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COMMISSION FOR ESTABLISHMENT OF ANALYTICAL METHODS

REFERENCE MATERIALS CATALOGUE

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French Alternative Energies and Atomic Energy Commission
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Nuclear Energy Division
Research Department on Mining and Fuel Recycling Processes
Commission for Establishment of Analytical Methods

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1. FOREWORD

In nuclear industrial and research applications, and particularly in the nuclear fuel cycle and safeguards, the accuracy of analytical results is extremely important :

- to optimize the operation of nuclear facilities ;
- to obtain accurate fissile material balances ;
- to allow reliable and effective monitoring for nuclear material accountancy ;
- to monitor environmental release in compliance with increasingly stringent standards.

The missions assigned to CETAMA include the organization of interlaboratory comparisons — notably EQRAIN (French acronym for Quality Assessment of Analytical Results in the Nuclear Industry) — and the production of nuclear certified reference materials (CRMs) and reference materials (RMs).

These CRMs can be used for :

- the development of analytical methods ;
- the calibration of measuring systems ;
- the preparation of in-house reference materials
- the validation of analytical methods.

These CRMs are referenced according following the categories below :

- reference materials certified for elemental content
- reference materials certified for isotopic composition
- reference materials certified for impurity content
- reference materials certified for specific area

Note that some CRMs are present in different categories as for example :

- MP2 material is certified for elemental content, for isotopic composition and for mass,
- STAM material is certified for elemental content and for isotopic composition.

CETAMA also has reference materials (MR).

2. PREPARATION OF THE REFERENCE MATERIALS

CETAMA produces these products to meet the objectives and requirements of the nuclear industry : increasing analytical accuracy, analysis of new materials, new specifications and replacement of CRMs that are nearly out of stock.

All the steps in the CRM production process are supervised by CETAMA : assessment of requirements, lot size, material selection and procurement, purification, homogeneity and stability tests, packaging, certification (measurement data processing, determination of certified value and its associated uncertainties, emission of the certificate).

The operations are undertaken jointly with the CETAMA Working Groups, and are carried out by French and foreign expert laboratories according to their fields of expertise.

3. CERTIFICATE

Each CRM is accompanied by a certificate containing at least the following information : certified values and their uncertainties, instructions for use and storage, date of certification and methods used for the certification.

4. AVAILABILITY AND ORDERING INFORMATION

To know the availability and prices of the CRMs, please contact :

Commissariat à l'énergie atomique et aux énergies alternatives
CEA/DEN/DMRC/CETAMA

Centre de Marcoule – Bâtiment 397
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5. REFERENCE MATERIALS CERTIFIED FOR ELEMENTAL CONTENT

5.1. AMERICIUM MATERIALS

Reference	Matrix	Certified values *		Unit size	Comments
NEW **STAM**	Nitric solution around 1 M	^{243}Am	**(5.696 ± 0.011) nmol g^{-1}** **(1.3845 ± 0.0026) µg.g^{-1}**	5.5 µg Am in 3.5 ml of nitric solution (glass ampoule)	Isotopic composition certified (*see paragraph 6.1*) Certified value at January 1st, 2017
		^{241}Am	**(0.7754 ± 0.0015) nmol g^{-1}** **(0.18692 ± 0.0036) µg g^{-1}**		
		Am	**(6.472 ± 0.012) nmol g^{-1}** **(1.5716 ± 0.0030) µg g^{-1}**		
		$\mathcal{M}$(Am)	**(242.821094 ± 0.000085) g mol-1**		

5.2. NEPTUNIUM MATERIALS

Reference	Matrix	Certified neptunium content * (g L^{-1} at 20°C)	Unit size	Comments
Np237	Nitric solution	**1.008 ± 0.006**	40 ml of solution per sealed ampoule	/

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

5.3. PLUTONIUM MATERIALS

Reference	Matrix	Certified plutonium content * ($g\ kg^{-1}$)	Unit size	Comments
MP2	Plutonium metal	**999.0 ± 0.4**	From 0.6 to 1 g per sealed ampoule	Certified isotopic composition (*see paragraph 6.2*) Certified mass ± 12 µg Value certified at the reference date of 03/12/2001

