until after inventory is complete and reconciled. After reconciliation the tag may be removed. To assure these tags are not applied inappropriately at times other than inventory, they will be kept in a locked, classified repository under control of the Dedicated Staff.

During the inventory, vessels will be tagged on the weight factor recorder as the weight factors are recorded onto the PUREX nuclear material inventory report form. The remaining tag of the match-paired set will be placed on the inventory report form next to the tank identification. Avoid the use of the words "empty" or "heel." Do not record the instrument SpG when liquid level is less than the diptube differential; laboratory results of SpG will be used instead. Using black ink, mark the charts and inventory report form readings with the date, the word "inventory" and initial.

Standards, waste containers, and product cans will be tagged on the outer container by any applied identifying label. The remaining tag of the match-paired set will be placed on the inventory report form next to the identification number taken at inventory.

Items (scrap or product cans) will be tagged on the Standard Fissile label that is affixed to the closest convenient hood face by the item. The remaining tag of the match-paired set will be placed on the inventory report form next to the identification number taken at inventory.

Transuranic (TRU) drums stored in the sample gallery and canyon lobby containing nuclear material must be tagged onto the Standard Fissile label.

All cup wire seal integrities must be checked by manual verification, and the seal number is documented onto the inventory report form.

Items containing nonreportable quantities only, such as sources, are also to be identified on the inventory report form.

6.6 HOOD NON DESTRUCTIVE ASSAY (NDA) OR ESTIMATE

Quantities of nuclear material located in the N-Cell hoods not accounted for via item count or vessel assay (hood holdup or constants) may be determined by NDA. The Analytical Laboratory will utilize both fixed and portable gamma detectors with multichannel analyzers and provide the managing custodian with a written report detailing the "best guess" gram quantities of plutonium for these areas. The calciner units and surrounding areas may be assayed using a neutron coincidence counting system. Results of both gamma and neutron assays will include any appropriate statistical measurement uncertainties. Those hoods which have had NDA measurements made prior to inventory, will be posted by the laboratory personnel. Those areas not measured by use of NDA equipment will be assigned an engineering estimate value approved by Safeguards and DOE-RL.

If the NDA equipment is not available for use, Safeguards and DOE-RL may decide to use visual estimation (WHC-CM-5-9, procedure 4.10, "N-Cell Visual Determinations".) Estimations will be performed by trained, certified estimators and the results will be turned over to statistics for validation, and the assignment of an error statement to the estimation.

6.7 CALCULATING THE INVENTORY

Inventory quantities shall be independently calculated from the weight factor, specific gravity, temperature and laboratory analysis by at least two dedicated staff personnel, and the managing custodian.

For liquid level determination, when available, use laboratory analytical specific gravity. If analytical specific gravity is not available, calculate a corrected specific gravity using the tank solution temperature.

For zero weight factor readings use the jet heel volumes from the calibration table. Calculate the tank volumes to the nearest liter. Calculate the total uranium, plutonium and sensitive actinides to the nearest gram(s).

The resulting quantities of nuclear material shall be reconciled by the Dedicated Staff and Process Engineering and verified on a "spot-check" basis by the MBA custodian and Safeguards. Rounding of the final calculations is to conform with DOE Order 5633.4.

Plutonium in PR cans for storage is reported at the item values developed during loadout operation.

The UNH tank trailer heels are calculated using the last known sample value of the appropriate tank cars contents.

6.8 RECONCILIATION

Each book inventory must be reconciled to the corresponding physical inventory within 15 calendar days of the receipt of the last piece of measurement data. Specific MBA inventory reconciliation is documented in WHC-CM-4-49, Safeguards Inventory Manual. The response plan for inventory confirmation/verification discrepancies is detailed in WHC-IP-0565, Safeguards Desk Procedures. Reconciliation will be followed by an authorization for resumption of operations. This authorization comes from the manager of Safeguards Material Control or his/her delegate, and must be submitted in writing within one day of preliminary telephone authorization.

7.0 REFERENCES

1. DOE Order 5633.4
2. FSS-808-00002, "PUREX Sampling Schedule."
3. PO-080-190, PUREX/UO3 Plant Operating Procedure.
4. WHC-CM-4-34, Nuclear Materials Control and Accountability Manual.
5. WHC-CM-4-49, Safeguards Inventory Manual, Appendix C.
6. WHC-CM-5-9, PUREX/UO3 Plant Administration,
   4.10, "N-Cell Visual Determinations."
   4.13, "Response to SNM Anomalies."
   4.26, "N-Cell Visual Determination Training."
6. WHC-IP-0565, "Safeguards Desk Procedures."

8.0 BIBLIOGRAPHY

1. WHC-CM-5-9, PUREX/UO3 Plant Administration, Sect. 4.8, "N-Cell Daily Administrative Checks."
2. WHC-CM-5-9, PUREX/UO3 Plant Administration, Sect. 4.9, "N-Cell Bimonthly Inventory."
3. WHC-CM-5-9, PUREX/UO3 Plant Administration, Sect. 4.12, "Solvent Extraction Dynamic Inventory."
4. WHC-CM-5-9, PUREX/UO3 Plant Administration, Sect. 4.13, "Response to SNM Anomalies."
5. WHC-CM-5-9, PUREX/UO3 Plant Administration, Sect. 4.28, "N-Cell Daily Administrative Checks During Extended Downtime."
6. WHC-CM-5-9, PUREX/UO3 Plant Administration, Sect. 4.31, "Dissolution/Solvent Extraction Daily Administrative Checks During Plant Operations."

Question 22

9.0 CONCURRENCES

B R Fitzpatrick — 4-17-91

B. R. Fitzpatrick, Manager
Material Control — Date

D. G. Harlow — 4/11/91

D. G. Harlow, Manager
Process Engineering — Date

T. F. Dale — 4-11-91

T. F. Dale, Manager
PUREX Analytical Laboratory — Date

L. L. Buckley — 4/10/91

Issued By: L. L. Buckley, Manager
PUREX Facility and Operational
Assurance — Date

Figure 1. PreInventory Documentation Checksheet
(sheet 1 of 2)

This form verifies all material transfer records have been sent to Safeguards.

Last Transfer	Last Batch #	Form #
MBA 201		
Dissolver Charged	_____	_____
D5 to E6	_____	_____
E5 to UGS	_____	_____
Sump to F18	_____	_____
MBA 202		
N-Cell to TK-F10	_____	_____
L9 to N-Cell	_____	_____
K6 to P1/P2/P3/P4	_____	_____
U1/U2 to Dissolver	_____	_____
U3 to UGS	_____	_____
U4 to UGS	_____	_____
F15/F16 to UGS	_____	_____
F18 to UGS	_____	_____
G8 to UGS	_____	_____
R8 to UGS	_____	_____
P13/P14/P15	_____	_____
P2 to E6	_____	_____

Question 22

Figure 1. PreInventory Documentation Checksheet
(sheet 2 of 2)

Last Transfer (continued)	Last Batch #	Form #
MBA 203		
Rework to L11		
Product Loadout		
N15/N16 to L11		
N21/N22 to F10		
N53 to L11		
MBA 204		
P1,P3,P4 to E6		
P1,P3,P4 to K-Cell		
Recovered Acid Receipt		
UNH Shipment to UO_3		
MBA 208		
Product Shipment		
J2 receipt		

Figure 2. Sampling size, agitation and recirculation requirements. (sheet 1 of 2)

Number	Title	Time	Time
PO-080-021	Sample D5 Sampler Cave	30 Minutes	15 Minutes
PO-080-032	Sample A Type Sampler D3 D4 D5 E1 E6 F8 F13 F15 F16 F26 F18 H1 H2 F18	30 Minutes	20 Minutes
PO-080-034	Sample B Type Sampler D2 E3 E5 E2 E4 F10 G7 G8 H3 J1 J1A J3 J4 J5A J5B J21 J22 J2 J23 K2 L1 L2A L2B L3 L5A L5B L6 L7 Q3 Q4 Q5 Q8 F18	30 Minutes	30 Minutes
PO-080-035	Sample Modified B Type Sampler F3 F5 G1 G5 H4 J7 J8A K1 G7 K3 K4 K5 J2	30 Minutes	30 Minutes
PO-080-038	Sample C Type Sampler J8A K6 R1 R2 R5 R7 R8 U1 U2 U3 U4 U7 U8		30 Minutes
PO-080-044	Sample L4 (inline monitor)		30 Minutes
PO-080-150	Sample L9		10 Minutes
PO-080-156	Sample L11		30 Minutes
PO-080-175	Dip Sample Canyon Vessels		

		Volume Gal	Time Hrs.
PO-080-190	Sample UNH & Rec HNO3 P1 P2 P3 P4	>72,000	18
		48,000 to 72,000	12
		24,000 to 48,000	8
		24,000	4

Question 22

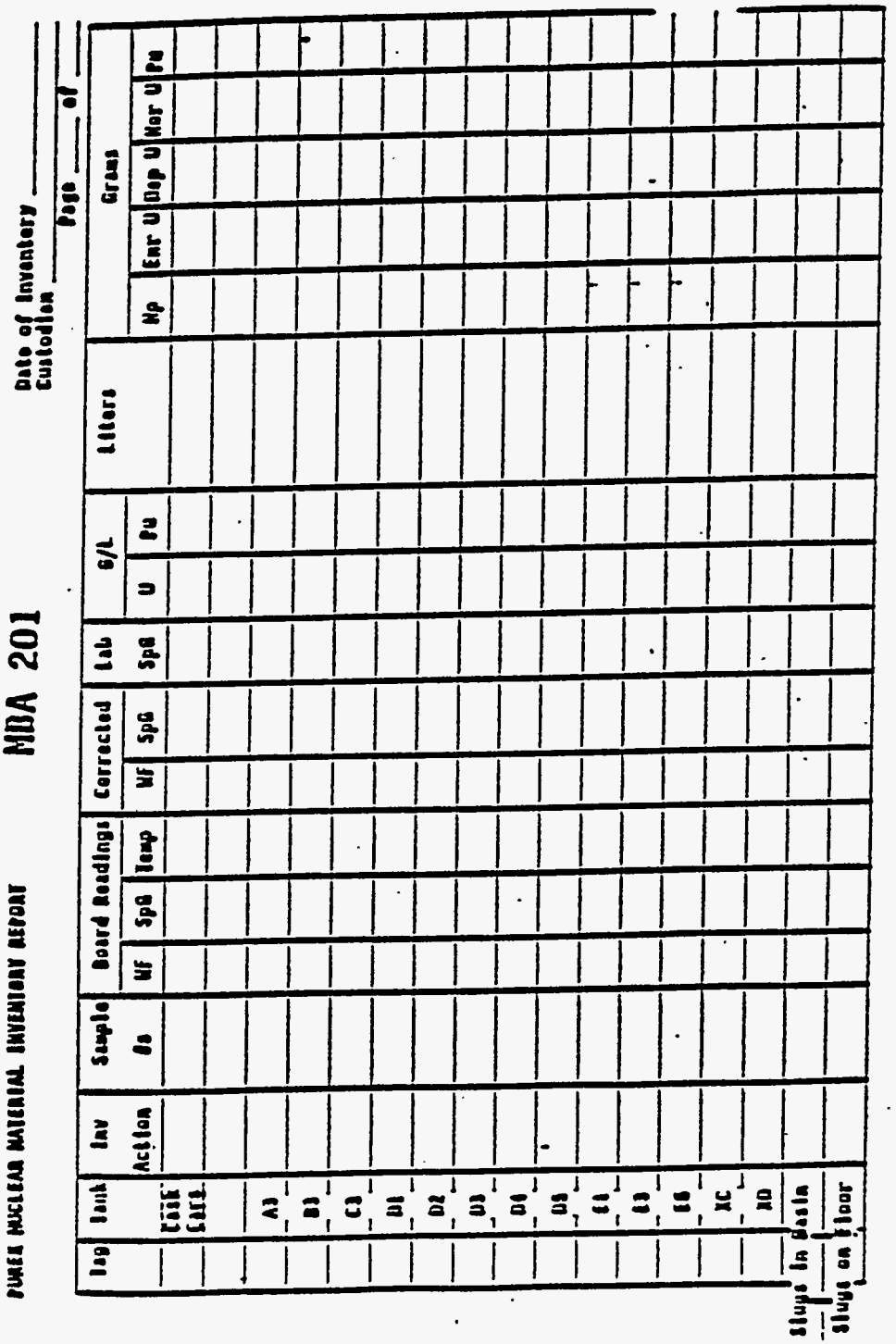
Figure 2. Sampling size, agitation and recirculation requirements. (sheet 2 of 2)

		Volume Gal	Time Hrs.
PO-080-190	P13, P14, P15	>10,000	3
		6,000 to 10,000	2 1/2
		3,000 to 6,000	1 1/2
		<3,000	30 Minutes

		Recirculation Time
PO-080-190	TK-P5	15 Minutes
	TK-P6	16 Hr. Sparge

		Recirculation Time
PO-080-200	Oxide Line Liquid Sampling M3 M4 M5 M6 N5 N6 N15 N16 N20 N21 N22 N30 N53 N13 N19	
PO-080-210	Solid Sampling N-Cell	
PO-465-040	M Cell Liq. Storage & Account. M3 M4 M5 M6	4 Hour
PO-465-106	Empty N30, N40, N43	15 Min
PO-465-190	Operate Tanks N52, N53, N54	30 Min
PO-465-070	Filtrate Concentration Handling N15 N16	30 Min
PO-465-075	Off Gas Scrubbing & Condensate Handling N21 N22	15 Min

Figure 3. PUREX Nuclear Material Report.
(sheet 1 of 14)



Question 22

Figure 3. PUREX Nuclear Material Report.
(sheet 2 of 14)

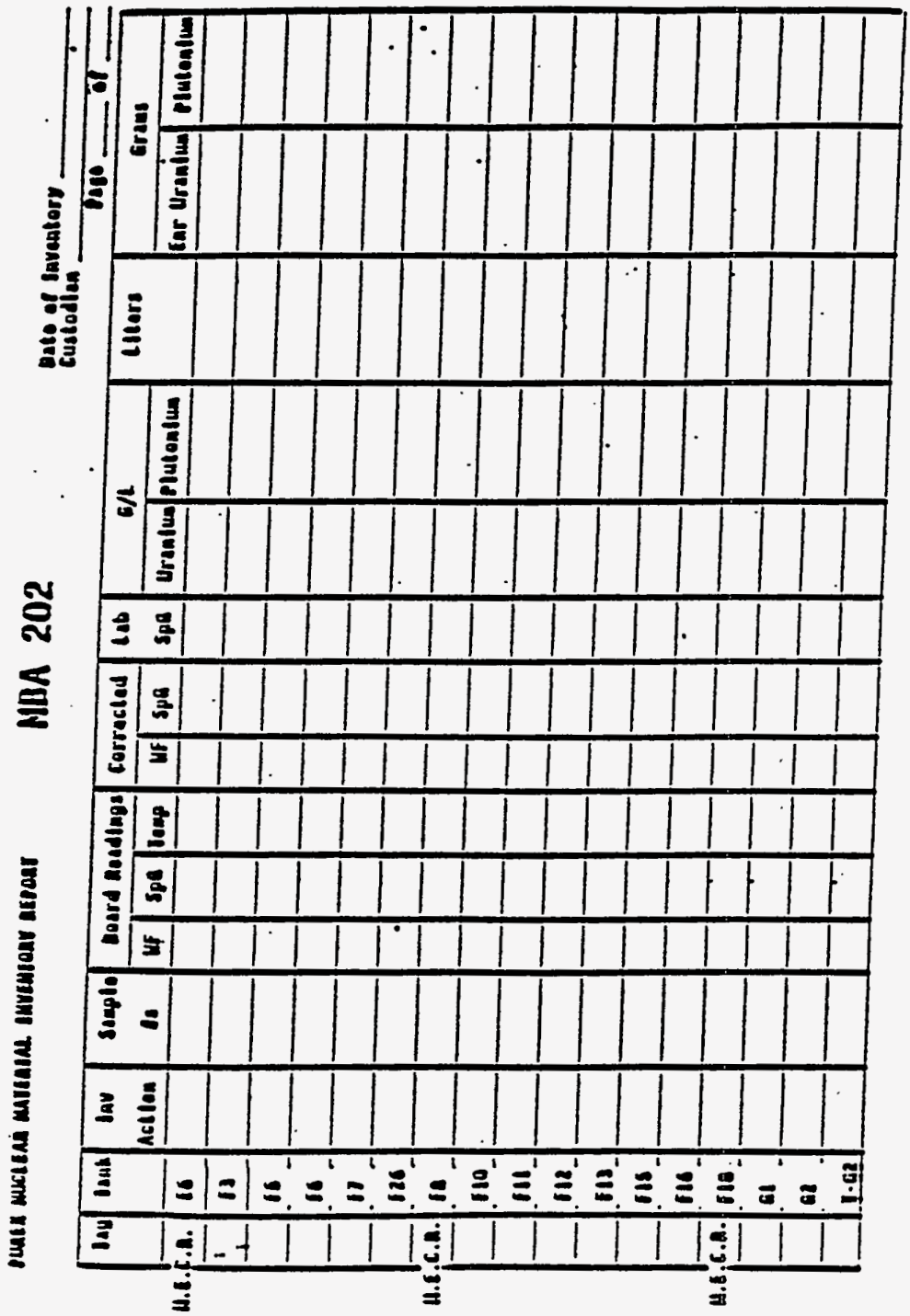
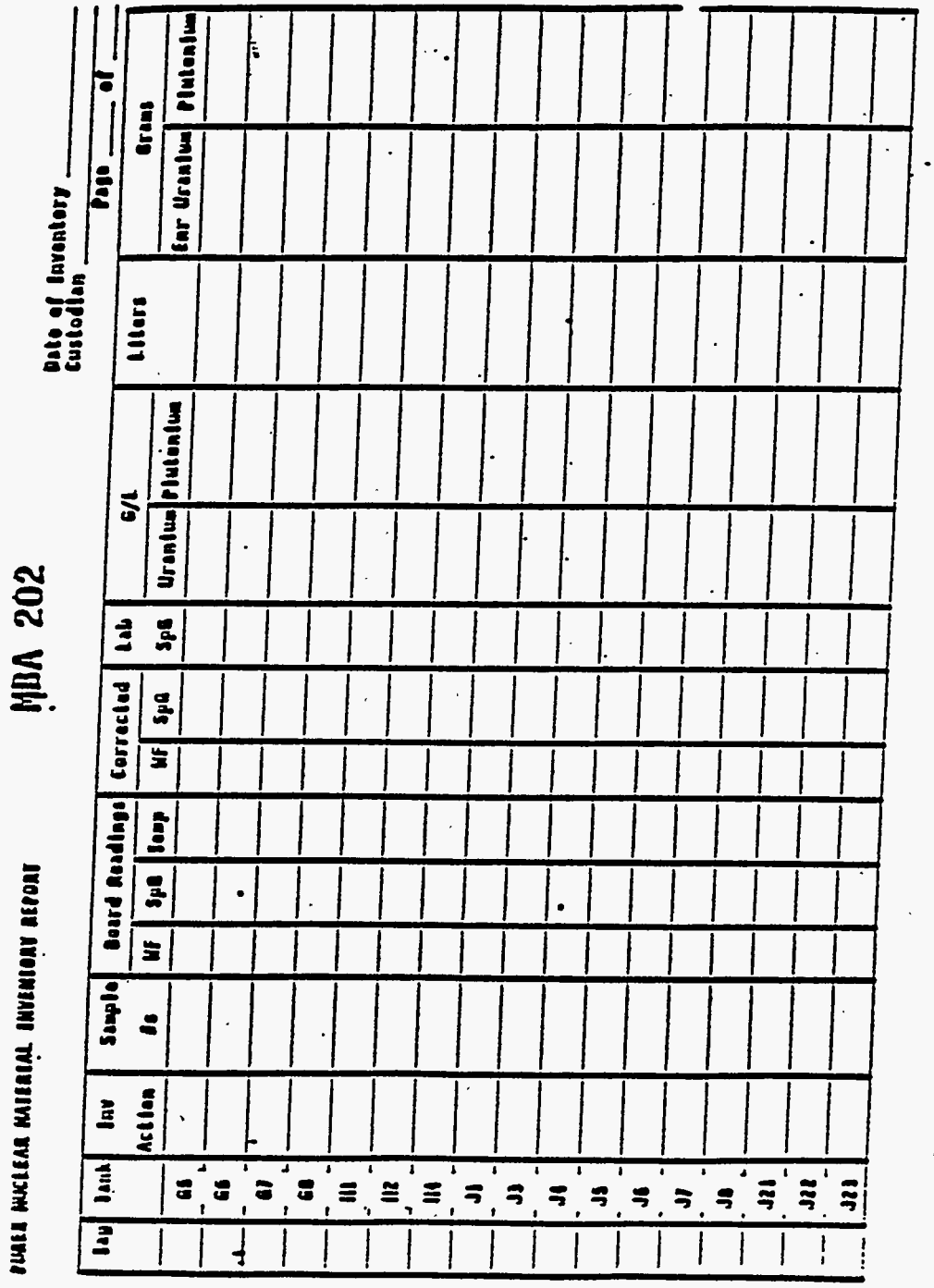


Figure 3. PUREX Nuclear Material Report.
(sheet 3 of 14)



Question 22

Figure 3. PUREX Nuclear Material Report.
(sheet 4 of 14)

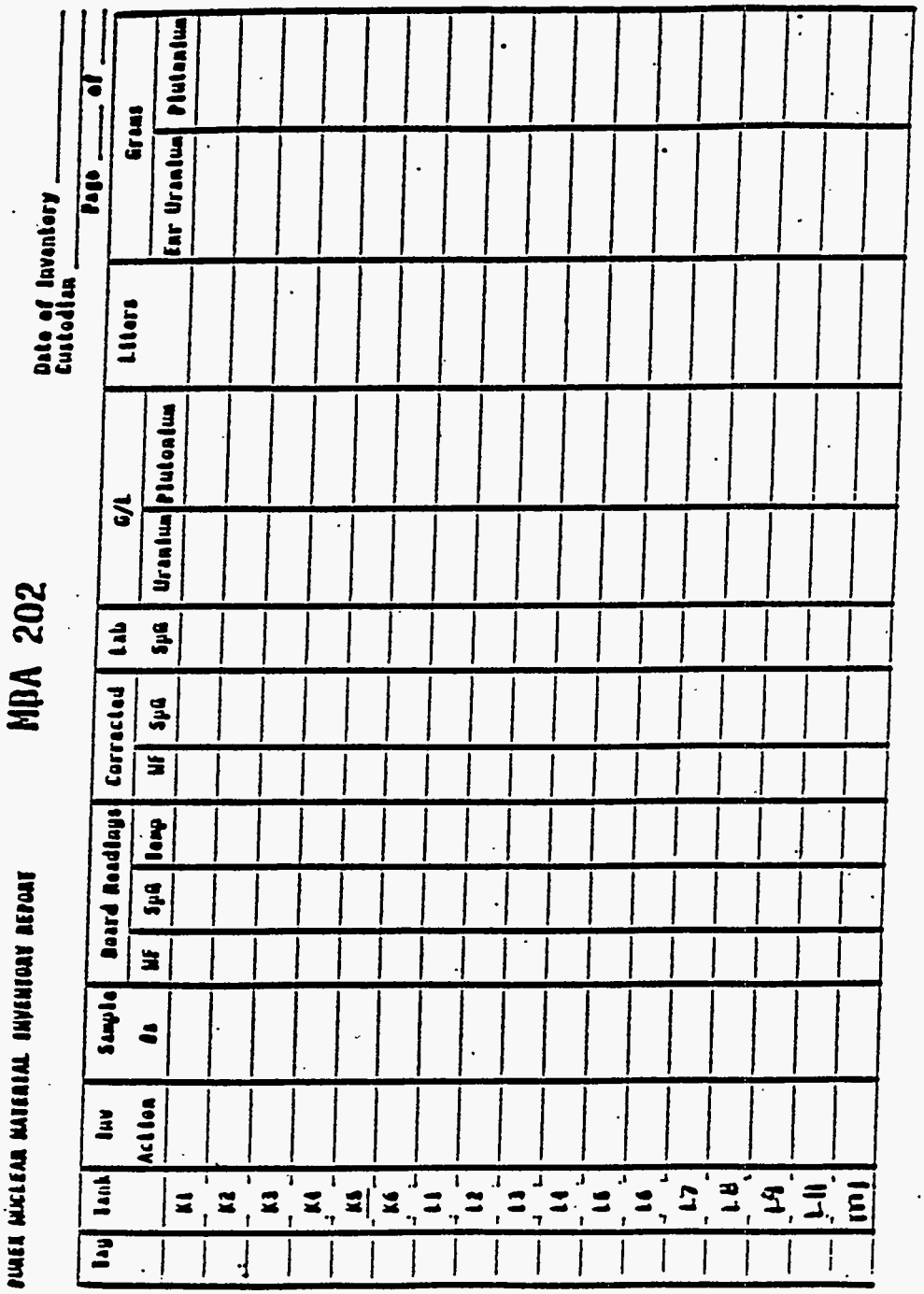
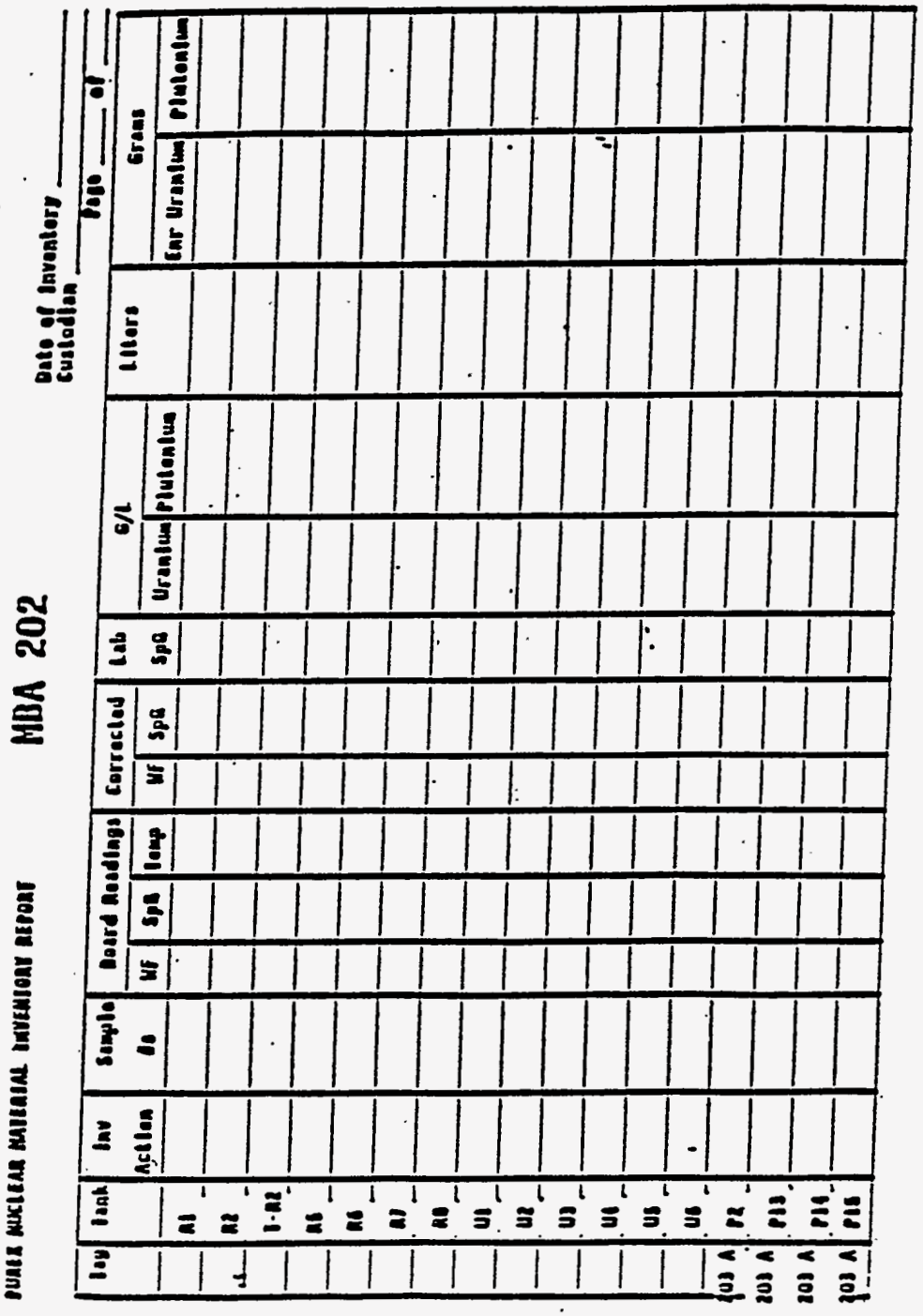


Figure 3. PUREX Nuclear Material Report.
(sheet 5 of 14)



Question 22

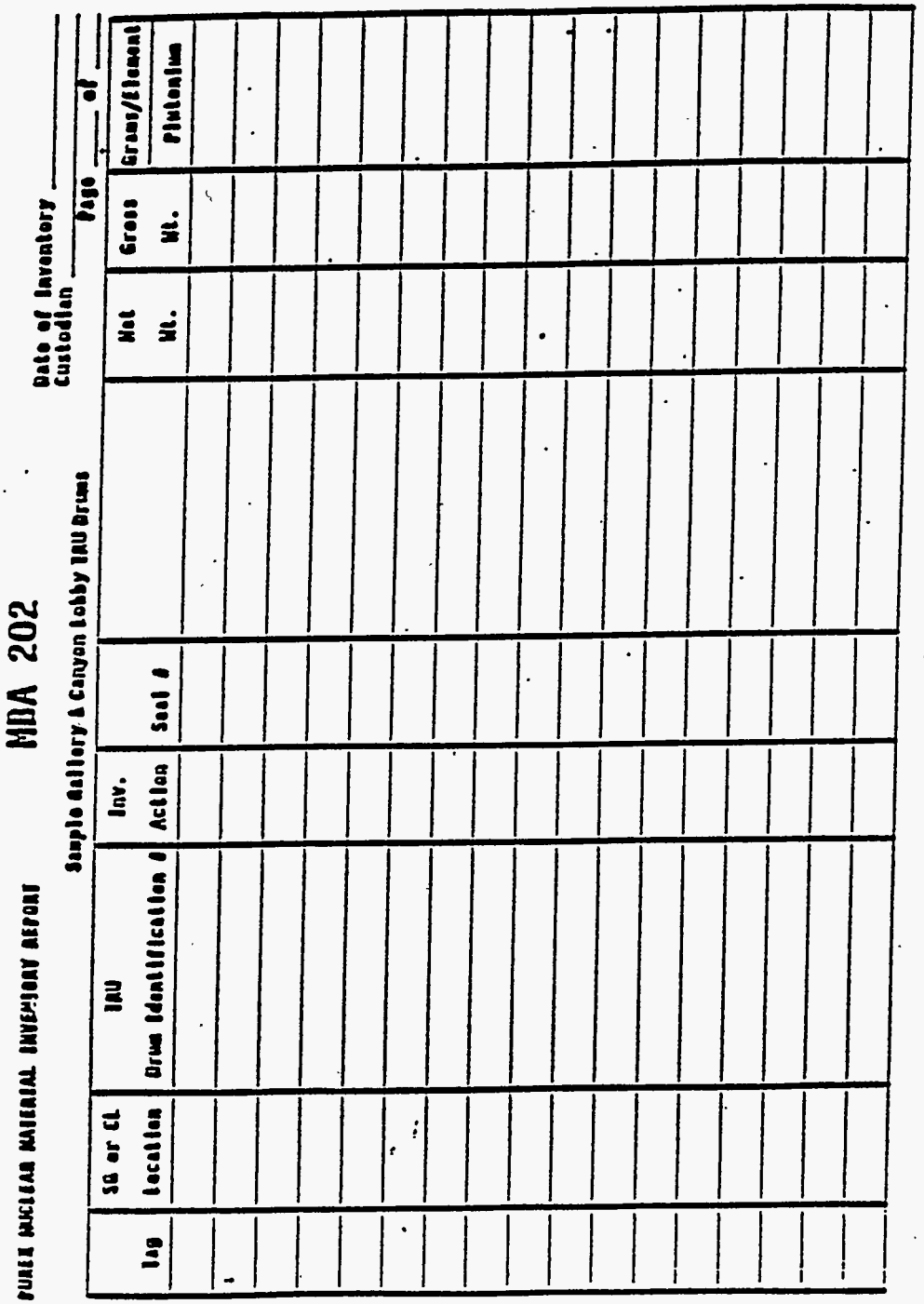
Figure 3. PUREX Nuclear Material Report.
(sheet 6 of 14)

PUREX NUCLEAR MATERIAL INVENTORY REPORT — NBA 202

Date of Inventory _____
Custodian _____ Page ____ of ____

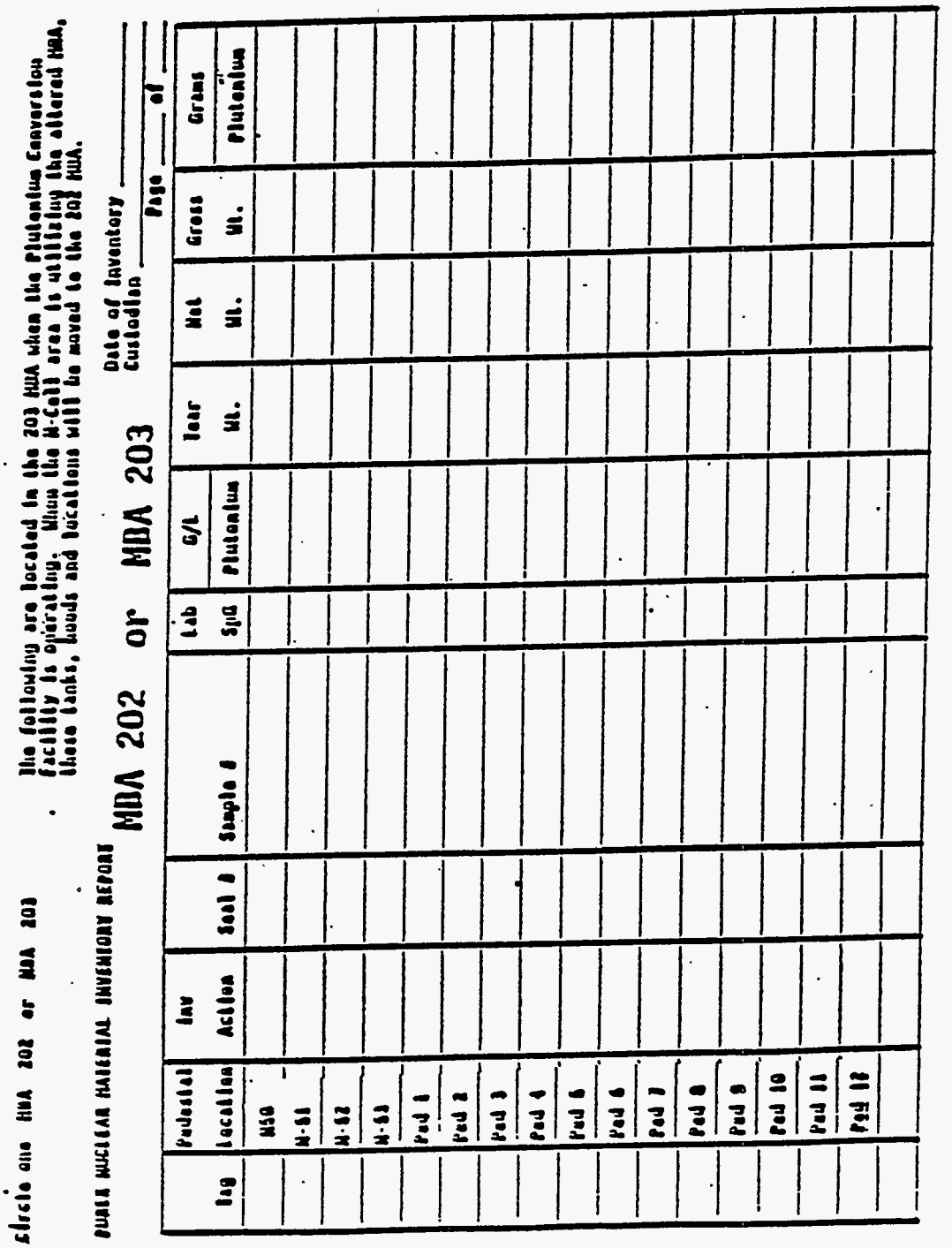
Tag	Inv. Action	Item Identification	Location	Grams Enr Uranium	Nor Uranium	Plutonium
		Lab Used Storage	Laboratory			
		Lab Used Storage	Laboratory			
		Lab Used Storage	Laboratory			
		Lab Used Storage	Laboratory			
		Lab Source	Laboratory			
		M-206 Drum Source	C. Lobby			
		133-16-60-11 (In the cabinet)	M-Cell			
		AI6956 Californium Source	M-Cell			
		6934 Californium Source	M-Cell			
		NND-A-PUS 009				
		NND-A-PUS 009				
		0.95 Enr. Aluminum Clad 4 6" Slug	Iodine Rm.			
		0.7110 Enr. Alum. Clad 8 8" Slug	Iodine Rm.			
		30" N Reactor Fuel Assembly	Iodine Rm.			

