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TITLE FLOWSHEET REPORT FOR BASELINE ACTINIDE BLANKET PROCESSING FOR ACCELERATOR TRANSMUTATION OF WASTE

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Flowsheet Report
for
Baseline Actinide Blanket Processing
for
Accelerator Transmutation of Waste

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Abstract

We provide a flowsheet analysis of the chemical processing of actinide and fission product materials from the actinide blanket of an accelerator-based transmutation concept. An initial liquid ion exchange step is employed to recover unburned plutonium and neptunium, so that it can be returned quickly to the transmuter. The remaining materials, consisting of fission products and trivalent actinides (americium, curium, . . .), is processed after a cooling period. A reverse TALSPEAK process is employed to separate these trivalent actinides from lanthanides and other fission products

I. INTRODUCTION

This report is a companion to an earlier report[1] detailing the concepts for chemical processing of the actinide blanket of an accelerator-based transmutation system. We present here the detailed results of a steady-state flowsheet model of the process based upon the commercial ASPEN PLUS flowsheet simulation software There are four primary sections to the flowsheet for the overall process, consisting of

- Dissolution of the feed stream from the transmuter blanket,
- Fast ion exchange recovery of Np and Pu,
- Separation of actinides, lanthanides, and fission products, and
- Waste stream treatment.

In Ref. 1, the dissolution step was depicted in Figure 2, the fast recovery step in Figure 3, the actinide/lanthanide separation step in Figures 4 and 5, and the waste treatment step in Figure 6. Each of these four sections is modeled as a separate ASPEN PLUS flowsheet. Communication between models is accomplished by saving the exit streams flows of one model and later retrieving them as feed stream flows of downstream processes in other models.

II. CHEMICAL COMPONENTS MODELED

The components modeled include both the materials in the transmuter blanket and the chemicals used to process these materials. Components present in the transmuter blanket are identified by their elemental makeup only, and are not modeled in their true chemical speciation. This restriction is made necessary because of the scarcity of physical property data available for most of the actinide and fission products present in the system. Since the modeling effort at present emphasizes material balances in the different flow streams, and not the thermodynamic behavior of the system, little physical property information is actually required.

The elemental components modeled in the transmuter blanket include the following:

- The six fission products Sr, Zr, Tc, Ru, Pd, and Cs are followed individually, either because their separations chemistry is unique, or they have relatively long half lives. The long-lived Tc component is separated from the rest of the mixture for further transmutation to stable Ru.

- The halogens Br and I and the noble gases Kr and Xe are lumped together as a single volatile component, which is recovered in the initial oxide dissolution step. The processing of these volatile gaseous materials is modeled in a separate flowsheet, and so they are not modeled in any greater detail in this one. In this model this lumped component is referred to as the `VOLATILE` component.
- Other transition metal fission products, with similar separations chemistry are lumped together as a single component referred to in the model as `FISSP`.
- The fission of actinides in the transmuter also produces significant quantities of elements in the lanthanide series. These elements also generally exhibit similar properties in their separations chemistry, and are modeled as a single lumped component, referred to as `LANTH`.
- The five actinide species U, Np, Pu, Am, and Cm are also modeled individually. In this version of the model, it has been assumed that there is no U present in the transmuter blanket feed, and little is produced by nuclear processes involving the other actinide species in the blanket. Consequently, there is never any U in the flowsheet.

Much of the separations chemistry for this model is based upon the selective extraction of material into an immiscible liquid organic phase. Consequently, this model includes the following additional chemical components which are used in these processing steps:

- `H2O`, normal water, used as a solvent for much of the separations chemistry.
- `HNO3`, nitric acid, present to adjust the pH of the aqueous phase and as a complexant for many of the actinide and fission product species.
- `O3`, gaseous ozone, used as a sparge in the dissolution step to promote the volatilization of the `VOLATILE` components as well as any Ru present.
- `DIPB`, di-isopropylbenzene, the organic solvent used in the liquid ion exchange extraction step for Pu and Np.
- `ALIQ`, Aliquat 336, a quaternary aliphatic amine, dissolved in the `DIPB` and used as the anionic ion exchange medium.

- `NH4OH`, ammonium hydroxide, used in the aqueous feed to strip Tc and Pd from the `DIPB/ALIQ` phase, and to adjust the pH in other parts of the process.
- `NPH`, a mnemonic for "normal paraffinic hydrocarbon" used as the organic solvent system for the reverse TALSPEAK separation of actinides from lanthanides. In this model, the `NPH` component is modeled as n-decane.
- `HDEHP`, di-2-ethylhexylphosphoric acid, used as the organic extractant in the reverse TALSPEAK extraction process.
- `LACTIC`, lactic acid, used in combination with `DTPA` (below) to strip the trivalent actinides Am and Cm from the `HDEHP/NPH` phase in the reverse TALSPEAK process.
- `DTPA`, diethylenetriaminepentaacetic acid, also used in the stripping of trivalent actinides in the reverse TALSPEAK step.
- `CARBNAT`, ammonium carbonate, used to clean and wash the organic solvent in the reverse TALSPEAK process.
- `FORMIC`, formic acid, used to remove excess nitrate from the feed to the reverse TALSPEAK process.

III. DISCUSSION OF UNIT OPERATIONS

There are three unit operation models used in the four sections of this model. They include

- a liquid-liquid extraction model (EXTRACT), used to model the solvent extraction chemistry,
- a stream mixer (MIXER), used to combine the flows of two or more material streams, and
- a component separator (SEP2), used to route feed components into two product streams using component split fractions.

The component separator model SEP2 relies on user-supplied parameters to define how much of each component is directed to each exit stream. This model relies little on physical property data and allows the user to model a separations process without a detailed description of the underlying physics or chemistry.

The significant separations chemistry employed in this concept for actinide blanket processing consists primarily of solvent extraction procedures. The ASPEN PLUS flowsheet simulation software provides the basic unit operation model (called EXTRACT) used to simulate these processes. Even without a complete database of physical property data for all the components of the material streams, this model allows the user to specify the liquid-liquid distribution coefficients D_i of the components being separated, defined as

$$D_i = \frac{[i]_O}{[i]_A}, \tag{1}$$

where $[i]_O$ represents the molar concentration of species i in the organic phase, and $[i]_A$ represents the molar concentration of i in an equal volume of the aqueous phase. In this manner, we can employ experimentally measured separation factors along with specifications for the number of extraction stages, flow rates of the aqueous and organic phases, and theoretical stage efficiencies to provide a more complete model of the separation process.