5.4. URANIUM MATERIALS

Reference	Matrix	Certified uranium content * ($g\ kg^{-1}$)	Unit size	Comments
MU2	Uranium metal	**999.85 ± 0.05**	From 0.4 to 1.5 g per sealed ampoule	natural Uranium
OU1	UO_2	**881.22 ± 0.90**	Sintered pellets of 0.4 g supplied in lots of 10 per sealed ampoule	natural Uranium
OTU1	U_3O_8	**847.74 ± 0.82**	25 g per bottle	natural Uranium
MIN A	Ore	**3.214 ± 0.042**	200 g per bottle	illite pitchblende at radioactive equilibrium
MIN B	Ore	**1.639 ± 0.016**	200 g per bottle	granite pitchblende at radioactive equilibrium
MIN C	Ore	**40.43 ± 0.21**	100 g per bottle	granite pitchblende at radioactive equilibrium
MIN D	Ore	**0.650 ± 0.016**	100 g or 200 g per bottle	pyrite pitchblende at radioactive equilibrium
MIN E	Ore	**4.343 ± 0.052**	100 g per bottle	sandstone pitchblende at radioactive equilibrium
MIN F	Ore	**0.140 ± 0.006**	100 g or 200 g per bottle	colophanite at radioactive equilibrium

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

6. REFERENCE MATERIALS CERTIFIED FOR ISOTOPIC COMPOSITION

6.1. AMERICIUM MATERIAL

Reference	Matrix	Ratios *			Unit size	Comments
STAM (NEW)	Nitric solution	Certified values	$n(^{241}Am)/n(^{243}Am)$	**(0.136138 ± 0.000054) mol mol^{-1}**	5.5 µg Am in 3.5 ml of nitric solution (glass ampoule)	Isotopic composition certified (*see paragraph 5.1)* Certified value at January 1st, 2017
			$m(^{243}Am)/m(Am)$	**(880.069 ± 0.042) *m*mol mol^{-1}** **(880.940 ± 0.042) *m*g g^{-1}**		
			$m(^{241}Am)/m(Am)$	**(119.810 ± 0.042) *m*mol mol^{-1}** **(118.940 ± 0.042) *m*g g^{-1}**		
		Indicative values	$n(^{242m}Am)/n(^{243}Am)$	**(0.1373 ± 0.0024) *m*mol mol^{-1}**		
			$m(^{242m}Am)/m(Am)$	**(0.1205 ± 0.0021) *m*g g^{-1}**		
			$n(^{242m}Am)/n(Am)$	**(0.1208 ± 0.0021) *m*mol mol^{-1}**		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

6.2. PLUTONIUM MATERIALS

Reference	Matrix	Certified isotopic ratios * (atomic fraction)		Unit size	Comments
MP2	Plutonium metal	$n(^{238}Pu)/n(^{239}Pu)$	**$3.083.10^{-5}$ ± $0.029.10^{-5}$**	From 0.6 to 1 g per sealed ampoule	Total Pu concentration certified (*see paragraph 5.3*) Isotopic composition certified at the reference date of November 7th, 2006
		$n(^{240}Pu)/n(^{239}Pu)$	**$2.24324.10^{-2}$ ± $0.00051.10^{-2}$**		
		$n(^{241}Pu)/n(^{239}Pu)$	**$2.378.10^{-4}$ ± $0.031.10^{-4}$**		
		$n(^{242}Pu)/n(^{239}Pu)$	**$7.570.10^{-5}$ ± $0.078.10^{-5}$**		
MIRF 01	Plutonium nitrate	$n(^{239}Pu)/n(^{242}Pu)$	**0.9783 ± 0.0005**	100 µg of Pu Dry extract	Value certified at the reference date of January 1st, 2000 Isotopic composition indicated
^{242}Pu	Plutonium nitrate	$n(^{238}Pu)/n(^{242}Pu)$	**0.25740 ± 0.00041**	10 ml solution per sealed vial	Value certified at the reference date of December 31st, 2011 2 levels of Pu content: C1 ≈ 0.9 g kg^{-1} C2 ≈ 4.5 mg kg^{-1}
		$n(^{239}Pu)/n(^{242}Pu)$	**0.2704 ± 0.0017**		
		$n(^{240}Pu)/n(^{242}Pu)$	**0.57166 ± 0.00027**		
		$n(^{241}Pu)/n(^{242}Pu)$	**0.3392 ± 0.0020**		
		$n(^{244}Pu)/n(^{242}Pu)$	**0.03830 ± 0.00011**		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