Figure 3. PUREX Nuclear Material Report.
(sheet 7 of 14)



Question 22

Figure 3. PUREX Nuclear Material Report.
(sheet 8 of 14)



PUREX NUCLEAR MATERIAL INVENTORY REPORT

Circle one MBA 202 or MBA 203

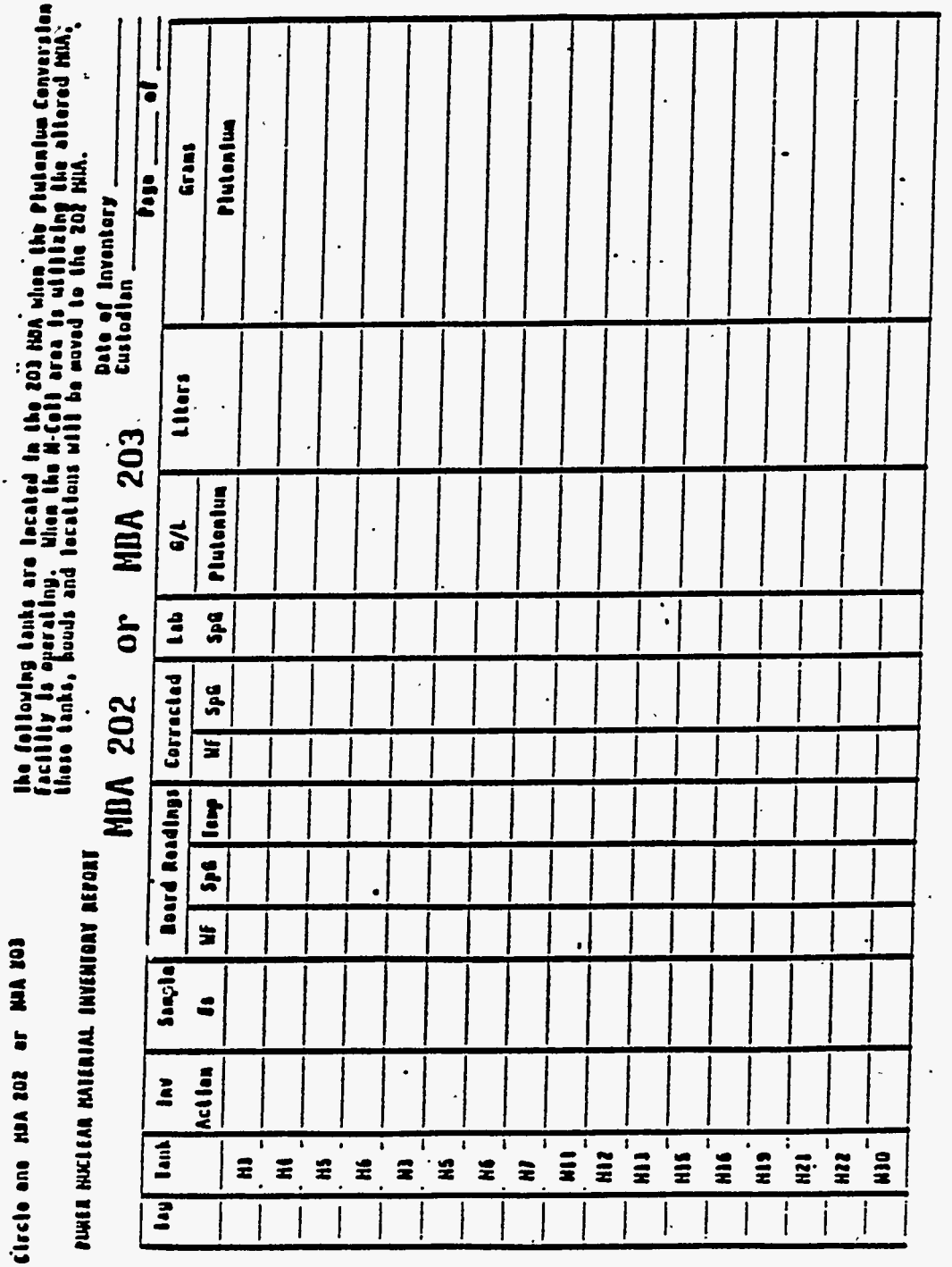
MBA 202 or MBA 203

The following are located in the 203 MBA when the Plutonium Conversion Facility is operating. When the N-Cell area is utilizing the altered MBA, these tanks, loads and locations will be moved to the 202 MBA.

Date of Inventory _____
Custodian _____
Page ____ of ____

Bag	Pedestal Location	Inv Action	Seal #	Sample #	Lab Syd	G/L Plutonium	Tear Wt.	Net Wt.	Gross Wt.	Grams Plutonium
	N58									
	N-51									
	N-52									
	N-53									
	Pad 1									
	Pad 2									
	Pad 3									
	Pad 4									
	Pad 5									
	Pad 6									
	Pad 7									
	Pad 8									
	Pad 9									
	Pad 10									
	Pad 11									
	Pad 12									

Figure 3. PUREX Nuclear Material Report.
(sheet 9 of 14)



PUREX NUCLEAR MATERIAL INVENTORY REPORT

Circle one MBA 202 or MBA 203

The following tanks are located in the 203 MBA when the Plutonium Conversion facility is operating. When the N-Cell area is utilizing the altered MBA, these tanks, hoods and locations will be moved to the 202 MBA.

MBA 202 or MBA 203

Date of Inventory _____

Custodian _____ Page ___ of ___

Day	Tank	Inv Action	Sample Gs	Board Readings NF	Board Readings SpG	Board Readings Temp	Corrected NF	Corrected SpG	Lab SpG	G/L Plutonium	Liters	Grams Plutonium
	H3											
	H4											
	H5											
	H6											
	H3											
	H5											
	H6											
	H7											
	H11											
	H12											
	H13											
	H15											
	H16											
	H19											
	H21											
	H22											
	H30											

Question

Figure 3. PUREX Nuclear Material Report.
(sheet 10 of 14)

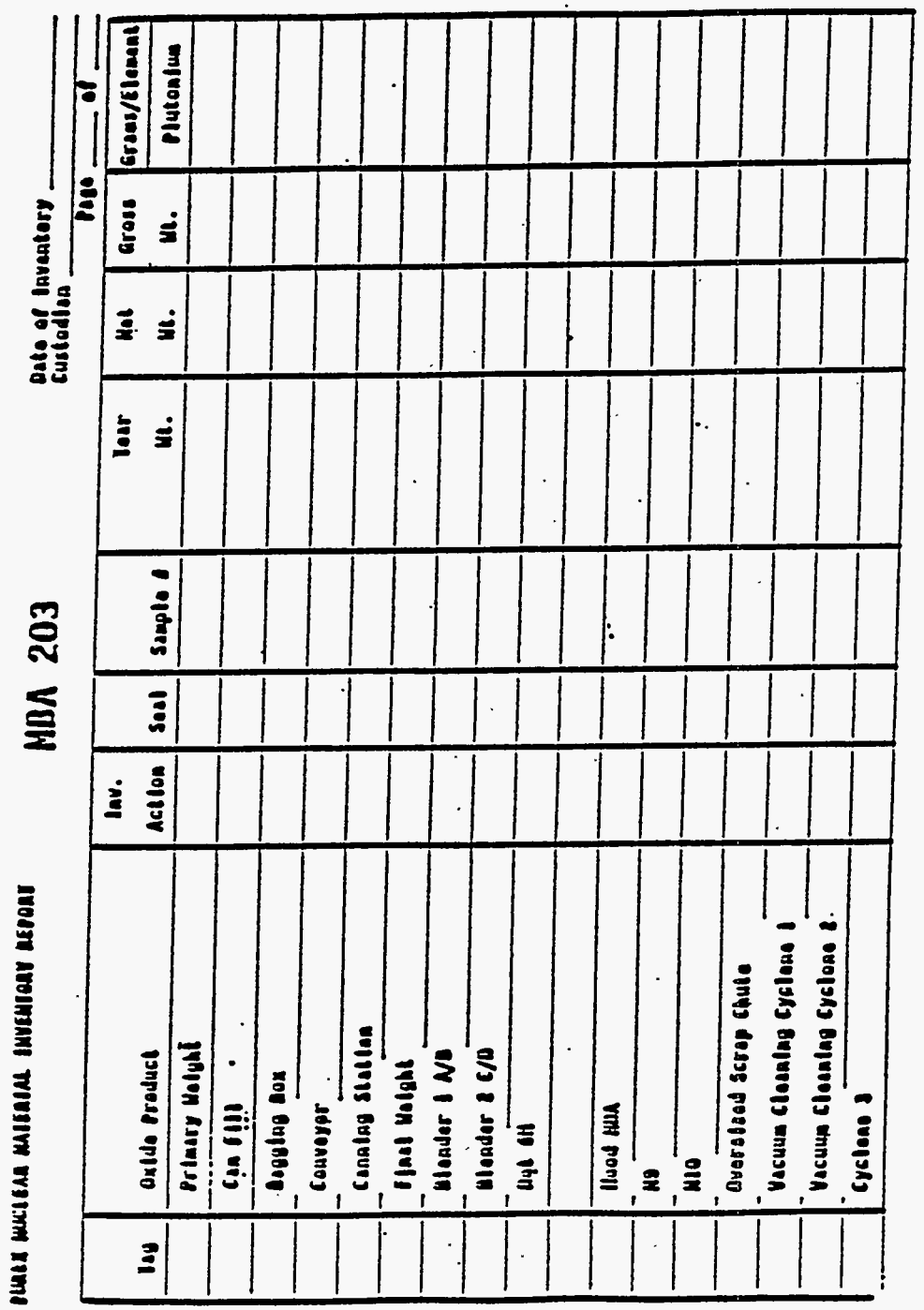
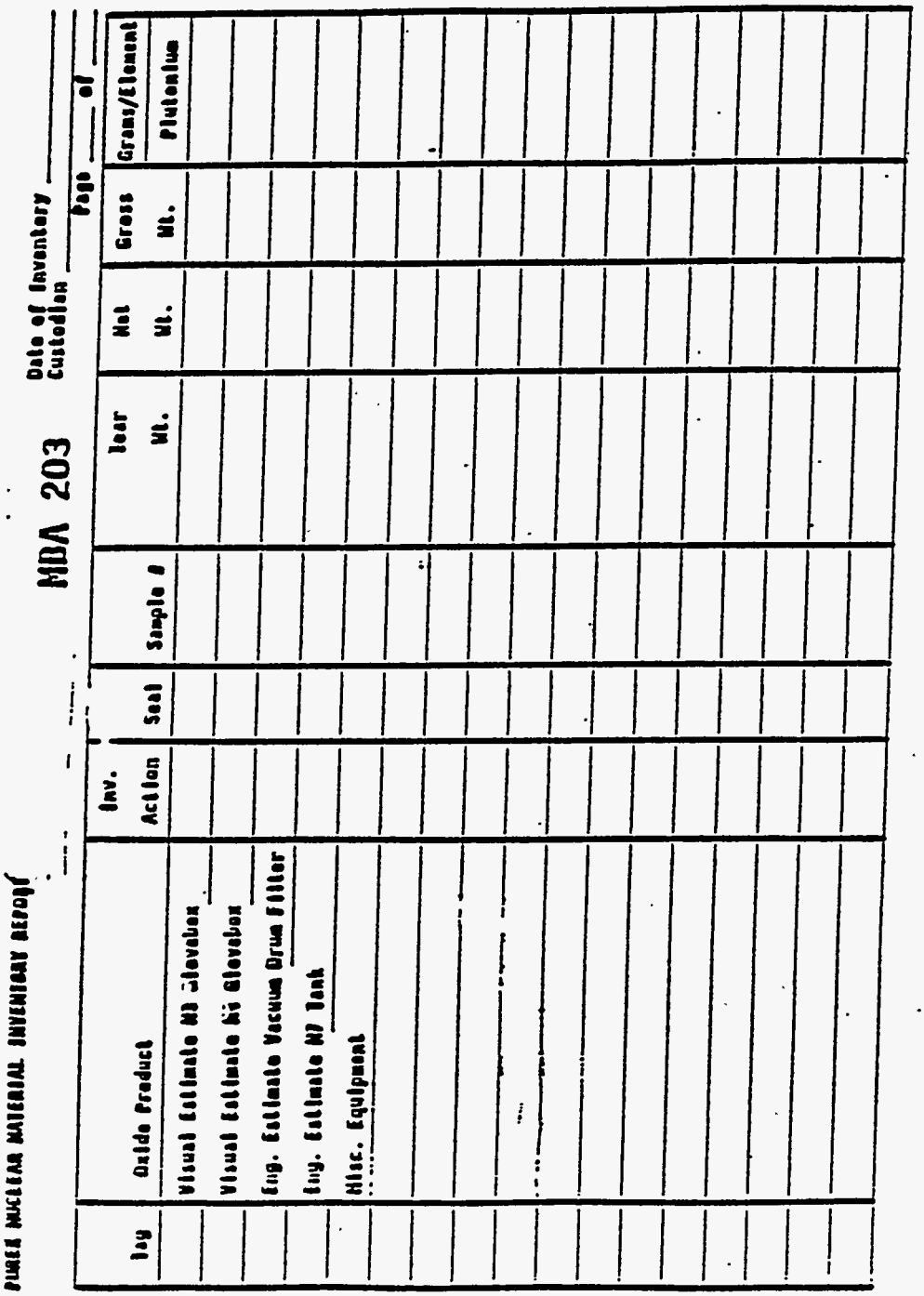


Figure 3. PUREX Nuclear Material Report.
(sheet 11 of 14)



Question 22

Figure 3. PUREX Nuclear Material Report.
(sheet 12 of 14)

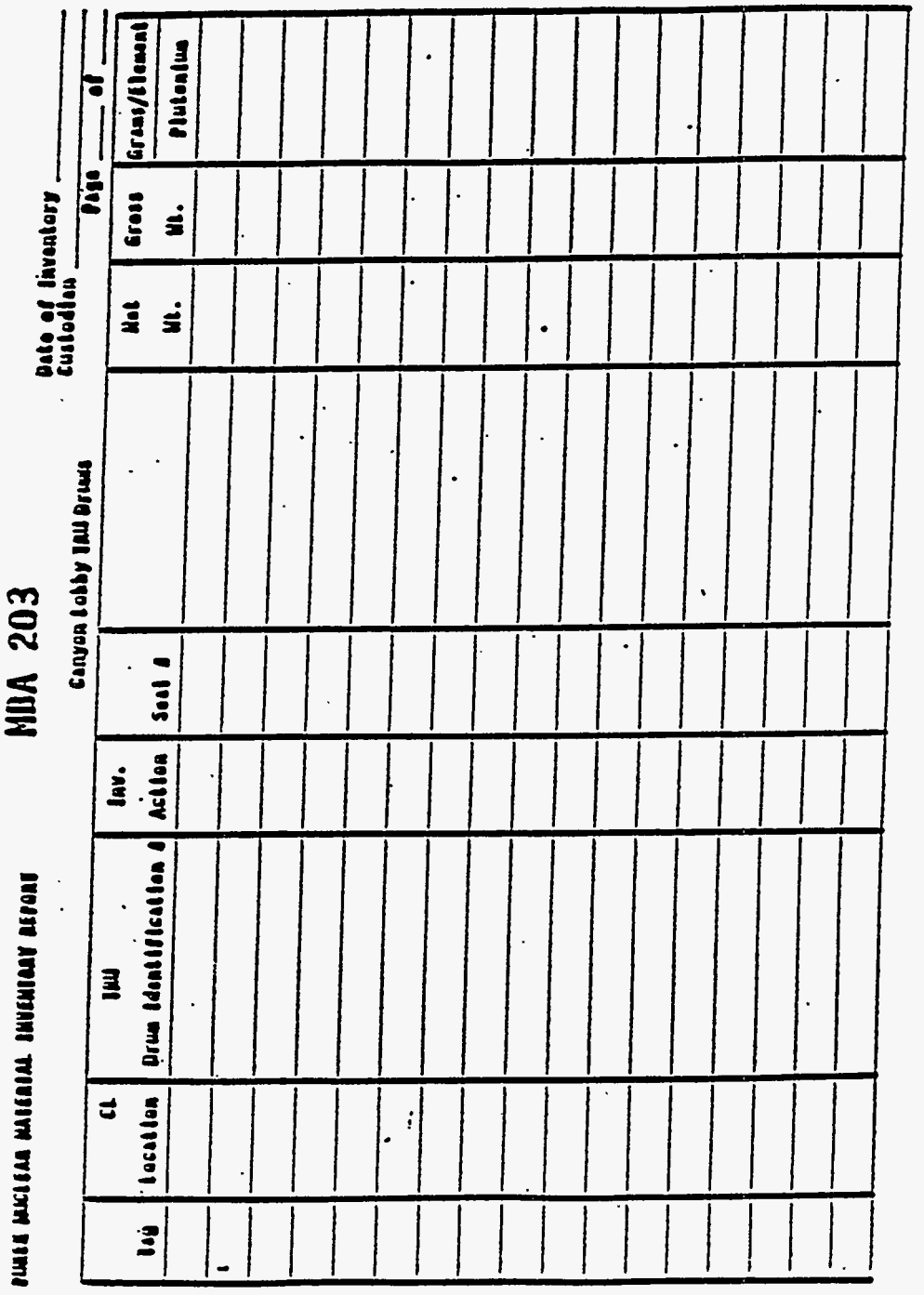


Figure 3. PUREX Nuclear Material Report.
(sheet 13 of 14)

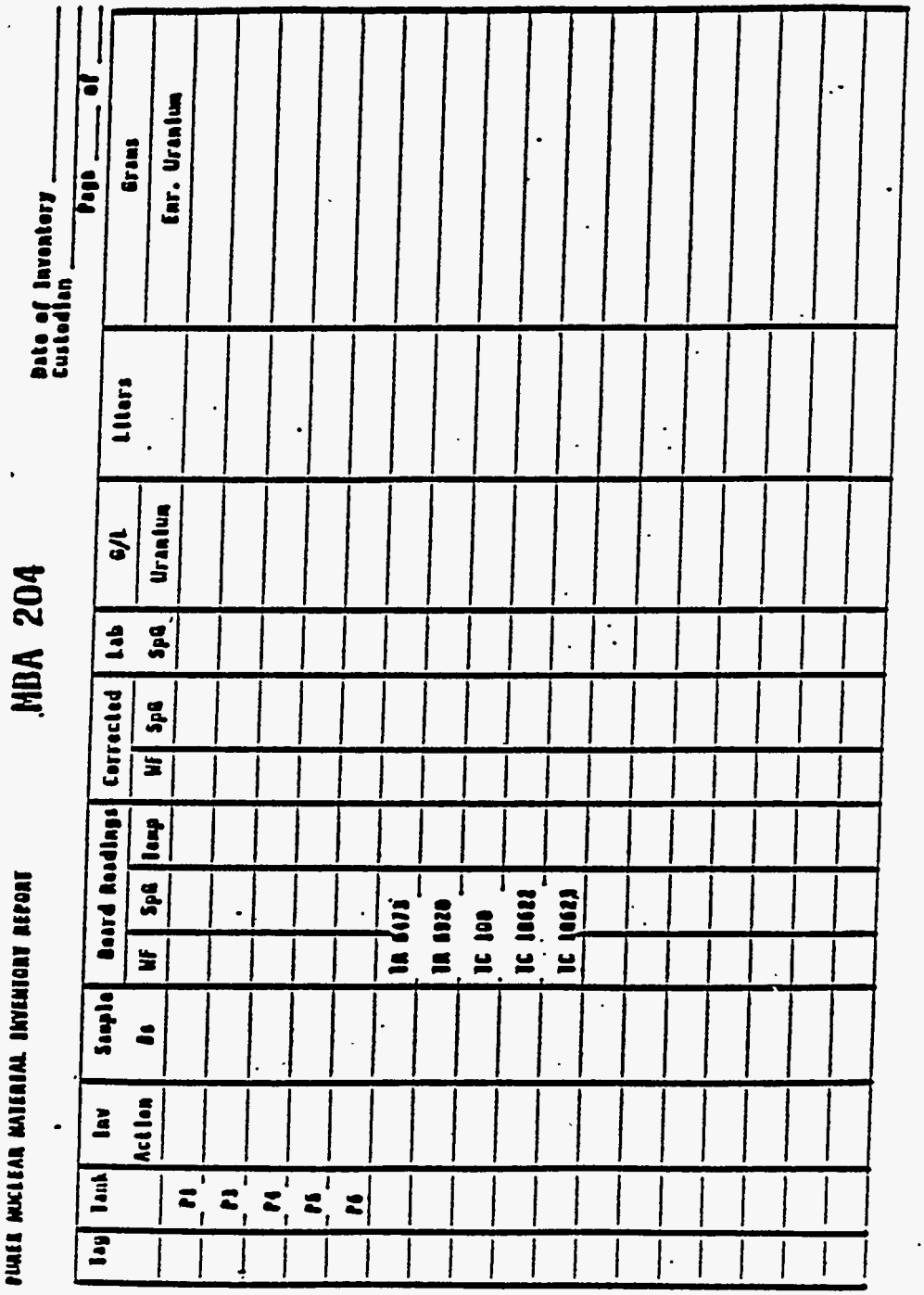
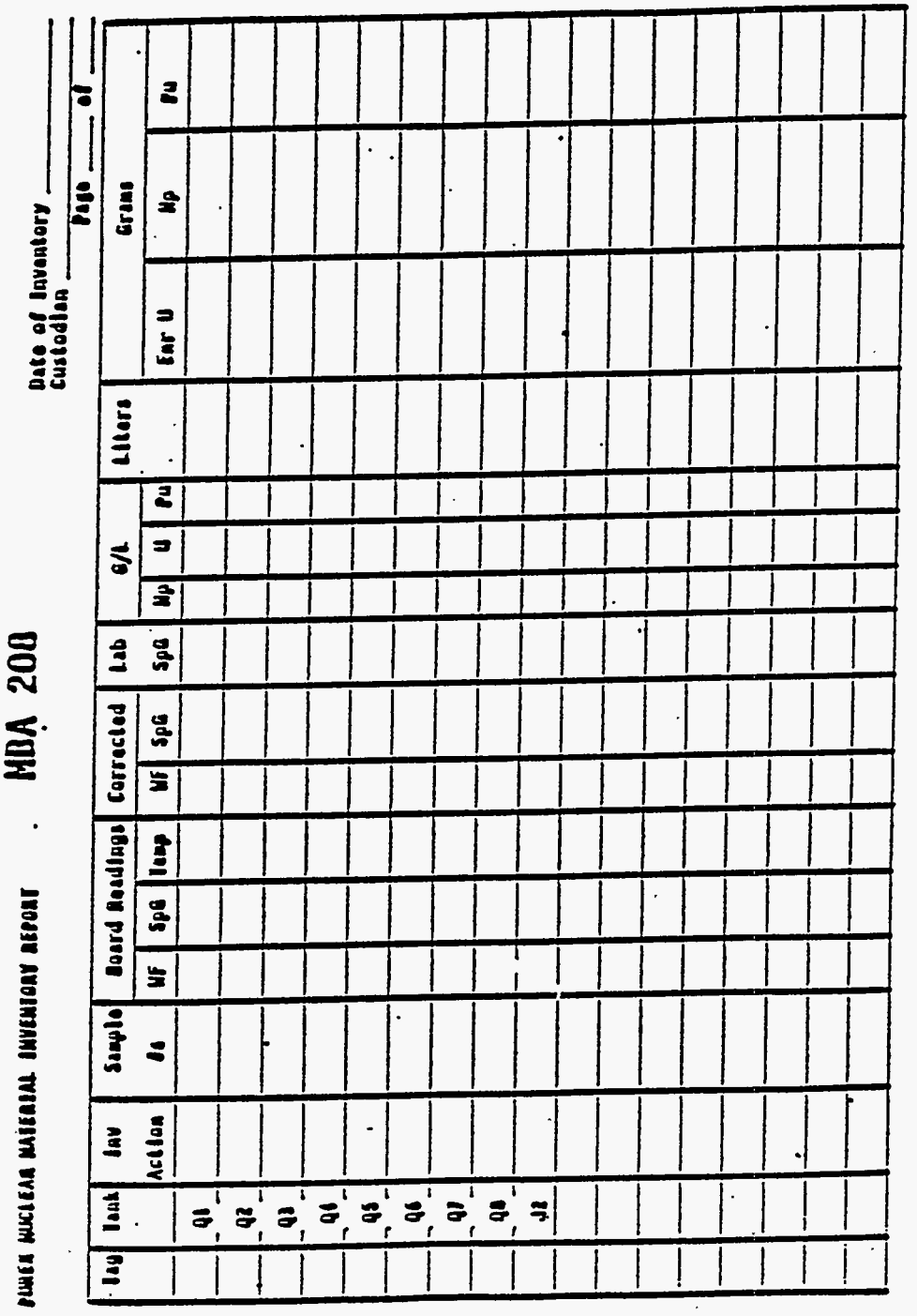


Figure 3. PUREX Nuclear Material Report.
(sheet 14 of 14)



23.	Types, form, ranges of enrichment, Pu content, ranges of quantities of nuclear material handling area:i.e.: - process area - storage area - other locations (also indicate the maximum quantities of nuclear malarial to be handed in accountability areas at one time)	- Identified storage area quantities in 18(v) - Identified process areas in 18 ii, iii, iv, v - Storage area quantities identified in 18 (v) - Process area quantities 10.2 MTU/day 0.9 to 1:25% enriched 20 Kg Pu/day

24. Recycle processes (briefly describe any such processes giving source and form of material, method of storage, normal inventory, frequency of processing, duration of temporary storage, schedules for any external recycling, and measurement methods for fissile content of recycled material)	Diagram(s) attached under Ref. Nos. - Recovered nitric acid from UO_3, - K-cell, recovered and inventory - Z plant - off spec material - redissolved N cell material through L-11 to process, Tk N50 & Tk N51 - Critical Mass Lab Material - un-concentrated Pu - P.R. Loadout room off spec Pu material. Transferred; L14 → L11 to E6 - Powder Tk N50 & Tk N51

25. Inventory	in reference flow sheet
i) In-Process (within plant and equipment during normal operation, indicate quantity, range of enrichment, Pu content, form and principal locations and any significant change in time or throughput; also indicate anticipated residual hold-up and mechanism)	covered in 18(v) Plant shut down for inventory and as much material cleaned out of dynamic systems as possible before sampling and NDA performance. At one time a dynamic inventory was tried on an experimental basis but the error was too large to be used for accountabilty. Results of these inventories was secret so data is not available. This inventory was performed by WHC-CM-5-9, Section 4.12. Inventory was accomplished by taking samples in several PUREX vessels. Weight factors and specific gravity information was obtained at the same time and all data recorded. Volumes were determined per the procedure and vessel Pu holdup determined. This data was then compared to input data from TK-D5 and output data as oxide or nitrate. Input and output were compared to determine differences.
ii) Feed and product storage	
iii) Other locations (quantity, enrichment range, Pu content, form and location of inventory not already specified)	

Supersession 25

WESTINGHOUSE
HANFORD COMPANY

PUREX/UO_3 PLANT ADMINISTRATION

MANUAL: WHC-CM-5-9
PROCEDURE NO.: 4.12
SUPERSEDES: RHO-MA-274
PX 5-044
PAGE: 1 of 8

TITLE

SOLVENT EXTRACTION DYNAMIC INVENTORY

APPROVED BY:

Manager, PUREX/UO_3 Operations — Date

A. PURPOSE

To provide an informal inventory of plutonium or neptunium in the PUREX Plant.

B. SCOPE

This procedure applies to the Solvent Extraction Material Balance Area.

C. RESPONSIBILITIES

1. Process Engineering is responsible for determining the times necessary for a dynamic inventory, requesting necessary samples, and assisting in engineering estimates to complete the inventory.

2. Production Control is responsible for performing most of the inventory calculations (excluding engineering estimates) and for determining book values.

D. PROCEDURE

ACTION BY	ACTION
PUREX Process Engineering	1. Determine when the Plant is in a condition for dynamic inventory. Notify PUREX Production Control and PUREX Operations of intent to perform a Dynamic Inventory, give date and time of the proposed inventory, and request specific samples for inventory.
PUREX Operations	2. Take requested samples, provide sample numbers per standard dispatch operations and deliver samples to PUREX Analytical Laboratory.

Question 25

ACTION BY	ACTION
PUREX Analytical Lab	3. Analyze samples per requests via standard operating procedures.
PUREX Production Control	4. Record board readings on Data Sheets I and II (Figure 1,2). Calculate book value for inventory comparison using Data Sheets III and IV (Figure 3, 4) at requested date and time. Using data provided on Data Sheets I (and II if applicable) calculate Process Tank and Column Hold Up, using H^+ Concentration and Pu Holdup (Appendix A).
PUREX Process Engineering/PUREX Production Control	5. Determine Inventory Difference (ID) of current dynamic inventory, repeat if necessary.
PUREX Process Engineering	6. Review Dynamic Inventory results and provide a report to Nuclear Materials Control. Provide report to PUREX Operations Management.