The user-supplied distribution coefficients are read from data files stored on disk; each separation process may in principle read its own set of distribution coefficient data. This data is supplied in an empirical form similar to that presented by Svantesson *et al.*[2] in their Table 3. Using this form, it is possible to express the dependence of the distribution coefficient on the acid concentration in the aqueous phase, so that

$$D = \frac{k_1 + k_2 A^{n_2} + k_3 A^{n_3}}{1 + k_4 A^{n_4} + k_5 A^{n_5}}, \tag{2}$$

where D is the distribution coefficient as a function of the acid concentration A. The empirical coefficients k_i can easily be determined from experimental data using a linear least squares fitting algorithm, once the exponents n_i are chosen. The input table for each separation process supplies the empirical parameters $k_1, k_2, \ldots, k_5$ and $n_2, \ldots, n_5$ for each species in the two-phase liquid extraction system.

In the rest of this section, we will discuss the process model for each of the flowsheet sections described in the introduction.

<u>Section 1, Blanket Feed Dissolution</u>. The first section describes the processing required to dissolve the oxide feed from the transmuter blanket, thereby prepar-

ing it for the extraction processes to follow. This section of the flowsheet is depicted in Fig. 1. The dissolution process consists of two component separator models, the first (labelled DISO) of which combines the oxide feed with water and concentrated nitric acid. An ozone sparge is present to facilitate the volatilization of fission-produced ruthenium (as RuO_4, see Ref. 1). This model does not explicitly treat the addition of sodium nitrite, which is used to adjust valences of the dissolved fission products and actinide materials (since the detailed chemistry of these species is not modeled). In the dissolution step, any volatile materials not recovered when the D_2O was replaced in the slurry with H_2O will be recovered and sent off for waste gas treatment (also not modeled here explicitly). The dissolved materials are then filtered (modeled by a second SEP2 process labelled FILO). The filtrate is sent on for further processing by the next section of the flowsheet, and any undissolved solids (assumed to be small in quantity) are retained for occasional, more aggressive processing (not modeled).

Section 2, Fast Return Loop. The second section of the flowsheet (see Fig. 2) models the fast return loop in which unreacted plutonium and neptunium from the transmuter blanket is recovered and returned to the transmuter. In this section, the fission products technetium and palladium are also recovered. Transmuter blanket material exiting the first section of the flowsheet in stream DS-5 enters this section of the flowsheet as stream FS-1. This stream is contacted with a ten-stage liquid anion exchanger (the quaternary amine Aliquat 336) dissolved in di-isopropylbenzene. Each extraction stage is modeled with an efficiency factor of 0.95, so that the effective distribution coefficient for component i is $D_i^{eff} = 0.95 D_i$. The ASPEN PLUS model treats this step with a liquid-liquid extraction unit operation model, with the ID LIXEXT in the flowsheet, and obtains user-supplied distribution coefficients from the data file

```
sulfur:/homes/rbw/aspen/atw/mm/ALIQX.dat .
```

All components present in the aqueous feed are modeled to have distribution coefficients which are independent of the acid concentration, so that in Eq. (2), k_1 is a constant, and $k_2 = k_3 = k_4 = 0$. The distribution coefficient for the components present are given in Table 1 below.

Table 1

organic soluble	*strong extraction*	*weak extraction*	*trace extraction*	*organic insoluble*
$D = 10^{20}$	$D = 50$	$D = 5$	$D = 0.001$	$D = 10^{-20}$
DIPB ALIQUAT	NP PU	TC PD	all others	H2O HNO3

The raffinate from this first extraction step contains fission products, the trivalent actinides, and lanthanides. This stream is diverted to holding vessels for a 180-day cool-down period, after which it is processed in the next section of the flowsheet. The organic phase from the LIXEXT extraction step is routed to the first of two stripping steps, named ACSTRP, which selectively strips the actinides *Pu* and *Np* using a low acid concentration wash. Distribution coefficients for this extraction step are obtained from the data file

```
sulfur./homes/rbw/aspen/atw/mm/ALIQS1.dat ,
```

and these distribution coefficients are also modeled to be independent of the concentrations of all other species present. The distribution coefficients for this step are defined in Table 2.

Table 2

organic soluble	*very weak extraction*	*weak extraction*	*trace extraction*	*organic insoluble*
$D = 10^{20}$	$D = 0.01$	$D = 5$	$D = 0.001$	$D = 10^{-20}$
DIPB ALIQUAT	NP PU	TC PD	all others	H20 HNO3

The ACSTRP step is modeled as a seven-stage liquid-liquid extraction process. The aqueous exit stream, containing the recovered *Pu* and *Np* components, is directed to a thermal denitration step (DENIT, modeled as a component separator), and the organic exit stream is routed to a second extraction/stripping operation, FPSTRP, which recovers *Tc* and *Pd* into its aqueous exit stream. The constant distribution coefficients for this five-stage liquid-liquid extraction model are defined in the data file

```
sulfur:/homes/rbw/aspen/atw/mm/ALIQS2.dat.
```

In the present model, the distribution coefficients for this step are defined so that the DIPB and ALIQUAT components are soluble in the organic phase ($D = 10^{20}$), and all others are insoluble ($D = 10^{-20}$), effectively stripping everything from the organic phase.

The aqueous exit stream (FS-10) feeds a calcination step CALCINE, modeled as a component separator, which further separates the *Tc* and *Pd*, since the *Tc* is volatilized as Tc_2O_7 and the Pd component remains in the calcined ash. The organic exit stream from FPSTRP, now stripped of most of its blanket materials, would be washed periodically and recycled as the organic feed stream to the original LIXEXT step. This washing and recycling operation is not modeled in any detail at present.

Section 3, Actinide/Lanthanide Separation. The third section of the flowsheet (see Fig. 3) models the separation of the remaining fission products and actinides from the blanket. The net result of the processing in this section is to produce three classes of material streams, one for the trivalent actinides americium and curium, one for fission product members of the lanthanide series, and one for other fission products, including cesium and strontium.

The raffinate from the LIXEXT step of the previous section, stream FS-4, is used as the feed stream TS-1 to this section. After a cooling period of 180 days, this stream is processed in preparation for the extraction steps to follow. The preprocessing steps are modeled as a component separator PRPFEED and a stream mixer MIXER, and serve to reduce the nitric acid concentration from $2M$ to $0.1M$. This acid adjustment is accomplished by the addition of formic acid, which reacts with the nitric acid component, evolving gaseous CO_2, NO_2, and O_2.

