Abstract

for

Exchange Program on Actinide and Fission Product Separation
and Transmutation. First meeting
Nov. 2 to 5, 1990, Mite, Japan

R & D Activities for
Actinide Partitioning and Transmutation in the
Nuclear Research Center Karlsruhe

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A coordinated R & D program between Institut fur Neutronenphysik und Reaktortechnik[1] and Institut fur Heiße Chemie[2] of the Nuclear Research Center Karlsruhe will be started in 1991.

In the first phase (1991 to 1992) the major activities are to assess different strategies for actinide transmutation. The aim is to chose the most promising alternative taking into consideration to use a partitioning process as simple as possible.

In the first program phase the actinide separation from LWR fuel is the prime goal. For fuel reprocessing the one-cycle PUREX process (IMPUREX) is choosen and directly connected with the solvent extraction partitioning process.

Actinide burning is discussed in thermal as well as in fast reactors.

R & D Activities for Actinide Partitioning and Transmutation in the Nucl. Res. Center Karlsruhe

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Contents

1) Institut fur Neutronenphysik und Reaktortechnik

2) Institut für Heiße Chemie

AIM OF P + T

- **Reduction of long-term risk potential**
- **Reduction of space for final dispost, if possible.**
- **Utilization of separated F. P., if possible**

NEW ASPECTS since begin of the 80's

- **Metal fueled FR with a very hard n-spetrum.**
  (IFR: very high burn-up possible; "interesting" fuel cycle, non-aqueous reprocessing.)
- **Burning actinides in outer core and/or inner blanket regions of Fast Oxide Reactors. (no recycle case)**
- Reduction of Pu build-up via replacement of U **by Ce in some fuel elements of LWR's.**

REQUIREMENTS FOR TRANSMUTATION:

- **Safe operation of corresponding reactors.**
  (e.g. maintaining a sufficient negative Doppler coeffic.; avoid increase of Na-void effect . ..)
- **Remote fuel refabrication.**
- **Minimization of actions for handling and transportation.**

*PROGRAM OBJECTIVES **(first part: 1991 -92,-8 My/y)**

P - **Actual work is concentrated on aqueous process steps for partitioning of LWR-HAW.**

Partitioning shall be considered as a part of the one-cycle PUREX process (IMPUREX)

Preliminary objective is to separate:

o Residues of Pu and U, Np, Am and Tc but not Cm (UO_2-LWR **Fuel).**

o alto. but Cm included (Pu-Recycle-LWR-Fuel).

T - **Concept for a Thermal-Pu-Burner**

Choice of a transmutation strategy

*** has to be harmonized with** Europ. Comm.

PROGRAM EXECUTION

P - Assessment of different separation methods.