What is the why?

when necessary

E. CONCURRING APPROVALS:

Manager, Nuclear Material Control _____ Date _____

Manager, PUREX Process Engineering _____ Date _____

Manager, PUREX Analytical Laboratory _____ Date _____

Issued By: _____ Date _____
Manager, PUREX Material Planning and Control

Question 25

APPENDIX A. METHODS OF CALCULATIONS

1. Assure the following samples are taken and analyses requested. If only Pu or Np balance is to be taken, do not request nonessential samples.

Vessel - Analysis	Vessel - Analysis	Vessel - Analysis
H2 (HAP) - Pu, Np	F10 - Pu, Np	* L9 - H^+,Pu
J3 (1BYF) - Pu,Np	J1 - Pu, Np	* L11 - H^+,Pu
J5A (1BP) - Pu	K1 - Np	* E6 - H^+,Pu,Np
J5B (2AF) - Pu	K6 - Np	* J21 - Np
L3 (3AF) - Pu	K4 (2EU)- Np	* J22 (2Np)- Np
L2B (2BP) - Pu		* J23 (2PM)- Np
L5B (PSF) - Pu,H^+		**M3,4,5,6-H^+,Pu,SpG

* These tanks to be sampled only if solution is known to contain Pu or Np. If in question request status from shift management or engineering.

** M-Cell tanks to be sampled only if transfered from 203 MBA Pu Oxide to 202 MBA SX.

2. At approximately the same time the samples are taken, complete Data Sheet I or II for date, time, name, vessel weight factors, specific gravities.

3. Record sample results on Data Sheets when received in appropriate columns. (concentrations, H^+ & SpG's)

For L7 and L8 H^+ values, use last L9 Batch (from SX MBA) values. Also use Last L9 Batch Pu for L8 unless there is a noticeable SpG difference (±.08). If the difference is greater than .08, use the most recent L9 H+ and L8 SpG in equation I, below, to determine L8 concentration.

4. Determine vessel volume by dividing WF by SpG to determine a corrected weight factor (~~CWF~~) and finding the corresponding volume from the PUREX Plant Calibration Manual, TCM-P-130-00001. Convert gallons to liters by multiplication with 3.7853. Record volumes on Data Sheets I and II.

5. To determine L7 Pu concentration use latest L9 H^+ and SpG in the following formula:

$$g/l\ Pu = \frac{(SpG + .07) - 1.09 - (.087 \times H^+)}{.001274}$$

For L6 Pu concentration use L6 SpG and L5B (PSF) H^+ results in the same equation. If a negative Pu concentration occurs, request Process Engineering to provide a usable concentration.

6. Determine vessel Pu holdup by multiplying Pu concentration by volume. Record in total Pu column.

7. Return Data Sheet to Manager, Production Control. If any questions arise about concentrations/volumes, etc., request engineering assistance. Engineering should review the Data Sheet to assure all tanks have proper data.

FIGURE 4. DATA SHEET IV

Dynamic Inventory Book Value Data Sheet

Date_____ Time_____

Removals:

L-9 to M-3	_____
L-9 to M-4	_____
L-9 to M-5	_____
L-9 to M-6	_____
F-16 to UGS	_____
F-18 to UGS	_____
G8 to UGS	_____
R8 to UGS	_____
U3 to UGS	_____
U4 to UGS	_____
Laboratory	_____
Miscellaneous	_____
Nitrate Loadout	_____
Total Removals	_____

Question 25.

FIGURE 3. DATA SHEET III

Dynamic Inventory Book Value Date Sheet

Date_____ Time_____

Beginning Inventory:_____

Additions:

D-5 Actuals to Date	_____
D-5 Estimates Outstanding	_____
H.E. Sumps (to F18)	_____
N15 Rework	_____
N16 Rework	_____
N21 Rework	_____
N22 Rework	_____
N30 Rework	_____
N53 Rework	_____
Laboratory	_____
Miscellaneous	_____
Total Additions:	_____

Inventory Formulas:

1. Beginning Inventory + Additions - Removals = Ending Inventory

_____ + _____ - _____ = _____

2. Physical Inventory - Ending Inventory = Inventory Difference

_____ - _____ = _____

Question 29

SECRET WHEN FILLED IN

FIGURE 2. DATA SHEET II

DYNAMIC INVENTORY FOR NEPTUNIUM DATA SHEET

Not necessary

Backcycle Waste System

Vessel	WF	SpG	CWF	Concentration	Volume	Grams Np
TK-F10				(TK-F10)		
E-H4				(TK-J1)		
TK-J1				(TK-J1)		
Partition Cycle						
TK-J3				(1BXF)		
T-J6				(1BXP)	1436 gal	
T-J7				(1CU)	706 gal	
E-J8				(K1)		
K-Cell						
TK-K1				(K1)		
T-K2				(K1)	1052 gal	
T-K3				(2EU)	1066 gal	
E-K4				(K6)		
TK-K5				(K6)		
TK-K6				(K6)		
F-Cell						
TK-F7				(HAW)		
E-F6				(F15)		
TK-F26				(F15)		
TK-F15				(F15)		
TK-F16				(F16)		
J-Cell Package						
TK-J21				(2NF)		
T-J22				(2NF)	**	
T-J23				(2PN)	**	

	J21 Volume	J23 Volume
** Phase I	65.1 gal	23.1 gal
II	51.1 gal	32.2 gal
III	67.7 gal	34.3 gal

Question 25

SECRET WHEN FILLED IN

FIGURE 1. DATA SHEET I
Dynamic Inventory for Plutonium
Solvent Extraction MBA

Conducted Date____ Time____ By_____

Process Columns

Board Data			Lab Data			Pu Holdup
Vessel	Volume (l)		Sample Pt.	Sample #	Pu conc	
J3/4	421.6	507 425	J5A			
J6	302.8	626	J3B (1BXF)			
L1	145.9	165	J5A (2AF)			
L2	116.2	346	L2B (2BP)			
L4	45.9	246	L3 (3AF).			
L5	28.5	55	L5B (3BP)			

Process Tanks

Tank	W.F.	Sp. G.	Corr. W. F.	Volume (Liters)	Sample Pt.	Sample #	Lab Data Pu conc	Pu Holdup
E6					D5			
H1					D5/E6			
					T/S*			
F8					F8			
F13					F13			
F15					F15			
F16					F15/F16			
F26					HAW			
F18					F18			
G8					G8			
R8					R8			
F10					F10			
H4					J1			
J1					J1			
J3					J3(1BXF)			
J5					J5(2AF)			
L3					L3(3AF)			
Other								

* Based on Tracking Sheet used to account for recycle Pu.

L-Cell Columns/Tanks

Vessel	W. F.	Sp. G.	Corr. W. F.	Volume (Liters)	Sample Pt.	H+	Pu Conc	Pu Holdup
L6					(PSF)*			
L7					(L9) *			
L8					(L9) *			
L11					(L11)			
L9					(L9)			

Question 25

Internal Letter

Rockwell International

Date April 3, 1985

MCI 65940-85-172

TO: (Name Organization Internal Address)
J. H. Ellis, Ass't. Mgr.
PUREX Operations Dept.
202A/200E

FROM (Name Organization Internal Address Phone)
M. B. Enghusen, Adv. Eng.
PUREX Process Engineering
202A/MO-023/200E
3-1207

Subject. Dynamic Inventories of Solvent Extraction

Three dynamic inventories of solvent extraction material balance area were completed. The results of these inventories are given in Tables I, II and III.

The dynamic inventory involves using plant operating data to estimate vessel plutonium holdup. The inventory is conducted only after solvent extraction has been operating on non Pu bearing (cold) feed for at least 24 hours. This minimized the Pu holdup in SX. The L-Cell vessels should contain the majority of Pu, about 85 & 90%, in tanks L6, L7, L8 and L9. Estimates of other Pu holdups are based upon known correlations.

The first dynamic inventory was conducted in February during a period when solvent extraction was on cold feed for more than 36 hours. Some material had been transferred at the time of the inventory which was accounted for prior to SX processing. The results of the inventory is given in Table I.

The second inventory was conducted March 18 after 36 hours of cold operation. Some complications were incurred when a Tank D5 to Tank E6 transfer of Pu material was made during the inventory. Book values of this transfer were used to determine E6 and H1 Pu content with an assumption that no Pu had gone through H2 column. The readings for the tanks were taken on graveyard shift and graveyard routine samples were used for analysis. The results of the second inventory is shown in Figure II.

The third inventory was conducted March 25 following 46 hours of cold feed operation. This inventory again used graveyard sample analysis and vessel readings. Two N-Cell to Tank E6 transfers of about 3200 grams Pu were made prior to the inventory which required estimation of separation, co-decontamination and some L-Cell columns Pu content. The result is shown in Table III.

Question 26

Rockwell International

Dynamic inventories of solvent extraction requires coordination of process operation and data accumulation to reduce error. Engineering will define the equations, samples and techniques required to estimate the physical inventory. Operations will need to define how the book and physical inventory will be coordinated.

M. B. Enghusen, Adv. Engineer
PUREX Process Engineering

MBE/srr

cc: G. E. Coulter REC
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Questions

TABLE I

SOLVENT EXTRACTION FOR FEBRUARY 21, 1985

Tank	Pu
E6	2,040
J1	138
F10	15
J3	20
J5	5
L3	2
L6	1,363
L7	2,346
L8	3,556
L9	6,260
Total Pu	15,745

Question 25

TABLE II

SOLVENT EXTRACTION INVENTORY FOR 3-18-85

NOTE: Solvent Extraction has been running on cold feed for more than 24 hours.

Tank	WF	SpG	H+	Volume(l)	PuConc	Pu
E6 + H1*	-	-	-	-	-	7,005
J3	25	0.88	-	6094	-	8.73
J5	45	1.09	-	901	.006	5.4
L3	39	1.03	-	216.5	.09	19.5
L5		234 lit. x 20% x 10.94 g/l =				19.5
L6	Full	1.15	2.96	53	43.9***	2,330
L7	Full	1.52 + .09**	11.01	35	202.78***	7,097
L8	25	1.68	11.01	12.3	329.4	4,051
L9	75	1.68	-	32.6	329.4	10,738
					Total Pu	31,767

NOTES

Basis: Samples as of 3-18-85, 0100 except L3 (1600 3-17-85)

* Based upon L11 to E6 and D5 to E6 Data Sheets

** Using 0.9 as a bias correction due to operating effects on SpG reading.

*** Using g/l $^{1}Pu = \frac{SpG-1 - (.031 \times M\ HNO_3)}{.001325}$

.001325 calculated from 84 M-Cell .ample data.

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TABLE III

SOLVENT EXTRACTION INVENTORY FOR 3-25-85

NOTE: Solvent Extraction has been running on cold feed for more than 24 hours.

Tank	WF	SpG	Vol	H+	Conc	Total Pu
E6	39.5	1.49	2475	-	.2058	1,928
H1	33	1.55	1907	-	.086	641
J3	33	.89	8024		.0243	195
1BX	= 1600 gal. x 80% x .09 g/l =					436
1BS	= 131 gal. x 80% x .09 g/l =					36
2A	= 133 gal. x 20% x .309 g/l =					31
2B	= 118 gal. x 80% x .309 g/l =					138
3A	= 36.6 gal. x 20% x 2.002 g/l =					35
					Sub Total Pu =	3,460

Tank	WF	SpG	Vol(l)	H+	Conc	Total Pu
J5	40	1.10	792 l	-	.0902	71.
L3	48	1.03	267	-	.309	83
L5		114 gal. x 80%		-	2.002	183
L6	63	1.19	42.1	.679	127.5	5,347
L7	.74	1.57	33.3	16.55	183.4	6,106
L8	42	1.68	20.1	-	336.2	6,758
L9	2	1.72	2.2	10.55	336.2	740
J1	34.5	1.23	10,050	-	.00152	15
					Total Pu =	22,763

Basis: Samples as of 3/25/85 0100.

26. Containers, packaging and storage area descriptions	Drawing(s) attached under ref. Nos. Separate note to be attached describing for feeds, products and wastes the size and type of containers and packaging used; method of storage including fuel element locations, handling equipment and its capabilities; any special identification features. reference description from the PUREX Tech Manual of: cans of oxide cans of Pu UO_3 describe outside storage tanks for UNH.

Each of the hand wands consists of a length of vacuum hose and a manual shut-off valve. The wand is used to clean surfaces inside the dry gloveboxes.

The vacuum cleaning system is designed for a minimum air velocity of 4,400 ft/min to ensure entrainment of the powder until separation at the cyclones. To achieve this velocity, the blower provides 18 ft^3/min at a vacuum of 30 in. of water. Blower suction pressure gauges and orifice flowmeters are provided for verification of system performance.

Separation of powder from the air stream is performed by two stages of cyclone separators and a blowback filter. The blowback filter has three sintered metal elements and a blowback system similar to the calciner off-gas filter (F-N18) discussed in Section 3.4.2. Powder falling from the cyclones and blowback filter is collected in sightglasses and unloaded in the same way as the oversize scrap collector (see Section 3.5.1). Final air cleaning is accomplished by two stages of HEPA filtration before discharge to the primary canning glovebox.

3.6 CAN HANDLING

Product canning starts in the primary canning glovebox and is completed in the secondary canning glovebox. If the product meets specification, the powder is triple-canned, sealed, and placed in DOT-6M shipping containers for shipment to 2736-Z Storage Facility in the 200 West Area. If the product needs rework, it is single canned, sealed, and returned to the calciners or the Rework Facility.

3.6.1 Primary Canning

The product canning system consists of a can conveyor and an air cylinder to raise and hold the can to the can-filling head at the can filling station in the N4 Glovebox. A blender filled with powder must be in place at the can fill station with the slide valves open.

The primary product can (holding ~1,500 gm) is 3 1/2 in. diameter by 5 1/2 in. high, constructed of steel with tin plating; a 3 1/2 by 3 1/2 in. high product can (holding ~900 gm) is also available. The can and lid are precleaned and marked with an identification number prior to introduction into the primary canning glovebox through a sphincter seal. The empty can and lid are weighed together (can weight) using the Product Loadout Balance (described below). The lid is removed and the can is manually set in the can-holder and conveyed to the can fill station (in the N4 Glovebox) by a screw conveyor. At the can filling station, the can is raised by an air piston to mate with the can-filling head.

The can is filled with powder (by pressing a button on the can fill control panel) using a chevron valve and vibrator. The vibrator operates for about 30 s to fill the can with powder. The vibration time can be changed to fill different sizes of slip-lid cans. After the can is filled, the vibrator stops and the chevron valve automatically closes. The filled can is then lowered by the air piston and is transported back to the primary canning glovebox on the screw conveyor.

After the conveyor carries the filled can to the primary canning glovebox, the lid is placed on the can and tape is applied around the rim of the lid to seal the lid on the can. The filled can is manually removed from the can holder and weighed to obtain the net product weight. The taped can is then pushed into a horizontal 4 in. diameter tube between the primary canning glovebox and the bagging glovebox. This tube is used for sealing the cans in plastic bags.

3.6.2 Bag Sealing

The taped product cans enter the bagging glovebox via a horizontal (4-in. diameter) tube enveloped by a polyethylene plastic bag. A can is manually pushed through the chute into the plastic bag against the sealed end. The can entering the bagging glovebox is thus inside the plastic bag. The can is then sealed in the bag using a manually operated bag sealer consisting of heated scissor-acting jaws providing a 1/2-in. wide melt strip.

The bag sealer heat, dwell (cooling time), and jaw pressure are adjustable. The cutter is a warm wire unit that cuts through the middle of the melted seal zone, leaving a 1/4-in. wide seal on either side. The sealed ends are taped to reinforce the seal. The sealed end remaining on the sleeve acts as the bag end for the next can. Care must be taken in performing bag sealing to prevent contamination spread to the outside of the bag or the glovebox. The plastic bag is manually replaced as needed.

The sealed can is surveyed for contamination and placed in a 4 1/16-in. diameter by 6 1/2-in. high overpack can, and transported by a horizontal conveyor to the secondary canning glovebox.

3.6.3 Secondary Canning

In the secondary glovebox the overpack can is sealed with a can sealing machine, and placed in a 4-1/4-in. by 7-in. can. This can is sealed with a second can sealing machine. The can sealing machines are simple commercial canning units. The can is positioned under the seaming head by clamping rollers. When the seam has been rolled, the sealed can is weighed (gross weight), surveyed, labeled, and removed for placement in a DOT-6M shipping container.

3.6.4 Weighing and Labeling

The Product Loadout Balance System is used to weigh the plutonium oxide during packaging. The system consists of two precision balances, a microcomputer, two data printers, and two terminals (see Figure 3-3). The first balance (Scale No. 1), located in the primary canning glovebox, is used to weigh the empty and filled slip-lid can. The second balance (Scale No. 2), located in the secondary glovebox, weighs the can with overpack cans. Terminal No. 1 (with Printer No. 1) controls Scale No. 1 and Terminal No. 2 (with Printer No. 2) controls Scale No. 2. The operator performs the weighing sequence using the terminals to control the data input. Terminal printouts are given to the plutonium accountability group, who monitors shipments leaving the PUREX Plant. A printed label filled out by the operator is used to label the outer can. A tamper-sensitive security seal is also applied to the outer can.

3.6.4.1 Loadout Balance Operation. When not in use, both terminals will display "READY" and the date and time. Data may be entered from either Station No. 1 or No. 2. The operator gains access to the system by keying any valid command followed by "RETURN" (R). All keyboard entries are terminated with (R).

After the "ENTER" key is depressed, the microcomputer responds with a request for the can identification number, while the other terminal displays "BUSY." Table 3-1 is an example of normal operation, from initial entry of a can identification to final weighing. The microcomputer always anticipates the next function to be performed and prompts the operator. Up to five can identities are allowed in the system at any one time. If five cans are in the cycle, a new can entry is not permitted.

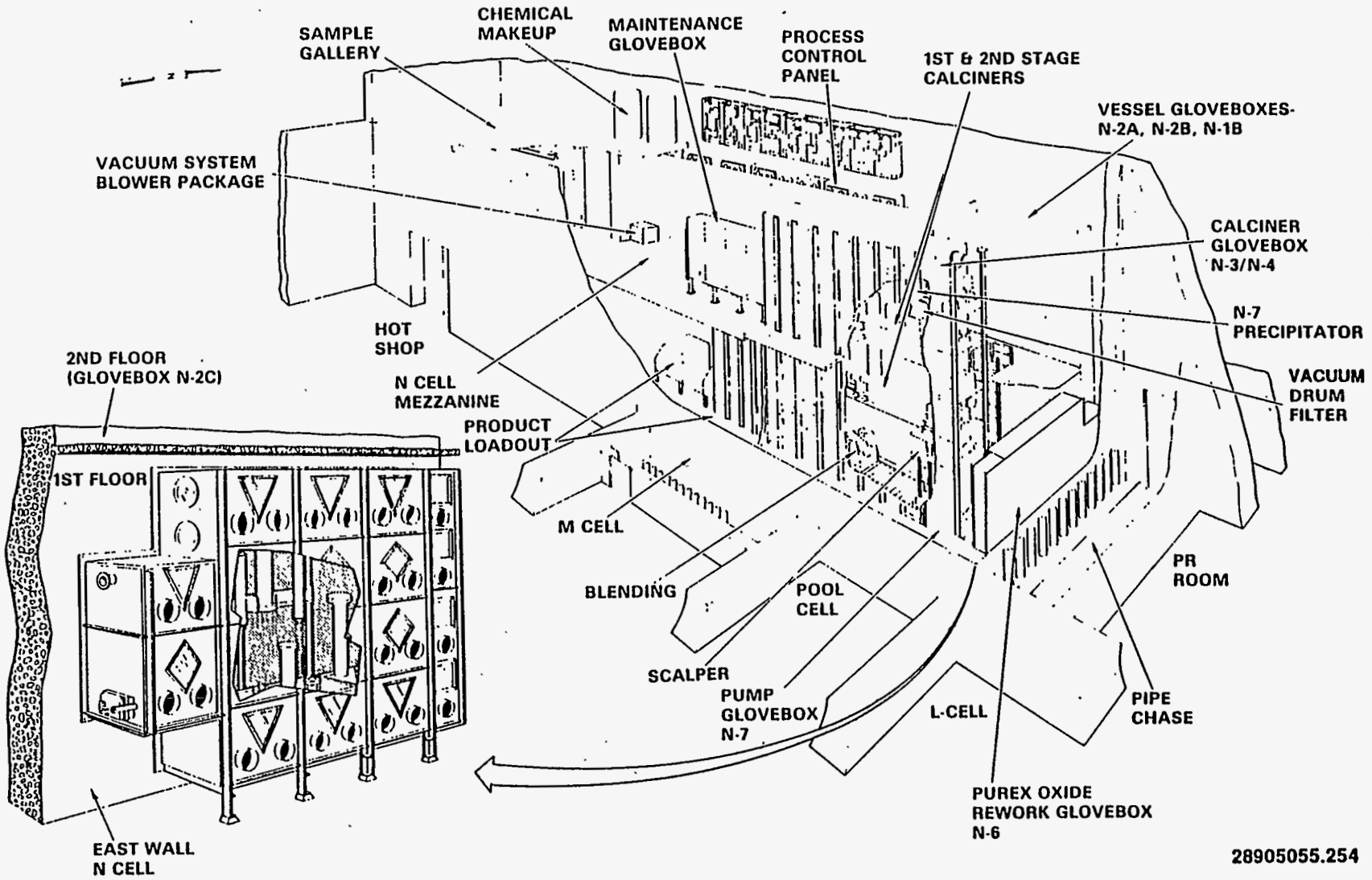

Figure 1.1-2. N Cell Showing Plutonium Oxide Production and Rework Facilities.

Question 26

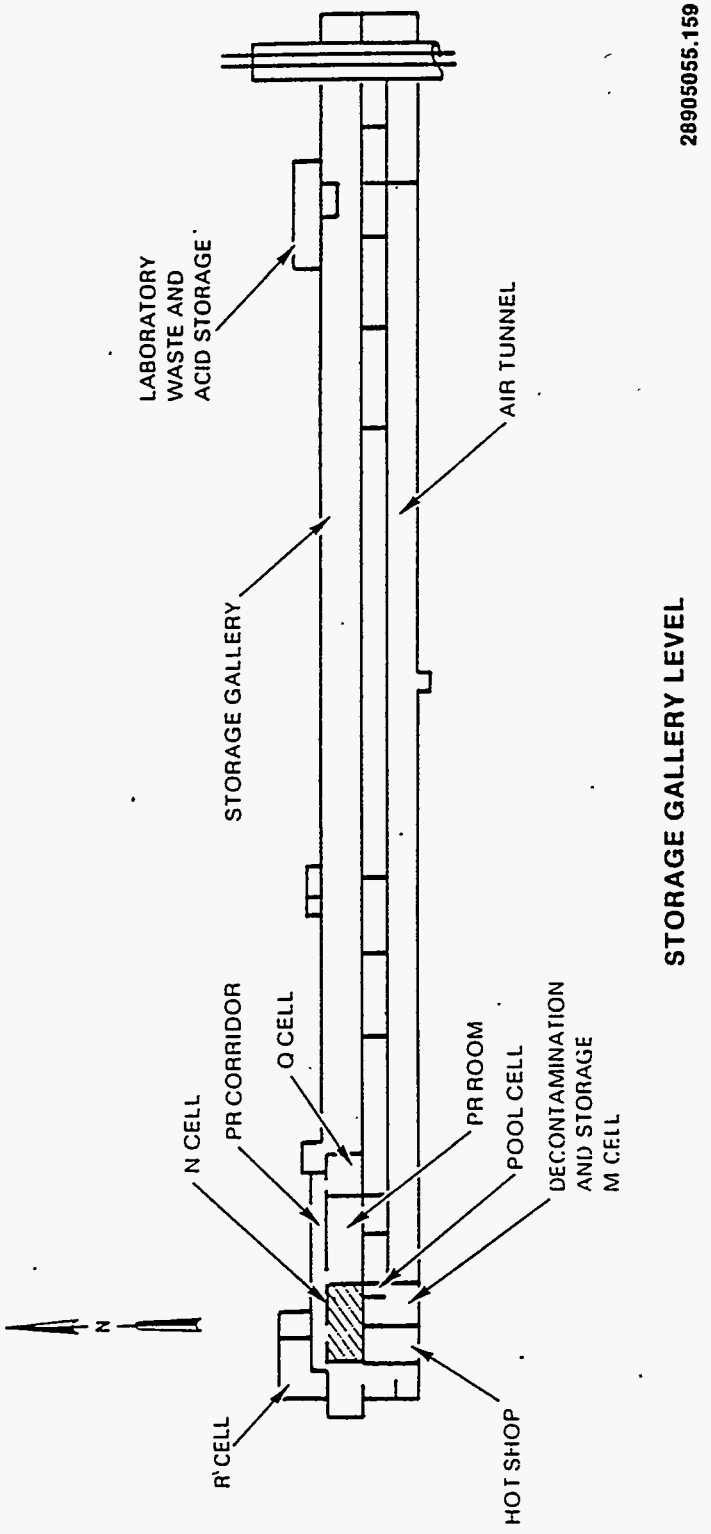

Figure 1.1-1. N Cell Location in PUREX.

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Table 2.1-1. Typical Plutonium Nitrate Specifications for Feed to the Oxalate Precipitation Process.

Chemical or property	Specifications	
Plutonium	100 to 450 g/L	
Nitric acid	2.0 to 13.0M	
^{240}Pu	Up to 12%	
^{241}Pu	Up to 2.7%	
Uranium Neptunium	Maximum 2,000 ppmp of plutonium Maximum 1,000 ppmp of plutonium	
^{95}Zr-Nb	2.8 µCi ^{95}Zr-Nb per gram plutonium	
Organic	No visible organic	
Maximum concentration of impurities (ppmp - plutonium)	Ag	100
	Al	1,500
	B	100
	Be	100
	Bi	200
	Cr	1,500
	Cu	100
	Fe	2,000
	Mn	200
	Mo	100
	Ni	500
	P	400
	Pb	100
	Si	500
	Sn	100
	Ti	500
	Zr	500
	(Ca + K + Li + Mg + Na)	12,000

PST89-3131-1

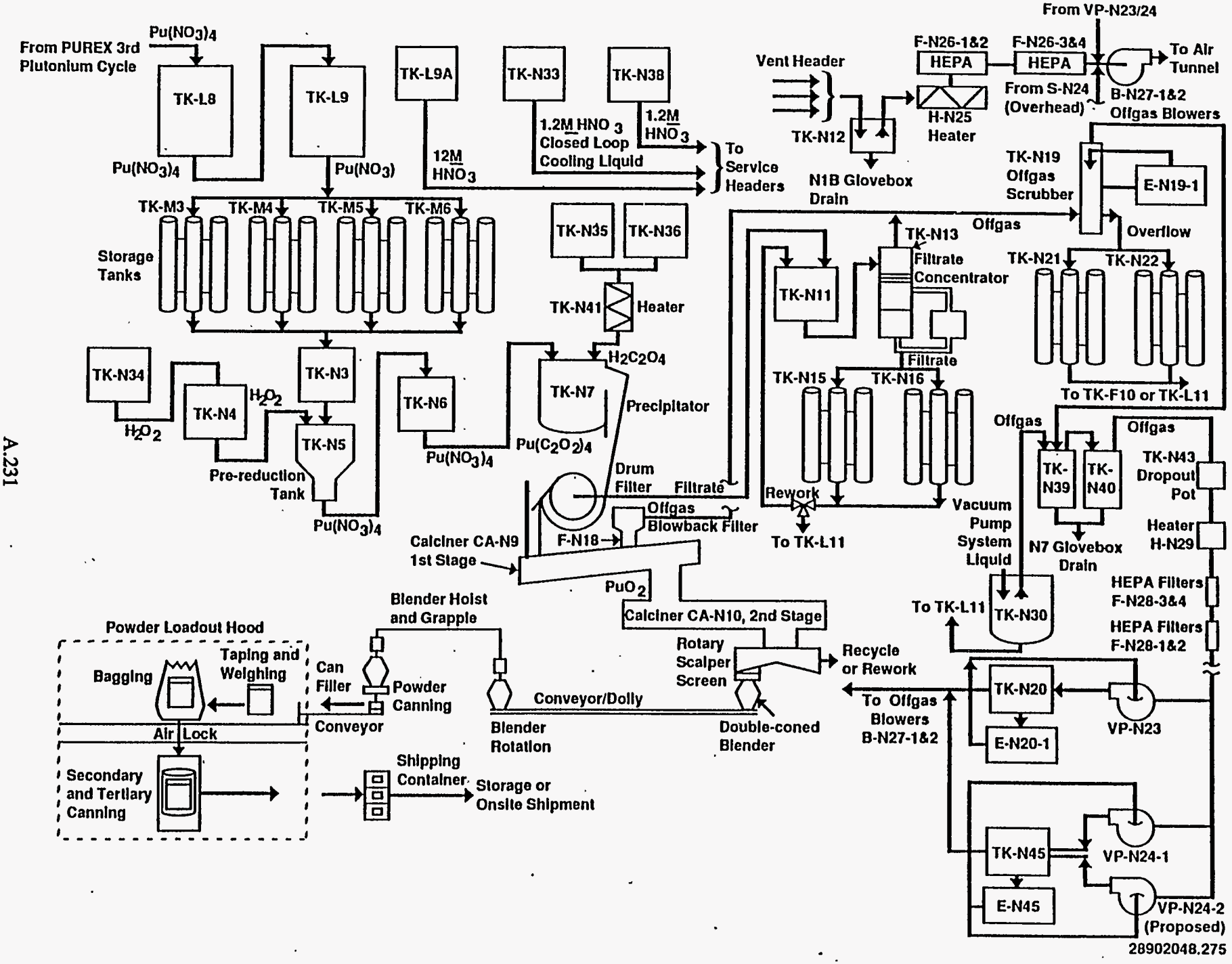

Figure 2.1-1. Oxalate Precipitation Process.

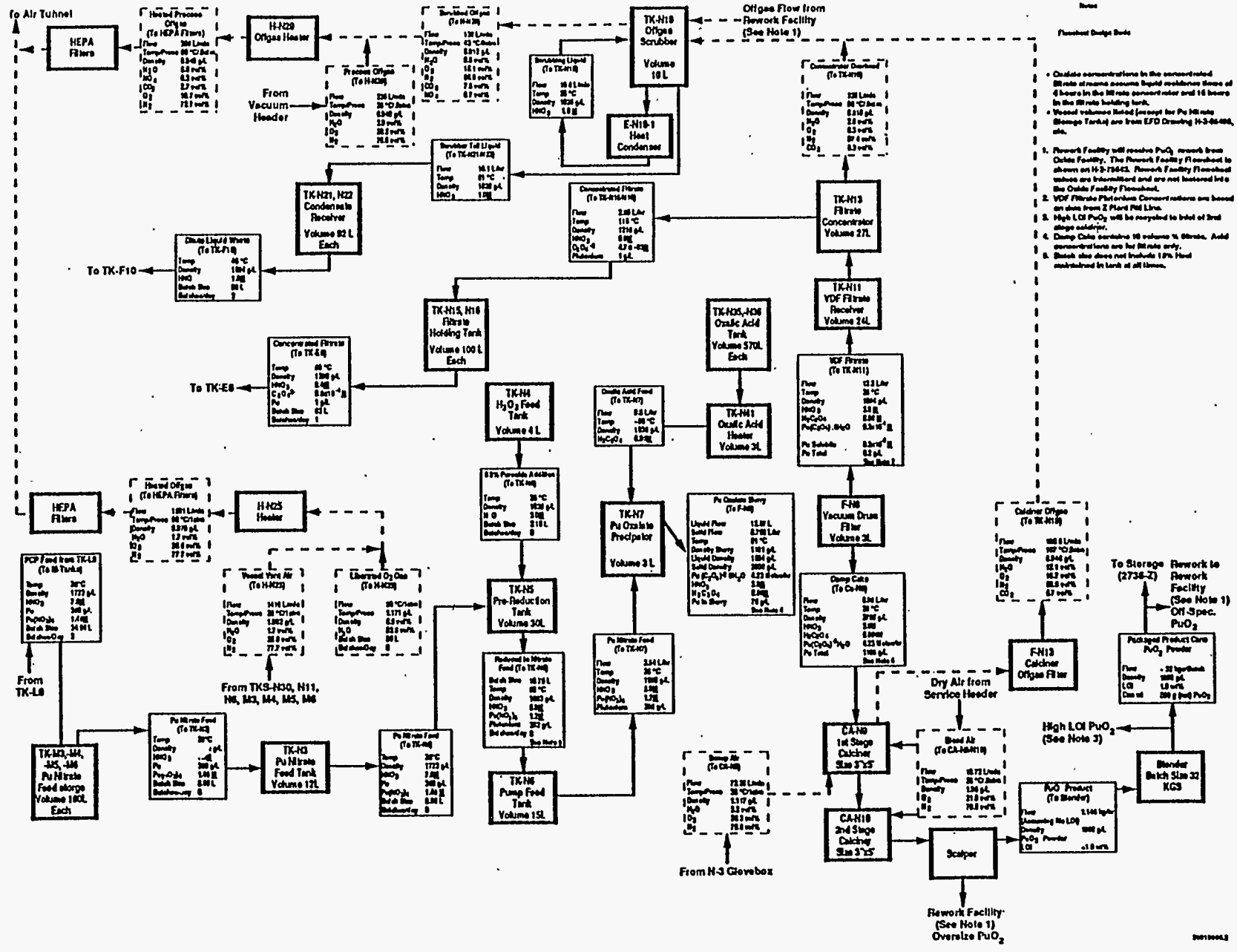

Figure 2.1-2. Plutonium Oxide Process Flowsheet.