> Actually, Ref. 1 doesn't specify exactly how this reaction goes, but a balanced redox pair for nitric/formic acid can be written to produce the equation $HCOOH + 2HNO_3 \rightarrow 2H_2O + CO_2 + 2NO_2$. The actual chemistry is more complex than this, and we should put in a reference.

The chemistry of this denitration reaction will be modeled more thoroughly in the future; at present we use a simple component separator. The PRPFEED separator simply routes all the formic acid and nitric acid, and some water to one exit stream (TSF-2), and remaining components to the other (TSF-4). A small amount of nitric acid is reintroduced in feed stream TS-3, and mixed (in MIXER) with the denitrated stream to adjust the pH of the feed to the reverse TALSPEAK operations to follow.

The initial step of the reverse TALSPEAK process (ACLNX, a two-stage liquid-liquid extraction model) extracts lanthanide and trivalent actinide components into an organic phase consisting of $1M$ HDEHP in NPH. Other fission products, including Sr and Cs, are not extracted in this step, and are routed (TS-4) for further treament in the final section of the flowsheet.

Distribution coefficients for the ACLNX step are obtained from the data file

```
sulfur:/homes/rbw/aspen/atw/mm/TALEX.dat ,
```

and these distribution coefficients are also modeled to be independent of the concentrations of all other species present. The distribution coefficients for this step are defined in Table 3.

Table 3

organic soluble	*strong extraction*	*trace extraction*	*organic insoluble*
$D = 10^{20}$	$D = 100$	$D = 0.001$	$D = 10^{-20}$
NPH HDEHP	AM, CM LANTH	all others	H2O HNO3

The second extraction step (ACSTRP) is a three-stage liquid-liquid extraction model that serves to preferentially strip the actinide components from the organic effluent of the previous step (TS-3) by contacting the organic phase with an aqueous wash of 0.05*M* DTPA in 1.5*M* lactic acid. The stripped actinides exit the flowsheet as stream TS-7, destined for denitration and further processing for feed preparation to the transmuter.

Distribution coefficients for the ACSTRP step are obtained from the data file

```
sulfur:/homes/rbw/aspen/atw/mm/TALS1.dat ,
```

and these distribution coefficients are independent of the concentrations of all other species present. The distribution coefficients for this step are defined in Table 4.

Table 4

organic soluble	*strong extraction*	*trace extraction*	*organic insoluble*
$D = 10^{20}$	$D = 100$	$D = 0.001$	$D = 10^{-20}$
NPH HDEHP	LANTH	all others	H20 LACTIC HNO3

The third extraction step (LNSTRP) is also a three-stage liquid-liquid extraction model that strips the lanthanide components from the organic effluent of the previous ACSTRP step (TS-6) by contacting the organic phase with an aqueous wash of 6*M* nitric acid. The stripped lanthanides exit this step in the raffinate stream TS-10, which is further processed in the final section of the flowsheet.

Distribution coefficients for the LNSTRP step are obtained from the data file

`sulfur:/homes/rbw/aspen/atw/mm/TALS2.dat,`

and these distribution coefficients are independent of the concentrations of all other species present. The distribution coefficients for this step are defined in three component classes, those which are completely soluble in the organic phase (NPH and HDEHP), those which are completely insoluble in the organic phase (HNO3, LACTIC, and H2O), and those which have only trace solubility in the organic phase ($D = 0.001$, all other components).

The final extraction step (SOLWSH) is a five-stage liquid-liquid extraction model that washes the organic effluent (stream TS-9) from the previous LNSTRP step with a 0.5*M* aqueous solution of ammonium carbonate.

Distribution coefficients for the SOLWSH step are obtained from the data file

`sulfur:/homes/rbw/aspen/atw/mm/TALWSH.dat`

In this version of the model, the distribution coefficients for this step are the same as for the previous step (LNSTRP). The organic effluent stream TS-12 consists of the 1*M* HDEPH in NPH, and is available for recycle as feed to the original extraction step ACLMX as stream TS-2. The aqueous exit stream TS-12 is further treated in the final section of the flowsheet.

Section 4, Waste Stream Treatment. The final section of the flowsheet describes final waste processing of exit streams from the reverse TALSPEAK section. A flowsheet diagram for this section is shown in Fig. 4. It consists of two unit operations, a mixer and a component separator. The mixer combines the feed from three streams exiting the TALSPEAK section, namely,

- TS-7, the raffinate from the TALSPEAK extraction step,
- TS-10, the raffinate from the TALSPEAK lanthanide stripping step, and
- TS-13, the raffinate fromthe TALSPEAK solvent washing step.

The combined stream is fed into a calcination step, modeled simply as a component separator (SEP2), which separates the nonvolatile fission products from the process additives such as lactic acid, ammonium carbonate, nitric acid, and DTPA. The calcination step also serves as a volume reduction operation, removing the water from the waste form, leaving a relatively small volume of HLW ash in the exit stream PS-6.

IV. DISCUSSION OF MATERIAL STREAMS

Mass flow rates for the components of each material stream in the simulation are presented in the tables that accompany Figs. 1-4. In this section, we will concentrate our discussion on the composition and dispositions of the feed and exit streams for each section of the flowsheet. Note that each flowsheet section will contain some streams that interconnect with other sections of the flowsheet, and some exit streams that contain materials suitable for recycle as feed elsewhere in the flowsheet. No discussion will be presented for internal material streams that interconnect substeps of each flowsheet section.

Recall that the entire flowsheet is sized to process one kilogram of blanket oxide material per hour; all other flow rates in the simulation will scale linearly with this basic input flow rate.

Section 1, Blanket Feed Dissolution. In the dissolution section of the flowsheet, illustrated in Fig. 1, there are two feed streams

- DS-1, the basic input stream that feeds transmuter blanket material to the chemical processing operation, and
- DS-2, containing water, nitric acid for dissolution, and an ozone sparge to control valences and to promote the degassing of volatile materials from the blanket feed,

and three exit streams

- DS-3, an off-gas stream containing unreacted ozone and volatilized components of the blanket feed, such as ruthenium (as the tetroxide), halogens, inert gases, and reaction byproduct gases such as oxygen (ozone to oxygen chemistry is not modeled, however),
- DS-5, an interconnect stream containing the dissolved blanket feed material that is passed on to the next section of the flowsheet, and

- DS-6, a stream containing any undissolved blanket materials.