Investigations of the extraction of Am

o Oxidation of Am-III

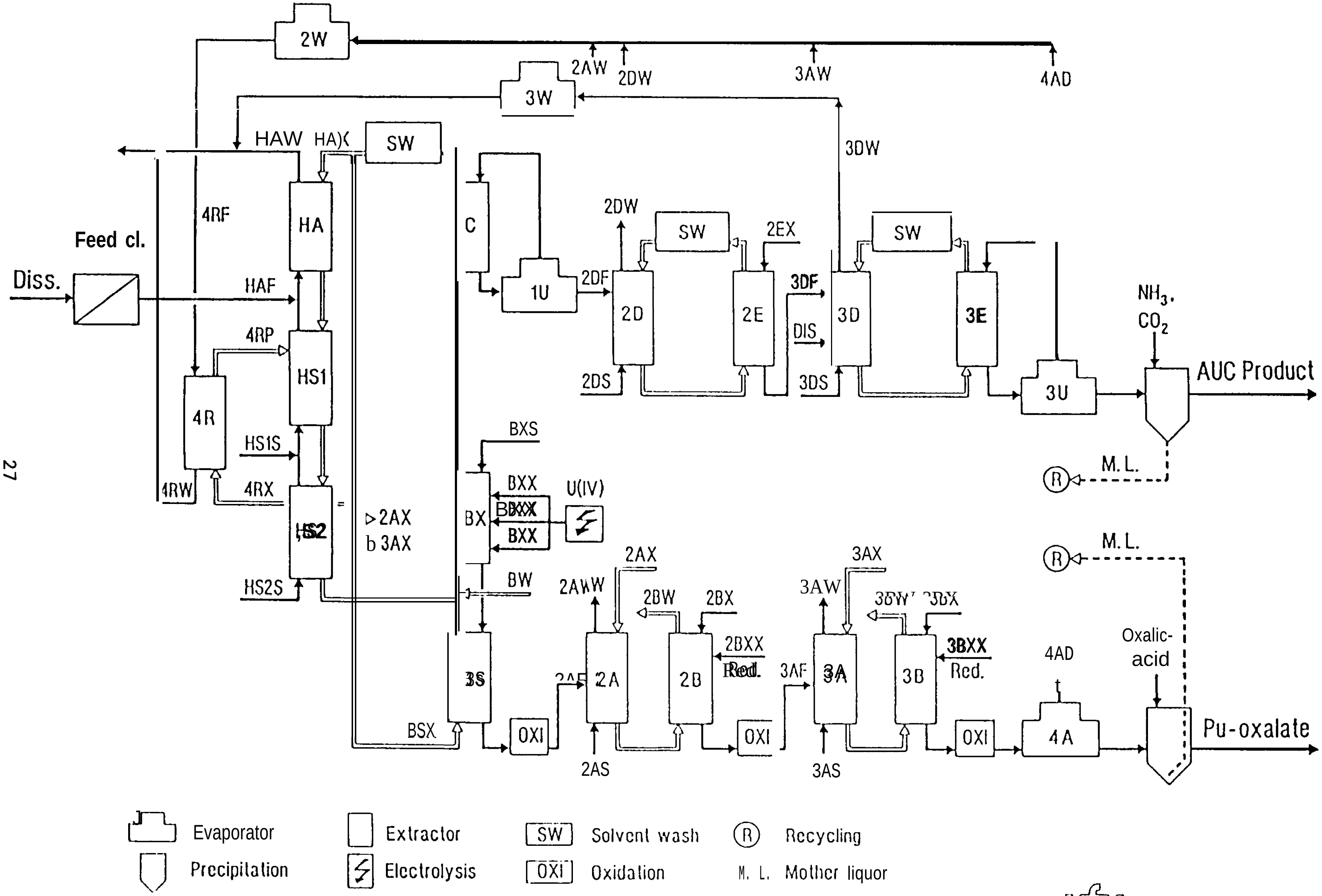
o **Choice of solvent (Am-IV . ..)**

Flowsheet design for partitioning experiments.

Preparation and function tests of miniature centrifugal extractors

T - **Design study of a thermal Pu-Burner.**

Investigations of different Transmutation Strategies.