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3.0 PROCESS DESCRIPTION

This chapter describes the operation of the Plutonium Oxide Production and Rework Facilities. Figures 3-1 and 3-2 provide an overview of the process flows for both facilities. Detailed flowsheets are provided in PUREX FLOWSHEET REPROCESSING N REACTOR FUELS (PFD-P-020-00001). Instrumentation and Engineering Flow Diagrams (IEFDs) are provided on the following drawings:

- H-2-65485 through H-2-65498 (Oxide Production - Wet Gloveboxes)
- H-2-65380 through H-2-65383 (Oxide Production - Powder Gloveboxes)
- H-2-75644 through H-2-75645 (Rework Facility).

3.1 PLUTONIUM NITRATE STORAGE - M CELL

Plutonium nitrate solution from the PUREX Third Plutonium Cycle, received in TK-L9, is transferred into one of four M Cell storage tanks (TK-M3, -M4, -M5, or -M6) for accumulation, blending, sampling, and acid adjustment. The transfer is performed by switching an MOV that places the appropriate M Cell tank under vacuum. Then the transfer MOV is opened and the solution in TK-L9 is transferred via a submerged leg. When the transfer is complete, the transfer MOV is closed and the M Cell tank is vented. The M Cell tank WF readings are taken before and after the transfer to determine the quantity of plutonium solution transferred from the solvent extraction MBA to the N Cell MBA.

The M Cell tanks provide about 10 d lag storage. The capacity of these four tanks permits flexibility in the blending and processing of PUREX plutonium nitrate. When an M Cell tank is full, the tank's recirculation pump is valved in and the tank is recirculated for at least 6 h to assure the solution is homogeneous prior to sampling.

As a safety precaution, an orifice is installed on the discharge of each of the M Cell tank pumps (P-M3-1, -M4-1, -M5-1, -M6-1) to restrict the pumping rate. This ensures that in the event of a line failure, plutonium nitrate solution will not fill the glovebox faster than the criticality drains can empty it.

The M Cell tanks are sampled for plutonium, plutonium(+6), nitric acid, and radionuclide and impurity concentrations. If nitric acid adjustment is necessary, 1.2M nitric acid can be added from TK-N38 or 12.0M nitric acid can be added from TK-L9A. Both of these tanks are located in the P&O Gallery White Room.

3.2 PRE-REDUCTION

To begin oxide line processing, the appropriate M Cell tank's pump is valved to transfer solution to plutonium feed tank TK-N3. A transfer MOV is opened and the pump is started. After a nominal 8.7-L batch is transferred to TK-N3, the pump is stopped and the transfer MOV closed.

The plutonium nitrate solution in TK-N3 is gravity transferred to pre-reduction tank (TK-N5) using a transfer MOV. To begin the pre-reduction in TK-N5, the recirculation pump (P-N5-1) is started to provide mixing, then the 9.9% to 14% hydrogen peroxide addition from TK-N4 is started.

Quantity

4.11.1 Uranium Product Handling

Uranium handling processes include storage and shipment of UNH product from PUREX Plant, receipt and rework of UNH waste from the UO_3 Plant, and receipt of nitric acid (slightly contaminated with uranium), which is recovered at the UO_3 Plant.

4.11.1.1 Uranium Product Facilities. The 203-A Facility, which is used to receive and store UNH and nitric acid, is located north of the 202-A Building. The flow diagram (Figure 4-20) illustrates the UNH storage area equipment and process routes. There is a great deal of built-in solution transfer flexibility in the UNH storage area. Valve manifolds provide for receiving product in any tank, transferring to PUREX from any tank, transferring to the shipping trailer from any tank, any tank-to-tank transfer, and "recirculating" through any tank.

Four 100,000-gal-capacity storage tanks, designated TK-P1 through -P4, together with the TK-P6 waste rework tank, permit segregation of UNH batches according to enrichment (^{235}U content) and/or product purity. All of the tanks are enclosed by concrete dikes, which control the spread of liquid spills.

Acid handling facilities for unloading nitric acid recovered from the UO_3 Plant consist of the railroad tanker unloading station, including a centrifugal pump, two 7,300-gal receiving tanks (TK-13 and -14) operated with open inlet and drain valves to maintain equal liquid levels in each vessel, a 13,800-gal storage and supply tank (TK-15), and two pumps for supplying the 202-A Building uranium oxide acid Header 7530 to TK-U5. The three tanks are located adjacent to TK-P4.

In the TK-P2 enclosure is a 14,000-gal stainless steel tank (TK-P6) for storing and concentrating UNH, and routing UNH solutions back to the process in K Cell for rework. Tank P6 is equipped with an off-gas treatment system consisting of a condenser, deentrainer, filter, and steam ejector. Condensate from TK-P6 is collected in TK-P5, and sump solutions from the basins are collected in TK-P1, also located in the TK-P2 enclosure.

The trailers used for transfer of UNH between PUREX and the UO_3 Plant are enclosed stainless steel tankers with self-contained unloading pumps. Nominal tanker capacity is 3,000 gal, but is normally loaded to ~2,800 gal. The tanker is loaded only when coupled to a tractor as the trailer landing gear was not designed to support a tanker full of UNH. A drawing of a shipping tanker, including liquid transfer lines, is shown in Figure 4-21.

4.11.1.2 Uranyl Nitrate Hexahydrate Product Storage and Shipping. The uranium product stream from PUREX solvent extraction is accumulated in TK-K6 as a solution of UNH. In composition, this solution contains 505 g/L uranium, 0.08M HNO_3, < 10 µCi ^{95}Zr-Nb/lb uranium, < 20 µCi ^{107}Ru and ^{106}Ru-Rh, and < 20 µCi/lb uranium of all other fission products except ^{99}Tc. Uranyl nitrate hexahydrate solution in storage is maintained at a temperature between 45 °C and 65 °C. Heating is necessary because the solution is about half UNH which freezes at 40 °C.

Uranyl nitrate hexahydrate solution is pumped from any of the 203-A storage tanks to semitrailer tankers for shipment to the UO_3 Plant. The loading is accomplished by pumping from a selected storage tank, through one of the pumps (P1 or P2) in the 203-A Building, to the loading dock, and from there through a flexible connector to the trailer. The loadout system provides for automatically stopping the transfer when the required batch is metered. As a backup control the transfer is automatically stopped if the liquid level becomes high enough to contact two electrodes near the top of the tanker. Standard operating procedures provide for the transfer to be stopped at a predetermined WF drop in the source storage tank.

Question 26

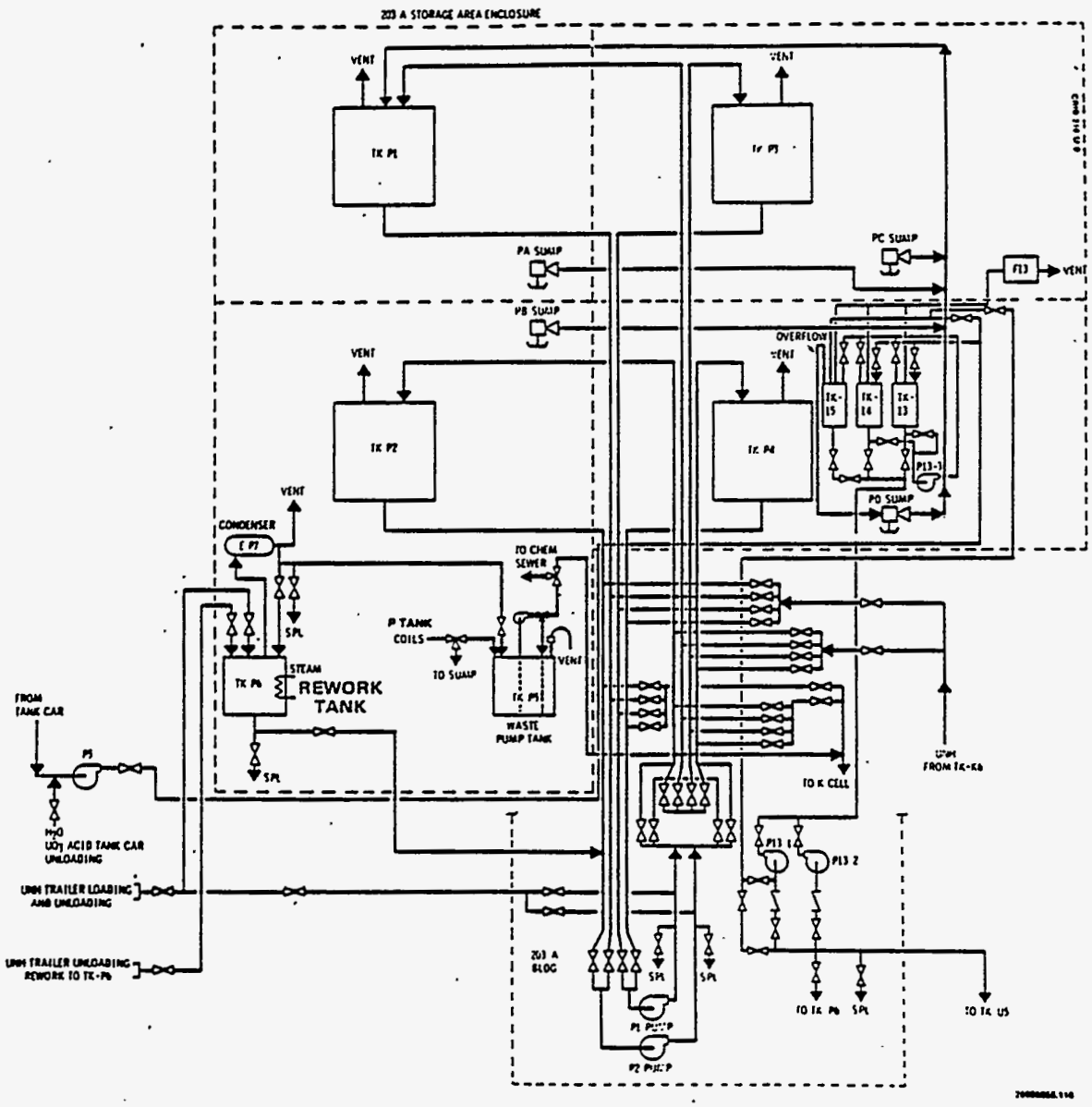


Figure 4-20. 203-A Uranyl Nitrate Hexahydrate Storage Area Process Piping and Flow Diagram.

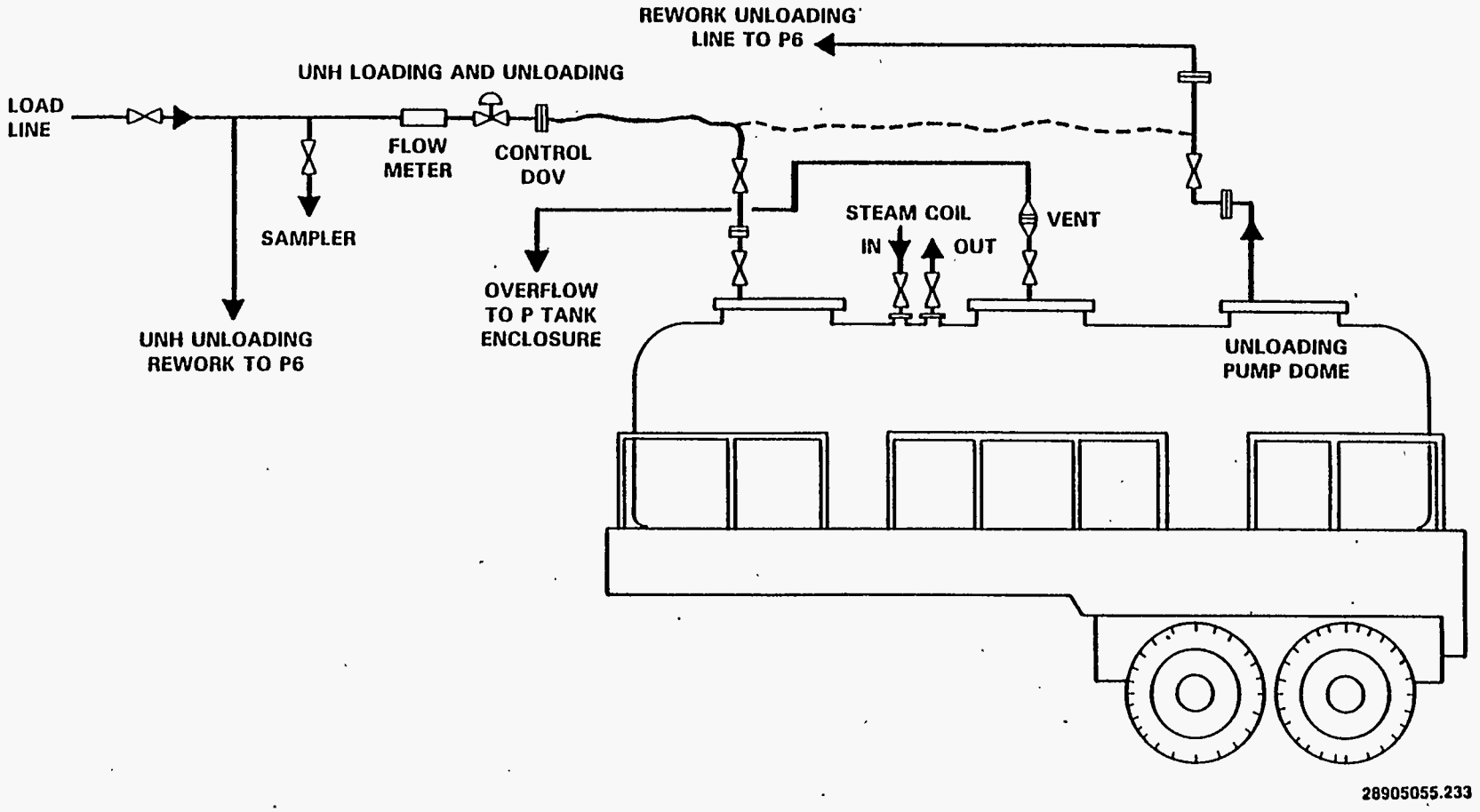


Figure 4-21. Uranyl Nitrate Hexahydrate Shipping Trailer Loading and Unloading Routes.

Question 26

A general outline of storage tank and trailer conditions that must be maintained, and the operating steps involved in loading UNH tank trailers, are as follows:

- Uranyl nitrate hexahydrate storage tank temperatures are maintained between 45 °C and 65 °C, and loading is scheduled so that the loaded trailer does not stand long enough to cool before delivery to the UO_3 Plant
- A minimum heel of 20 in. (6,500 gal) of solution is left in the storage tank when pumping out to prevent loading of organic
- The trailer hookup for UNH loading is shown in Figure 4-21. Overflow alarm circuits are tested before starting liquid transfer to the trailer
- The batch controller is set for 2,800 gal, and the pump valves are opened. The batch controller stops the pump when the transfer is complete
- A DOV controller, which regulates the flowrate, is set once the pump is started. The DOV is closed when the transfer is complete
- The trailer lines are disconnected and the vent valve is closed. The load-in well is flushed with water and drops or leaks are cleaned up.

4.11.1.3 Unloading Uranium Oxide Plant Nitric Acid and Waste. During calcination of UNH to uranium oxide at the UO_3 Plant, large quantities of gaseous nitrogen oxides are given off (about 4,450 ft^3 of gas per ton of uranium processed). These oxides are recovered as 50 wt% HNO_3 by absorption into a countercurrent water flow in a bubble-cap tower. This recovered acid, which contains about 0.03 lb U/gal, is received at the 203-A Building in railroad tank cars containing ~7,500 gal for reuse in the PUREX process.

The general procedure for unloading a tank car of recovered acid is outlined below:

- The receiving tanks (TK-13 and -14) must contain a minimum liquid level (8 to 12 in.) before unloading the car
- A stop sign is attached to the rail car and chocks are placed under the wheels
- A flex line is attached between the car nozzle and the tank manifold, and the valves listed in the appropriate operating procedures are opened
- The P5 unloading pump is primed by backfilling the line with water until fumes exit the tank car vent valve
- The P5 unloading pump is started and a manometer check of TK-13 and -14 is made
- When the car is empty, a volume material balance is made and the flex line is disconnected
- A sample of the acid is taken in TK-13 and -14 for uranium and specific gravity analyses before being recycled to the PUREX process.

Uranyl nitrate hexahydrate waste solutions collected at the UO_3 Plant are received at the 203-A Building in the trailer tankers. The UNH waste is reworked to meet process specifications, then is returned for calcination to the UO_3 Plant. The unloading operation at the 203-A Building consists of connecting a flexible unloading line to the unloading pump in the trailer dome, connecting the pump motor to the power supply cable in the unloading dock, and pumping the solution to TK-P6. The routing is shown in Figure 4-19.

When the trailer pumping is completed, the trailer is water-flushed to TK-P6, disconnected from the unloading line and closed.

The waste receiving procedure is similar to the UNH loading procedure.

- Tank P6 must contain <10,000 gal before pumping out the UNH truck
- The TK-P6 coil steam is turned off, the coil is air blown, and coil cooling water is turned on to cool TK-P6 to 70 °C
- The TK-P6 off-gas system and condenser remain in operation during the transfer with the E-P7 Condenser condensate routed to TK-P6
- Air to the TK-P6 air sparger is turned off and the WF/specific gravity readings are recorded
- A flex line connection is made between the trailer unloading pump and the receiving line to TK-P6
- The tank trailer contents are pumped to TK-P6
- The final TK-P6 WF/specific gravity readings are recorded and a volume material balance is completed
- Tank P6 temperature is adjusted to 45 °C to 65 °C unless concentration is required; air to the tank air sparger is turned on.

4.11.1.4 **Uranyl Nitrate Hexahydrate Waste Rework.** Tank P6 is used for the concentration of UO_3 Plant and 203-A Area uranium-bearing waste to the PUREX process feed specification. This tank can also be used for the vaporization and hydrolysis of organic that may be present in the uranium waste.

Tank P6 is a 14,000-gal, steam-coil heated, "oval-shaped" tank vented to the E-P7 Condenser. The E-P7 Condensate may be routed to TK-P5 via the collection tank when waste concentration is desired, or may be returned to TK-P6 as reflux.

Uranyl nitrate, which may contain emulsified process solvent, is boiled under reflux for an extended period of time prior to processing. This operation eliminates any organic present by vaporization and hydrolysis, thus removing the potential for formation of red oil. This mixture, a potentially explosive decomposition products of TBP, nitric acid, and UNH, is reactive only at temperatures above 135 °C. For this reason, there is a maximum temperature limit of 130 °C for the TK-P6 operation.

Question 26

The route for returning rework UNH to the process system for rework is an underground 3-in. pipe from the 203-A Pump Pit to a gallery wall nozzle in K Cell. In-cell and hot pipe trench connections are available to route the material to first-cycle (TK-E6) or to second-cycle feed (TK-K1). Rework UNH may be transferred to the extraction process from TK-P6 or any of the product storage tanks. Transfers to process are frequently made to provide cold feed for plant shutdown or startup, and sometimes for plutonium dilution. The necessary valves are set up by inspection, making sure that all other systems are isolated, and that no other transfer is in progress.

General guidelines for the waste concentration operation are:

- Tank P6 contents must not exceed a temperature of 130 °C and a specific gravity of 1.58 at 108 °C to prevent precipitation
- Full flow of cooling water is turned on to the condenser
- Condensate is routed to TK-P5 via the collection tank
- The tank contents are heated to boiling with steam on the TK-P6 coil
- When a specific gravity of 1.54 at 108 °C is reached, the concentrate is cooled and sampled for uranium, specific gravity, gamma scan, nitric acid, and total metallic impurity (emission spectrographic) analyses.

Uranium waste is sometimes refluxed in TK-P6 for a period of 3 wk to remove organic. The reflux operation differs from concentration in the following ways:

- The condensate is refluxed totally to TK-P6
- Liquid level and specific gravity will normally remain constant
- Tank P6 contents are sampled for uranium, nitric acid, and visual (organic detection) analyses after 1 wk.

The tank contents are then cooled to 45 °C before transfer to either TK-K1 or -E6, and the air sparger is turned off.

4.11.1.5 Uranium Product Handling Safety. Compared to the upstream process systems in PUREX, the 203-A Facility processing is relatively simple. The UNH and recovered acid handled in this facility are sufficiently decontaminated to permit contact operation of the equipment. However, both streams are corrosive, mildly radioactive liquids that must be confined in tanks and transfer lines.

In addition to the potential hazards of chemical burns, thermal burns from steam and hot liquids, and radioactive contamination, there are other items to consider during UNH trailer loading:

- Care should be taken to prevent falls when climbing and working on the trailer catwalk
- In the event of a UNH spill on the loading pad, the liquid must be returned via the pad sump pump

- A tank may be loaded only when coupled to a tractor. The trailer landing gear is not designed to support a tanker of UNH

- The normal minimum heel in a UNH storage tank is 20 in. Heel solutions are recirculated and sampled to determine if separable organic is present prior to loading to the trailer to reduce the risk of transferring organics to the UO_3 Plant concentrators. A second sample from the loaded trailer is also inspected for organic.

In addition to previously mentioned safety aspects of UO_3 Plant acid unloading, safety measures must be taken when a railroad car is positioned for unloading:

- The car wheels must be chocked

- The car must be marked with a rail-mounted sign between the car and the railroad gate to the north.

The chocks and sign must remain in place as long as the unloading line is connected to the car, or as long as personnel are working on or around the car.

4.11.2 Plutonium Product Handling

Concentrated plutonium nitrate product from the Third Plutonium Cycle is routed to the PR Room, which contains specially designed vessels for nuclear safety. In the PR Room, the product is sampled to assay the solution before transferring it to the Plutonium Oxide Production Facility or, alternatively, the product solution may be loaded out into plutonium containers. Plutonium-bearing liquids are routed to the PR Room for rework through solvent extraction.

4.11.2.1 Product Removal Room Facilities. The flow diagram, Figure 4-22, illustrates the PR Room equipment, but more detailed equipment descriptions are given in Chapter 3.0. A concentrated product solution of plutonium nitrate is received in the PR Room from the Third Plutonium Cycle product receiver (TK-L8). There is a product receiving and sample tank in the PR Room glovebox. Originally, two identical horizontal cylindrical vessels of 14-gal (53 L) capacity were installed. One (TK-L9) has been replaced with a 10.5-gal tank constructed of three 5-in. diameter vertical cylinders connected together at the top and bottom by crossover pipes, and equipped with an improved system for blending, sampling, and measuring solutions. The other (TK-L10) has been removed.

Tank L11, a 25-gal-capacity (95-L), 3-cylinder vessel, has a dual function. Tank L11 is operated as a vacuum receiver for the jet and pump used in TK-L8 and PR Room vacuum transfers and also serves as a sump waste and rework receiver. Normally vacuum pump VP-N23 (or VP-N24), associated with the Plutonium Oxide Production Facility, will provide the vacuum source for PR Room transfers through TK-L11. A backup motive steam jet is also available in the L11 Glovebox in the event that the vacuum pump is out of service. The jet discharges into a water-cooled condenser (E-L12) where the jet stream is condensed and the condensate is routed to the backcycle decanter (TK-F10).

Another jet is routinely used for liquid transfers to TK-E6. The jet motive fluid can be either 3AS solution from TK-211, via the pump at TK-151, or a cadmium nitrate solution from TK-151. Because of a criticality prevention specification resulting from using the wrong solution, cadmium nitrate is normally used for all TK-L11 to TK-E6 transfers. Rework sampling is accomplished by pumping solution out of TK-L11, recirculating it through a three-way valve, and returning it to the top of the

27.	Methods and means of transfer of nuclear material (describe also equipment used for handling of feed, product and waste)	Process for loading dissolver equip - test manual section 3 and 4 - dissolver charging procedure Refer to answers to questions 13, 14, 15, and 26 for more information on processes. UNH → storage Pu → PuO_2 → cans addendum #1 of Tech Manual Waste - measured in all points

28. Transportation routes followed by nuclear material (with reference to plant layout)	Diagram(s) attached under ref. nos Reference PUREX Tech Manual diagrams: Routes from N reactor to PUREX. Fuel casks are brought in on rail cars from reactor areas and moved into the PUREX tunnel. Oxide → Z plant. Oxide or Pu Nitrate is loaded into cans and drums and transported by truck to Z plant. During operating days shipments were guarded and the times of transfer kept secret. Waste to waste tanks in tank farms. Wastes transferred by standart operating procedures and sampled for accountability before transfer. Solid wastes in drums, burial boxes, or placed on railroad cars in PUREX burial tunnel

29. Shielding (for storage and transfer)	Reference plant design description Refer to questions 13 and 14 for a description of shielding and overall plant design information which covers storage of material. Refer to question 26 for UNH and Pu Nitrate storage along with filling of Pu Oxide cans. Pu Nitrate and Pu Oxide are loaded into containers which are suspended by spiders in drums. These packages become the shielded transfer containers for transfer to Z Plant. Question 26 includes a discussion of the UNH tanker which is used to transfer solution to the UO_3 Plant and that becomes the uranium solution's shielded container. Further descriptions of packaging for shipment can be found in PUREX Operating Procedures.

30. Maintenance, Decontamination, Clean-out	Separate note to be attached describing plans and procedures for decontamination and clean-out of equipment containing nuclear material, defining all sampling and measurement points associated with: i) normal plant maintenance; ii) plant and equipment decontamination and subsequent nuclear material recovery; iii) plant and equipment clean-out including means of ensuring vessels are empty; iv) plant start-up and plant shut-down (if different from normal operation) (In cases where clean-out and/or sampling is not possible, indicate how the hold-up of nuclear material is measured or calculated.) Procedures to support normal plant maintenance are considered one time procedures and are separated from the normal operating procedures. This includes operations procedures to support normal plant maintenance, plant and equipment decontamination and nuclear material recovery and any clean out procedures used. Independent operations and maintenance procedures are written for these operations. Work for non-routine and maintenance items is controlled by Job Control System and Work Plans. Both are described in WHC-CM-5-9 manual. That manual can be referred to for further information on these items. Decontamination for infrequent operations handled in the same manner. Overall plant decontamination will be handled by a separate organization.

31.	Basic measures for physical protection of nuclear material	DOE orders

32. Specific health and safety rules for inspector compliance (If extensive, attach separately)	DOE orders Inspectors provided with training & briefings as necessary

33. System Description Give a description of the nuclear material accountancy system, the method of recording and reporting accountancy data and establishing material balances, frequency of material balances, procedures for account adjustment after plant inventory. mistakes, etc. under the following headings: 33. i) General (This section should also state what general and subsidiary ledgers will be used, their form (hard copies, tapes, microfilms, etc.) as well as who has the responsibility and authority. Source data (e.g. shipping and receiving forms, the initial recording of measurements and measurement control sheets) should be identified. The procedures for making adjustments, the source data and records should be video taped as well as how the adjustments are authorized and substantiated.)	Specimen forms used in all procedures attached under ref. nos. Nuclear Accountability Procedures are used to designate parameters. These procedures have been discussed under question 26 and that question can be referred to for further information. Controlling procedures for PUREX are as follows: - WHC-CM-5-9, Section 4.11, PUREX Nuclear Materials Inventory. - WHC-CM-5-9, Section 4.7, PUREX Nuclear Material Control. - PUREX Procedure PO-020-19, Shut Down Solvent Extraction for Inventory. - Adjustments to inventory by Safeguards procedures. (Tom Ellis or Aldie Riddell) Accountability of PUREX MBAs is recorded in PUREX perpetual inventory books-handwritten and hard copies-m,aintained by PUREX Nuclear Materials Control Specialist. Derived from tracking of Irradiated Nuclear Material Control Forms. Nuclear Material Item Transfer Forms and Liquid Transfer Forms. Data gathered from transfer data sheets attached to plant operating procedures for the transfers.

System Description Continued	
33. i) General continued	

System Description continued	
33. ii) Receipts (including method of dealing with shipper/receiver differences and subsequent account corrections, the checks and measurements used to confirm nuclear material content and persons responsible for these determinations should be defined).	1. Quantities of nuclear materials in fuel assemblies are assigned by reactor operator from calculations based on fuel irradiation history 2. Receipt geared on combined measurements in - D5 accountability - D2 declad rinse solution - E5 cladding waste Differences evaluated on a cumulative basis by PUREX MC&A supervision (RBI concept)

33. iii) Shipments (products, waste, measured discards)	a) Uranium product K tanks to P tank (P tanks in UO_3 plant MBA): Volume check transfer from K tank to P tank. Evaluated by PUREX operators (at time of transfer) and PUREX MC&A supervisor). Cold uranium can be returned to system via E6 to accept recycle material from L11 or for startup on cold feed. Reference PO-230-019, Prepare and Handle Feed. b) PuO_2 cans check weighed at receipt at Z plant Pu Nitrate cans check weighed at receipt at Z plant S-R differences evaluated by respective MC&A supervisors

System Description continued	List of major items of equipment regarded as nuclear material containers attached under ref. nos
33. iv) Physical inventory Description of procedures, scheduled frequency, estimated distribution of nuclear material, methods of operator's inventory taking (both for item and/or bulk accountancy, including relevant assay method). accessibility and possible verification method for irradiated nuclear material (in particular the description of procedures should also provide the basic inventory approach to be used, i.e. planning, organizing, and conducting the inventory, relisting, use of prior measurement data; who has the primary responsibility to the inventory; how process clean-out is accomplished; the accountancy of process residual hold-up).	See procedure PO-020-019 1. Dissolver area flushed through to D5 tank (D3 & D4 empty dissolver area inspected (by video camera) for residual fuel assemblies 2. D5 flushed and transferred to H1 (feed tank) final feed transferred through first cycle fuel shut off and 500 liters solution added to H1 & sampled and measured 3. - First cycle code contamination & partition is operated on cold streams without feed until 1UC stream sample is below 5 g U/l - First cycle shut down quantities assigned bold on final stream samples and equipment measurements - Pu cycle after 2A Feed tank reaches <570 capacity 4. a) 200 liter flush solution added to 2A Feed tank (sampled), run to 57 capacity, inventoried 5. Uranium cycles - 1 CU concentrator flushed w/100 liters acid transferred to 2D Feed tank - Final U cycle operated until 2D Feed <570, 300 liter and added - Sampled, operated to 570 of 2D Feed level, 2D Feed shut down

	- Final U cycle operated on cold streams until 2EU less than 1 g/l. - Final U cycle shut down and inventory based on final stream samples and measurements 6. 2 EU concentrator flushed (after final product transfer. Flush solutions collected & measured in tank K5. K6 final product transferred to UO_3 plant 7. Pu concentrators flushed, collected and measured in L9 tanks final product transferred to M cell. Flush solutions collected in L11 tanks. 8. Acid recovery system shut down. Final quantities guard on measurements and stream samples. 9. Solvent treatment systems shut down. Inventory based on final stream samples & measurements. 10. Waste concentrating system is shut down. Final inventory quantities based on stream samples and final measurements.

Inventory Listing (after physical inventory)

DISSOLVER AREA	VOLUME	U(Kg)	Pu(g)
Dissolvers A3	empty		
B3	empty		
C3	empty		
Contaminating waste D2	2000l	<1	<1
Dissolver storage Tk D3	empty		
Dissolver storage Tk D4	empty		
Centrifuge feed Tk E3			
Centrifuge			
Counting waste Tk E5	500l	<1	<1
Z reflex product Tk E1	500l	<1	<1
E cell Ammonia Tk E3	500l	<1	<1
catch tank			
SOLVENT EXTRACTION			
Accountability Tk D5	500l	<1	<1
Feed tank Tk H1		0	0
Code contamination & Partitions			
HA column	7000l	<1	<1
1 BX column	6000l	<1	<1
1C column	3145l	<1	<1
1 Bx feed	500l	<1	<1
1UC concentrator	empty	0	0
2D feed tank	500l	<1	<1
2D column	3000l	<1	0
2E column			
2EU concentrator	empty	<1	0
Receiver Tk K5	empty	0	0
U sampler Tk K6	5000	50	0
2ND Pu CYCLE			
2A feed (Tk J5)	200l	0	20
2A column	240	0	200
2B column			
3A feed (Tk L3)	200l	0	20
3A column			
3B column			
3BP stripper L-6	empty	0	0
3BP concentrator L-7	empty	0	0
Product Receiver Tk L8	empty	0	0
Product Sample Tk L9	50	0	500
Pu Product Per Work Receiver Tk L-11	250	0	25,000

Inventory Listing (after physical inventory)

DISSOLVER AREA	VOLUME	U(Kg)	Pu(g)
WASTE CONCENTRATION			
Feed Tk F7	1000	<1	<1
Concentrator Tk E-F6-1	1000	<1	<1
1WW Receiver Tk F-26	1000	<1	<1
1WW Denitration Tk-F15	empty	0	0
1WW Denitration Tk-F16	empty	0	0
Waste Receiver Tk F-18	empty	0	0
Waste Receiver Tk F-8	5000	5	1
ACID RECOVERY			
Nitric Acid Absorber Tk F5	15000	0	0
HNO_3 Acid Receiver Tk F3	15000	0	0
AF Feed Tk U5	15000	0	0
50% Nitric and Storage	Tk U1 15000	0	0
SOLVENT RECOVERY			
Flushed		0	0
BACKCYCLE WASTE			
Flushed		0	0

33. v) Measured discards (method of estimation of quantities per year/months, method of disposal)	Wastes streams as discussed in question 19 also. Gaseous wastes based on cumulative air flow and monitors. Grab samples, verification, and composite samples available Low level waste solutions to cribs as aqueous streams. Grab samples, verification samples, and composite samples available. Aqueous streams monitored by alpha monitors. Periodic (weekly) uranium samples. Monitoring as a warning that too much is going out stream for initiating investigation of losses.