No further modeling is done for the two exit streams DS-3 and DS-6. Modeling for off-gas treatment will be incorporated into future process models. In the present model, it is assumed that all the blanket feed is rendered soluble in the dissolution process, and so the DS-6 exit stream is empty.

Section 2, Fast Return Loop. In this section, there are four feed streams and six exit streams, as illustrated in Fig. 2. The feed streams consist of

- FS-1, the dissolved blanket materials arriving from the previous flowsheet section as stream DS-5,
- FS-2, the organic liquid stream feeding the liquid ion exchange step, containing a 0.2*M* solution of Aliquat 336 in di-isopropylbenzene,
- FS-5, a dilute aqueous solution of nitric acid for stripping *Pu* and *Np* from the organic phase produced by the liquid ion exchange step, and
- FS-8, a 1*M* ammonium hydroxide solution for stripping *Tc* and *Pd* from the organic phase produced by the liquid ion exchange step.

The six exit streams are

- FS-4, the raffinate from the liquid ion exchange step, containing fission products and trivalent actinides. This stream is held in storage to allow highly radioactive components to decay prior to processing in the next flowsheet section.
- FS-9 contains recovered organic solvent from the liquid ion exchange process. Depending on the degree of radiolytic decomposition of the solvent, it will either be disposed or treated and used as makeup feed for the FS-2 stream above. How much organic recovery will be possible will be addressed in future models as experimental data becomes available.
- FS-11 is a stream containing primarily vaporized water originally used in the first stripping step. The water can be recovered by condensation after the denitration step and recycled as solvent for makeup to the feed stream FS-5.

- PS-5 contains all stream components that will be vaporized in the spray calcination process. These will include, by design, all the process chemicals used in the TALSPEAK process. In addition, any technetium not fully recovered from earlier processing, may contaminate this stream. If it is experimentally determined that technetium will be present in this stream, additional stream polishing will be required to reduce the technetium component to an acceptable level. The water vaporized in the process may be recovered and recycled as feed to earlier process steps.
- PS-6 contains the ash from the final calcination step, including recovered lanthanides and other nonvolatile fission products.

Flow Pathway Summaries. Finally, we summarize in Fig. 5 and Fig. 6 two simplified versions of the overall flowsheet for this separation model. In Fig. 5, we present the stream connectivity for the flowsheet, showing only those flow pathways designed to carry blanket components.

In Fig. 6, we present the flowsheet in block form, showing the four major flowsheet sections, with the feed and exit streams that accompany each section. Feed streams are shown to the left of the process operation blocks, and waste streams are shown to the right. The first column of waste streams are designed to contain little or no blanket components, and the second column identifies streams that contain blanket components. Many of the blanket components are fed back to the transmuter, including the iodine component of the volatile stream, the technetium stream, the neptunium/plutonium stream, and the trivalent actinide stream.

V. OVERALL FLOWSHEET EVALUATION

This baseline concept for the processing of the actinide-containing blankets of an accelerator-based transmutation scheme is based upon proven technology. A more detailed discussion of the design criteria for this concept, along with its advantages and disadvantages, is presented in the companion paper, Ref. 1.

Several unresolved features of the modeling of the current baseline concept include the following:

- Need to incorporate a model for the off-gas processing, including iodine recovery.
- Need to model the heel processing.

- Need to improve the modeling of the chemistry of many steps in the processing. This includes the denitration chemistry in the feed preparation stage for the TALSPEAK operations and the calcination chemistry in sections 2 and 4.
- Need better data on the liquid-liquid distribution coefficients.
- Need a more detailed model of solvent recovery processes.
- Need to model feed preparation of materials returned to the transmuter

VI. References

1. G. D. Jarvinen, S. F. Marsh, B. F. Smith, S. L. Yarbro, M. Yates, and R. B. Walker, "Baseline Actinide Blanket Processing Flowsheet for ATW," Los Alamos National Laboratory Report LA-UR-92-63.
2. I. Svantesson, I. Hagstrom, G. Persson, and J. O. Liljenzin, "Distribution Ratios and Empirical Equations for the Extraction of Elements in PUREX High Level Waste Extraction," J. Inorg. Nucl. Chem. 41, 383-389 (1979).

Appendix I. Aspen Input Files

The four ASPEN PLUS input files for this concept are stored as

```
sulfur:/homes/rbw/aspen/atw/mm/dissolve.inp
sulfur:/homes/rbw/aspen/atw/mm/fastrtrn.inp
sulfur:/homes/rbw/aspen/atw/mm/talspk.inp
sulfur:/homes/rbw/aspen/atw/mm/polish.inp
```

The liquid-liquid extraction chemistry in the second and third sections of the flowsheet obtain distribution coefficients from several files, stored as

```
sulfur:/homes/rbw/aspen/atw/mm/EXTRACT.dat
sulfur:/homes/rbw/aspen/atw/mm/ALIEX.dat
sulfur:/homes/rbw/aspen/atw/mm/ALIQS1.dat
sulfur:/homes/rbw/aspen/atw/mm/ALIQS2.dat
sulfur:/homes/rbw/aspen/atw/mm/ALIQX.dat
sulfur:/homes/rbw/aspen/atw/mm/TALEX.dat
sulfur:/homes/rbw/aspen/atw/mm/TALS1.dat
sulfur:/homes/rbw/aspen/atw/mm/TALS2.dat
sulfur:/homes/rbw/aspen/atw/mm/TALWSH.dat
```

The following FORTRAN source files were used in the ASPEN PLUS models for liquid-liquid extraction:

```
sulfur:/homes/rbw/aspen/atw/examples/usrrdt.f
sulfur:/homes/rbw/aspen/atw/mm/usrkll.f
sulfur:/homes/rbw/aspen/atw/fits/pafit.f
```

Listings of these files are available on request.

Appendix II. Aspen Stream Report File

The ASPEN PLUS report files for each flowsheet section are stored as

```
sulfur:/homes/rbw/aspen/atw/mm/dissolve.out
sulfur:/homes/rbw/aspen/atw/mm/fastrtrn.rep
sulfur:/homes/rbw/aspen/atw/mm/talspk.rep
sulfur:/homes/rbw/aspen/atw/mm/polish.rep
```

To ensure that the blanket component feed stream compositions for the second, third, and fourth flowsheet sections are accurately copied from the appropriate exit streams of previous sections, we make use of the ASPEN PLUS stream library utility. Before a downstream flowsheet section is run that depends upon the exit flows of an earlier section, we enter the upstream component flows into a stream library after the completion of a simulation of the upstream flowsheet section The stream library is stored as the file

```
sulfur./homes/rbw/aspen/atw/mm/sct.slb
```

The input specifications for downstream flowsheet sections automatically retrieves the needed stream flow data from the information stored in the stream library prior to the execution of downstream flowsheet section simulations.