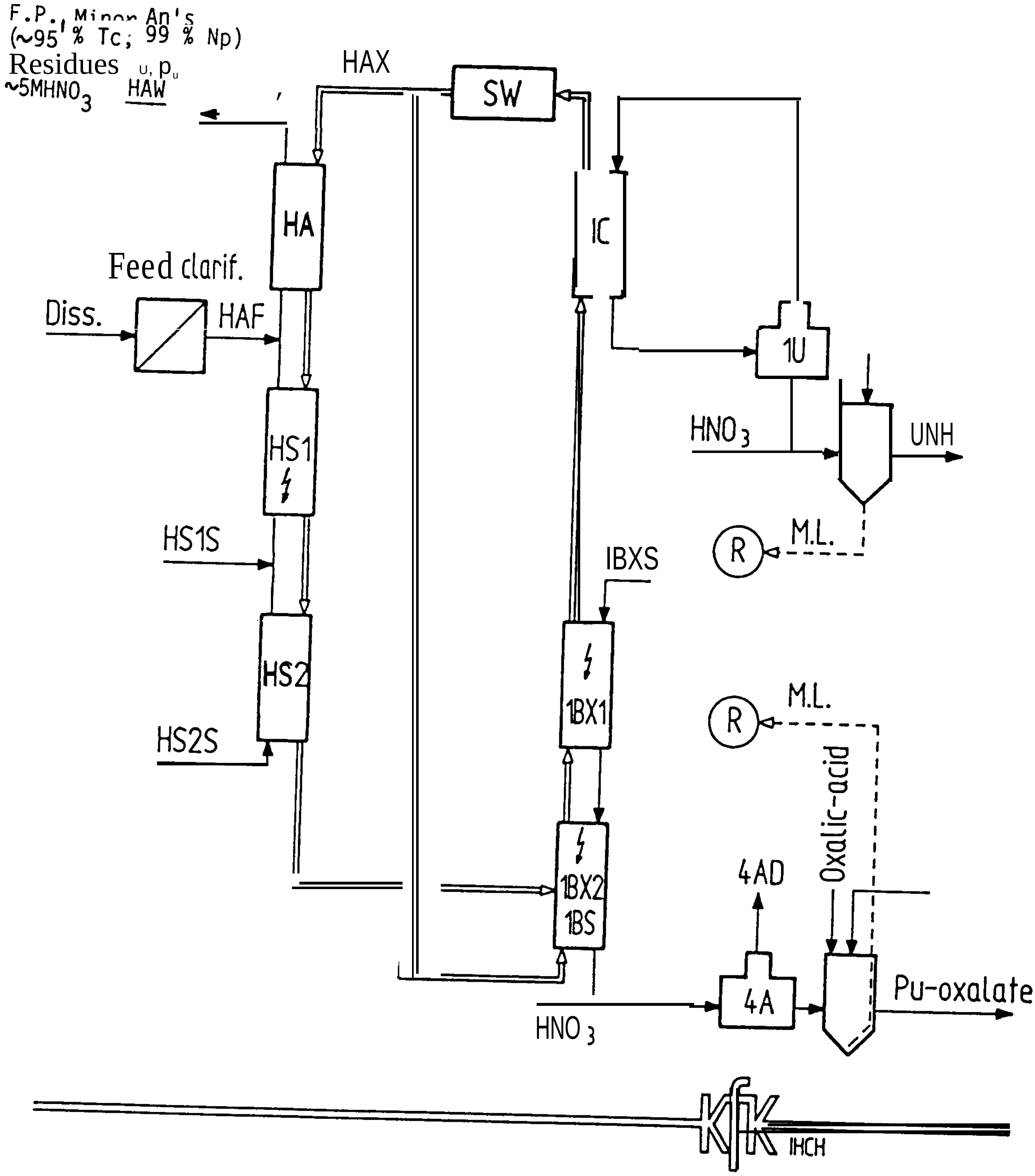
PUREX

KfK IHCH

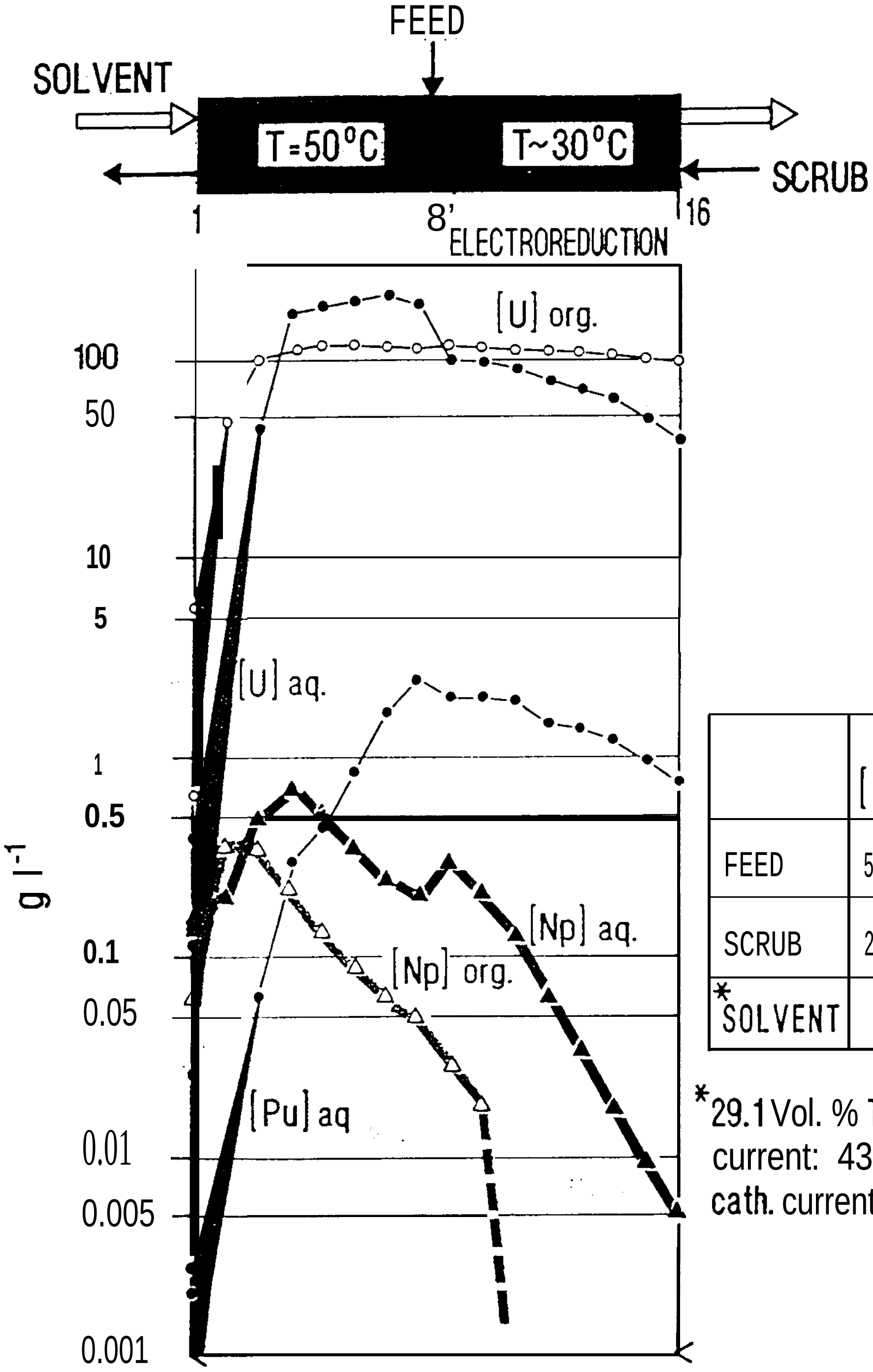
IMPUREX = IMproved PUREX

Components of the one-cycle Purex process:

WHAT?	WHY?	HOW?
Feed clarification:	avoid interracial crud and	1. sintered metal filter
	minimize solvent degradation	2. diathomaceous earth filter bed
"100 %" solvent loading:	high decontamination vs. yield	Auto-control U extraction front
Feed pre-reduction:	avoid Pu(VI) losses	e.g. electro-chemically
Make distr.coeffs. $D_{Pu} > D_U$:	avoid Pu(IV) accumulations	increased acidity and/or
		elevated temperature
Optim. extraction cycle:	increase decontamination	HA/HS1/HS2 length
		adjust scrub flow ratios
Advanced U / Pu split:	improve Pu-decontamination	2 ser. electro-reduction columns
Add. product refinement:	Moderate maloperations backup	crystallization
N_2H_5OH/CO_2 solvent wash:	MAW minimization	Oxid.--> N_2 + evap. --> HAW


F.P., Minor An's
(~95 % Tc; 99 % Np)
Residues U, Pu
~5MHNO3
HAW
HAX
SW
HA
Feed clarif.
Diss.
HAF
HS1
HS1S
HS2
HS2S
IC
1U
HNO3
UNH
R
M.L.
IBXS
1BX1
1BX2
1BS
4AD
Oxalic-acid
4A
HNO3
Pu-oxalate
KfK IHCH

IMPUREX

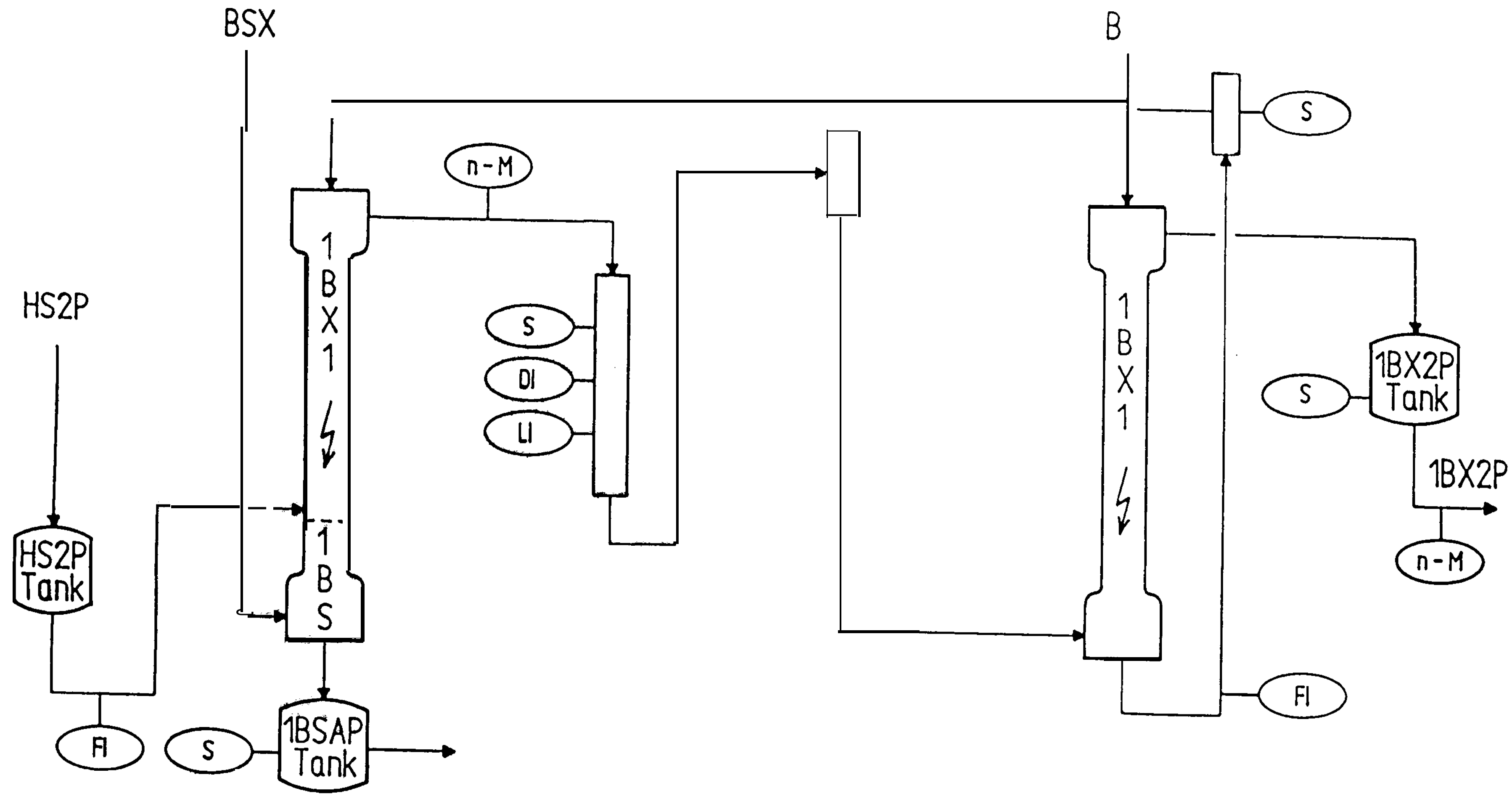


	$[H^+]$	[U]	[Pu (IV)]	[Np]	Flow ml h^{-1}
	M l^{-1}				
FEED	5.05	0.99	0.012	$5.2 \cdot 10^{-4}$	153
SCRUB	2.97	-	–	-	60
*SOLVENT	–	-	–	/	333

