



ТУ – СОФИЯ, ЕМФ
Доклад
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^{233}U

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2015-

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2

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2

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,

^{233}U ^{235}U ^{232}Th

1)

²³³U

²³³U, ²³⁹Pu, ²³³U, ²³⁵U, ²³³U, 5kg, ²³³U, 2kg

		I	II	III
²³⁹ Pu	20% ²³⁹ Pu < 80%	2kg	< 2kg > 500g	< 500g > 15g
²³⁵ U	20% ²³⁵ U < 80%	5kg	< 5kg > 1kg	< 1kg > 15g
-/-	10% ²³⁵ U < 20% ²³⁵ U		10kg	< 10kg
-/-	0.7% ²³⁵ U < 10% ²³⁵ U			10kg
²³³ U	12% ²³³ U < 80%	2kg	< 2kg > 500g	< 500g > 15g
-/-	6% ²³³ U < 12% ²³³ U		4kg	< 4kg
-/-	0.66% ²³³ U < 6% ²³³ U			4kg

I, II III

²³³U: U 12%
²³⁵U: U 20%

233
 235

²³³U ²³⁵U

²³³U

(MSRE)

²³³U

²³³U

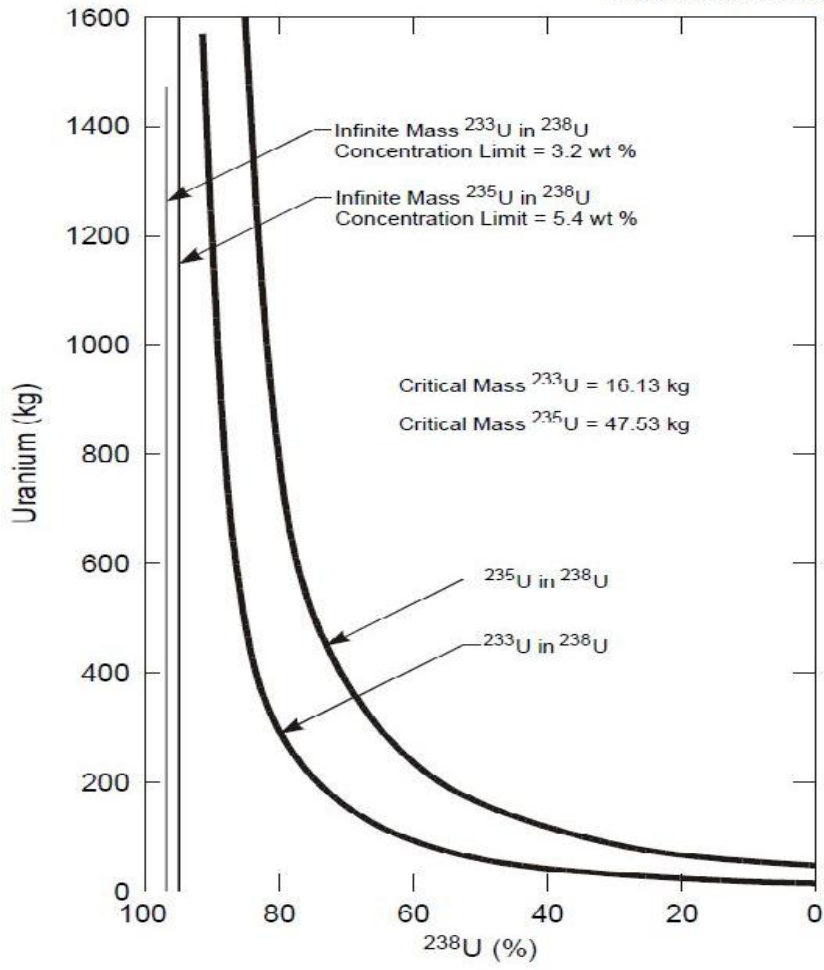
²³³UF₄

750 kg	20% ²³⁵ U
~750 kg	12% ²³³ U
47.53kg	100% ²³⁵ U
16.13kg	100% ²³³ U

²³³U

²³⁸U

Convair NB-36H



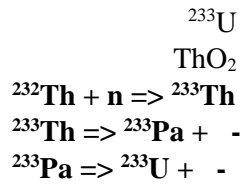
^{235}U	$6.0 \cdot 10^{-8}$ W/g
^{233}U	$2.8 \cdot 10^{-4}$ W/g

^{232}U

(^{208}Tl).