1192 1055

Fig. 1

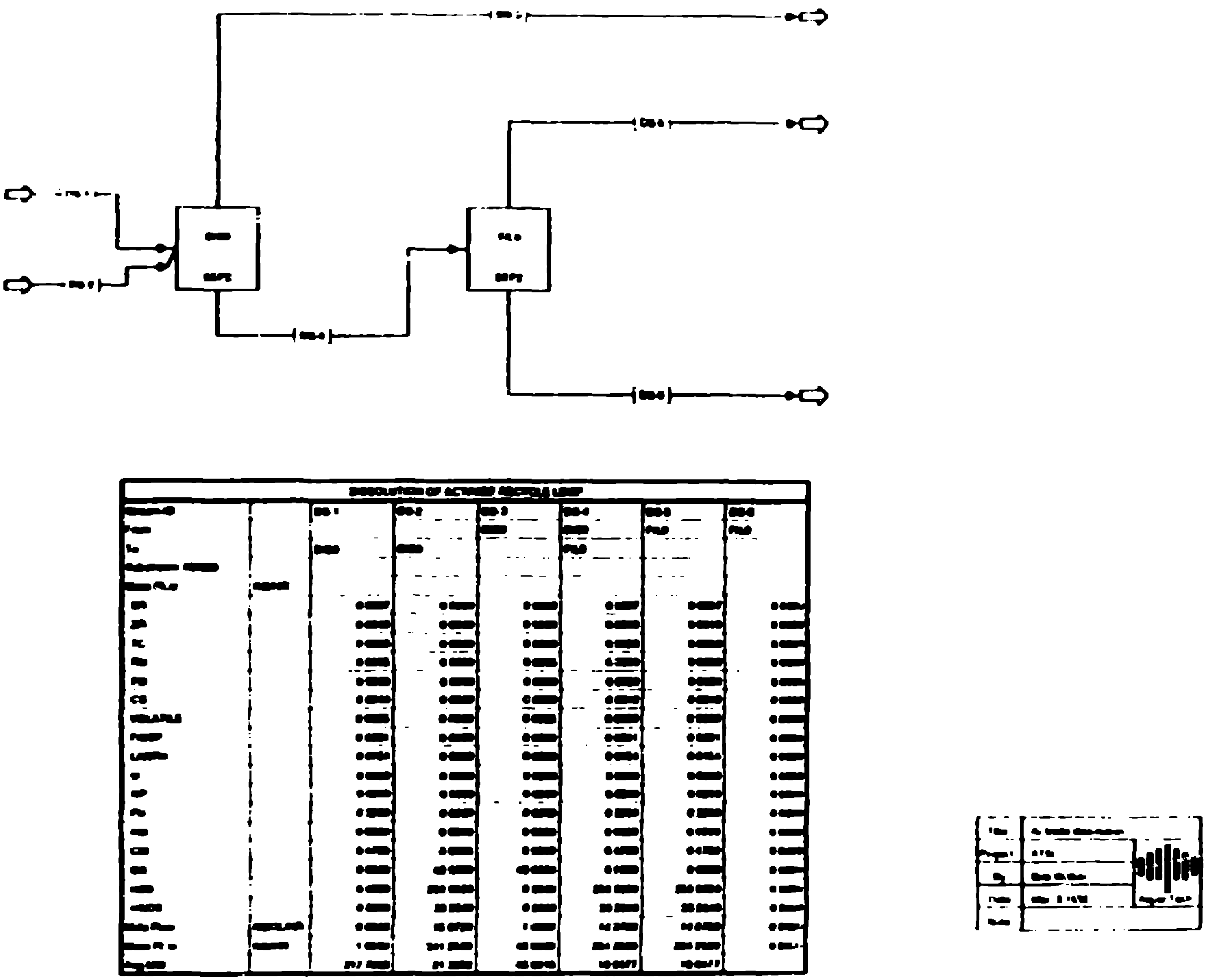
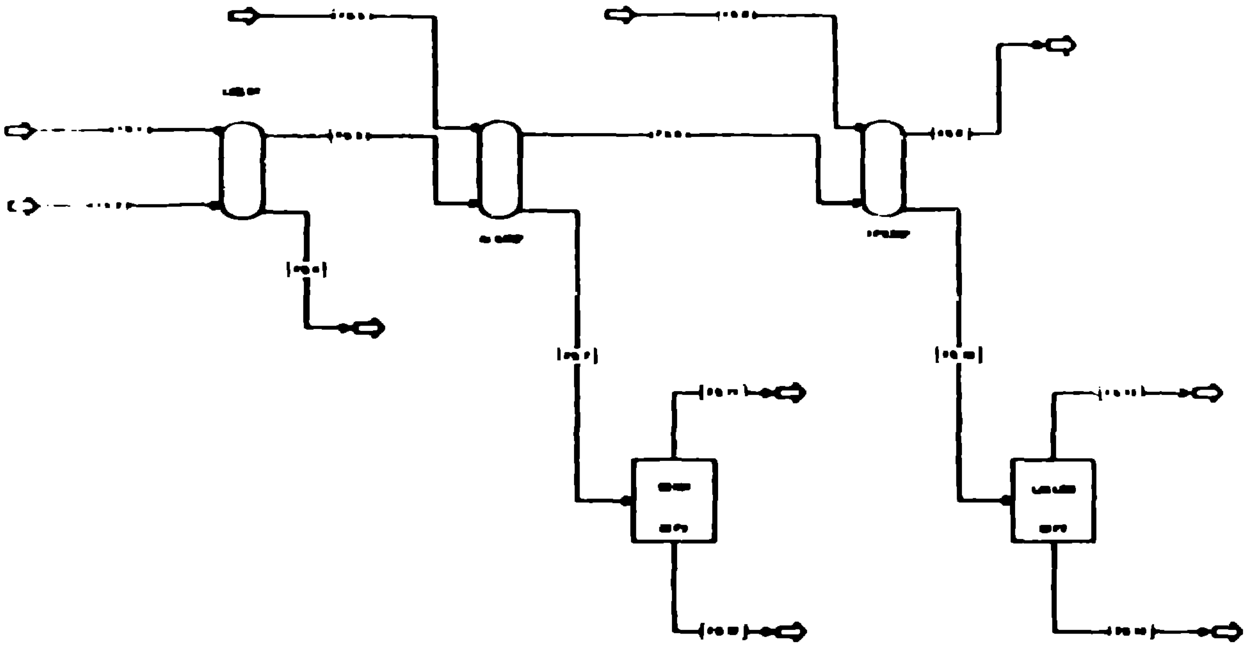
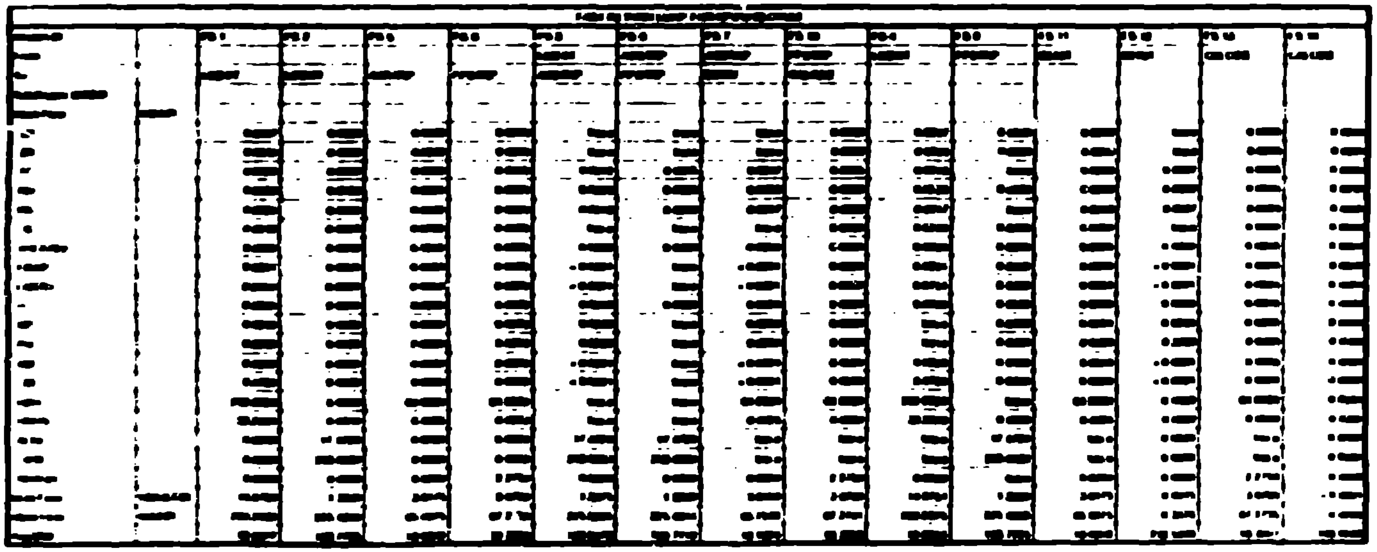