6.3. URANIUM MATERIALS

Reference	Matrix	Certified isotopic ratios * (atomic fraction)		Unit size	Comments
MIRF 02	Uranyl nitrate	$n(^{233}U)/n(^{236}U)$	**0.9681 ± 0.0010**	200 µg of U Dry extract	Value certified at the reference date of January 1st, 2000 Isotopic composition indicated
CETAMIR 1	U_3O_8	$n(^{234}U)/n(^{238}U)$	$\mathbf{2.881.10^{-4}}$ $\mathbf{\pm 0.011.10^{-4}}$	1g of U_3O_8 per bottle	Values certified at the reference date of January 1st, 1996
		$n(^{235}U)/n(^{238}U)$	$\mathbf{1.1152.10^{-2}}$ $\mathbf{\pm 0.0010.10^{-2}}$		
		$n(^{236}U)/n(^{238}U)$	$\mathbf{4.098.10^{-3}}$ $\mathbf{\pm 0.006.10^{-3}}$		
CETAMIR 2	U_3O_8	$n(^{234}U)/n(^{238}U)$	$\mathbf{1.038.10^{-3}}$ $\mathbf{\pm 0.005.10^{-3}}$	1g of U_3O_8 per bottle	Values certified at the reference date of January 1st, 1996
		$n(^{235}U)/n(^{238}U)$	$\mathbf{4.7746.10^{-2}}$ $\mathbf{\pm 0.0045.10^{-2}}$		
		$n(^{236}U)/n(^{238}U)$	$\mathbf{1.255.10^{-2}}$ $\mathbf{\pm 0.001.10^{-2}}$		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

7. REFERENCE MATERIALS CERTIFIED FOR IMPURITY CONTENT

7.1. URANIUM METAL MATRIX

Reference	Matrix	Certified impurity content * (mg kg^{-1})		Unit size	Comments
OPERA 103	Uranium metal	**Carbon**	**226 ± 11**	Sample mass unit : 1 g 50 samples per bottle	Depleted Uranium Uranium/Vanadium alloy (Vanadium 0.2%)
OPERA 104	Uranium metal	**Carbon**	**58 ± 7**	Sample mass unit : 1 g 50 samples per bottle	Depleted Uranium

7.2. URANIUM OXIDE MATRIX

Reference	Matrix	Certified impurity content * (mg kg^{-1} of UO_2)			Unit size	Comments
VIOGNIER	UO_2	**Certified values**	**Cl**	**17.9 ± 1.0**	100 g of UO_2 powder per bottle	/
			F	**32.7 ± 1.1**		
			N	**45.2 ± 3.3**		
			P	**43.2 ± 1.8**		
		Indicative value	**Br ****	**4.4 ****		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*
*** Indicative value from one analytical method*

URANIUM OXIDE MATRIX :

Reference	Matrix	Certified impurity content * (mg kg^{-1} of uranium)		Unit size	Comments
AGARIC	U_3O_8	**Ag**	**0.07 ± 0.04**	25 g of U_3O_8 powder per bottle	Isotopic composition of natural uranium Total impurities : < 45 mg kg^{-1} of uranium
		Al	**9.1 ± 2.8**		
		Ba	**0.56 ± 0.24**		
		Be	**< 0.2**		
		Bi	**< 0.2**		
		Ca	**6 ± 2**		
		Cd	**< 0.15**		
		Co	**< 0.25**		
		Cr	**1.04 ±0.49**		
		Cu	**< 0.36**		
		Dy	**< 0.13**		
		Eu	**<0.02**		
		Fe	**11.7 ± 7.1**		
		Ga	**< 0.40**		
		Gd	**< 0.05**		
		In	**<0.06**		
		Li	**< 0.24**		
		Mg	**1.2 ± 1.1**		
		Mn	**< 0.22**		
		Mo	**< 0.5**		
		Pb	**0.21 ±0.01**		
		Si	**5 ± 2**		
		Sm	**< 0.14**		
		Sn	**< 0.40**		
		Th	**1.34 ± 0.18**		
		Ti	**< 0.35**		
		V	**< 0.05**		
		W	**< 0.20**		
		Zn	**0.73 ± 0.11**		
		Zr	**1.71 ± 0.19**		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