^{233}U

^{233}U



^{232}Th



^{235}U .

$$\sigma_c \text{}^{232}\text{Th} = 7.37 \text{ barn}$$

$$\sigma_c \text{}^{233}\text{Pa} = 200 \text{ barn}$$

$$\sigma_c \text{}^{234}\text{U} = 100.1 \text{ barn}$$

$$\sigma_c \text{}^{235}\text{U} = 680.9 \text{ barn}$$

I V.

$$\text{}^{233}\text{Th } t_{1/2} = 22$$

$$\text{}^{233}\text{Pa } t_{1/2} = 27$$



Th, Pa U

^{233}U

^{233}U

7 \$/mg 7 000 000\$/kg.
1,5

8+

^{233}U

$^{238}\text{U} \Rightarrow \text{}^{234}\text{Th} + \alpha$	$^{238}\text{U } t_{1/2} = 4,5 \cdot 10^9$
$^{234}\text{Th} \Rightarrow \text{}^{234\text{m}}\text{Pa} + -$	$^{234}\text{Th } t_{1/2} = 24.1$
$^{234\text{m}}\text{Pa} \Rightarrow \text{}^{234}\text{U} + -$	$^{234\text{m}}\text{Pa } t_{1/2} = 1.17$
$^{233}\text{Th} \Rightarrow \text{}^{233}\text{Pa} + -$	$^{233}\text{Th } t_{1/2} = 27$

^{233}U

^{233}Pa

^{234}U

^{233}U

^{233}U

^{238}U

^{235}U

ORNL DWG 98-3898

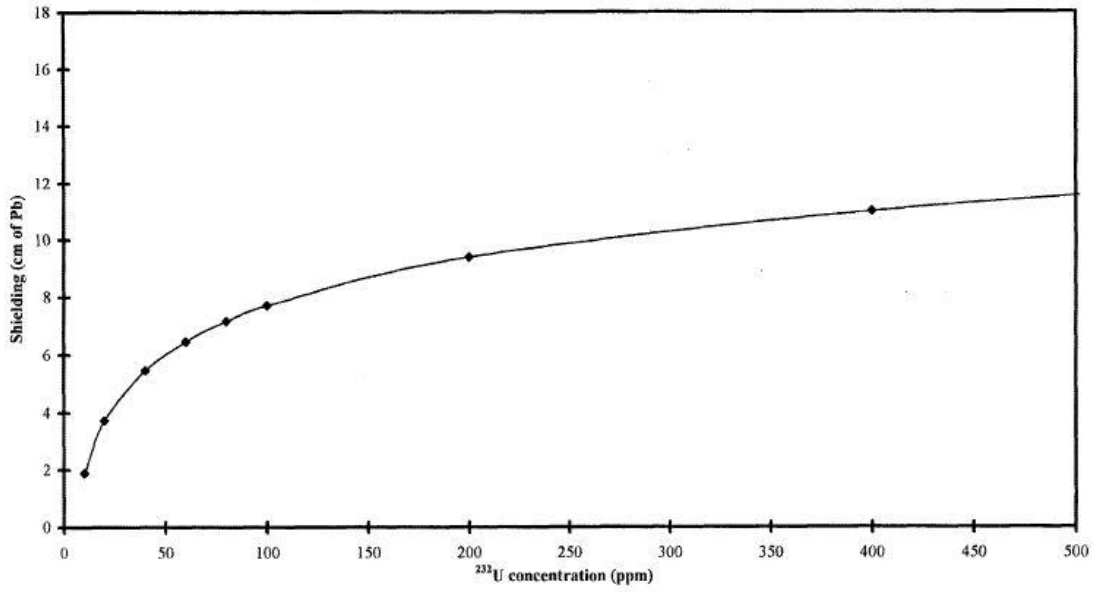


Fig. 4.1. Lead shielding for ^{233}U with various concentrations of ^{233}U .