Fig. 1

1192 1[illegible]

Fig 2





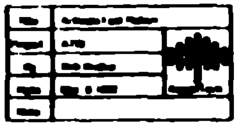


Fig 3

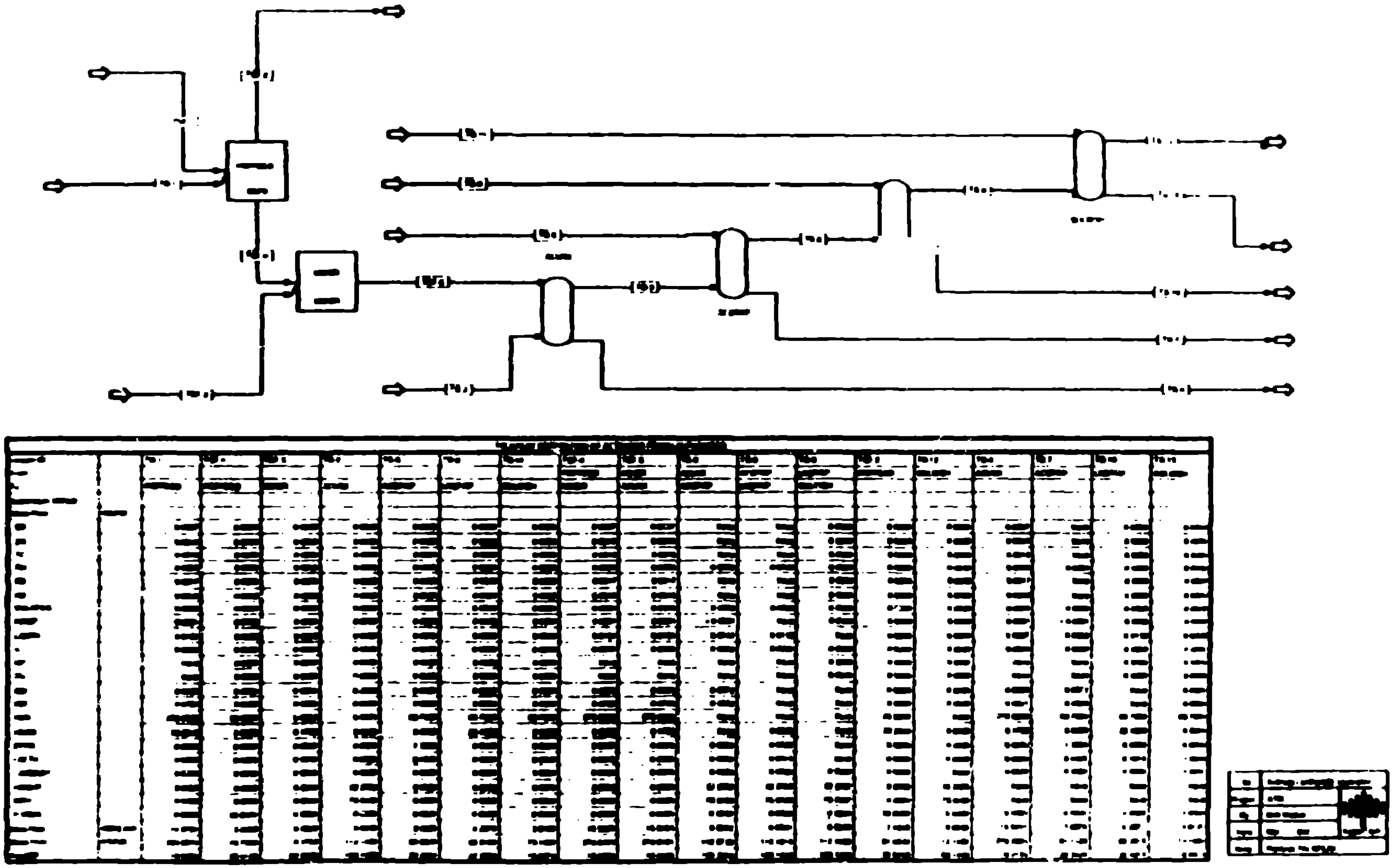
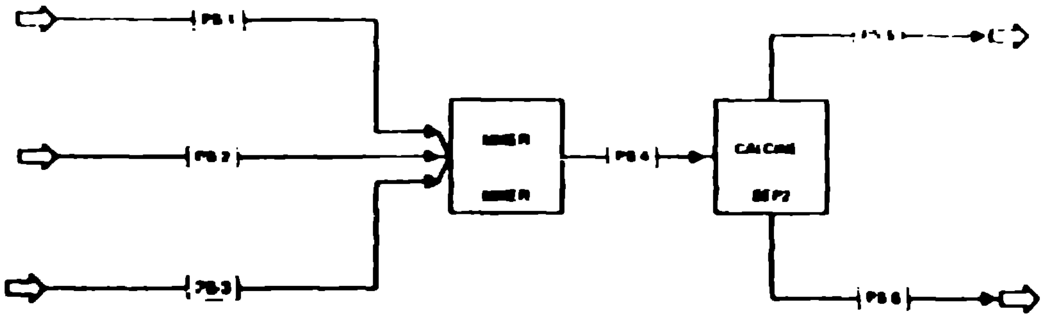