URANIUM OXIDE MATRIX :

Reference	Matrix	Certified impurity content * (mg kg^{-1} of uranium)		Unit size	Comments
BOLET	U_3O_8	**Ag**	**2.09 ± 0.46**	25 g of U_3O_8 powder per bottle	Isotopic composition of natural uranium Total impurities : 245 mg kg^{-1} of uranium
		Al	**22.7 ± 2.9**		
		B	**1.09 ± 0.12**		
		Ba	**5.4 ± 1.0**		
		Be	**0.52 ± 0.82**		
		Bi	**3.95 ± 0.71**		
		Ca	**12.4 ± 1.3**		
		Cd	**0.53 ± 0.09**		
		Co	**1.02 ± 0.11**		
		Cr	**9.37± 0.55**		
		Cu	**10.36± 0.77**		
		Dy	**0.20± 0.07**		
		Eu	**0.21 ± 0.05**		
		Fe	**54.8 ± 1.9**		
		In	**2.05 ± 0.38**		
		Li	**2.11 ± 0.39**		
		Mg	**5.75 ±0.77**		
		Mn	**4.66 ± 0.37**		
		Mo	**4.88 ± 0.49**		
		Ni	**18.2 ± 1.1**		
		Pb	**6.61 ± 0.80**		
		Si	**28.6 ± 5.1**		
		Sm	**0.23 ± 0.06**		
		Sn	**4.38 ± 0.88**		
		Th	**2.90 ± 0.89**		
		Ti	**5.09 ± 0.64**		
		V	**4.55 ± 0.33**		
		W	**9.3 ± 1.5**		
		Zn	**9.6 ± 2.6**		
		Zr	**9.7 ± 2.0**		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

URANIUM OXIDE MATRIX :

Reference	Matrix	Certified impurity content * (mg kg^{-1} of uranium)			Unit size	Comments
CHANTERELLE	U_3O_8	Certified values	**Ag**	**5.0 ± 0.6**	25 g of U_3O_8 powder per bottle	Isotopic composition of natural uranium Total impurities : 642 mg kg^{-1} of uranium
			Al	**51 ± 3**		
			B	**1.1 ± 0.4**		
			Be	**0.86 ± 0.10**		
			Bi	**5.2 ± 0.5**		
			Ca	**56 ± 7**		
			Cd	**1.1 ± 0.4**		
			Co	**5.2 ± 1.1**		
			Cr	**49.6 ± 4.1**		
			Cu	**26.4 ± 3.4**		
			Fe	**122 ± 10**		
			Ga	**2.8 ± 0.6**		
			Mg	**11 ± 1**		
			Mn	**9.9 ± 1.7**		
			Mo	**54 ± 4**		
			Ni	**50 ± 3**		
			Pb	**45 ± 3**		
			Si	**35 ± 9**		
			Ti	**9.8 ± 2.1**		
			V	**9.4 ± 1.3**		
			W	**18.1 ± 2.6**		
			Zn	**44 ± 4**		
			Zr	**24 ± 7**		
		Indicative value	**Sn ****	**5.3 ± 0.7 ****		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*
*** Indicative value : only one analytical method used*

URANIUM OXIDE MATRIX :

Reference	Matrix	Certified impurity content * (mg kg^{-1} of uranium)			Unit size	Comments
MORILLE	U_3O_8	**Certified values**	**Ag**	**10.4 ± 1.6**	25 g of U_3O_8 powder per bottle	Isotopic composition of natural uranium Total impurities : 1557 mg kg^{-1} of uranium
			Al	**99 ± 6**		
			B	**3.8 ± 1.6**		
			Ba	**9.6 ± 0.4**		
			Be	**5.4 ± 0.6**		
			Bi	**24.4 ± 1.9**		
			Ca	**93 ± 8**		
			Cd	**4.9 ± 0.7**		
			Co	**9.8 ± 2.0**		
			Cr	**99 ± 2**		
			Cu	**50.2 ± 1.0**		
			Dy	**0.50 ± 0.06**		
			Eu	**0.52 ± 0.03**		
			Fe	**211.6 ± 6.5**		
			Gd	**0.56 ± 0.06**		
			In	**9.4 ± 1.0**		
			Li	**5.0 ± 0.2**		
			Mg	**19.3 ± 1.5**		
			Mn	**24.5 ± 0.5**		
			Mo	**147 ± 5**		
			Ni	**147 ± 3**		
			Pb	**101 ± 3**		
			Si	**100 ± 8**		
			Sm	**0.50 ± 0.12**		
			Sn	**18.5 ± 5.6**		
			Ti	**49.2 ± 2.6**		
			V	**48.7 ± 2.8**		
			W	**100 ± 9**		
			Zn	**98.6 ± 5.5**		
		Indicative values	**Th ****	**6.2 ± 0.8 ****		
			Zr **	**59.9 ± 4.1 ****		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*
*** Indicative value : only one analytical method used*