*29.1 Vol. % TBP-dodecane
current: 430 mA
cath. current density : ca. 6 mA cm^{-2}

IHCH

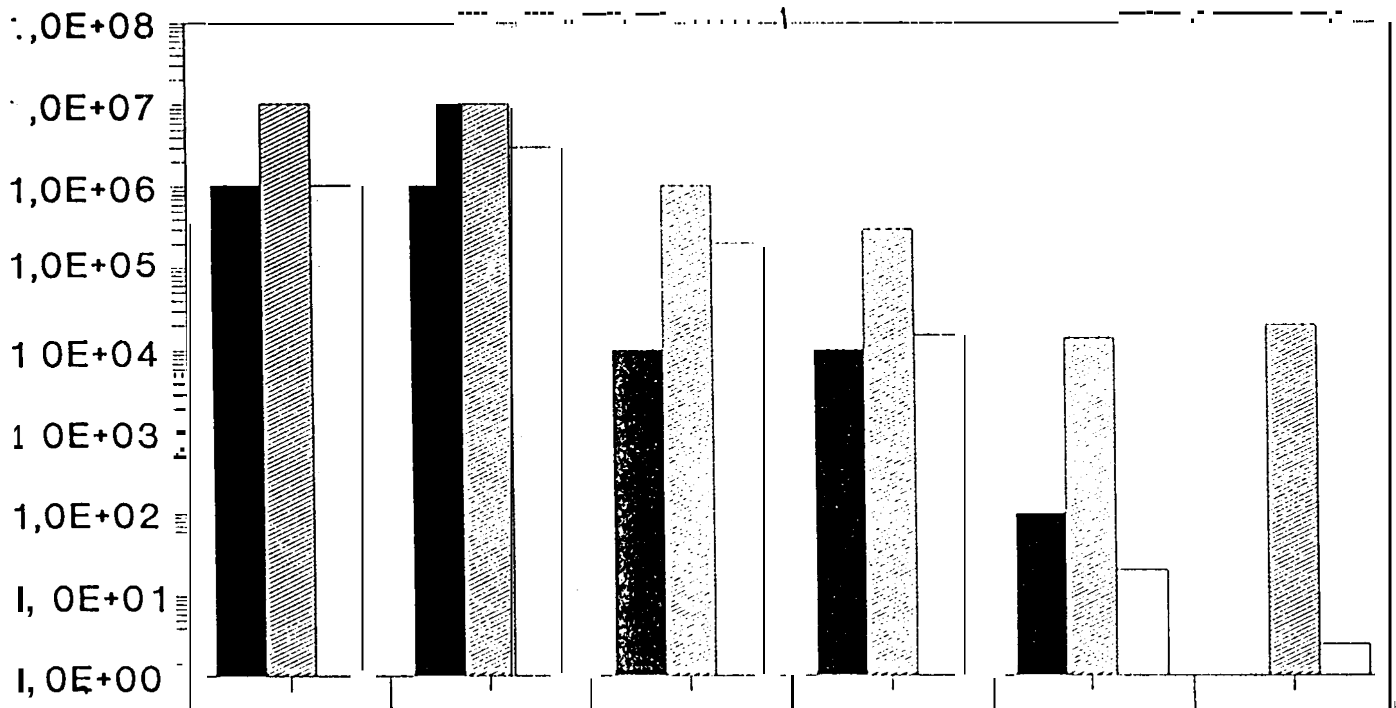
BEHAVIOR OF Np IN A MIXER-SETTLER BANK UNDER HIGH LOADING CONDITIONS (increased temperature and increased $[HNO_3]$ in the feed) AND USE OF ELECTRO-REDUCTION IN SEVEN STAGES OF THE SCRUB SECTION



KfK IHCH

ELECTRO U/Pu SPLIT

MILLI-DECO-FACTORS



	Cs-137	Ce-144	Ru-1OG	Zr-95	Np	Tc
LWR req'd (1)	1,0 E+06	I, 0E+06	1,0E+04	1,0E+04	., JE .02	
MILLI'90 Icu	1,0E+07	1,0 E+07	1,0 E+06	3. 0E+06	. 1,4 E+04	2,0 E+04
MILLI'88 HS2P	1.0 E+06	3. 0E+06	2,0E+06	1,5E+04	2,0E+01	2,5E+00