^{233}U

12 m

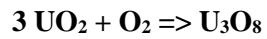
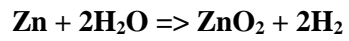
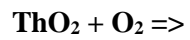
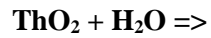
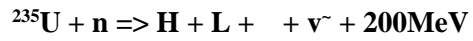
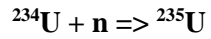
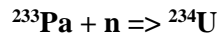
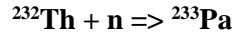
10

^{233}U

^{235}U

^{233}U

2) ^{233}U



(1430°)

(700)

ThO_2

MSR –

$^{233}\text{UF}_4$

6 bar

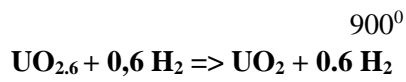
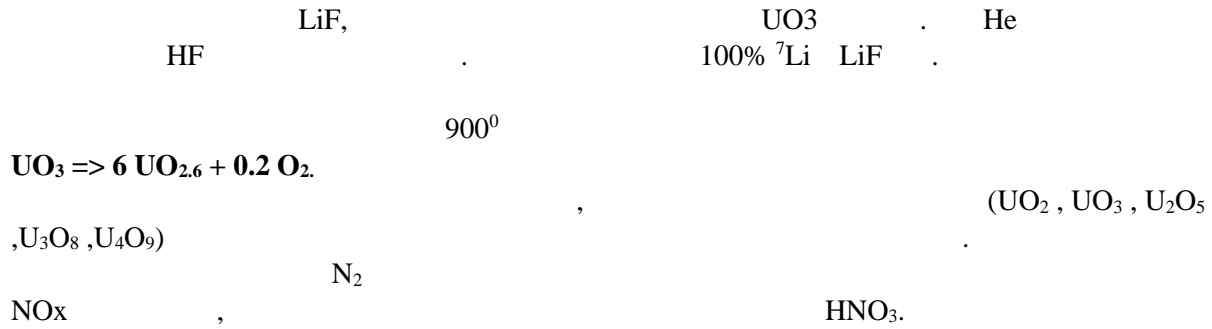
350° –

1100°

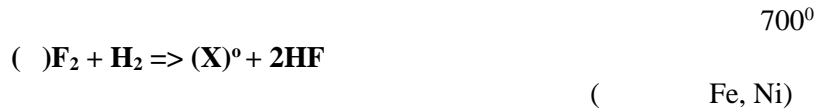
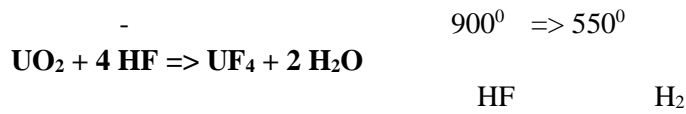
^{233}U ,

^{135}Xe .

²³³UF₄:



²³³U,



²³³UF₄

BeF₂.

- LiF-BeF₂-ZrF₄-UF₄ (65-29-5-1)**
- LiF-BeF₂-ThF₄-UF₄ (72-16-12-0.4)**
- LiF-BeF₂-UF₄ (72-16-12)**
- NaF-ZrF₄-UF₄ (53-41-6) –**