33. System Description continued vi) Retained waste (method of estimation of quantities per year; method and any/paged period of storage; indicate also possible subsequent uses of retained waste)	None other than failed large equipment items which are loaded on railroad cars after being flushed and the performance of an NDA for the determination of nuclear material present. These railroad cars are then transferred into the PUREX Storage Tunnels for indefinite long term storage.

33. vii) Unmeasured losses (indicate the methods used to estimate unmeasured losses)	None

System Description continued	
33. viii) Operational records and accounts (including logbooks, general lechers, internal transfer forms, method of adjustment or correction and retention location, and language; control measures and responsibilities for records)	1. System of internal and external transfer documents - Kept for permanent storage at Records Holding Area 2. Solvent Extraction Shift Log Books and Oxide Conversion Line Log Book - Kept on plant in PUREX records management vault. a) Nuclear Material/Item Transfer forms - discreet items b) Liquid Transfer Forms - tank to tank transfers c) Tamper Indicating Devices and Accounting forms - Seal Application and Removal Forms d) Irradiated Nuclear Material Transfer Forms 3. Instrumentation strip charts for accountability are retained for 1 year at PUREX Records Management Vault then sent to permanent storage.

34.	Features Related to Containment and Surveillance Measures (General description of applied or possible measures)	TBD for video and Pu can seals

35.	For Each Flow and Inventory Measurement and Sampling Points of accountability Areas, identified in Particular Under OS. 13, 22, 23, Give the following	D2 Declad waste (rinse) E5 (cladding waste) D5 Input Accountability Oxide to loadout Nitrate to loadout K6 U Product F16 & F18 High Level Waste U3 & U4 Lab Waste R8 & G8 Solvent Cleaning Waste Solid Waste All sample points for inventory are by batch. Sample requirements and frequency are listed in sample schedule. Other samples by request. Refer to question 14 and to PUREX Sample Schedule for further information on sampling points. In-line equipment used for process control but not for accountability.
i)	Description of location, type, identification	

35. ii) Type of inventory change expected at this measurement point	Kg U/batch g U/batch D2 Declad waste (rinse) E5 (cladding waste) D5 Input Accountability Oxide to loadout Nitrate to loadout K6 U Product F16 & F18 High level waste U3 & U4 Lab Waste R8 & G8 Solvent Cleaning Waste Solid Waste
For each sampling measurement point fill in separate sheet.	

For Each Flow and Inventory Measurement and Sampling Points of Accountability Areas, Identified in Particular Under OS. 13, 22, 23, Give the Following continued 35. iii) Possibilities to use this measurement point for physical inventory taking	All of the following points can be used for physical inventory taking: - D2 Declad waste (rinse) - E5 (cladding waste) - D5 Input Accountability - Oxide to loadout - Nitrate to loadout - K6 U Product - F16 & F18 High level waste - U3 & U4 Lab Waste - R8 & G8 Solvent Cleaning Waste - Solid Waste

35. iv) Physical and chemical form of nuclear material (including enrichment range, Pu content, and cladding materials description)	The following are all liquids except oxide and solid wastes. Refer to the referenced flow sheets (included in question 20) for the Pu and U concentrations expected in the solutions. - D2 Declad Waste (rinse) - E5 (Cladding Waste) - D5 Input Accountability - Oxide to loadout - Nitrate to loadout - K6 U Product - F16 & F18 High Level Waste - U3 & U4 Lab Waste - R8 & G8 Solvent Cleaning Waste - Solid Waste

35. v) Nuclear material containers, packaging and method of storage			
		Container	Storage
	D2 Declad Waste (rinse)	Tanks	No
	E5 (Cladding Waste)	Tank	No
	D5 Input Account -ability	Tank	No
	Oxide to loadout	Can	No
	Nitrate to loadout	Can	No
	K6 U Product	Tank	No
	F16 & F18 High level Waste	Tank	No
	U3 & U4 Lab Waste	Tank	No
	R8 & G8 Solvent Cleaning Waste	Tank	No
	Solid Waste	Tank	No

			U		Pu	
35. vii)	Measurement/analytical method(s) and equipment used, and corresponding accuracies		Method	Error	Method	Error
		D2 Declad Waste (rinse)	D/G	45%	alpha count	47%
		E5 (Cladding Waste)	D/G	45%	alpha count	67%
		D5 Input Account -ability	IDMS	0.45%	IDMS	1%
		Oxide to loadout	_____		IDMS	0.3%
		Nitrate to loadout	_____		IDMS	1.0%
		K6 U Product	D/G	0.51%	____	0.5%
		F16 & F18 High level Waste	D/G	45%	alpha count	61%
		U3 & U4 Lab Waste	D/G	25%	alpha count	40%
		R8 & G8 Solvent Cleaning Waste	D/G	45%	alpha count	67%
		Solid Waste	NDA	100%	alpha count	100%
		DG=davis gray				

For Each of Flow and Inventory Measurement and Sampling Points of Accountability Areas. Identified in Particular Under Os. 13, 22, 23, Give the following continued 35. vi) Sampling procedure and equipment used (including number of samples taken, frequency and rejection criteria)	Sampler D2 Declad Waste (rinse) Recirculating sampler E5 (Cladding Waste) Recirculating sampler D5 Input Accountability Recirculating sampler Oxide to loadout Gender grab sample Nitrate to loadout Recirculating sample K6 U Product Recirculating sample F16 & F18 High level Waste Recirculating sample U3 & U4 lab Waste Recirculating sample R8 & G8 Solvent Cleaning Waste Recirculating sample Solid Waste NDA

35. viii)	Source and level of Random and Systematic errors for feed, product, waste (weight, volume, sampling analytical)		Bulk		Samples
			random	systematic	
		D2 Declad Waste (rinse)	2.5%	2.5%	0.1%
		E5 (Cladding Waste)	2.5%	2.5%	0.1%
		D5 Input Account -ability	0.2%	0.1%	0.05%
		Oxide to loadout	0.2g	0.15g	0.1%
		Nitrate to loadout	10g	8g	0.1%
		K6 U Product	0.2%	0.1%	0.1%
		F16 & F18 High level Waste	2.5%	2.5%	0.1%
		U3 & U4 Lab Waste	2.5%	2.5%	0.1%
		R8 & G8 Solvent Cleaning Waste	2.5%	2.5%	0.1%
		Solid Waste	___	___	___

For Each Flow and Inventory Measurement and Sampling Points of Accountability Areas, identified in Particular Under Os. 13, 22. 23, Give the Following continued 35. ix) Calculative and error propagation techniques	All of the following employ standard techniques for error propagation: - D2 Declad Waste (rinse) - E5 (Cladding Waste) - D5 Input Accountability - Oxide to loadout - Nitrate to loadout - K6 U Product - F16 & F18 High level Waste - U3 & U4 Lab Waste - R8 & G8 Solvent Cleaning Waste - Solid Waste

35. x) Technique and Frequency of Calibration of Equipment used, and Standards used		Calibration Bulk	Instruments	analytical
	D2 Declad Waste (rinse)	6 years	6 months	Analytical O/C
	E5 (Cladding Waste)	6 years	6 months	daily QC checks;
	D5 Input Account -ability	3 years	3 months	monthly instruments
	Oxide to loadout	6 months	_____	calibration
	Nitrate to loadout	6 months	_____	
	K6 U Product	3 years	3 months	
	F16 & F18 High level Waste	6 years	6 months	
	U3 & U4 Lab Waste	6 years	6 months	
	R8 & G8 Solvent Cleaning Waste	6 years	6 months	
	Solid Waste	_____	_____	

35. xi) Program for the continuing appraisal of the accuracy of weight, volume, sampling and analytical techniques and measurement methods	Weight - daily checks with field weights 6 mo full calibration Volume - re-calibration as detailed in 35 X instruments as detailed in 35 X Sampling - replicate sampling program density comparison Analytical - daily standard checks
For each sampling, measurement point fill in separate sheet.	

For each Flow and Inventory Measurement and Sampling Points of Accountability Areas, Identified in Particular Under Os. 13, 22, 23, Give the following continued 35. xii) Program for statistical evaluation of data from (x) to (xi)	Standard Statistical Methods

35. xiii)	Method of converting source date to batch data (standard calculative procedures, constants and empirical relationships for feed, products in sub-accounting areas, and waste)	Calibration tables etc. to be supplied.

35. xiv)	Means of batch identification	D2 Declad Waste (rinse)	Sequential ID's (by year) D-94-1, 2, 3 etc.
		E5 (Cladding Waste)	Sequential ID's (by year) D-94-1, 2, 3 etc.
		D5 Input Accountability	Sequential ID's (by year) D-94-1, 2, 3 etc.
		Oxide to loadout	can ID's
		Nitrate to loadout	can ID's
		K6 U Product	Sequential ID's (by year) K6-94-1, 2, 3 etc.
		F16 & F18 High level Waste	Sequential ID's (by year) K6-94-1, 2, 3 etc.
		U3 & U4 Lab Waste	Sequential ID's (by year) K6-94-1, 2, 3 etc.
		R8 & G8 Solvent Cleaning Waste	Sequential ID's (by year) K6-94-1, 2, 3 etc.
		Solid Waste	Gas Code Labels

For Each Flow and Inventory Measurement and Sampling Points of Accountability Areas, Identified in Particular Under Os. 13, 22, 23, Give the following continued 35. xv) Anticipated batch flow rate per year	batches based on-	250 operating days/year
	D2 Declad Waste	250
	E5 (Cladding Waste)	125
	D5 Input Accountability	250
	Oxide to loadout	50
	Nitrate to loadout	50
	K6 U Product	250
	F16 & F18 High level Waste	33
	U3 & U4 Lab Waste	30
	R8 & G8 Solvent Cleaning Waste	10
	Solid Waste (packages	30 drums)

35. xvi)	Anticipated number of inventory batches present at measurement point	Information based dn-inventory/year D2 Declad Waste (rinse) 1 E5 (Cladding Waste) 1 D5 Input Accountability 1 Oxide to loadout 0 Nitrate to loadout 0 K6 U Product 1 F16 & F18 High level Waste 1 U3 & U4 Lab Waste 1 R8 & G8 Solvent Cleaning Waste 1 Solid Waste 0

35. xvii)	Anticipated number of items per flow and inventory batches	D2 Declad Waste (rinse)	1 tank
		E5 (Cladding Waste)	1 tank
		D5 Input Accountability	1 tank
		Oxide to loadout	10 cans per Gender
		Nitrate to loadout	30 cans per tank
		K6 U Product	1 tank
		F16 & F18 High level Waste	1 tank
		U3 & U4 Lab Waste	1 tank
		R8 & G8 Solvent Cleaning Waste	1 tank
		Solid Waste	1 package

35. xviii) Type, composition and quantity of nuclear material per batch (with indication for batch data, total weight of each element of nuclear material and form of nuclear material)	Types of material mentioned previously. Amounts can be based on referenced flow sheet and taking into consideration the amount of batches. D2 Declad Waste (rinse) E5 (Cladding Waste) D5 Input Accountability Oxide to loadout Nitrate to loadout K6 U Product F16 & F18 High level Waste U3 & U4 Lab Waste R8 & G8 Solvent Cleaning Waste Solid Waste

For Each Flow and Inventory Measurement and Sampling Points of Accountability Areas, Identified in Particular Under Qs. 13, 22, 23, Give the following continued 35 xix) Features related to containment-surveillance measures	None

36. Overall Limit of Error Describe procedure to combine individual measurement error measurements to obtain the overall limit of error for: i) S/R Differences ii) Book Inventory iii) Physical Inventory iv) MUF	I) Shipper/Receiver differences are at the same point so are assumed to be zero. II) Book inventory. Differences tracked and monitored. III) Physical Inventory. Solutions moved around and vessels flushed. Operations shut down and tanks sampled. NDA performed and used to compare to input and previous inventories to determine discrepancies. IV) MUF-Material amount kept track of. It has been known to show up in later inventories or when special flushes or cleanouts performed.
For each sampling, measurement point fill in separate sheet.	

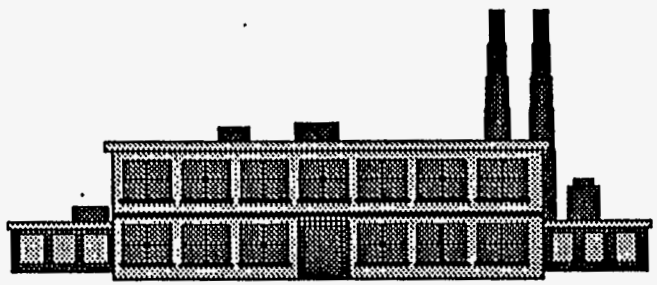
37. Optional Information (that the operator considers relevant to safeguarding the facility)	

Appendix B

Design Information Questionnaire (DIQ) Presentation

Purex Inspection Exercise
DIQ Presentation

- PUREX is the example facility
- Using an operating scenario (to start)
  - Others are subsets of the operating scenario
  - Actual PUREX capabilities (to the extent possible)
- Explore:
  - how much effort is involved
  - what information is available
  - sensitivity of information
  - etc.



The DIQ Form

- 37 Questions
- provide sufficient information for Agency to plan for inspection requirements
- describe general plant for safeguards.
- we will describe the answers to each question in this presentation

Questions 1-6

- 1. Name of facility
  - PUREX
- 2. Location and Postal Address
  - somewhere in the east Washington desert
- 3. Owner
  - Josh Segal - for these three days anyway
- 4. Operator
  - Guido Bailey and the boys
- 5. Description
  - A monument to days gone by
- 6. Purpose
  - an open question to say the least

Question 7 Status:

- planned?
- under construction?
- in operation?
  - decomissioning is not given as an option!

Questions 8-9

- 8. Construction Schedule
  - if not in operation
- 9. Normal Operating Mode
  - 3 shifts per day
  - 7 days per week
  - 250 operating days per year
    - » three shift operation during shutdown

Question 10
Facility Layout

- Structured containment, fences, access, nuclear material storage areas, laboratories, waste disposal areas, routes followed by nuclear material, experimental and test areas, etc.

PUREX Tech Manual
Figure 2-3
PUREX Area Plot

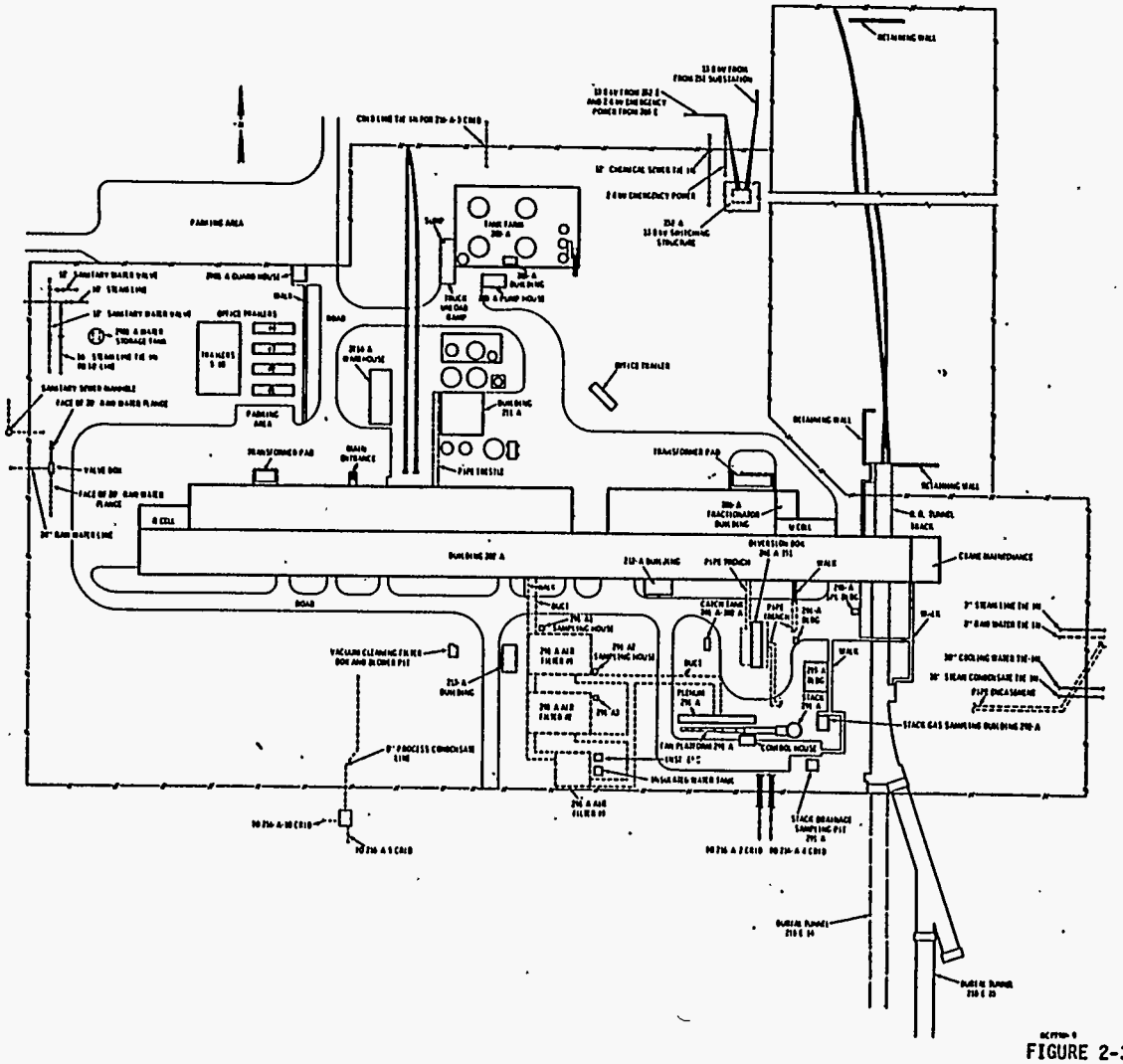


FIGURE 2-3. PUREX Area Plot Plan.

Question 11:
Site Layout

- **site plan showing "in sufficient detail"; location, premises and perimeter of facility, other buildings, roads, railways, rivers,** *restaurants, hotels and local watering holes,* **etc.**

PUREX Tech Manual
Figure 2-3
PUREX Area Plot

(plus Hanford town map?)

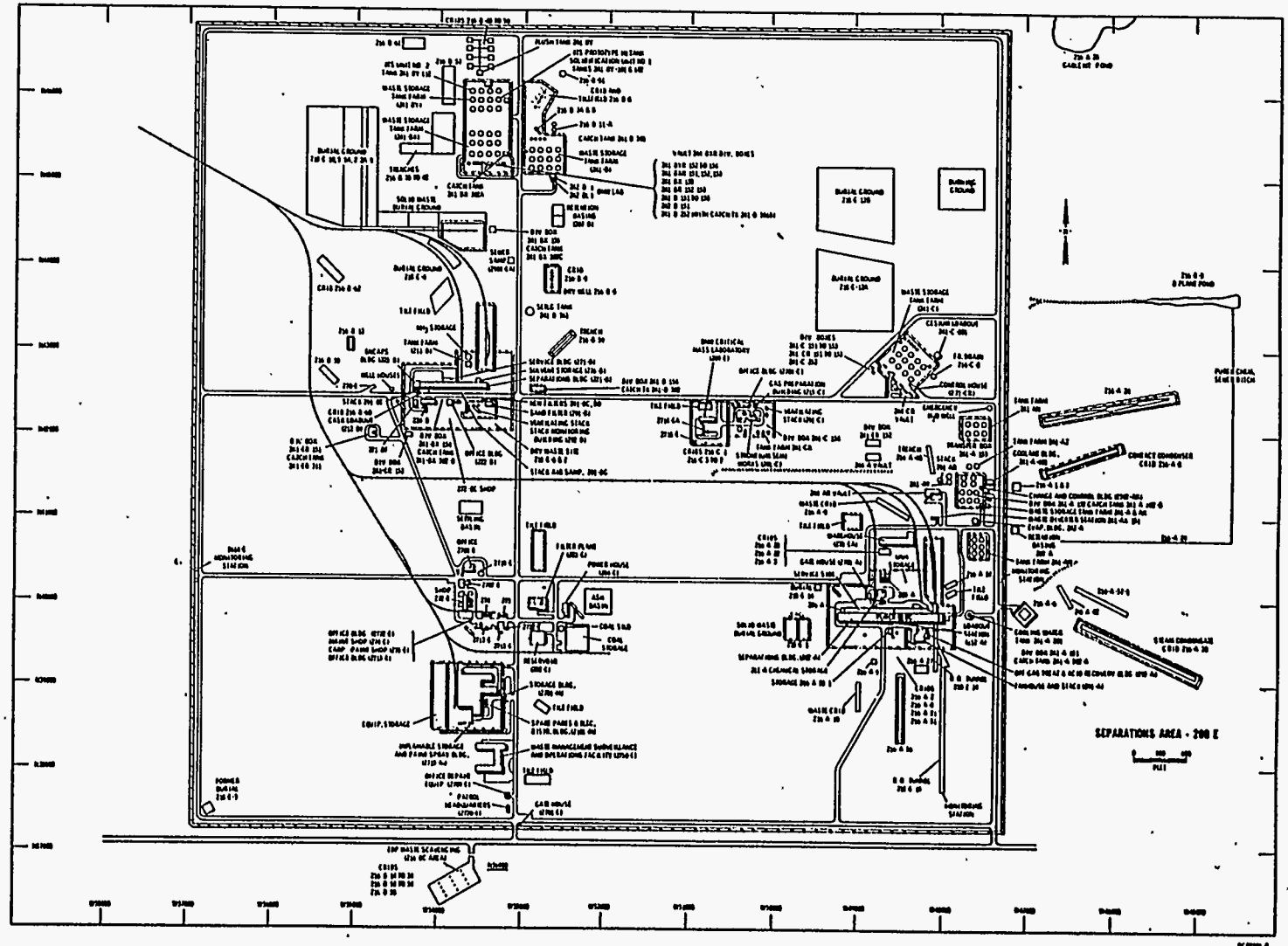
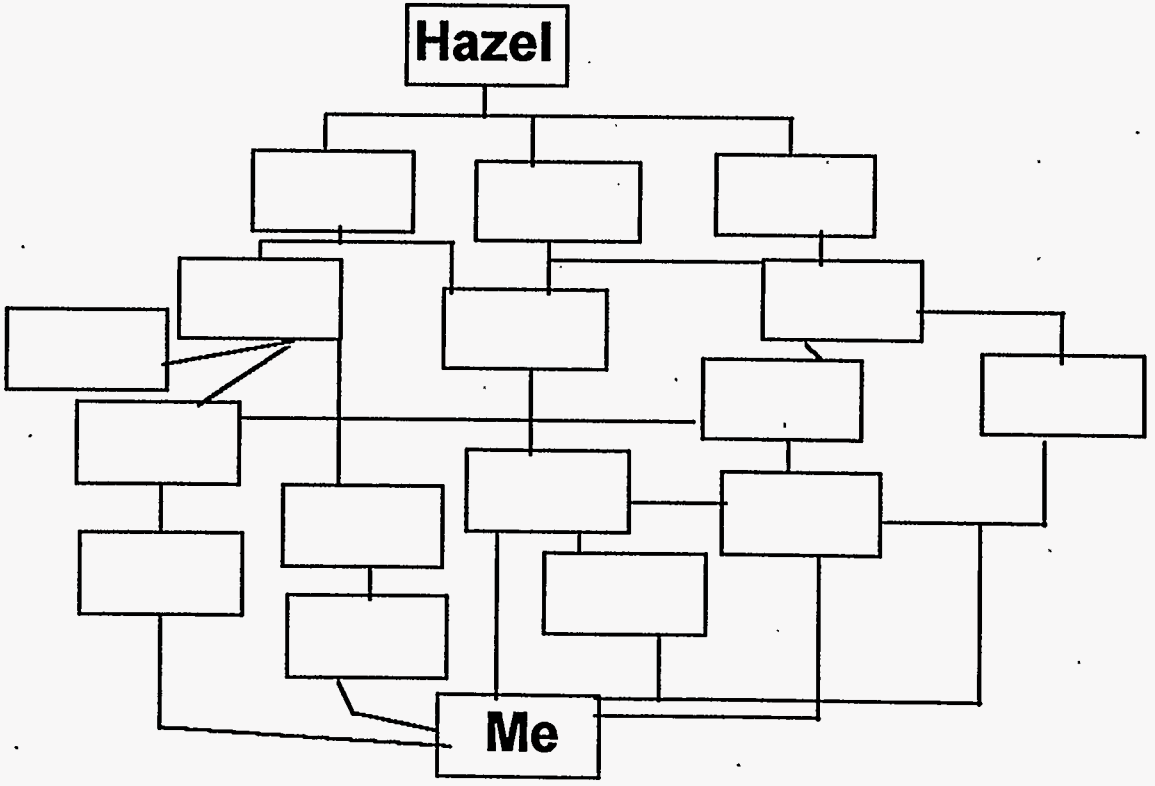


FIGURE 2-2. Map of Hanford Area.

2-3/(2-4 blank)

Question 12
Names and/or Title and address of Responsible Officiers

- for nuclear material accountancy and control and contacts with the Agency. If possible attach organization charts showing position of officers.



Question 13:
Facility Description

- Indicating all process modification stages, storage areas and feed, product and waste points as pertaining to the measurement, control and accountancy of nuclear material.

PUREX Tech Manual
Section 2
(how much detail???)

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
PUREX Technical Manual

Chapter and Title

2.0 PUREX PLANT DESCRIPTION

CONTENTS

FIGURES:

Question 14:
Process Description

- **Also indicating the modifications of physical and chemical forms**

PUREX Tech Manual
Sections 1 and 4
(detail again????)

Question 15:
Design Capacity

- In weight of principle products per annum

10.2 MTU per day
~20 kg Pu per day
250 operating days/year
2550 MtU/yr
5000 kg Pu/yr
(dissolver capacity theoretically greater
3 dissolvers of 10.2 MT on 53 hr cycle)

Question 16:
Anticipated Annual Throughput

- in the form of a foward programme (if applicable) indicating the proportion of various feeds and products

10.2 MTU per day
~20 kg Pu per day
250 operating days/year
2550 MtU/yr
5000 kg Pu/yr
(Assumes operating plant. A new facility would describe the startup plan, including commissioning activitiesm startup on low burnup fuel, etc.)

Question 17:

Other important items of equipment using, producing or processing nuclear materials, if any.

- such as testing and experimental equipment

NONE!!!!!!!!!!

we will not mention any of the development or test facilities!!!

NOTE:

Z-Plant not included
UO3 not included
P-Tanks in 203-A storage area are part of UO3 MBA

Question 18:
Main Material Description

- **i) Main types of accountability units to be handled in the facility**

Feed	Product	
Fuel assemblies/ *input accountability batches*	*Pu Nitrate* *L-9 tank (~40l) to MKIV and MKV cans (~8 l/can)* *Pu Oxide* *(1.5l slip lid oxide cans, 1 kg/can)*	*Uranium nitrate product tank batches* *(K6 tank batches)*

Question 18:
Main Material Description

- **ii) Chemical and Physical Form (for feed include types of fuel element/assemblies, give detailed description indicating general structure and overall dimensions of fuel element/assemblies, including nuclear material content and enrichment). attach drawings**

Feed	Product	
per specification sheet (PUREX Tech Manual) - attached	*Pu Nitrate solution MKIV and V PR cans <350 gPu/l ~1.4 M HNO3* *Pu Oxide powder stioiiometric ratio ~1800 gPu/l*	*UNH ~500 gU/l ~0.4 M HNO3*

MARK IV AND MARK IA FUEL ELEMENT DESCRIPTION

	MARK IV				MARK IA		
Preirradiation enrichment of uranium-235	0.947% Enriched				1.25 - 0.947% Enriched "Spike"		
Type	E	S	A	C	M	T	F
Length (inches)	26.1	24.6	23.2	17.4	20.9	19.6	14.9
Diameter of element (inches)							
1. Outer of outer element	2.42	2.42	2.42	2.42	2.40	2.40	2.40
2. Inner of outer element	1.70	1.70	1.70	1.70	1.77	1.77	1.77
3. Outer of inner element	1.28	1.28	1.28	1.28	1.25	1.25	1.25
4. Inner of inner element	0.48	0.48	0.48	0.48	0.44	0.44	0.44
Cladding Thickness (mils)							
1. Outer of outer element	17-22	17-22	17-22	17-22	18-24	18-24	18-24
2. Inner of outer element	12-18	12-18	12-18	12-18	18-24	18-24	18-24
3. Outer of inner element	23-30	23-30	23-30	23-30	33-40	33-40	33-40
4. Inner of inner element	13-20	13-20	13-20	13-20	18-24	18-24	18-24
Weight of uranium in outer (lbs)							
1. (0.947% U-235)	35.2	33.1	31.2	23.1			
2. (1.25% U-235)					24.4	22.9	17.3
Weight of uranium in inner (lbs)							
0.947% U-235	16.5	15.5	14.6	10.9	12.1	11.3	8.6
Weighted Average of uranium in element (lbs)	50.3				36.1		
Ratio of Zircalloy-2 to uranium (lbs/ton)	139.8	141.5	143.3	153.4	170.4	172.2	181.1
	140.5				170.8		
% of Processing load of each	88	7	1	4	88	10	2
	80				20		
Displacement Volume gal/ton uranium	16	16	16	16	16	16	16

Question 18:
Main Material Description

- **iii) Throughput, enrichment, ranges and PU contents (for normal flowsheet operation indicating if blending and/or recycling takes place)**

Feed	Product	
10.2 MTU/day *0.9 and 1.25% u235* *~0.2 % PU content* *~20 kg Pu/day*	*Purified Pu as* *oxide or nitrate* *in same ratios as feed* *~20 kg PU/day*	*UNH solution* *0.9 or 1.25% U-235* *nominal 10 MTU/day*

Question 18:
Main Material Description

- **iv) Batch size/flow rates, campaign period. Means of batch identification.**

Feed	Product	
450 assemblies/day (1 dissolver charge) 3-6 month campaign identification by Basket # piece count (procedure PO-219-001 for basket charge)	Pu Nitrate tk-L9 (~40 l.) to 10 l. PR cans (nominal 8l.) Oxide fill blender (15-17 kg) sample blender 1.6 kg.can 15 cans/blender Can IDs for both	K6 UNH tank 5000 gallons K6 batch ID to P tanks and tankers to UO3

Question 18:
Main Material Description

- **v) Storage and plant inventory (indicating any change with throughput)**

Feed	Product	
no on-site storage fuel assemblies received daily in rail casks. 6 casks/day	Pu Nitrate PR cans stored in corridor prior to transfer to Z-plant ~15 cans (interim) Pu Oxide Interim - 2 cans/DOT6M ~12 DOT6M = 24	UNH stored in 100,000 gallon P-tanks (considered in UO3 MBA!!)

Question 18:
Main Material Description

- **vi) Frequency of receipts or shipments (batches/units/ per month)**

Feed	Product	
Nominal 1 dissolver/da 6 rail casks/day ~450 assemblies nominal 30 days/mo.	<u>Pu nitrate</u> 1 sample/day 4-5cans /sample 10 cans/day loadout can/2 hr <u>Oxide</u> sample/blender/day 10 cans/8hr.	<u>UNH</u> 1 tank/day 1 sample/day 1 bulk /day

Question 19:
Waste Material

- **(including contaminated equipment, measured discards and retained waste.**
  - **Describe each stream:**
    - **» i) major contributions(sources)**

1) Zirflex	- cladding waste solutions
2) Ammonia	- declad waste (scrubber)
3) F-16&F18	- high level process waste solutions
4) U3&U4	- lab wastes solutions
5) R8&G8	- solvent cleanup waste
6) cribs	- low level aqueous effluents
7) Off gas	- gaseous
8) solid wastes	- process solid wastes (from N -cell)

question ii: Types of waste
same information.....

Question 19:
Waste Material

- **iii) Chemical and physical form**

1) Zirflex	- liquid waste - PH ~12
2) Ammonia	- liquid - scrubber solutions
3) F-16&F18	- liquid - denitrated - neutralized
4) U3&U4	- liquid - lab chemicals
5) R8&G8	- solvent cleanup waste
6) cribs	- low level aqueous effluents (table attached)
7) Off gas	- gaseous
8) solid wastes	- process solid wastes (from N -cell)

TABLE 4-39. PUREX Plant Aqueous Effluents.