LWR req'd (1) MILLI'90 ICU MILLI'88 HS2P

HA= IO, HS1=6, HS2=8 **stages**

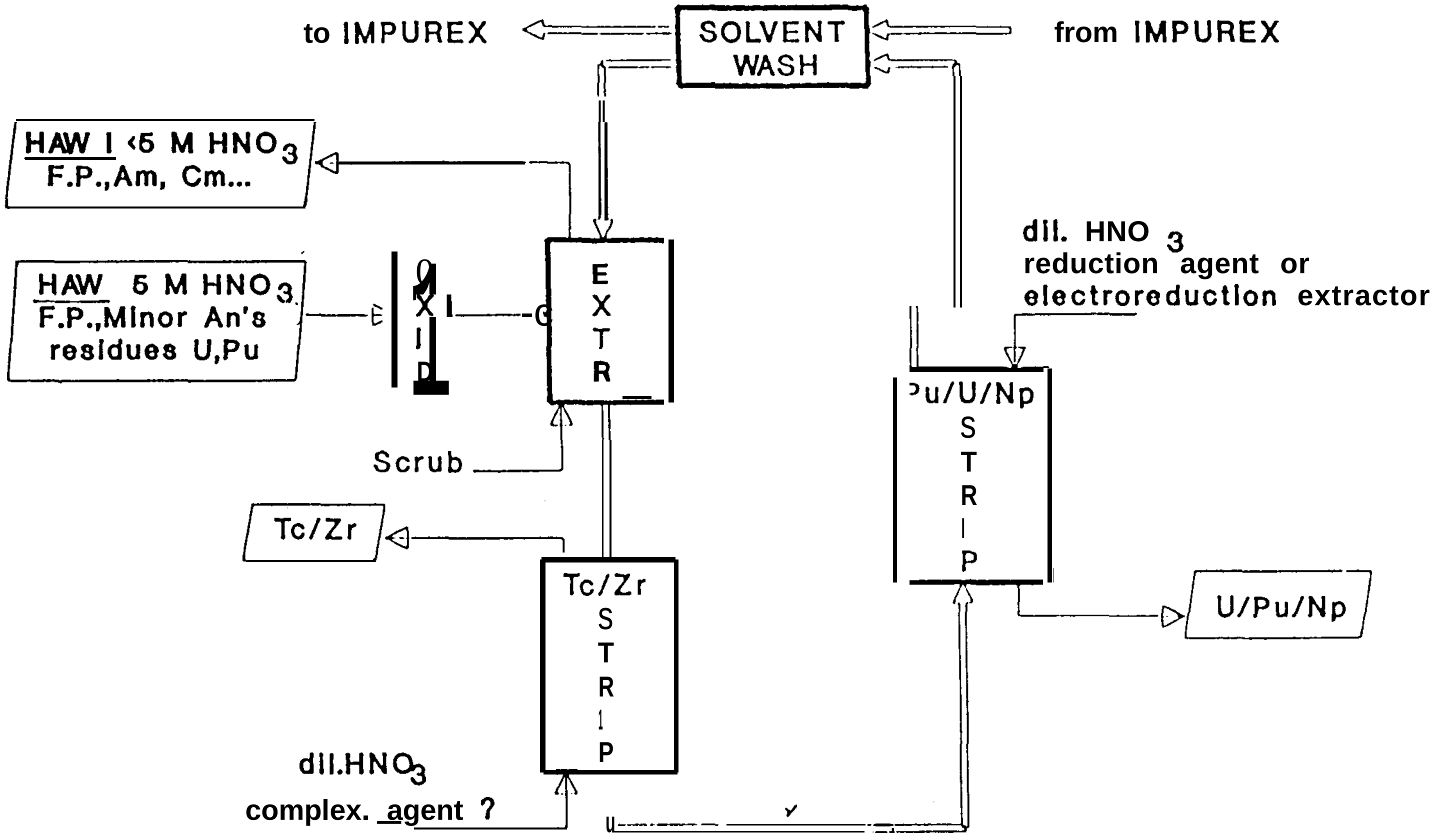
(I): U-product, 33 GWd/t, **7a cooling**

For fuel reprocessing a lot of equipment is saved by

IMP UREX

These savings can be used for further separations:

PARTITIONING



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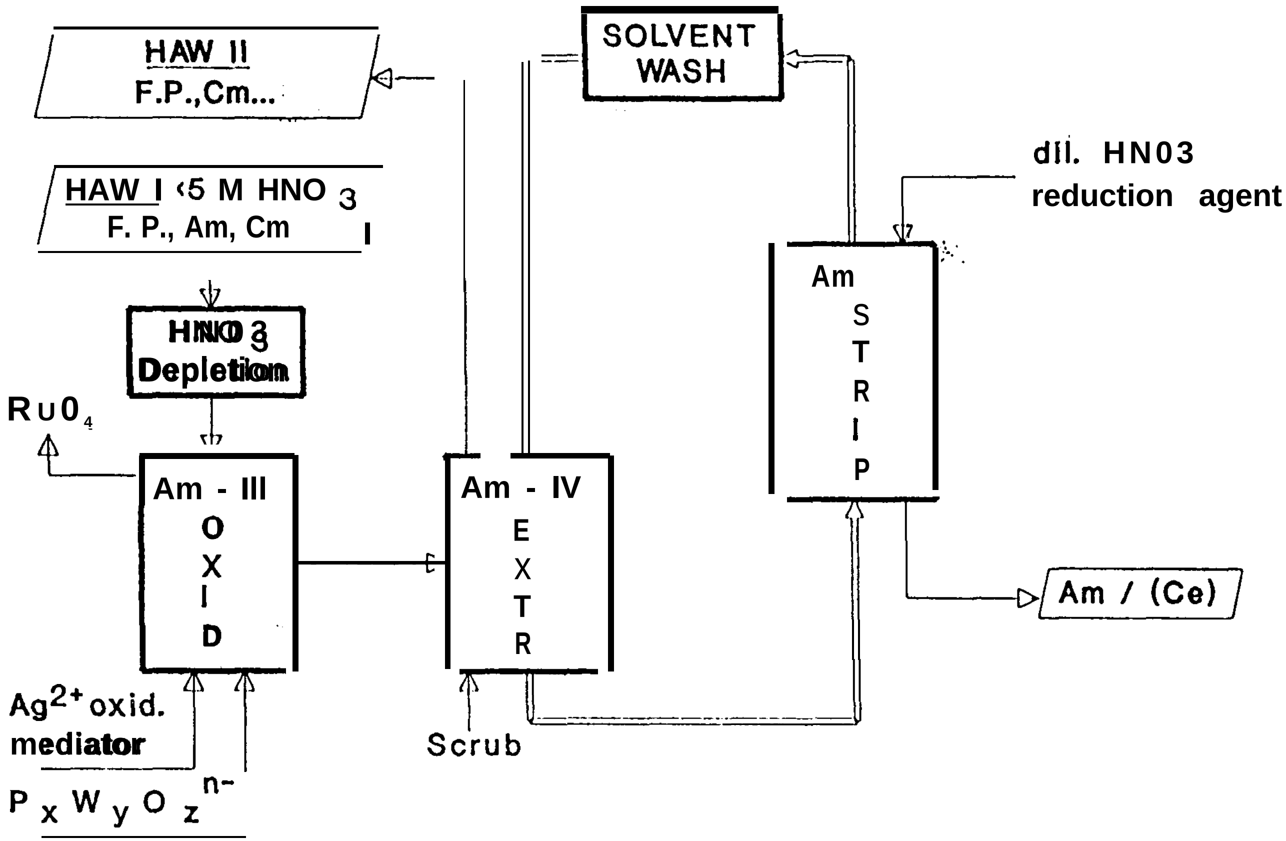
First Partitioning step:

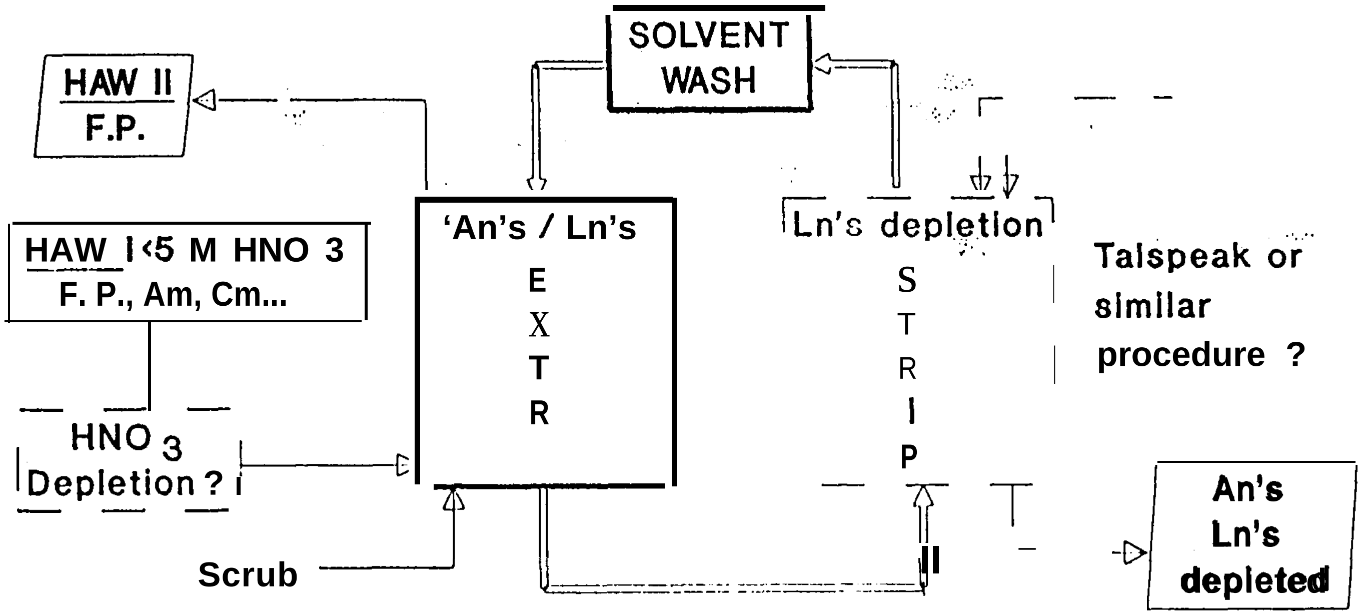
Separation of U, Pu residues, Np and Tc by TBP extraction



Option for UO_2-LWR-fuel (small amount Cm)

Second partitioning step:

Separation of Am by extraction with secondary amine.