⁷Li

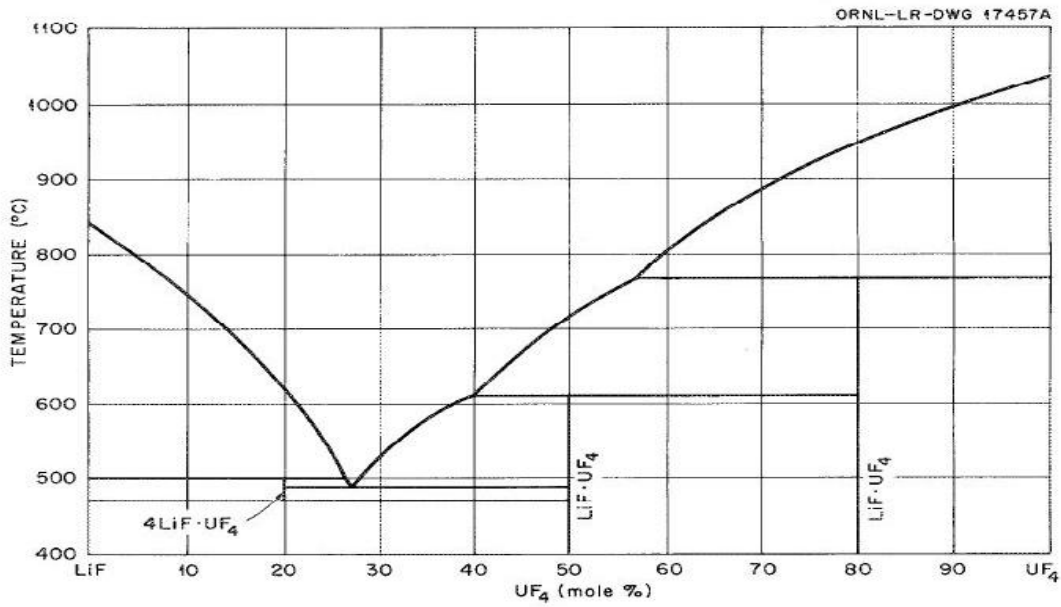


Fig. 22. LiF-UF₄ Phase Diagram.

²³³UF₄:

UF₄ LiF.

200°

650°

⁷Li

. NaF e

⁷Li.

"Colex"

Mg.

, ²³³U

²³²Th

3)

^{233}U

^{233}U

$^{233}\text{U} : ^{238}\text{U} = 1:188,$

^{233}U

$^{233}\text{U}.$

$\text{O} : ^{235}\text{U} = 100 ($

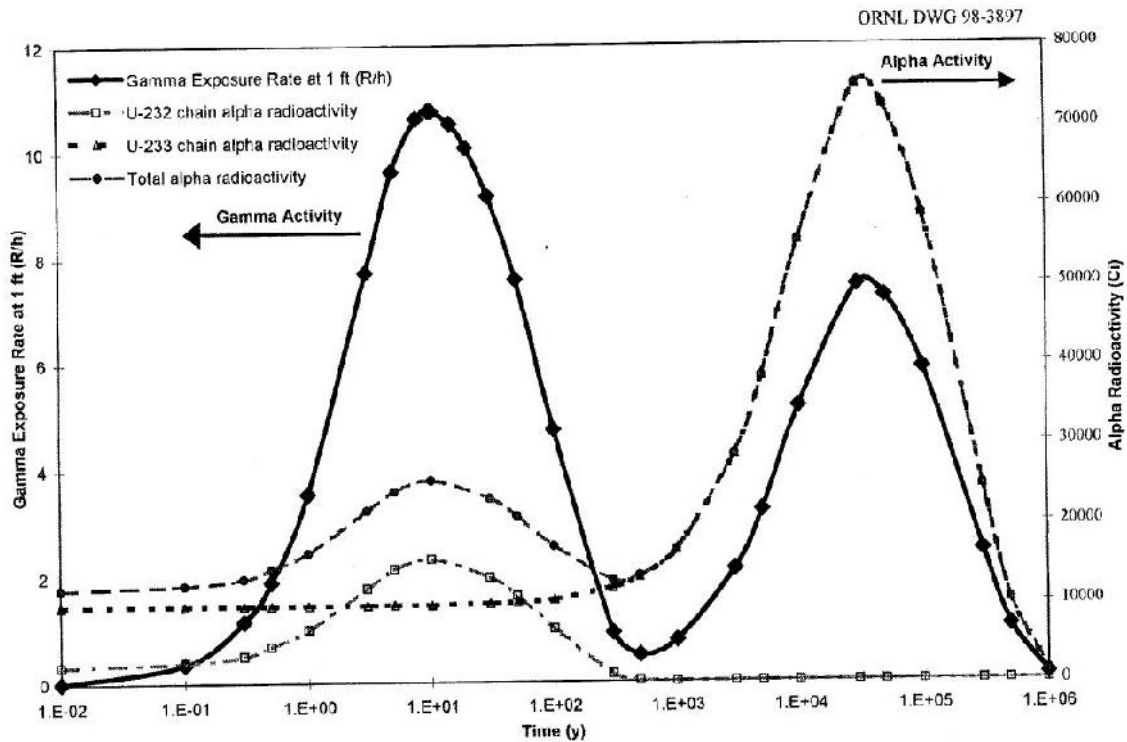
$) \quad ^{238}\text{U} : ^{235}\text{U} = 100$