Discharge stream	Flow measurement	Sampling	Diversion	Radiation monitoring	Emergency sampling	Estimated volume (10^6 gal/year)
Cooling water (CWL to 216-A-25)	1. Weir 2. Dip tube 3. Flow integrator/ totalizer	1. EMV Sampler 2. Tank drain sample	Retention Basin (automatic)	Single probe (non-redundant) (non-failsafe)	None	1100.0
Chemical sewer (CSL to 216-B-3)	1. Parshall flume 2. Flow integrator/ totalizer	Proportional	Retention Basin (automatic)	Single probe (validated periodically by automatically actuated check source)	Automatic verification sample	230.0
Steam condensate (SCD to 216-A-30)	1. Magnetic flowmeter 2. Integrator/ totalizer	1. EMV sampler 2. Jug pour sample	Retention Basin (automatic)	Single probe (non-redundant) (non-failsafe)	Automatic verification sample	47.0
Process condensate (PDD to 216-A-10)	1. Magnetic flowmeter 2. Integrator/ totalizer	Proportional	None	Single probe (validated periodically by automatically actuated check source)	Automatic verification sample	2.5
ASW condensate (ASD to 216-A-36B)	1. Magnetic flowmeter 2. Integrator/ totalizer	Proportional	None	Single probe (Validated periodically by automatically actuated check source)	Automatic verification sample	5.0
203-A Bldg Discharge (PTD to 216-B-3)	Collection tank volume measurements	1. P-Tank condensate line 2. Sump sample 3. Waste pump tank (TK-P5) sample	Capability for recycle to PUREX tanks in E or K Cells depending on U concentration and purity, or to TK-F18 for disposal to UGS	Not required (collection tank sample analysis)	Not required	0.06

Question 19: Waste Materials

- **iv) Estimated Enrichments and Uranium/plutonium content**

U at 0.9 or 1.25% enriched

1) Zirflex	- 0.18gU/l	1.3x10-3 gPu/l
2) Ammonia	- nominal	nominal
3) F-16&F18	- 5x10-1gU/l	3x10-3 gPu/l
4) U3&U4	- 4x10-3gU/l	5x10-6 gPu/l
5) R8&G8	- 5x10-1gU/l	3x10-4gPu/l
6) cribs	- nominal	nominal
7) Off gas	- nominal	nominal
8) solid wastes	- nominal	~40g Pu/drum

Question 19: Waste Materials

- **v) Estimated quantities per year, period of storing.**

250 operating days

10.2 MTU/day	2550MTU/yr
20 kgpu/day	5000 kg Pu/yr

1) Zirflex	cladding	2.5 MTU	5 kg Pu
2) Ammonia		<kg	grams
3) F-16&F18	high level	5.1 MTU	10 kg Pu
4) U3&U4*	analytical	~1 kg	~1 gram
5) R8&G8	solvent	~5 kg	10 gram
6) cribs	low level	nominal	nominal
7) Off gas		nominal	nominal
8) solid wastes		nominal	~2 kg

*250,000 liters/yr

Question 19: Waste Materials

- **vii) Waste generation rates (as % of input/throughput, quantities per month)**

250 operating days

10.2 MTU/day	2550MTU/yr
20 kgpu/day	5000 kg Pu/yr

1) Zirflex	cladding	0.1%.
2) Ammonia		~0%
3) F-16&F18	high level	0.2%
4) U3&U4*	analytical	~0%
5) R8&G8	solvent	~0%
6) cribs	low level	0%
7) Off gas		~0%
8) solid wastes		~0.04%

Question 19:
Waste Materials

- **Store Inventory Range and Maximum capacity**

  No storage - waste transferred to permanent storage
  - terminaltion of safeguards on waste at time of final measurement.

Question 19: Waste Materials

- viii) Methods and frequency of recovery/disposal
  - dissolution/declad waste
    - » solution centrifuge/solids recycled to next dissolver
    - » no recycle after measurement/termination of safeguards
  - liquid wastes
    - » internal recycle based on throw-away limits
    - » no recycle after measurement/termination of safeguards

Question 20
Waste Treatment System

- **references to Tech manual**
  - **high level waste**
    - » **coating wastes - section 4.2**
    - » **HAW - section 4.9.1**
  - **low level process waste**
    - » **sections of 4.9.2**

Flowsheets and diagrams as appropriate
- high level waste as example (fig. 4-6)

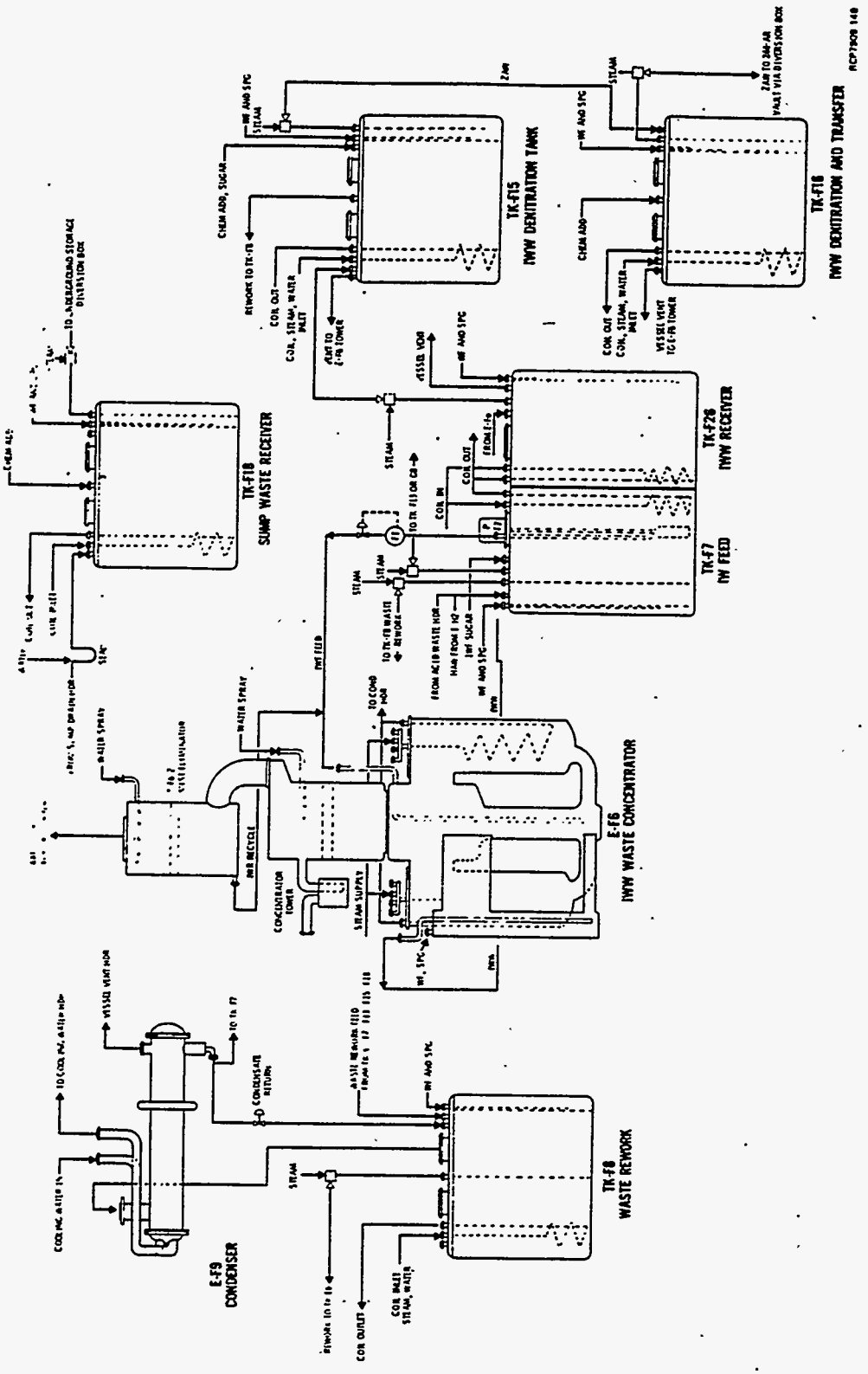


FIGURE 4-16. Waste Concentration and Handling Flow Diagram.

Question 21: Other Nuclear Material in the Facility

- None ??????

Question 22:
Schematic Flowsheet for Nuclear material

- **(identifying sampling points, flow, invemtory measurement points, accountability areas, inventory locations, etc.**
  - **flowsheet schematic from Tech manual**

flow measurements

declad waste	tk-D2
cladding scrubber	tk-E5
Input accountability	tk-D5
Pu Oxide Product	sample blender, weigh cans
Pu Nitrate Product	sample tank, weigh cans
Uranium Product	tk-K6
High Level Waste	tk-F16 & tk-F18
Lab Waste	tk-U3 & tk-U4
Solvent Cleaning Waste	tk-R8 & tk-G8
Gaseous Waste	stack monitor
Solid Waste	waste packages

Inventory points as described in question 25

2 process areas - 1)head end/dissolution - 2) process area

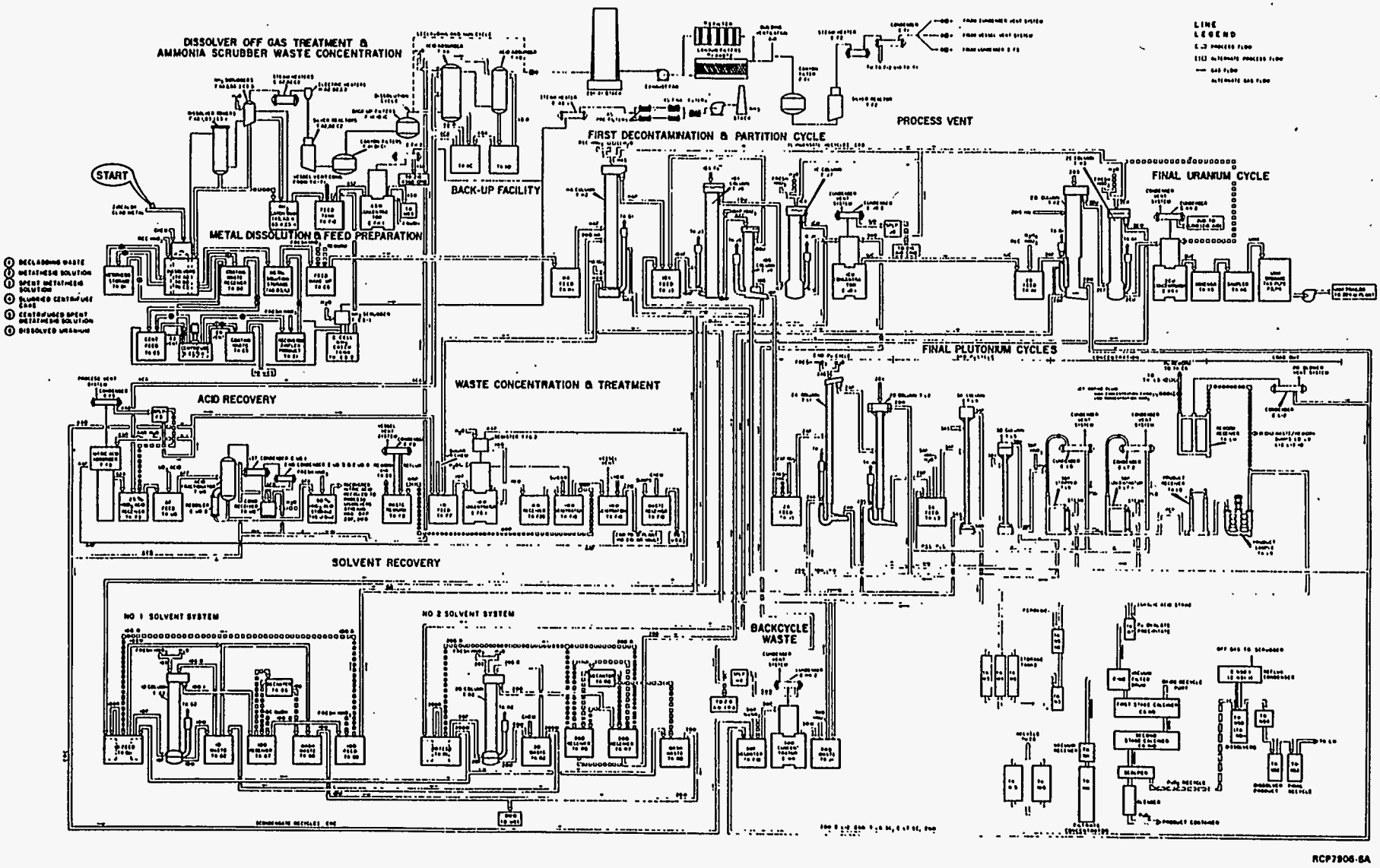


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FIGURE 4-1. PUREX Process Flow Diagram.

Question 23:

Types, Forms, Ranges of Enrichment, Ranges of Quantitiesof Nuclear Material Flow for Each Nuclear Material Handling Area; i.e.:

(also indicate the maximum quantities of nuclear material to be handled in accountability areas at one time)

- process areas; head end and process (answered in 18)
  - 10.2 MTU/day (0.9% and 1.25%)
  - 20 kg Pu/day
  - nominal 20-30 MTU (40-50 kg Pu) as process holdup during operation.
- storage areas (answered in 18(v))
  - only interim Pu storage, <30 kg Pu

Would need decisions on:
UNH/P-Tank
Z plant, etc

Question 24:
Recycle Processes

- **(Briefly describe any such processes giving source and form of material, method of inventory and form of material, method of storage, nominal inventory, frequency of processing, duration of temportary storage, schedule for any external recycling, and measurementt methods for fissile content of recycled material)**

Recovered nitric acid from UO3

- K-cell receipt
- regular receipt/ essential no contained material

Z-plant - off spec plutonium (oxide)

- dissolved in N-cell
- recycled through L-11 tank to process
- infrequent transfers

Special processing - critical mass lab Pu

- received in PR cans- returned to process in PR room
- L-14 to L-11 to E-6 for recycle
- infrequent

Off spec nitrate and oxide as internal recycles

nitrate; L-14 to L-11 to E-6

powder; tk-N50 or tk-N51

Question 25: Inventory

- **In process**
  - **(within plant and equipment during normal operation, indicate quantity, range of enrichments, Pu content, form and principle location and any significant change in time or throughput; also indicate anticipated residual holdup and mechanism.)**

dissolver (1 full dissolver at any time)		10,000 kgU	20,000 g Pu
D2	Coating waste receiver	10	20
D3-5	Metal Sol stg	20,000	40,000
E6	feed make-up	5,000	10,000
E3	centrifuge feed	10	20
E5	coating waste	10	20
E1	zirflex tank	10	20
H1	HA Feed	5,000	10,000
	CoDecon and Partition	3,000	6,000
	ICU Concentrator	8,000	0
	Final Uranium Cycle	8,000	0
J5	2A Feed	0	6,000
	Final Plutonium Cycles	0	10,000

Question 25: Inventory

- **i) In process**
  - **– (within plant and equipment during normal operation, indicate quantity, range of enrichments, Pu content, form and principle location and any significant change in time or throughput; also indicate anticipated residual holdup and mechanism.)**

dissolver (1 full dissolver at any time)		10,000 kgU	20,000 g Pu
D2	Coating waste receiver	10	20
D3-5	Metal Sol stg	20,000	40,000
E6	feed make-up	5,000	10,000
E3	centrifuge feed	10	20
E5	coating waste	10	20
E1	zirflex tank	10	20
H1	HA Feed	5,000	10,000
	CoDecon and Partition	3,000	6,000
	ICU Concentrator	8,000	0
	Final Uranium Cycle	8,000	0
J5	2A Feed	0	6,000
	Final Plutonium Cycles	0	10,000

Question 25:
Inventory

- **i) In-process (continued)**

L6	3BP stripper	0	1,000
L7	3BP concentrator	0	10,000
L8	Product receiver	0	10,000
L9	Product Sam ple	0	10,000
	Waste Concentration	5	20
	Solvent Recovery	5	10
	Backcycle Waste	5	10
	N-cell	0	20,000
	(includes glovebox holdup)		

Refinements???????????? - example from operation

Question 25:
Inventory

- **ii) Feed and product Storage**
  - **– as detailed in 18(v) ***
- **iii) Other locations**
  - **– none**

* - no fuel assembly storage
- only interim product storage
- intermediate dissolver solution storage, etc. as part of in-process inventory

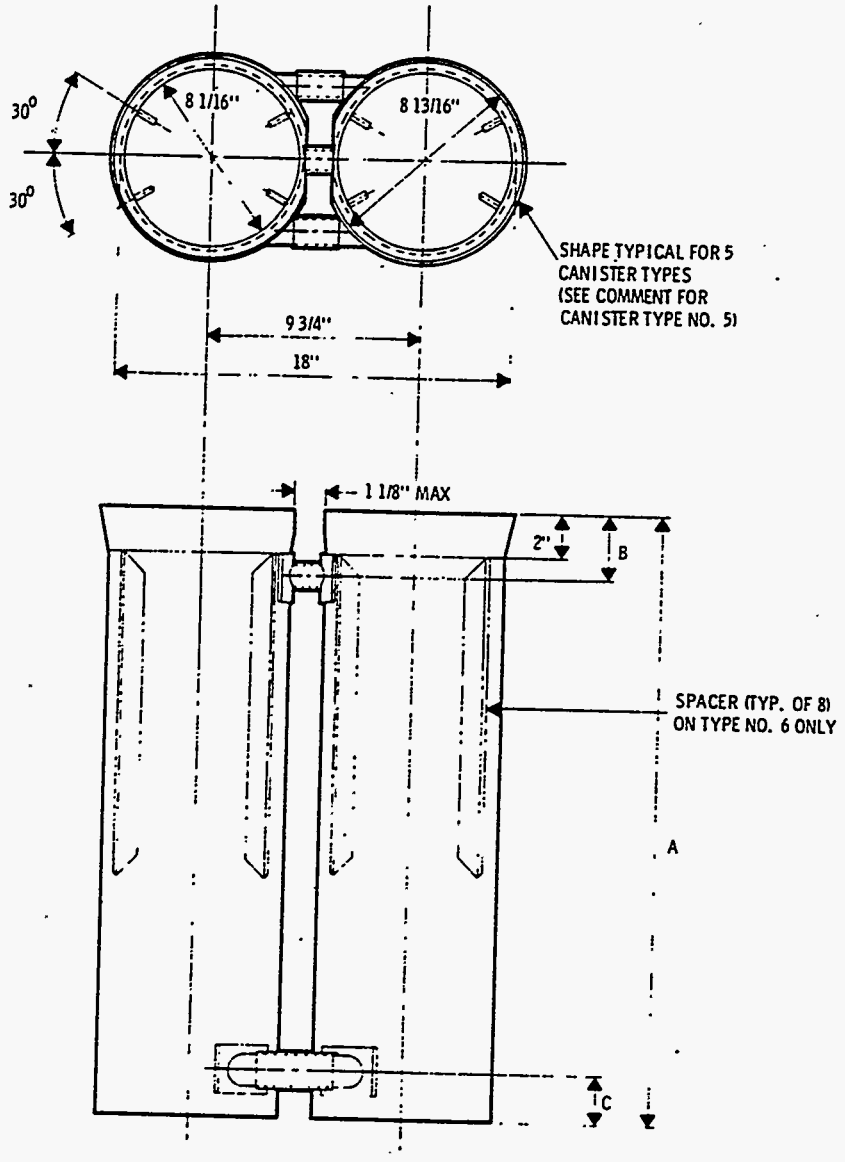
Question 26:
Containers, Packaging and storage area descriptions

- No fuel assembly storage
  - ignore Al fuel in pool
- Pu Product cans
  - interim storage only
  - as described elsewhere
- UNH
  - transferred to P tanks after measurements
  - tanker truck to UO3
  - storage as separate plant MBA.

Question 27:
Methods and Means of Transfer of Nuclear Material

(describe also equipment used to handle feed, product and waste)

- Fuel Assemblies by rail transfer cask
  - process described in Section 3 of Tech Manual
  - drawing and procedures as appropriate
- UNH loadout to P-tanks
  - diagram from tech manual
- Pu nitrate
  - PR cans (10 liters capacity/ 8 liter nominal volume)
  - diagram from tech manual
- Pu Oxide
  - slip lid cans - DOT-6M containers (1-1.5 kg Pu/can)
  - figures from Tech manual Addendum 1
    - » blender
    - » load station
    - » can handler equipment



TYPE NO.	CANISTER MATERIAL	DIMENSIONS INCHES A	B	C	COMMENTS	DRAWING NUMBER
1	SST, ANY 300 SERIES, 16 ga	79	7.13	7.0	FEW IN EXISTENCE	H-1-37916
2	SST, ANY 300 SERIES, 16 ga	71	3.13	7.0	STD FOR SPIKE	H-1-37916
3	SST, ANY 300 SERIES, 16 ga	28	2.87	2.25		H-1-42594 SHT. 'S 1 2
4	Al ALLOY 5086, 0.090 in.	28	2.87	2.25	MAJOR K BASIN LOAD	H-1-36935, SHT. 1
5	Al ALLOY 5086, 0.090 in.	28	2.87	2.25	OCTAGONAL TOP	H-1-36935, SHT. 'S 1 2
					FOR SPIKE FUEL	
6	Al ALLOY 6061-T6, 0.090 in.	28.25	2.87	2.25	SALVAGED CO-	H-1-37916
					PRODUCT CANISTERS	

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FIGURE 3-1. Fuel Element Canisters.

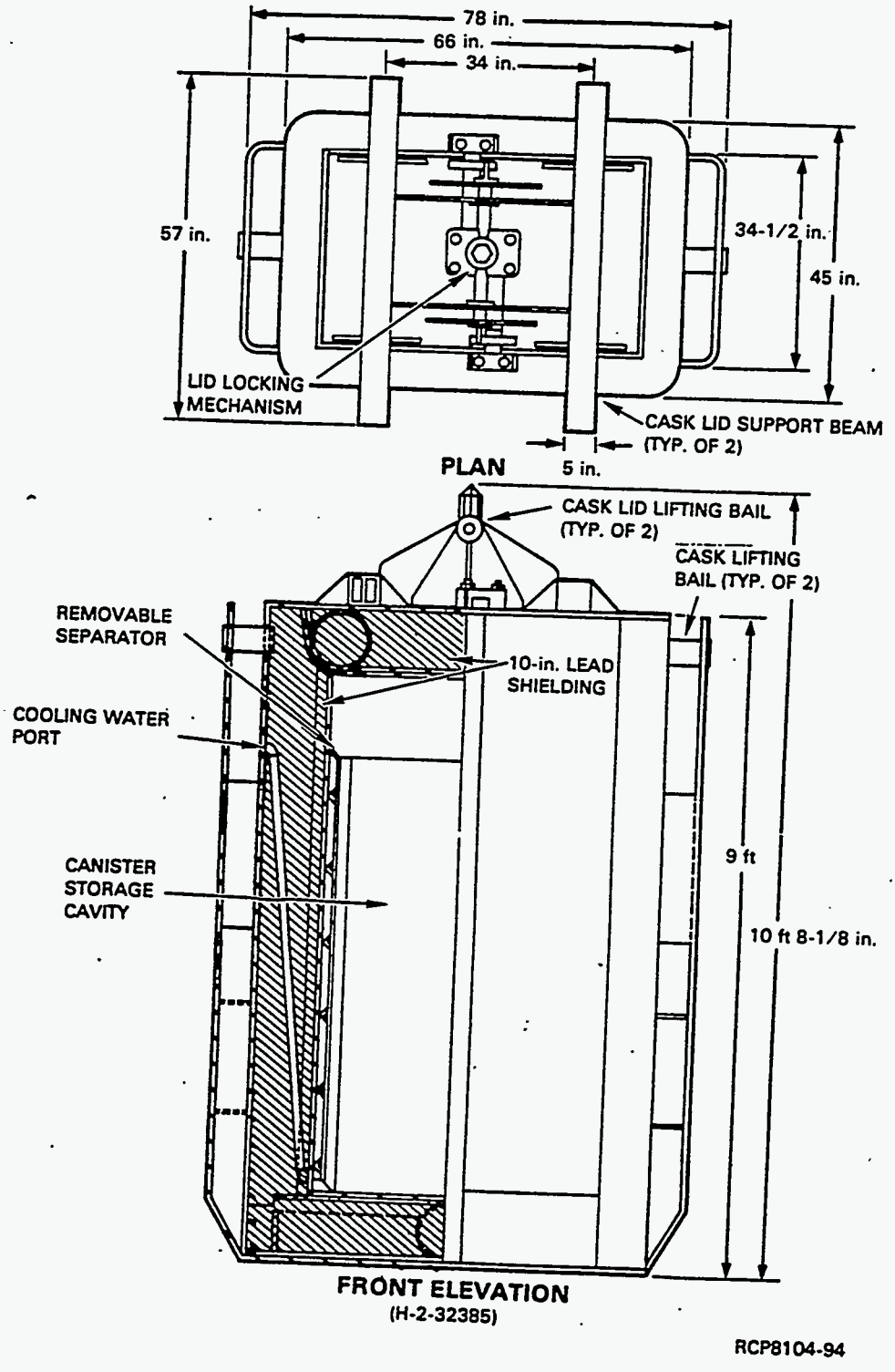


FIGURE 3-3. NPR Basin Fuel Cask.

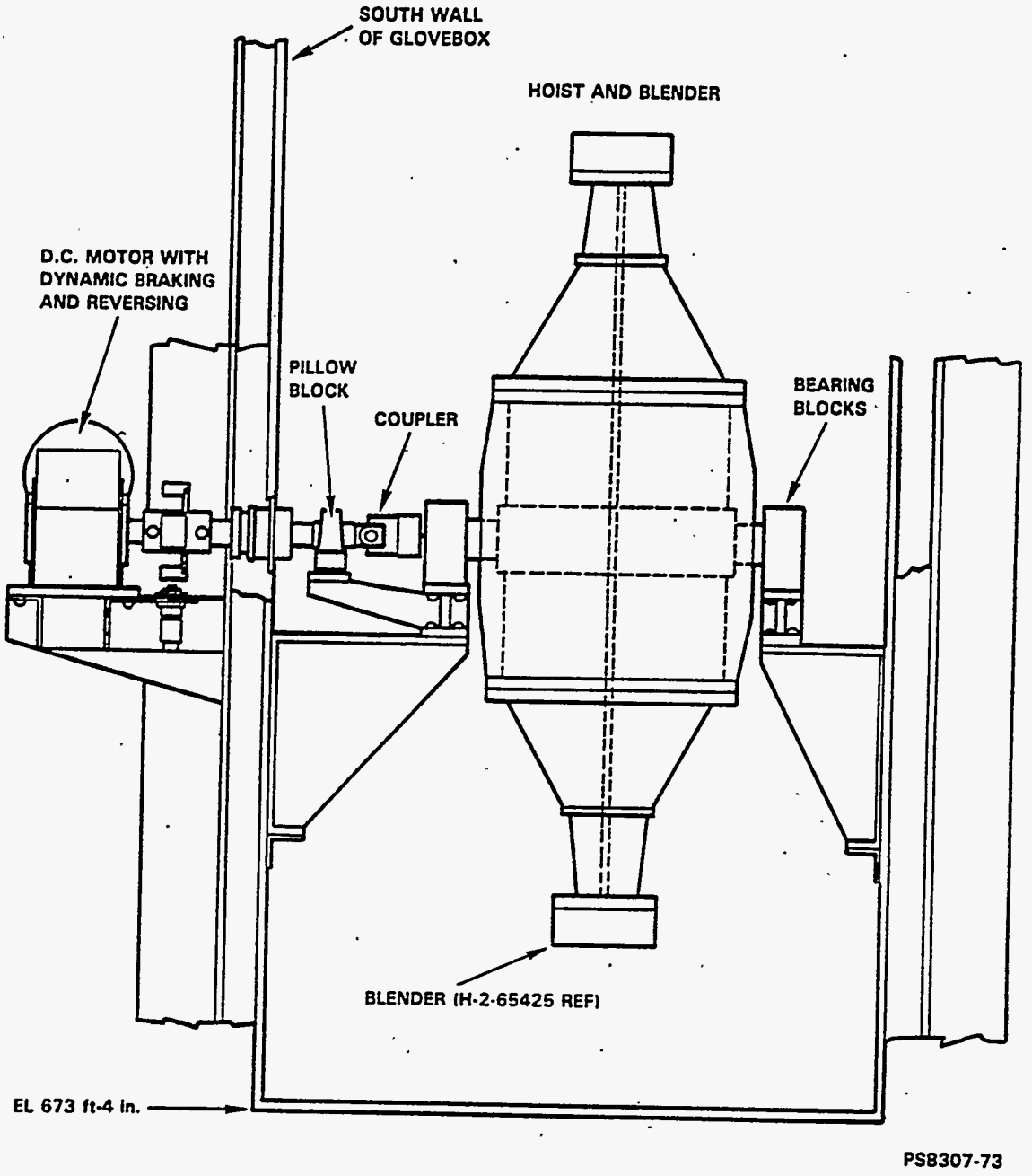


FIGURE 4.1-31. Blender Rotation Stand.

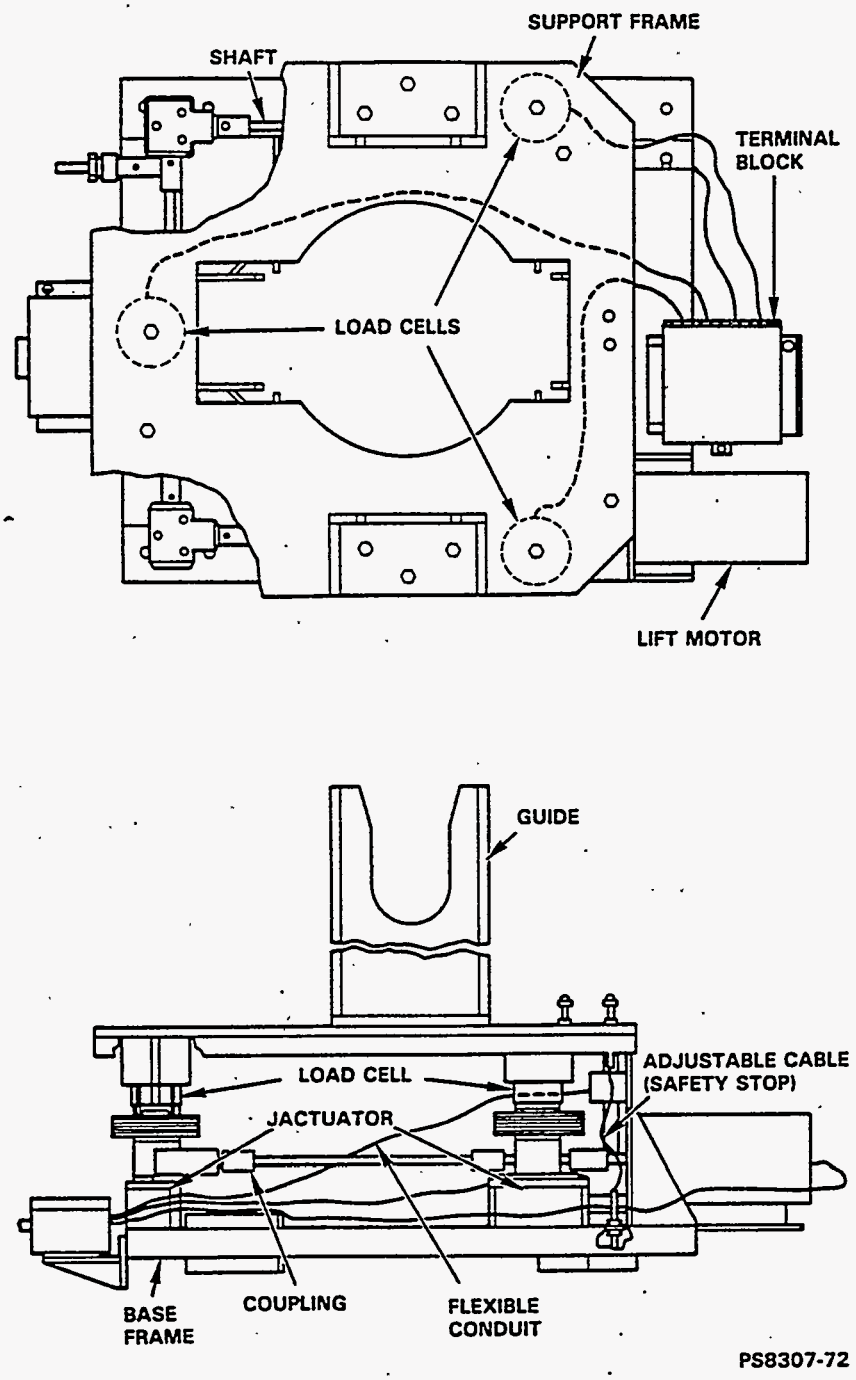


FIGURE 4.1-30. Blender Dolly.