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Option for MOX-LWR-fuel (high amount Cm)

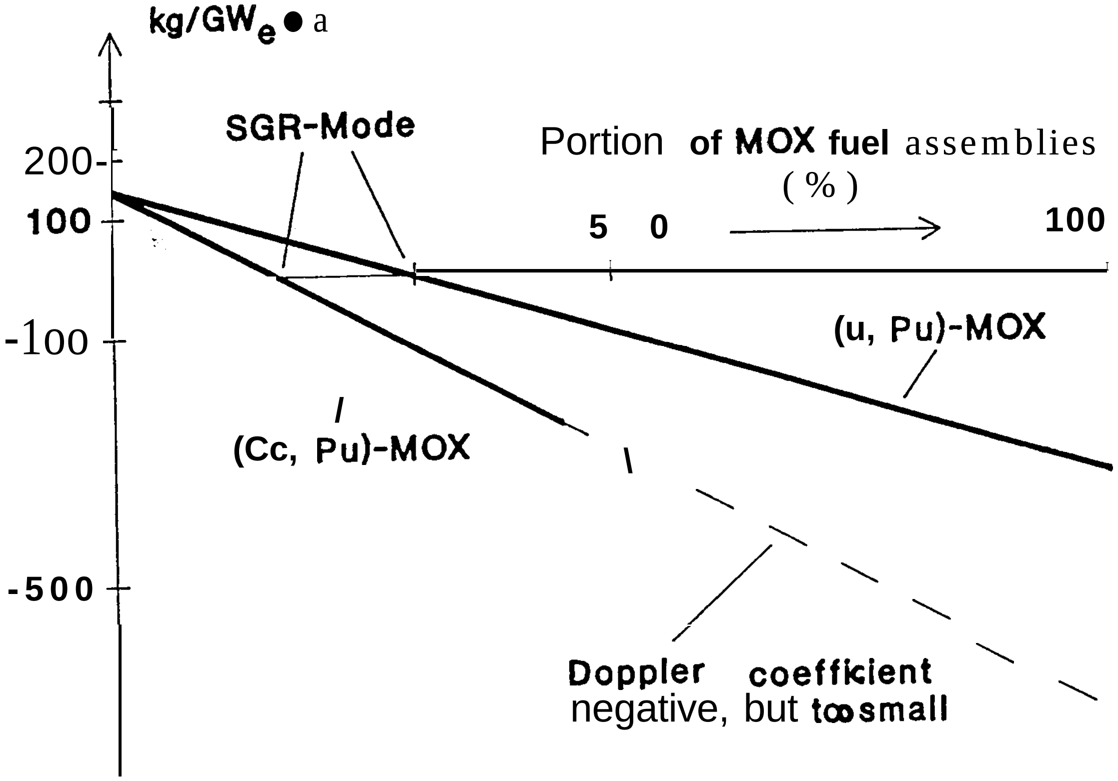
Second partitioning step:

Extraction of An's/Ln's probably by CMPO or diamides. Ln's depletion not yet defined.

ACTINIDE BURNING IN THERMAL REACTORS

Minor actinide “destruction” is ineffective in Light Water Reactors.

Pu burning is more efficient, if in a part of the MOX fuel assemblies U is rep’laced by e.g. Ce: Pu - build up does not occur.



Pu (fiss) production with different portions of MOX

Minor - ACTINIDE (MA) BURNING IN FAST REACTORS

Neutron spectrum should be as hard as possible. (Me $\approx$ C, N > O)

Np and Am could be destroyed most efficiently in case of full core loading (admixture up to several % MA).

Forlarger admixtures of MA:

Doppler coeffic. not acceptable.

Na-void effect increases drastically.

Consequence:

Heterogeneous and very flat core design necessary (metal fuel)

or

Partial core loading (also oxide fuel).

Preliminary preposal for an oxide fueled FBR

Recycling (INTERATOM)

1. Admixture of MA (5 %) to about 30 % of fuel elements. (acceptable Doppler- and Void-coeffic.)

No Recycling (KfK)

2. Load of MA fuel assemblies in outer core and/or inner blanket

region (long residence times).

- Efficient transmutation of Np and Am.

Build-up of Pu-238, but decreasing significantly after 5y residence time.

Cm cannot be “destroyed” in residence times of about 10 years.

Actinide-isotopes during HAW-Irradiation in SPX-Blanket