$k = 0,5.$

$\text{H} : ^{235}\text{U} = 500 \quad \text{O} : ^{235}\text{U} = 250 ($

$) \quad ^{238}\text{U} : ^{235}\text{U} = 100$

$k = 0,895.$



$^{233}\text{U} e,$

4)

^{233}U

MMRTG,

на Циолковски
двигател у

$$\Delta v = I_{sp} * g * \ln \left(\frac{m_0}{m_f} \right)$$

Δv – разлика в началната и крайната скорост на апарата

I_{sp} – специфичният импулс

g – ускорението/притеглянето на небесното тяло

m_0 – начална маса със заредено горивото

m_f – крайна маса след изразходване на горивото

$$I_{sp} = m_c * v_c = m_{изх} * v_{изх}$$

m –

v –

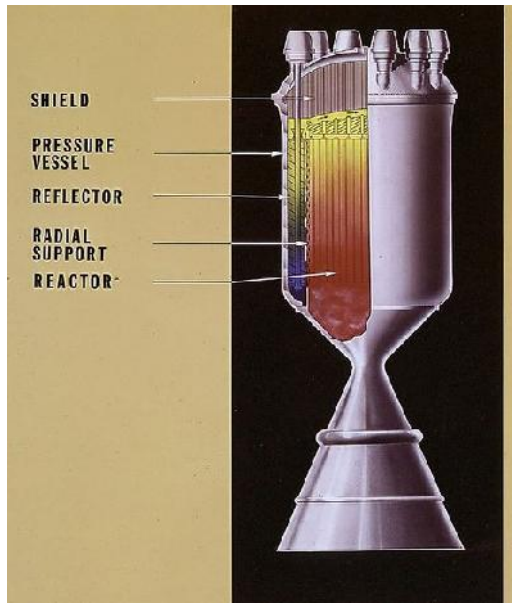
m –

(H_2 –

)

v –

Двигател	Скорост в изходящата дюза (m/s)	Специфичен импулс (s)	Енергия на изходното вещество (MJ/kg)
На твърдо гориво	2500	250	3,0
С двукомпонентно гориво	4400	450	9,7
Йонен двигател	29000	3000	430
Магнитоплазмен двигател	120000	12000	1400



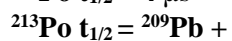
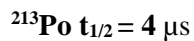
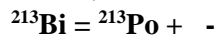
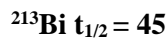
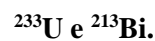
Недостатъкът на сегашните двигатели с висок специфичен импулс е, че консумират прекалено много електрическа енергия и генерират малко ускорение. В контраст с това ракетните двигатели имащи нисък специфичен импулс разполагат с голяма тяга/ускорение.

Ядрен ракетен двигател нагнетяващ водород до високи налягания би създал компромисен вариант между ускорение и специфичен импулс. Така бъдещите космонавти биха се придвижват в слънчевата ни система значително по-бързо между различните небесни тела тъй като биха разполагали с голям запас от Δv за разлика от сегашната генерация кораби.

Един от ценните актиниди, който остава като отпадък от утилизацията на ^{233}U и ^{237}Np . Облъчвайки го с неутрони получаваме ^{238}Pu . Вътрешното енергоотделяне на този изотоп позволява да е отличен източник на надеждна високо потенциална енергия в продължение на десетилетия. ⁽¹⁰⁾

	:		:
^{235}U		$6.0 \cdot 10^{-8} \text{ W/g}$	
^{233}U		$2.8 \cdot 10^{-4} \text{ W/g}$	
^{238}Pu		$5.6 \cdot 10^{-1} \text{ W/g}$	

:



(Anti-CD20,

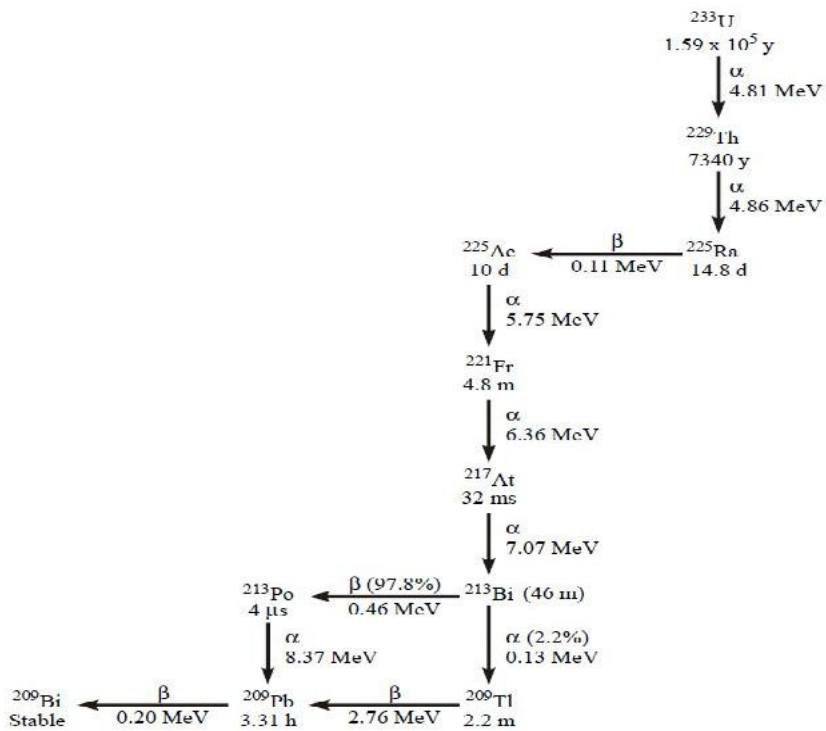
Anti-CD33)

Anti-CD33

^{233}U $t_{1/2} = 7340$ \Rightarrow ^{229}Th \Rightarrow ^{213}Bi \Rightarrow ^{229}Th \Rightarrow ^{225}Ra \Rightarrow ^{225}Ac \Rightarrow ^{225}Bi $t_{1/2} = 46$ \Rightarrow ^{225}Ac

1kg ^{233}U \Rightarrow 30 ^{213}Bi \Rightarrow 10 ^{229}Th \Rightarrow 120 mg. ^{229}Th

0,1 mol ^{229}Th \Rightarrow 25 ^{229}Th



^{209}Pb ^{209}Bi

^{233}U

^{232}U

^{233}U

- 1) ORNL-1368 *Some Effects of Transmutation Products on U233 Breeder Pile Operation*
- 2) ORNL-1567 *Heavy Isotope Buildup in Core of 233U Breeder*
- 3) ORNL-4371 *Preparation of Enriching Salt 7LiF-233UF4 for Refueling the Molten Salt Reactor*
- 4) ORNL-5388 *Interim Assessment of the Denatured 233U Fuel Cycle*
- 5) ORNL-6952 *Uses For Uranium-233 What Should Be Kept for Future Needs*
- 6) ORNL-TM-13517 *Definition of Weapons-Usable Uranium-233*
- 7) ORNL-TM-13524 *Isotopic Dilution Requirements for 233U Criticality Safety in Processing and Disposal Facilities*
- 8) ORNL-TM-13552 *Strategy for the Future Use and Disposition of Uranium-233*
- 9) ORNL-TM-13553 *Disposition Options for Uranium-233*
- 10) *"Radioisotope Power Systems for Space Exploration"*
- 11) Robbins, W.H. and Finger, H.B., *"An Historical Perspective of the NERVA Nuclear Rocket Engine Technology Program"*, NASA Contractor Report 187154/AIAA-91-3451, NASA Lewis Research Center, NASA, July 1991
- 12) *Pharmacokinetics and Dosimetry of an α -Particle Emitter Labeled Antibody: ^{213}Bi -HuM195 (Anti-CD33) in Patients with Leukemia*
- 13) IE – << >> 1976