7.3. URANATE MATRIX

Reference	Matrix	Certified elemental content *			Unit size	Comments
FELDSPATH 	Ammonium uranate	Certified values	**U**	**(746.5 ± 4.1)** g kg^{-1} ammonium uranate dry	20 g ammonium uranate per bottle	/
			Ca	**(128.5 ± 3.0)** mg kg^{-1} of uranium		
			Fe	**(42.7 ± 3.1)** mg kg^{-1} of uranium		
			Mg	**(25.0 ± 1.1)** mg kg^{-1} of uranium		
			Mo	**(30.3 ± 2.1)** mg kg^{-1} of uranium		
			Zr	**(68.2 ± 6.1)** mg kg^{-1} of uranium		
		Indicative values (mg kg^{-1} of uranium)	**V**	< 0.34		
			La	0.0083 ± 0.0047		
			Ce	0.0178 ± 0.0065		
			Sm	0.0041 ± 0.0012		
			Eu	0.00068 ± 0.00032		
			Gd	0.0045 ± 0.0023		
			Tb	0.00054 ± 0.00018		
			Dy	0.00262 ± 0.00066		
			Ho	0.00049 ± 0.00012		
			Er	0.00129 ± 0.00039		
			Yb	0.00126 ± 0.00053		
			Lu	0.00020 ± 0.00011		
			Pr	< 0.0088		
			Nd	< 0.043		
			Tm	< 0.00061		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

URANATE MATRIX :

Reference	Matrix	Certified impurities content * (g kg^{-1} of magnesium or ammonium uranate)		Unit size	Comments
AMETHYSTE	Magnesium uranate	**Ca**	**1.29 ± 0.10**	50 g of Magnesium uranate per bottle	/
		Cl	**1.92 ± 0.12**		
		Fe	**2.07 ± 0.06**		
		Na	**30.8 ± 1.0**		
		SiO_2	**2.79 ± 0.18**		
		SO_4^{2-}	**23.7 ± 1.1**		
BERYL	Ammonium uranate	**Fe**	**0.108 ± 0.030**	50 g of Ammonium uranate per bottle	/
		Na	**0.050 ± 0.010**		
		PO_4^{3-}	**0.211 ± 0.036**		
		SO_4^{2-}	**20.50 ± 0.06**		
CALCEDOINE	Magnesium uranate	**Fe**	**4.74 ± 0.05**	50 g of Magnesium uranate per bottle	/
		Mo	**1.53 ± 0.09**		
		Na	**26.2 ± 0.9**		
		V	**0.684 ± 0.025**		
		Zr	**2.08 ± 0.09**		
		SiO_2	**4.76 ± 0.32**		
		PO_4^{3-}	**1.25 ± 0.06**		
		SO_4^{2-}	**12.2 ± 0.9**		
DIAMANT	Magnesium uranate	**Ca**	**9.13 ± 0.15**	50 g of Magnesium uranate per bottle	/
		Cl	**3.21 ± 0.25**		
		Fe	**6.39 ± 0.04**		
		Na	**22.2 ± 0.5**		
		SiO_2	**29.7 ± 0.6**		
		PO_4^{3-}	**5.58 ± 0.29**		
		SO_4^{2-}	**5.30 ± 0.27**		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

URANATE MATRIX :