Fig 4



WASTE STREAM POLISHING FOR ACTINIDE SEPARATIONS							
Stream ID		PS-1	PS-2	PS-3	PS-4	PS-5	PS-6
From					MIXER	CALCINE	CALCINE
To		MIXER	MIXER	MIXER	CALCINE		
Substream: MIXED							
Mass Flow	KG/HR						
SR		0.0007	[illegible]	[illegible]	0.0007	[illegible]	0.0007
ZR		[illegible]	0.0020	[illegible]	[illegible]	[illegible]	0.0040
TC		0.0016	[illegible]	[illegible]	0.0016	0.0016	[illegible]
RU		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PD		0.0017	[illegible]	[illegible]	0.0017	[illegible]	0.0017
CS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VOLATILE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PMBP		0.0001	[illegible]	[illegible]	0.0051	[illegible]	0.0051
LANTH		0.0007	0.0125	[illegible]	0.0146	[illegible]	0.0146
U		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NP		trace	[illegible]	[illegible]	trace	[illegible]	trace
PU		trace	[illegible]	[illegible]	trace	[illegible]	trace
AM		[illegible]	trace	[illegible]	[illegible]	[illegible]	0.0070
CM		0.0221	trace	[illegible]	0.0221	[illegible]	0.0221
H2O		270.[illegible]	68.7[illegible]	68.7[illegible]	416.[illegible]	416.[illegible]	[illegible]
HNO3		0.1700	25.4[illegible]	[illegible]	25.[illegible]	25.[illegible]	[illegible]
DTPA		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LACTIC		[illegible]	0.0016	[illegible]	0.0016	0.0016	[illegible]
CARBNAT		[illegible]	[illegible]	3.7[illegible]	3.[illegible]	3.[illegible]	[illegible]
HDEHP		trace	trace	trace	trace	trace	[illegible]
NPH		trace	trace	trace	trace	trace	[illegible]
FORMIC		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mole Flow	KMOL/HR	15.[illegible]	4.2071	3.0179	23.7122	23.7112	0.0010
Mass Flow	KG/HR	270.[illegible]	85.2015	73.1400	440.6051	440.[illegible]	0.1350
Avg MW		18.0[illegible]	22.4915	18.0[illegible]	18.[illegible]	18.[illegible]	135.0000