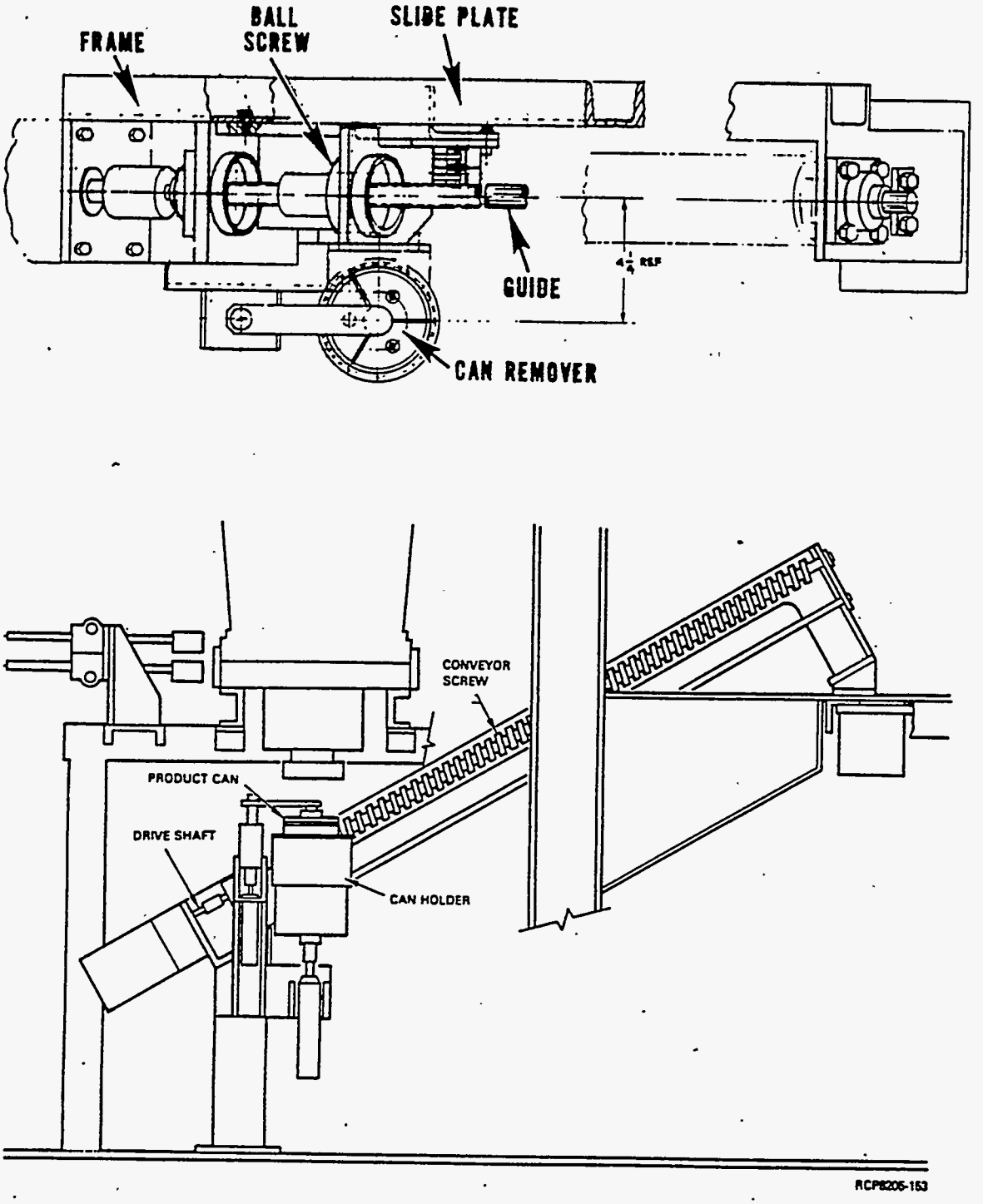


FIGURE 4.1-32. Can Conveyor System.

Question 28:
Transportation Routes Followed by Nuclear Material

(with reference to plant layout)

- Fuel Assembly casks
  - from reactor areas in receiving area

  (site layout diagram in question 11)
- Pu Oxide and Nitrate by transporter to Z-plant

  (site layout diagram in question 11)
- UO3 from K6 to P-Tanks (100,000 galons)
  - tanker transport by road to UO3 plant.

  (Figure 4-20 from Tech Manual for routing to P-tanks)
- High level wastes to waste tanks
- Low level aqueous effluents

  (Figure 4-19 from Tech Manual for effluent routing)

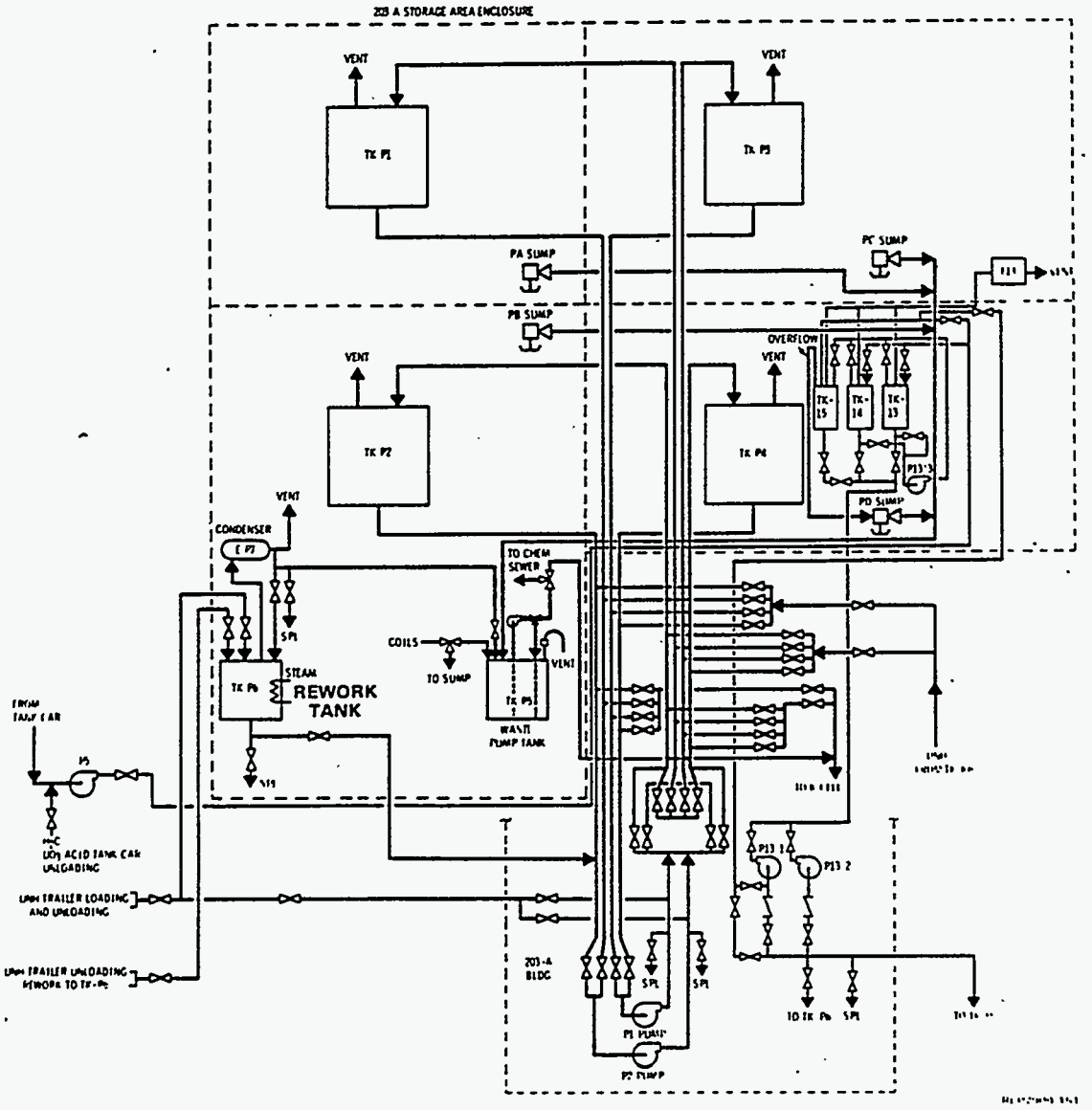


FIGURE 4-20. 203-A Uranyl Nitrate Hexahydrate Storage Area Process Piping and Flow Diagram.

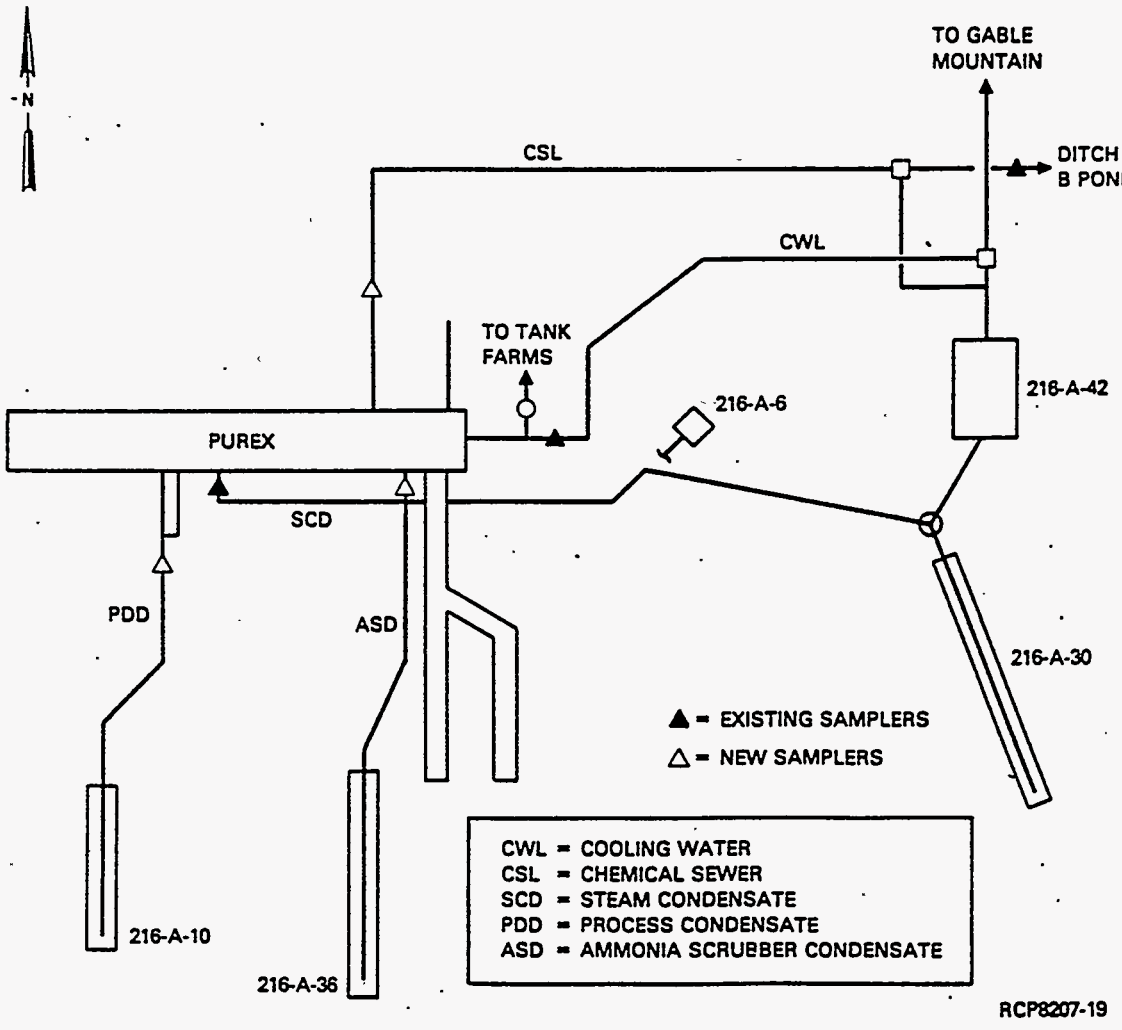


FIGURE 4-19. Aqueous Effluents Disposal Flow Diagram.

Questions 29 :
Shielding (for storage and Transfer)

- **Shielding (for storage and transfer)**
  - reference plant design description - Tech Manual 1&2
  - reference fuel cask drawings (tech manual section 3.2)
  - Dot 6M specifications.

Question 30:
Maintenance, Decontamination , Cleanout

- describe plans and procedures for decontamination and cleanout of equipment containing nuclear material, defining all sampling and measurement points associated with:
  - » i) normal plant maintenance;
  - » ii) plant equipment decontamination and subsequent nuclear material recovery;
  - » iii) plant and equipment clean-out including means of ensuring vessels are empty;
  - » iv) plant start-up and plant-shutdown (if different from normal operation);
- in cases where clean-out and/or sampling is not possible, indicate how the hold-up of nuclear material is measured or calculated.

The difficult question for PUREX in the decommissioning mode!!!

Question 31:
Basic Measures of Physical Protection of Nuclear Material

- Reference
  - DOE orders
  - NRC - 10CFR73?????

Question 32:
Specific Health and Safety Rules for Inspector Compliance

(if extensive, attach separately)

- What training will be needed for inspectors?
- RADCON Manual????
- 10CFR20???

Nuclear Material Accountancy and Control
Question 33:
System Description

Give a description of the nuclear material accountancy system, the method of recording and reporting accountancy data and establishing material balances, procedures for account adjustment after plant inventory, mistakes, etc., under the following headings:

- **i) General**

  (This section should also state what general and subsidiary ledgers will be used, their form (hard copies, tapes, microfilms, etc.) as well as who has responsibility and authority. Source data (e.g. shipping and receiving forms, the initial recording of measurements and measurement control sheets) should be identified. The procedures for making adjustments, the source data and records should be covered as well as how the adjustments are authorized and substantiated.)

Responsibilities and authorities with the MC&A manager,
with reporting to DOE, audits etc.
General ledger accounts parallel to KMP's, etc.
The general problem of reports and records to be transmitted.

Question 33:
System Description

- **ii) Receipts**

  (including method of dealing with shipper/receiver differences and subsequent account corrections, the checks and measurements used to confirm nuclear material content and persons responsible for these determinations should be defined)

1) Quantities of inuclear materials in fuel assemblies are assigned by the reactor operator from calculations based on initial fabrication data fuel irradiation history.
2) Preliminary check based on dissolver process control measurements
3) Receipt quantities based on combined measurements in:
   D5 - accountability tank
   D2 - declad rinse solution
   E5 - cladding waste solution
   *(differences are evaluated on a cumulative basis by PUREX MC&A Manager/designee) - (RBI concept) - warning limits established, reporting to DOE on excessive differences)

Question 33:
System Description
iii) Shipments (products, waste, measured discards)

a) Uranium Product
- K6 tank to P-tanks by pump transfer
- volume check (transfer vs. received)
- operator makes preliminary check at time of transfer as part of the transfer routing check
- MC&A manager has responsibility for formal check and establishing limits

b) Plutonium
- PuO_2
  - » cans check weighed upon receipt at Z-plant
- Pu Nitrate
  - » cans check weighed upon receipt at Z-plant
- Z plant and PUREX MC&A managers responsible
- discrepancies reported to DOE

c) High Level Waste
- Volume transfer comparisons as process control checks.

Question 33:
System Description
iv) Physical Inventory

- **Description of procedures, scheduled frequency , estimated distribution of nuclear material, methods of operator's inventory (both item and/or bulk accountancy, including relevant assay method), accountability and possible verification method for irradiated nuclear material, expected accuracy, and access to nuclear material . (In particular the description of procedures should also provide the basic inventory approach to be used, i.e. planning, organizing, and conducting of the inventory, relisting , use of prior measurement data; who has the primary responsibility for the inventory; how process cleanout is accomplished; the accountancy of process residual holdup).**

PUREX was typically inventoried by a general shutdown,
with inventory measurement in place.
(procedure PO-020-019)

INVENTORY IS (by experiece) THE BIGGEST CHALLENGE TO MATERIAL BALANCE PERFORMANCE AND PROBABLY THE LARGEST CONTRIBUTOR TO ID PROBLEMS!!!!!

For sake of this discussion, use a theoretical inventory capability (based a lot on Barnewell):
- assume a head end flushot with turn-around for different enrichments (perhaps 3 mo)
- annual shutdown and flushout physical inventory of full process

We can talk about actual inventories in the discussion.

Question 33:
System Description
iv) Physical Inventory

General procedure for theoretical flushout Inventory

- **Dissolver Area** *
  - **last dissolver batches transferred through metal storage (D3,D4) and accountability (D5).**
  - **dissolver area inspected for fuel (video)**
  - **flush batches for each dissolver moved through D3 and D4 (samples and transfer to heel, <5%)**
  - **Flush batch moved through accountability (D5)**
  - **coating waste receiver (D2) processed through centrifuge, final Zirflex product (E1) saved for restart**
  - **last waste batch (E3) to waste.**
  - **scrubber system shut down, last batch to waste.**
- **Accountability//Feed Preparation**
  - **last dissolver batch to feed tank H1**
  - **dissolver area flush batch transferred through to feed make-up (E6) - sample and heel measurement in D5 and E6.**

* Dissolver area procedure for head end turnaround or full inventory

Question 33:
System Description
iv) Physical Inventory (cont)

- First Decontamination and partition Cycle
  - process final feed in H1 to <5%
  - transfer lat flush from E6 to H1, sample
  - process h1 to <5%
  - shut down feed from H1
  - continue operation on cold streams until 1CU <4gU/l
  - shut down system measure with column weight factors and final process control samples
- 1CU concentrator/Final Uranium Cycle
  - transfer last concentrated solution to 2D feed (K1)
  - use last solutions from decon cycle shutdown as rinse for 1CU concentrator
  - process k1 to <5%
  - transfer concentrator flush to K1
  - process to <5%
  - shut down feed, continue on cold streams (2EU<4gU/l)
  - shut down system and inventory as for codecon

Question 33:
System Description
iv) Physical Inventory (cont)

- Uranium Product
  - transfer last product from 2Eu concentrator
  - use shutdown solutions from uranium cycle as rinse
  - after uranium cycle shutdow, transfer to K5
  - Inventory in K5, save as startup solutions.
- Plutonium Cycle
  - After shutdown of partion, process 2A feed (J5) to <5%
  - add 200 l. flush
  - process to <5%
  - operate on cold streams till 2BP< 1gPu/l
  - sample 3A feed (L3), operate to <5%
  - operate on cold streams until 3Bp<1gPu/l
  - shut down and inventory columns (+3BP stripper
- Plutonium Product
  - last Pu Product to N-cell
  - Concentrator flush through L8, L9, held in L11

Question 33:
System Description
iv) Physical Inventory (cont)

- Solvent Systems
  - shut down systems
  - final waste transferred
  - inventory columns and tanks
- N-cell
  - Process final solutions from M3, M4, M5 to N3
  - process final solutions through N3 (<1%)
  - shut down calciners
  - disassembly??/NDA measurement??
  - final batch through blended/canning
  - Inventory equipment (NDA???)
  - flush M3,M4,M5 to N3
  - recycle flush soluions to L11
  - glove box inventory (Kodman factor!!!/NDA??)
  - final solid waste transferred

Question 33:
System Description
iv) Physical Inventory (cont)

- **Back Cycle Waste**
  - **sample, process F10 to <10%**
  - **shut down system**
  - **inventory concentrator and 3Bw waste tank (J1)**
    - » **note: Backcycle feeds to first cycle - should coordinate with first cycle shutdown or must inventory and side-pocket solutions for restart.**
- **Acid Recovery**
  - **shut down system and inventory equipment**
- **Waste Concentration**
  - **final waste batches transferred**
  - **shut down system and inventory equipment**

Note: The sequential nature of inventory is important.
There is a significant potential to back cycle material.
Monitoring of the process is key to inventory performance.
Significant room for improvement in this area!!!!

Question 33:
System Description
iv) Physical Inventory (cont)
Inventory Listing - "flushout inventory"

		vol	(kg)	Pu(g)
Dissolver Area				
dissolver	A3	empty	0	0
"	B3	empty	0	0
"	C3	emoty	0	0
coating waste	D2	2500	1	1
centrifuge sys		---	<1	<1
E3,G-E2/E4,				
zirflex waste	E5	empty	0	0
zirflex product	E1	5000	2	2
metal storage	D3	500	<1	<1
metal storage	D4	500	<1	<1
scrubber system		---	<1	<1
Accountability/Feed Adjust				
accountability	D5	500	5	5
make-up	E6	500	5	5
HA Feed	H1	5000	5,000	1,000

		vol	(kg)	Pu(g)
First Decontamination and Partition				
HA column		7000	1	5
1BX column		6000	1	5
1C column		3100	1	5
1BX feed	J3	500	1	5
1CU conc		1000	10	--
Final Uranium cycle				
2D feed	K1	1000	10	--
2D column		5000	1	--
2E column		5000	1	--
2EU conc		400	4	--
receiver	K5	5000	1,000	--
sampler	K6	100	10	--

Question 33:
System Description
iv) Physical Inventory (cont)
Inventory Listing - "flushout inventory"

		vol	(kg)	Pu(g)
Final Plutonium Cycles				
2A feed	J5	500	--	1000
2A column		600	--	100
2B column		600	--	100
3A feed	L3	200	--	50
3A column		600	--	100
3B column		600	--	100
3BP strip		300	--	100
3BP conc		30	--	50
product rec.	L8	100	--	50
prod samp.	L9	empty	--	0
rework	L11	300	--	10,000
N-Cell				
M3,M4,M5 feed		empty	--	0
N3,N5,N6		empty	--	0
1st calciner			--	5,000
2nd calciner			--	5,000
blender		empty	--	0
N cell dissolvers		empty	--	0
filtrate recycle (N15.16			--	10

		vol	(kg)	Pu(g)
Backcycle Waste				
3WF decanter	F10	1000	<1	<1
3WB concentrator		1000	<1	<1
3BW waste	J1	1000	<1	<1
Solvent Recovery				
No 1 and No 2 systems combined tankage			1	2
Acid Recovery				
combined tankage			<1	<1
Waste Concentration				
combined tankage			5	5

Totals

<10 MTU

<20 kgs

Question 33:
System Description
v) measured discards

(methods of estimation of quantities per year/months, methods of disposal)

- Waste streams as discussed in question 19, also;
  - gaseous wastes based on cumulative airflow and monitors -- quantity????
- Low level process aqueous effluents
  - alpha monitors for plutonium
  - weekly samples for uranium
  - quantities ???

Question 33:
System Description

vi) retained waste

(method of estimation of quantities per year, method and envisioned period of storage; indicate also possible subsequent uses of retained waste.

- **NONE !!!!!**

vii) unmeasured losses

(indicate the methods used to estimate unmeasured losses)

- **NONE !!!!!**

Question 33:
System Description
viii) Operational records and accounts

(including logbooks, general ledgers, internal transfer forms, methods of adjustment or correction, and retention location, and language; control measures and responsibilities for records)

- System of internal and external documents
  - Nuclear material Item Transfer forms - discrete items
  - Liguid Waste Transfer Forms - tank to tank transfers
  - Tamper indicating devices and acounting forms- seal application and removal forms
    - » kept for permanent storage at Records Holding Area
- Solvent Extraction Shift Logbooks and Oxide Conversion Line Logbooks
    - » kept on plant in PUREX records management vault
- Instrument strip charts for accountability
  - retained for 1 year at PUREX records management vault
    - » sent to permanent storage

Question 34:
Features related to Containment and Surveillance Measures

(general description of applied or possible measures)

- Seals, etc
- cameras in head end area
- possible applications in oxide or nitrate loadout
  - oxide loadout system is automated
    - » possible applications here.

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

(NOTE: we will address flow, <u>not inventory - detail),</u>

i) Description of location, type, identification

tk-E,F11-1	Ammonia waste
tk-E5	Cladding Waste(zirflex)
tk-D5	Accountability
Pu oxide to loadout	
Pu nitrate to loadout	
tk-K6	U product
F16&F18	High Level Waste
U3&U4	Lab Waste
R8&G8	Solvet Cleanup
other inventory tanks	
Solid Wastes	

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

ii) type of inventory change at this measurement point

tk-E,F11-1	Ammonia waste	-- batch, solution
tk-E5	Cladding Waste(zirflex)	-- batch, solution
tk-D5	Accountability	-- batch, solution
Pu oxide to loadout		-- batch/cans
Pu nitrate to loadout		-- batch/cans
tk-K6	U product	-- batch, solution
F16&F18	High Level Waste	-- batch, solution
U3&U4	Lab Waste	-- batch, solution
R8&G8	Solvet Cleanup	-- batch, solution
other inventory tanks		-- batch, solution
Solid Wastes (N-cell)		-- drum

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

iii) Possibility to use this measurement point for physical inventory taking

tk-E,F11-1	Ammonia waste	-- yes
tk-E5	Cladding Waste(zirflex)	-- yes
tk-D5	Accountability	-- yes
Pu oxide to loadout		-- blender only
Pu nitrate to loadout		-- tank only
tk-K6	U product	-- yes
F16&F18	High Level Waste	-- yes
U3&U4	Lab Waste	-- yes
R8&G8	Solvet Cleanup	-- yes
other inventory tanks`		-- yes
Solid Wastes (N-cell)		-- no

** NOTE: Inventory points not included

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

iv) Physical and chemical form of nuclear material

(including enrichment range, Pu content, and cladding material description)

tk-E,F11-1	Ammonia waste	--	0.9 or 1.25% U-235
tk-E5	Cladding Waste(zirflex)	--	
tk-D5	Accountability	--	
Pu oxide to loadout		--	
Pu nitrate to loadout		--	
tk-K6	U product	--	
F16&F18	High Level Waste	--	
U3&U4	Lab Waste	--	
R8&G8	Solvet Cleanup	--	
other inventory tanks		--	
Solid Wastes (N-cell)		--	

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

v) Nuclear material containers, packaging, and method of storage

			container	store
tk-E,F11-1	Ammonia waste	--	tank	none
tk-E5	Cladding Waste(zirflex)	--	tank	none
tk-D5	Accountability	--	tank	none
Pu oxide to loadout		--	slip lid can	interim only
Pu nitrate to loadout		--	PR can	interim only
tk-K6	U product	--	tank	none
F16&F18	High Level Waste	--	tank	none
U3&U4	Lab Waste	--	tank	none
R8&G8	Solvet Cleanup	--	tank	none
Solid Wastes (N-cell)		--	drums	interim only

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

vii) Measurement/analytical method(s) equipment used, and corresponding accuracies.

		Uranium		Plutonium	
		method	error	method	error
tk-E,F11-1	Ammonia waste	D/G	45%	alpha ct	47%
tk-E5	Cladding Waste(zirflex)	D/G	45%	alpha ct	67%
tk-D5	Accountability	IDMS	0.45%	IDMS	1%
Pu oxide to loadout		--	--	IDMS	0.3%
Pu nitrate to loadout		--	--	IDMS	1.0%
tk-K6	U product	D/G	0.81%	--	--
F16&F18	High Level Waste	D/G	45%	alpha ct	67%
U3&U4	Lab Waste	D/G	25%	alpha ct	40%
R8&G8	Solvet Cleanup	D/G	45%	alpha ct	67%
other inventory tanks		D/G	40%	alpha ct	60%
Solid Wastes (N-cell)		--	--	NDA	100%

D/G = Davies-Gray titration method

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

vi) Sampling procedure and equipment used (including number of samples taken, frequency, rejection criteria)

		sampler	no. samples	rejection
tk-E,F11-1	Ammonia waste	recirculation	2	repl. dens.
tk-E5	Cladding Waste(zirflex)	recirculation	2	repl. dens.
tk-D5	Accountability	recirculation	4	repl. dens.
Pu oxide to loadout		blender/grab	4	
Pu nitrate to loadout		recirc l/o tank	4	repl. dens
tk-K6	U product	recirculation	4	repl. dens
F16&F18	High Level Waste	recirculation	2	repl. dens
U3&U4	Lab Waste	recirculation	2	repl. dens
R8&G8	Solvet Cleanup	recirculation	2	repl. dens
most other inventory tanks		recirculation	2	repl. dens
Solid Wastes (N-cell)		N/A		repl. scans

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

viii) Sources and level of random and systematic errors for feed, product, waste (weight, volume, sampling, analytical)

NOTE: analytical in vii

		BULK		Sampling
		random	systematic	random
tk-E,F11-1	Ammonia waste	2.5%	2.5%	0.1%
tk-E5	Cladding Waste(zirflex)	2.5%	2.5%	0.1%
tk-D5	Accountability	0.2%	0.1%	0.05%
Pu oxide to loadout		0.2g	0.15g	0.1%
Pu nitrate to loadout		10g	8g	0.1%
tk-K6	U product	0.2%	0.1%	0.1%
F16&F18	High Level Waste	2.5%	2.5%	0.1%
U3&U4	Lab Waste	2.5%	2.5%	0.1%
R8&G8	Solvet Cleanup	2.5%	2.5%	0.1%
most other inventory tanks		2.5%	2.5%	0.1%
Solid Wastes (N-cell)		---	---	---

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

x) Calculative and error propo]agation trchniques.

tk-E,F11-1	Ammonia waste	--
tk-E5	Cladding Waste(zirflex)	--
tk-D5	Accountability	--
Pu oxide to loadout		--
Pu nitrate to loadout		--
tk-K6	U product	--
F16&F18	High Level Waste	--
U3&U4	Lab Waste	--
R8&G8	Solvet Cleanup	--
Solid Wastes (N-cell)		--

Standard Statistical Techniques

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xi) Techniques and frequency of calibration of equipment used, and standards used.

		calibration frequencies		
		bulk	instruments	analytical
tk-E,F11-1	Ammonia waste	6 yr	6 mo	
tk-E5	Cladding Waste(zirflex)	6 yr	6 mo	analytical
tk-D5	Accountability	3 yr	3 mo	QC --
Pu oxide to loadout (scale)		6 mo	--	daily QC
Pu nitrate to loadout (scale)		6 mo	--	checks
tk-K6	U product	3 yr	3 mo	with
F16&F18	High Level Waste	6 yr	6 mo	monthly
U3&U4	Lab Waste	6 yr	6 mo	instrument
R8&G8	Solvet Cleanup	6 yr	6 mo	calibration
other inventory tanks		6 yr	6 mo	
Solid Wastes (N-cell)		weekly NDA calibration source checks		

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xi) Programme for the continuing appraisal of the accuracy of weight, volume, sampling and analytical techniques and measurement methods.

Weight	- daily checks with field weights/ - 6 mo. full calibration
Volume	- recalibration as detailed in 35(x) - instruments as detailed in 35(x) - redundant instruments for accountability tanks - tank to tank transfer comparisons
Sampling	- replicate sampling program with density comparison
Analytical	- QC program as destailed in 35 x) - process control to accountability analysis comparisons for accountabuility samples

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xii) Programme for statistical evaluation of data from (x) and (xi)

Standard statistical techniques

- control charts
- control limits

xiii) Method of converting source data to batch data

(standard calculative procedures, constants and empirical relationships for feed, products in sub-accounting areas, waste)

Calibration tables, etc. to be supplied

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xiv) Means of batch identification

tk-E,F11-1	Ammonia waste	--	sequential batch (F11-94-1,2,3,etc.)
tk-E5	Cladding Waste(zirflex)	--	sequential batch (E5-94-1,2,3,etc.)
tk-D5	Accountability	--	sequential batch (D5-94-1,2,3,etc.)
Pu oxide to loadout		--	can IDs
Pu nitrate to loadout		--	can IDs
tk-K6	U product	--	sequential batch (K6-94-1,2,3,etc.)
F16&F18	High Level Waste	--	sequential batch (F16-94-1,2,3,etc.)
U3&U4	Lab Waste	--	sequential batch (U4-94-1,2,3,etc.)
R8&G8	Solvet Cleanup	--	sequential batch (R8-94-1,2,3,etc.)
Solid Wastes (N-cell)		--	bar code labels

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xv) Anticipated batch flow per year

250 operating days per year

		batches per year	
tk-E,F11-1	Ammonia waste	250	
tk-E5	Cladding Waste(zirflex)	125	
tk-D5	Accountability	250	
Pu oxide to loadout		250	(oxide or
Pu nitrate to loadout		50	nitrate or mix)
tk-K6	U product	250	
F16&F18	High Level Waste	33	
U3&U4	Lab Waste	30	
R8&G8	Solvet Cleanup	10	
Solid Wastes (N-cell)		30 drums	

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xvi) Anticipated number of inventory batches present at measurement points

1 inventory per year

tk-E,F11-1	Ammonia waste	--	1
tk-E5	Cladding Waste(zirflex)	--	1
tk-D5	Accountability	--	1
Pu oxide to loadout		--	0 (all cans shipped)
Pu nitrate to loadout		--	0 (all cans shipped)
tk-K6	U product	--	1
F16&F18	High Level Waste	--	1
U3&U4	Lab Waste	--	1
R8&G8	Solvet Cleanup	--	1
Solid Wastes (N-cell)		--	0 (all drums to waste)

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xvii) Anticipated number of items per flow and inventory batch

tk-E,F11-1	Ammonia waste	--	1
tk-E5	Cladding Waste(zirflex)	--	1
tk-D5	Accountability	--	1
Pu oxide to loadout		--	10 cans per blender
Pu nitrate to loadout		--	10 cans per tank
tk-K6	U product	--	1
F16&F18	High Level Waste	--	1
U3&U4	Lab Waste	--	1
R8&G8	Solvet Cleanup	--	1
Solid Wastes (N-cell)		--	1

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xviii) Type, coposition and quantity of nuclear material per batch.