Title	Waste Stream Polishing
Project	ATW
By	Bob Walker
Date	Apr 3 1997
Note	

AspenTech

Fig. 5

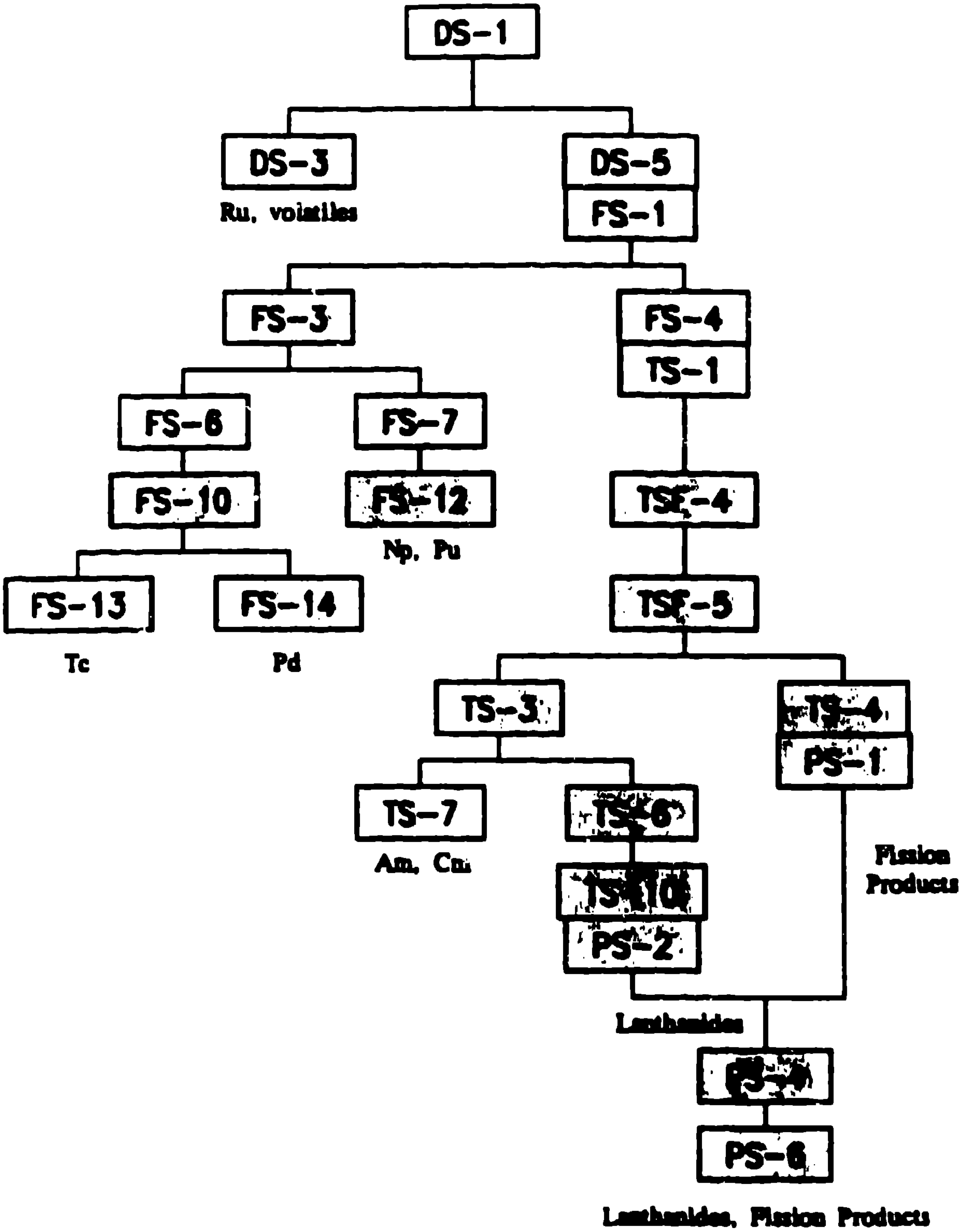
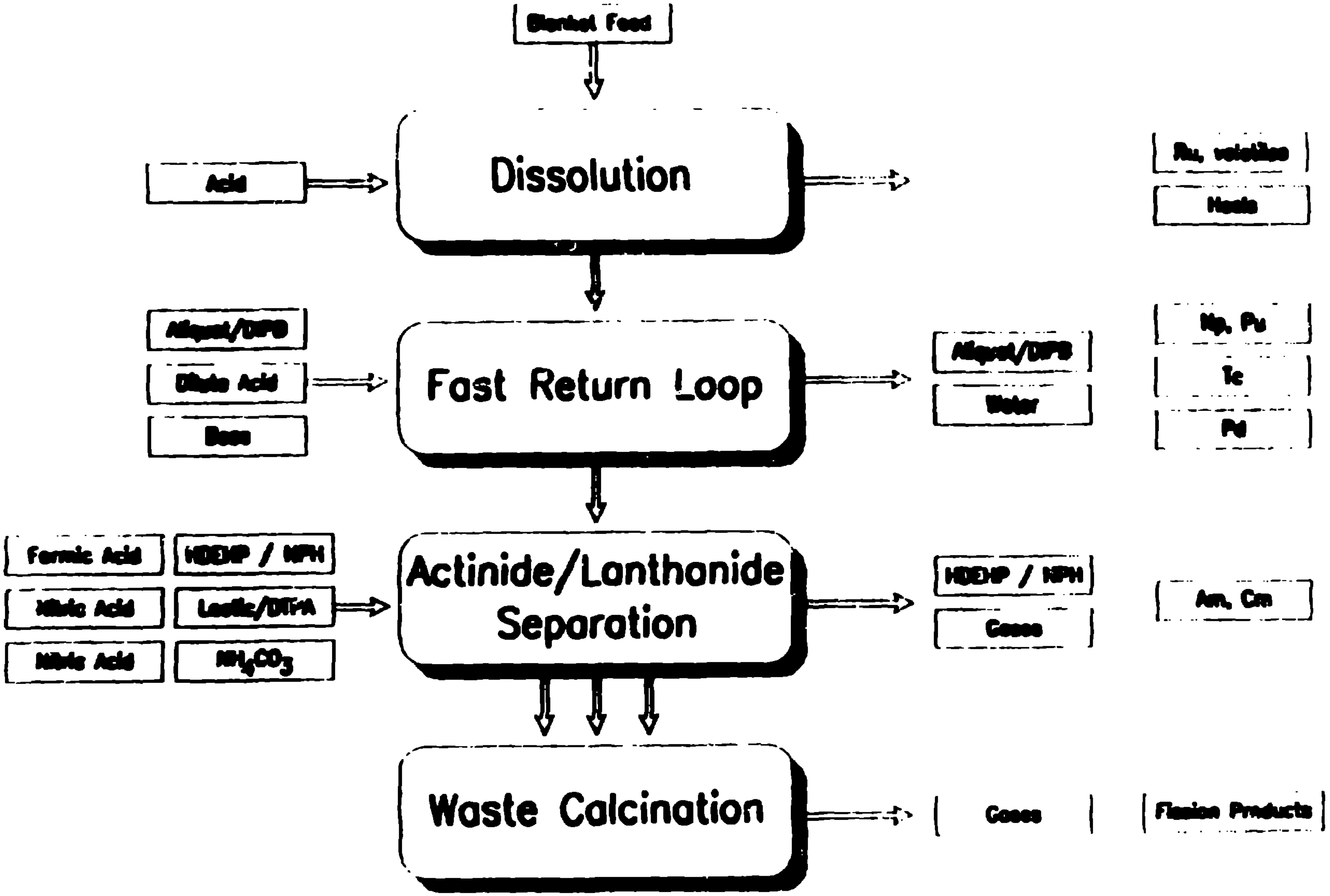

DS-1
DS-3
Ru, volatiles
DS-5
FS-1
FS-3
FS-4
TS-1
FS-6
FS-7
FS-10
FS-12
Np, Pu
TSF-4
FS-13
FS-14
Tc
Pd
TSF-5
TS-3
TS-4
PS-1
TS-7
Am, Cm
TS-6
TS-10
PS-2
Fission
Products
Lanthanides
PS-4
PS-6
Lanthanides, Fission Products

Fig 6


Blanket Feed
Acid
Dissolution
Ru, volatiles
Heels
Aliquat/DIPB
Dilute Acid
Base
Fast Return Loop
Aliquat/DIPB
Water
Np, Pu
Tc
Pd
Formic Acid
HDEHP / NPH
Nitric Acid
Lactic/DTPA
Nitric Acid
NH_4CO_3
Actinide/Lanthanide Separation
HDEHP / NPH
Gases
Am, Cm
Waste Calcination
Gases
Fission Products