(with indication of batch data, total weight of each element of nuclear material and form of nuclear material)

		U (kg)	Pu(g)
tk-E,F11-1	Ammonia waste	10	20
tk-E5	Cladding Waste(zirflex)	~0	~0
tk-D5	Accountability	10,200	20,000
Pu oxide to loadout		--	15,000
Pu nitrate to loadout		all oxide	
tk-K6	U product	10,200	--
F16&F18	High Level Waste	150	300
U3&U4	Lab Waste	~0	~0
R8&G8	Solvet Cleanup	~0	~0
Solid Wastes (N-cell)			50

Question 35:

For each flow and inventory sampling point of accountability areas identified in particular under qs. 13,22,23, give the following:

xiv) Features related to containment and surveillance

tk-E,F11-1	Ammonia waste	-- none
tk-E5	Cladding Waste(zirflex)	-- none
tk-D5	Accountability	-- none
Pu oxide to loadout		-- seals
Pu nitrate to loadout		-- seals
tk-K6	U product	-- none
F16&F18	High Level Waste	-- none
U3&U4	Lab Waste	-- none
R8&G8	Solvet Cleanup	-- none
Solid Wastes (N-cell)		-- none

Question 36:

Describe procedures to combine individual measurement error measurements to obtain overall limit of error for:

i) S/R difference

ii) Book inventory

iii) physical Inventory

iv) MUF

LEID for Plutonium

		random	systematic
tk-E,F11-1	Ammonia waste	--	--
tk-E5	Cladding Waste(zirflex)	--	--
tk-D5	Accountability	3.2	25.0
Pu oxide to loadout		2.1	7.5
Pu nitrate to loadout		all product as oxide	
tk-K6	U product		
F16&F18	High Level Waste	5.7	1
U3&U4	Lab Waste	--	--
R8&G8	Solvet Cleanup	--	--
Solid Wastes (N-cell)		--	--
inventory (20 kgs in 5 locations)		1	0.2

<u>overall LEID ~27 kgPu</u>

Question 37:
Optional Information

(That the operator considers relavent to safeguarding the facility)

You have got to be kidding!!!!!!
What else is there????

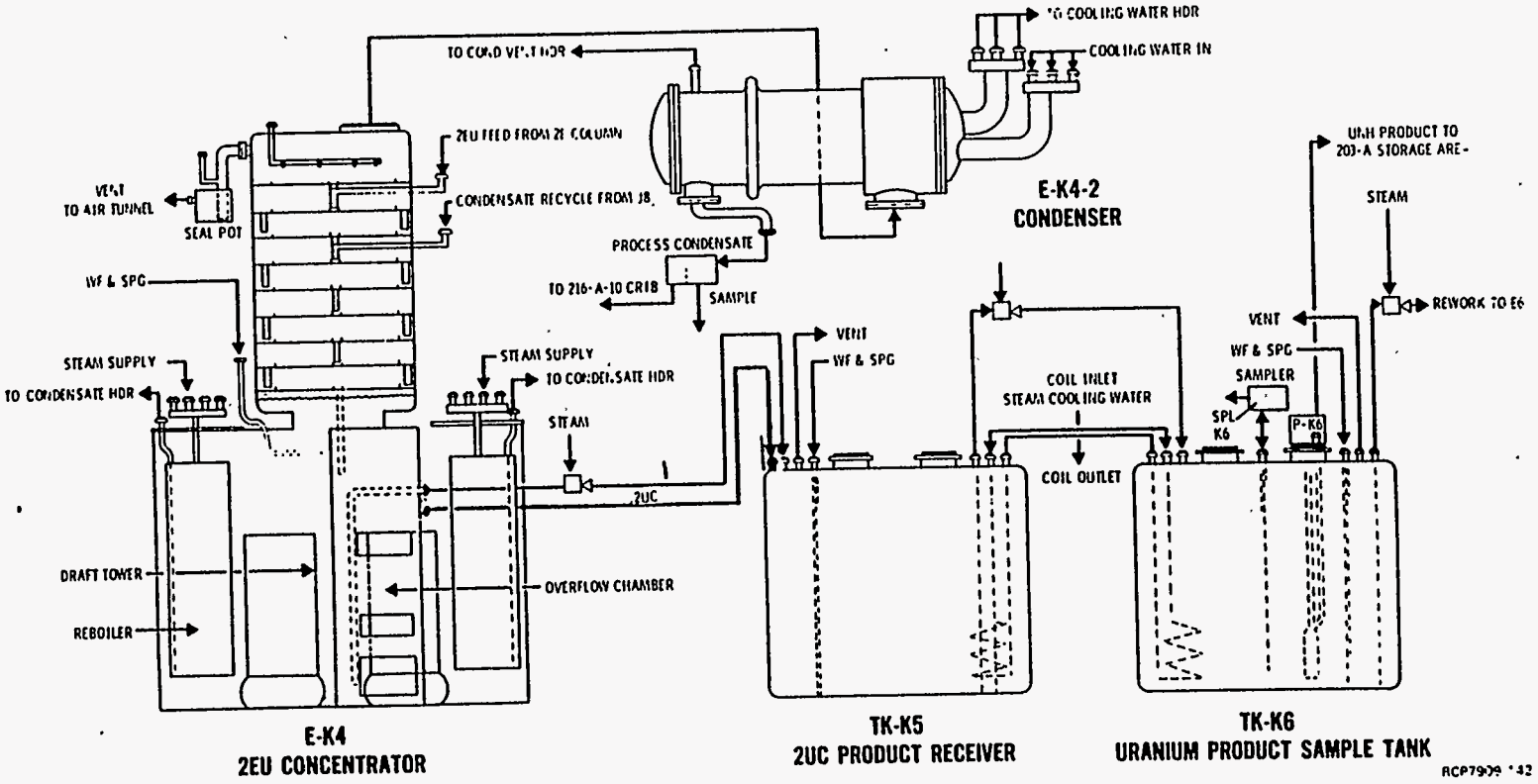


FIGURE 4-9. Uranium Concentration Process Flow Diagram.

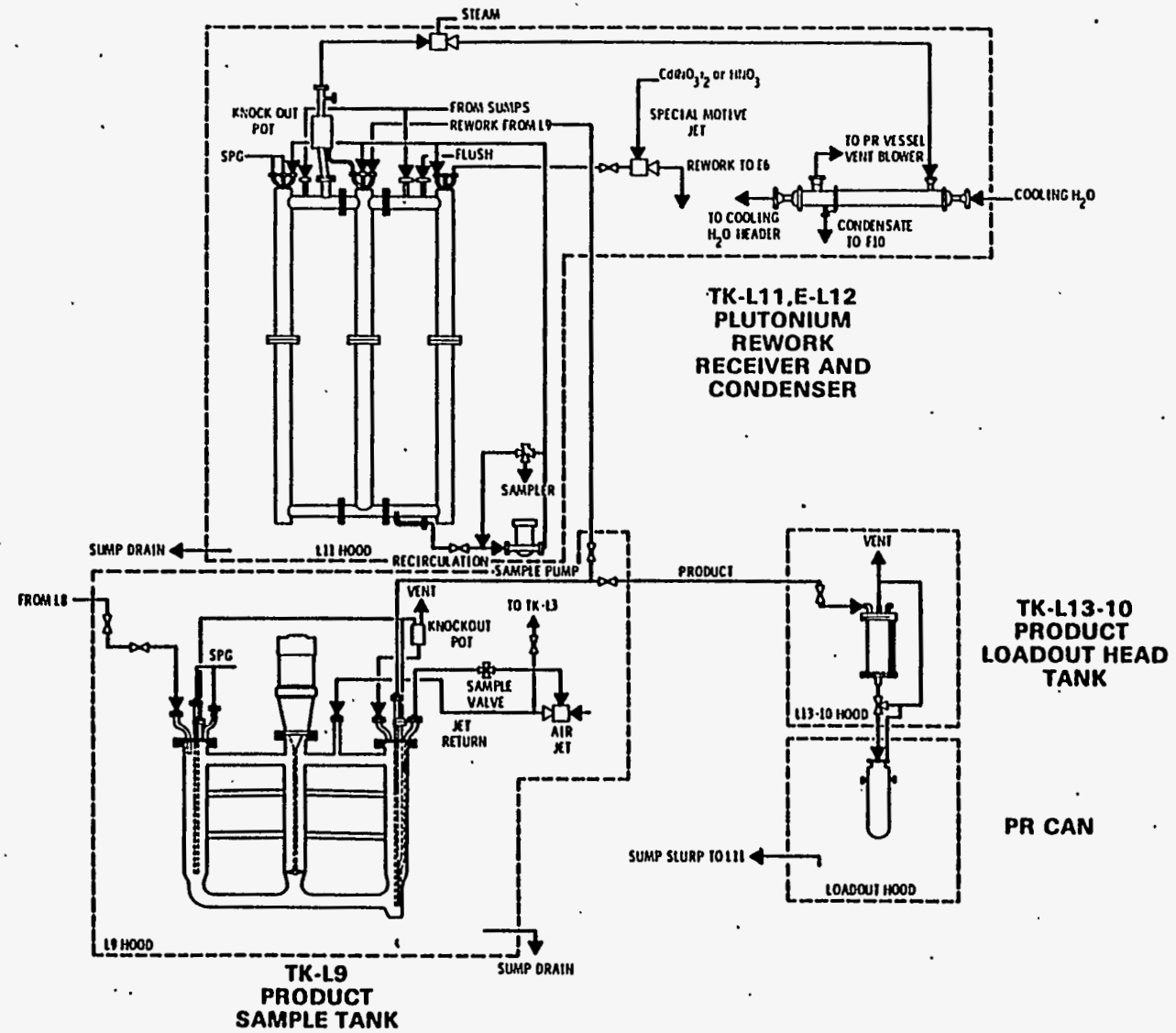


FIGURE 4-22. Product Removal Room Process Flow Diagram.

Appendix C

Inspection Plan
PUREX Safeguards Measures

Note: Paragraph references in Inspection Plan refer to paragraphs in the International Atomic Energy Agency Safeguards Criteria 1991-1995, Section 7 for Reprocessing Plants.

PUREX SAFEGUARDS MEASURES

TABLE OF CONTENTS

1.0

Initiation and Implementation Process

OUTLINE FOR INITIATING AND IMPLEMENTING IAEA SAFEGUARDS AT A PREVIOUSLY UNSAFEGUARDED FACILITY UNDER INFCIRC/153

Activity	Action for Party		
	State System	Facility Operator	IAEA Secretariat
Offer facility for safeguards (SG)	Notify Agency		Dispatch DIQ form/instr.
Prepare Design Information Questionnaire (DIQ)	Organize SSAC relation with fac.	Complete tech. aspects of DIQ	Anticipate and prepare for manpower increase
Review DIQ	Answer IAEA questions	Answer IAEA questions	Check DIQ for completeness and initiate SG approach; resolve questions on DIQ with State system officials
Submit initial inventory list	Prepare list from operator and submit to IAEA	Prepare inventory list	Check initial inventory list for arithmetic and code correctness and consistency with DI and model Facility Attachment (FA)
Verify DI	Arrange visa protocols, agree on ver. activities & schedule	Arrange visitor requirements, agree on ver. activities and schedule	At HQ: design verification strategy, prepare ver. team, agree (with State & op.) on ver. activities & schedule At facility: identify diversion routes, validate operators system (soundness of containment, vessel calibrations), C/S points, KMPs, sampling points, sample prep. stations, identify inspector office area and local arrangements (transportation, lodging, medical services, communications)
Prepare SG approach			Prepare approach considering SG of similar facilities, SG Criteria, staff requirements (PLARIE)
Prepare FA			Prepare FA based on SG approach, "model" FAs, other IAEA experience
Negotiate and agree on FA	Consider other SG FA in place for consistency, prepare for foreign national access (visa, nat'l/industrial security, protocol), report prep'n., sample transport	Consider facility impacts (staffing, accessibility, safety, training, feasibility of verification measures, labor relations, sample shipment reqs., additional IAEA records/reports reqs.)	Negotiate equivalent measures (if required) to meet SG approach, install & test IAEA equipment for C/S measures ASAP,
Verify initial inv.	As defined in FA	As defined in FA	As defined in FA

2.0

Plant Characteristic Verification

VERIFICATION OF PLANT CHARACTERISTICS

Verification of Design Information (¶11)

Design information provided to the IAEA by the State during the discussions of Subsidiary Arrangements is examined and verified according to established IAEA procedures.

Actions:
1. Check DIQ for completeness; resolve questions by correspondence with State.
2. Design verification strategy; select and train ver. team members.
3. Agree (with State and Operator) on verification activities and schedule.
4. At facility, identify diversion routes, soundness of containment, C/S points, KMPs, sample preparation stations, IAEA local office arrangements (communications, lodging, transportation).

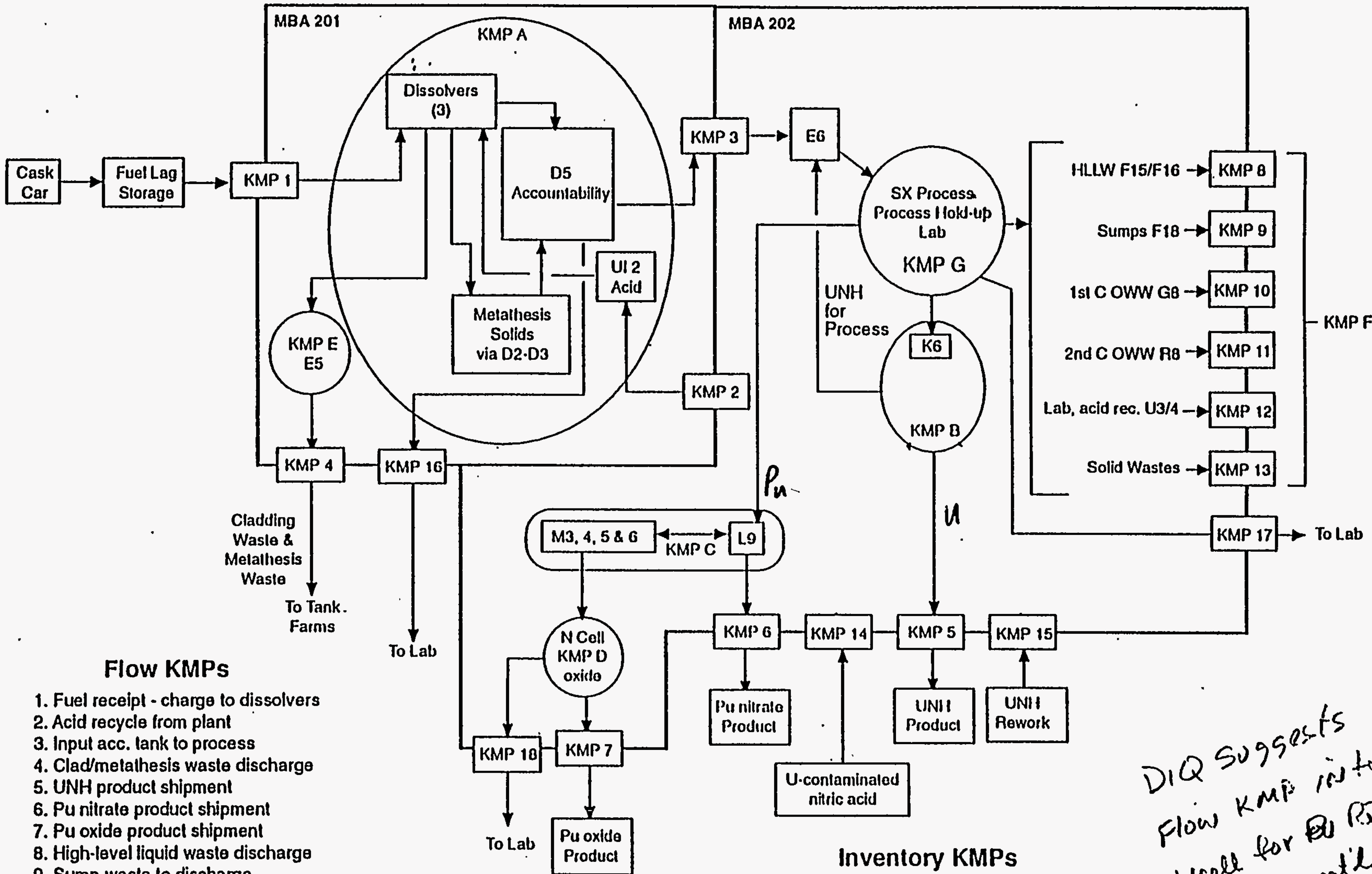
Re-examine design information annually in light of facility changes and safeguards implementation changes.

Re-verify design changes relevant to safeguards as they occur and change safeguards approach accordingly.

Verification of the Operator's Measurement System (¶12)

The quality and functioning of the operator's measurement system are evaluated annually.

Actions:
1. Observe the calibration and recalibration of scales, vessels, and other nuclear material measuring equipment used for accounting purposes (including the calibration of scales by IAEA weight standards).
2. Verify quality and functioning of the measurement system (analytical and NDA equipment) using independent standards and/or duplicate samples.
3. Observe operator sampling and sample treatment procedures.



Flow KMPs

1. Fuel receipt - charge to dissolvers
2. Acid recycle from plant
3. Input acc. tank to process
4. Clad/metathesis waste discharge
5. UNH product shipment
6. Pu nitrate product shipment
7. Pu oxide product shipment
8. High-level liquid waste discharge
9. Sump waste to discharge
10. First cycle organic wash waste discharge
11. Second cycle organic wash waste discharge
12. Lab and acid recovery waste discharge
13. Solid wastes to burial
14. Acid return from UO_3 plant
15. UNH return from UO_3 plant
16. Analytical Samples from D5
17. Analytical Samples from lab
18. Analytical Samples from N Cell

Inventory KMPs

A. D5 accountability vessel
B. UNH vessels (K6 acc. vessel)
C. Pu nitrate product vessels (L9 acc. vessel and M3,4,5
D. Pu oxide product - N cell
E. Cladding waste vessel E5
F. Acid waste vessels F15, F16, F18, G8, R8, U3/4 and solid waste
G. Process hold-up

DIQ suggests Flow KMP into Ncell for Pu Returns (out of spec mt'l)

29402078.1

newer version w/ Δs

3.0

Accountancy Verification

BOOK ACCOUNTABILITY

Examination of Records and Reports (¶1)

The facility accounting and operating records and supporting documents are examined for correctness and internal consistency. All records examined by time of the material balance closing.

The facility accounting records are compared with the inventory change (ICR), material balance (MBR) and any special reports by the State to the IAEA.

The list of inventory items (LII) received from the operator at the time of the PIV is compared for consistency with the MBR and the associated physical inventory listing (PIL).

The ICRs and MBRs are compared for consistency.

Confirmations of transfers (¶13)

All transfers (receipts and shipments) recorded by a facility are confirmed by comparison with the corresponding reports or records of shippers or receivers. International and domestic inter-facility transfers of direct-use materials are confirmed within the period of the timeliness goal, modified for normal shipping times.

4.0

Material Verification

FLOW VERIFICATION

MBA 201 KMP	TRANSACTION	VERIFICATION MEASURE (Safeguards Criteria Citation)
1	Fuel receipt and load fuel to dissolver	Item count all (item ID not possible), G (gamma, neutron) @ M, C/S on dissolver loading (¶3.1, 5.1)
2	Acid from MBA 202	No verification identified in Criteria (¶4.2)
3	Input accountancy	Vol. and G/P/B all, C/S to detect transfers (¶4.2)
4	Cladding waste	G @ level such that unverified <0.5 SQ/MBP (¶4.1)
MBA 202 KMP	**TRANSACTION**	**VERIFICATION MEASURE (Safeguards Criteria Citation)**
5	UNH product shipment accountancy	Vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶3.3ci)
6	Pu nitrate shipment accountancy	Wt./vol. and G/P/B and C/S (seal or inspector observation) @ H (¶3.3a)
7	Pu oxide shipment accountancy	Wt. and G/P/B and C/S (seal or inspector observation) @ H (¶3.3a)
8	High level waste disposal	G @ level such that unverified <0.5 SQ/MBP (¶4.1)*
9	Sump waste disposal	G @ level such that unverified <0.5 SQ/MBP (¶4.1)
10	Org. wash waste #1 disposal	G @ level such that unverified <0.5 SQ/MBP (¶4.1)
11	Org. wash waste #2 disposal	G @ level such that unverified <0.5 SQ/MBP (¶4.1)
12	Acid rec./lab waste disposal	G @ level such that unverified <0.5 SQ/MBP (¶4.1)
13	Solid waste disposal	G @ level such that unverified <0.5 SQ/MBP (¶4.1)
14	Acid from UO_3 Plant	Wt./vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶3.3ci)
15	UNH return from UO_3 Plant	Wt./vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶3.3ci)
16	Analytical samples from D5	Wt./vol. and G/P/B @ H (¶3.3a)
17	Analytical samples from lab	For Pu: wt. and G/P/B and C/S (seal or inspector observation) @ H (¶3.3a) For U: vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶3.3ci) For irrad. direct use: wt./vol. and G/P/B @ H (¶3.3a)
18	Analytical samples from N Cell	Wt. and G/P/B and C/S (seal or inspector observation) @ H (¶3.3a)

*Total unverified by all routes <0.5SQ/MBP.

VERIFICATION AT INTERIM INSPECTIONS FOR TIMELY DETECTION

MBA 201 KMP	LOCATION	VERIFICATION MEASURE (Safeguards Criteria Citation)
A	Input accountability	Case-by-case procedure approved by DDG-SG (¶9.4b)
E	Cladding waste (Tk E5)	G @ M (¶9.4c)
MBA 202 **KMP**	**LOCATION**	**VERIFICATION MEASURE** **(Safeguards Criteria Citation)**
B	UNH product	No requirement for indirect use material
C	Pu nitrate product	Wt./vol. and G/P @ M (G only if <3SQ); for C/S, seal ver. @ L^2 plus item count and ID (¶9.4a,d)
D	Pu oxide product/process	Wt. and G/P @ M; for C/S, seal ver. @ L plus item count and ID (¶9.4a,d)
F	Waste-holding vessels (Tks F15/16/18, G8, R8 and U3/4)	G @ M for Pu; nothing for U (¶9.4c)
G	Pu process hold-up	Case-by-case procedure approved by DDG-SG (¶9.4b)
H	Miscellaneous (samples, standards)	For Pu: wt./vol. and G/P @ M; for C/S, seal ver. @ L plus item count and ID; for U, no requirement (¶9.4a,d)

PHYSICAL INVENTORY VERIFICATION

MBA 201 KMP	LOCATION	VERIFICATION MEASURE (Safeguards Criteria Citation)
A	Input accountability	Vol. and G/P/B all @ H (¶2.3a)
E	Cladding waste (Tk E5)	G @ M (¶2.5)
MBA 202 **KMP**	**LOCATION**	**VERIFICATION MEASURE** **(Safeguards Criteria Citation)**
B	UNH product	Vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶2.3b,c)
C	Pu nitrate product	Wt./vol. and G/P/B @ H; solutions normally to be collected in calibrated tanks; for C/S, seal ver. @ M plus item count and ID with remeasurement @ 10% det. prob. (¶2.3a, 2.4a, 2.6a)
D	Pu oxide product/process	Wt. and G/P/B @ H; for dirty scrap, NDA (P) allowed if more accurate than DA (B); for C/S, seal ver. @ M plus item count and ID with remeasurement @ 10% det. prob. (¶2.4a, 2.6a)
F	Waste-holding vessels (Tks F15/16/18, G8, R8 and U3/4)	G @ H (for Pu) and @ M (for U) (¶2.5)
G	Pu/U process hold-up	For Pu: vol. and G/P/B @ H; for residual hold-up, NDA (P) allowed if more accurate than DA (B) (¶2.3a) For U: wt./vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶2.3b,c)
H	Miscellaneous (samples, standards)	For Pu: wt./vol. and G/P/B @ H; for C/S, seal ver. @ M plus item count and ID with remeasurement @ 10% det. prob. (¶2.3a, 2.4a, 2.6a) For U: wt./vol. and G/P/B @ M for EU, G/P for NU, G only for DU (¶2.3b,c)

Verification at Other Strategic Points (¶5)

Activities in the Process Area:

Status of process, product and waste vessels is reviewed by instrument readings and through recorded data. Dissolution completeness is verified by monitoring vessel readings (e.g., recorders of radiation, density, level, temperature). Recycle material is sampled for analysis as required.

Activities for Extended Shutdown of the Process Area:

Verification of the operator's record of inventory in the process area. Continuation of safeguards at the input (dissolver), process output and product areas. Operational data provided by the facility operator such as in-plant radiation monitors and strip chart recorders may also be used for confirmation.

5.0

Material Balance Evaluation

Material Balance Evaluation (¶8)

Shipper-receiver differences (SRDs) are evaluated for statistical significance whenever MUF and MUF-D are evaluated and when SRDs are greater than 0.1 SQ in an MBP.

MUF is evaluated for statistical and safeguards significance using international standards of accountancy.

The operator/inspector difference statistics (D) are calculated for strata having P and/or B verification.

For reprocessing plants, SRDs from a single shipper usually are evaluated by campaign.

If the inventory for a material type is less than 2 SQ, MUF and MUF-D are not evaluated.

Discrepancy and Anomaly Follow-up (¶10)

All anomalies are followed-up. The sum of unresolved discrepancies and anomalies at the end of the calendar year total more than 1 SQ of any material type, actions must taken to determine whether a diversion has occurred.

6.0

Suspended Operations

ACTIVITIES WHEN INVENTORY IS LESS THAN 1 SQ (¶14)
(suspended operations if clean-out <1 SQ)

Activities in criteria ¶1 (examination of records and reports), 10 (discrepancy and anomaly follow-up), 13 (confirmation of transfers) and 14.3 (PIV, see below) are carried out.

The PIV is performed according the safeguards criteria (¶2) modified as follows (¶14.3):

1. For solutions. For Pu: G/P @ M. For LEU: G/P @ L. For NU/DU: G @ L.
2. For compounds without C/S. For Pu: G/P @ M. For LEU: G/P @ L. For NU/DU: G @ L.
3. For nuclear material in waste not under C/S. For Pu: G @ M. For others: G @ L.
4. For material under C/S, the C/S is evaluated. Seal verification @ L. If C/S unacceptable, reverification is performed at the same level (G/P/B) and assurance (L/M/H) as for comparable material not under C/S (Annex C, ¶6.2).
5. The quantity of each material type unverified is increased from 0.3 to 0.6 SQ.

7.0

Criteria Not Applicable

CRITERIA NOT APPLICABLE

The following Criteria are not applicable to INFCIRC/153 safeguards of a reprocessing plant as a stand-alone facility:

¶7 - Confirmation of the absence of borrowing of nuclear material. Not applicable to "stand-alone" reprocessing plants.

¶15 - Activities related to non-nuclear material under safeguards. INFCIRC/66 only.

¶16 - Activities related to equipment and facilities under safeguards. INFCIRC/66 only.

¶17 - Activities related to the preparation and maintenance of inventories and of lists of information. INFCIRC/66 only.

8.0

Inspection Effort

INSPECTION EFFORT

OPERATION	DESCRIPTION	INSPECTOR SHIFTS/DAY (PERSON-DAYS/Y)
Witness loading of dissolver	Witness crane operations in charging of dissolver from rail car cask; 16 crane picks (32 canisters) per dissolver load; 3 dissolvers; 56 hour dissolver cycle time; about one dissolver charge per day	3
Sample input acc. tank	Witness D5 sampling and sample prep. (dilution) in sampling pit; take manometer readings in control room	0.5
Pu nitrate product sampling or	Witness loading, sampling and sealing of product removal (PR) cans; about 20 kg Pu per day; about 2 kg Pu per PR can; about 10 PR cans per day; also take Pu accountability tank (L9) readings and samples	3 or
Pu oxide product sampling	Witness loading, sampling and sealing of Pu oxide powder cans; about 20 kg Pu per day; about 1.6 kg Pu per can; about 12 can per day; also take Pu accountability tank (L9) readings and samples	2
UNH product accountability	Witness load-out, sampling and manometer readings of UNH product tank K6	0.25
Waste discharges	Witness waste discharges on random basis (E5, F16/F18, R8/G8 primarily)	0.25
Administration	Perform administrative tasks, records/reports checks, reports to IAEA, scheduling, sick-day relief.	1
	Routine operations inspection total (person-day total assuming 250 operating days per year)	7 - 8 (1750 - 2000)
Interim inventory verifications	Two IIV per year (for the two months shut-down)	(12)
Physical inventory verification	One PIV per year	(20)
	Shut-down operations inspection total (person-days)	(32)

INSPECTION EFFORT DEFINITIONS

MRIE: Maximum routine inspection effort. Defined in paragraph 80 of INFCIRC/153 as 30 man-days x the square root of the annual throughput of the facility, in effective kilograms. For PUREX, the annual throughput is assumed to be 5000 kg plutonium. The MRIE is 2130 man-days per year.

PLARIE: Planned annual routine inspection effort. This figure was calculated to be 1782 to 2032 person-days annually based on the capacity figures submitted in the DIQ.

ARIE: Actual routine inspection effort. This figure will be somewhat lower than PLARIE based on operating experience. For PUREX, an "on-line availability" of 50% of the DIQ operating capacity is expected based on 1980s performance.

9.0

Appendix

VERIFICATION MEASUREMENTS

MATERIAL CATAGORY	MAIN STRATUM	MATERIAL TYPE COMPONENTS	DEFECT TYPE	DEFECT DESCRIPTION	MEASUREMENTS REQUIRED	APPLICABLE METHOD	RECOMMENDED INSTRUMENTS
UNIRRADIATED DIRECT-USE	PLUTONIUM NITRATE SOLUTION (SO)	PU	G/P/B	NO PU PART OF PU MISSING PU CONTENT BIAS	PU CONTENT	(C or B) + (D or E)	ELTM + KEDG DA
	PLUTONIUM OXIDE POWDER (PD)	PU	G	NO PU	PU RADIATION	H	HLNC PMCG
			P	PART OF PU MISSING	PU CONTENT	F	HLNC + SLNC INVS + SLNC + EBAL
			B	PU CONTENT BIAS	PU CONTENT	B + D E	DA CALR + SLNC
IRRADIATED DIRECT-USE	DISSOLVER SOLUTION (DS)	PU	G/P/B	NO PU PART OF PU MISSING PU CONTENT BIAS	PU CONTENT	(C OR B) + D	ELTM + DA ELTM + HKED
		DNLEU	G/P/B	NO U PART OF U MISSING U CONTENT BIAS	U CONTENT	(C OR B) + D	ELTM + DA ELTM + HKED
	MEASURED DISCARDS, WASTE (WL, WS)	PU, DNLEU	G	PU OR U MISSING			PMCG DA (1)
	SPENT FUEL (SF)	PU, DNLEU	G	ASSEMBLY REPLACED BY DUMMY, OR MISSING	ITEM COUNT, RADIATION	I + H	ICVD GRN1, CPMU, HSGM (2) SFAT (3)
INDIRECT-USE	URANIUM SOLUTION (SO)	DNLEU	G/P/B	NO U PART OF U MISSING U CONTENT BIAS	U CONTENT	(C OR B) + D	ELTM + DA
	URANIUM POWDER (PD)	DNLEU	G	NO URANIUM	U RADIATION	H	PMCN
			P	PART OF URANIUM MISSING	U ENRICHMENT, WEIGHT	B + F	PMCN + EBAL
		LEU	B	U-235 CONTENT BIAS	U CONTENT	B + D	DA + EBAL

(1) Hull monitors recommended where available
(2) In special cases (long cooling time, poor visibility) where fuel sufficiently isolated.
(3) NDA based on gamma radiation or neutrons recommended for closed containers

GLOSSARY

Verification sensitivity: G=gross (RSD=0.25), P=partial (RSD=0.0625), B=bias (RSD=best analytical)

Detection probability: L=low (det. prob.=0.2), M=medium (det. prob.=0.5), H=high (det. prob.=0.9)

		Description	G/P/B
Methods:	B	weighing	B
	C	volume	B
	D	DA	B
	E	NDA with low RSD (e.g., KEDG)	B
	F	U enrichment	P
	H	qualitative radiation	G
	I	item count	

C/S: containment/surveillance
CALR: calorimeter
CPMU: CP (Cutie Pie) monitor
DA: destructive analysis
DDG-SG: Deputy Director General - Department of Safeguards (IAEA)
DU: depleted uranium (enrichment <0.72% U-235)
EBAL: electronic balance
ELTM: electromanometer and fluid manometer (dip tubes)
EU: enriched uranium (enrichment >0.72% U-235)
GRN1: Grand-1, neutron/gamma measurement spent fuel fork-shaped detector
HKED: K-edge for uranium
HLNC: high-level neutron coincidence counter
HSGM: high-sensitivity gamma monitor
ICVD: improved Cerenkov viewing device
ID: identification number verification
INVS: inventory sample device (neutron based)
KEDG: K-edge densitometer
KMP: key measurement point
MBA: material balance area
MBP: material balance period
NDA: non-destructive analysis
NRTA: near real-time accountability
NU: natural uranium (0.72% U-235 natural enrichment)
PMCG/PMCN: portable multichannel analyzer, Ge/NaI detector
RSD: relative standard deviation
SFAT: spent fuel attribute tester
SLNC: Silena multichannel analyzer (high-resolution for Pu isotopics)
SQ: significant quantity (8 kg Pu, 25 kg U-235 at enrichment ≥20%, 75 kg U-235 others)
UNH: uranyl nitrate hexahydrate solution

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