Reference	Matrix	Certified impurities content * (g kg^{-1} of magnesium, ammonium or sodium uranate)		Unit size	Comments
EMERAUDE	Magnesium uranate	**As**	**1.46 ± 0.12**	50 g of Magnesium uranate per bottle	/
		Ca	**17.7 ± 2.1**		
		Fe	**4.03 ± 0.09**		
		Mo	**0.38 ± 0.06**		
		Zr	**9.95 ± 0.26**		
		SiO_2	**14.3 ± 0.9**		
		SO_4^{2-}	**14.8 ± 1.2**		
FELDSPATH	Ammonium uranate	**Fe**	**0.0343 ± 0.0009**	50 g of Ammonium uranate per bottle	/
		PO_4^{3-}	**0.156 ± 0.016**		
		SO_4^{2-}	**16 ± 1**		
GRENAT	Sodium uranate	**Fe**	**0.303 ± 0.019**	50 g of Sodium uranate per bottle	/
		Mo	**0.558 ± 0.027**		
		Na	**81.2 ± 2.3**		
		Zr	**13.8 ± 0.6**		
		SiO_2	**1.41 ± 0.10**		
		CO_3^{2-}	**21.1 ± 1.8**		
		SO_4^{2-}	**8.72 ± 0.14**		
HYACINTHE	Magnesium uranate	**Ca**	**1.35 ± 0.12**	50 g of Magnesium uranate per bottle	/
		Fe	**2.90 ± 0.06**		
		Na	**31.6 ± 1.0**		
		PO_4^{3-}	**1.22 ± 0.07**		
		SO_4^{2-}	**4.31 ± 0.33**		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

7.4. GLASS MATRIX

Reference	Matrix	Certified components * (% mass)			Unit size	Comments
NEW **VERRE LCV UOX**	crushed glass type uranium oxide	CERTIFIED VALUES	SiO_2	44.52 ± 0.67	20 g of glass per bottle	/
			B_2O_3	13.38 ± 0.28		
			Na_2O	9.23 ± 0.19		
			CaO	3.66 ± 0.19		
			Nd_2O_3	3.512 ± 0.042		
			Fe_2O_3	2.921 ± 0.040		
			ZrO_2	2.771 ± 0.035		
			ZnO	2.383 ± 0.032		
			MoO_3	2.221 ± 0.030		
			Li_2O	1.951 ± 0.034		
			La_2O_3	1.521 ± 0.034		
			Cs_2O	1.361 ± 0.019		
			BaO	0.865 ± 0.029		
			RuO_2	0.853 ± 0.016		
			Pd	0.776 ± 0.022		
			Pr_2O_3	0.660 ± 0.021		
			MnO_2	0.470 ± 0.016		
			SrO	0.402 ± 0.013		
			P_2O_5	0.220 ± 0.011		
			NiO	0.080 ± 0.010		
			Cr_2O_3	0.0501 ± 0.0063		
			SnO_2	0.0300 ± 0.0038		
		Indicative values	TeO_2	0.205 ± 0.017		
			Al_2O_3	4.183 ± 0.072		
			Ce_2O_3	1.221 ± 0.021		

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

8. REFERENCE MATERIALS CERTIFIED FOR SPECIFIC AREA

8.1. URANIUM MATRIX

Reference	Matrix	Certified Specific Area * ($m^2\ g^{-1}$)	Unit size	Comments
SYRHA	UO_2	**3.41 ± 0.04**	100 g of UO_2 powder per bottle	/

** The uncertainties specified are the expanded uncertainties with a coverage factor k = 2*

9. REFERENCE MATERIALS

The values in the following tables are indicative and are given without uncertainties.

9.1. ORGANIC COMPOUNDS REFERENCE MATERIALS

Dibutyl phosphate reference material :

Reference	Purity (kg kg^{-1})	Unit size	Comments
HDBP	**0.991**	50 ml of solution per bottle	/

Monobutyl phosphate reference material :

Reference	Purity (kg kg^{-1})	Unit size	Comments
H_2MBP	**0.992**	50 ml of solution per bottle	/

9.2. METAL URANIUM REFERENCE MATERIALS : FLORALIES

The Floralies materials are natural uranium shavings in metal form, impregnated with paraffin oil. Their packaging under paraffin oil is realized on request. The minimum mass is 20 g

Reference	Impurity content (mg kg^{-1} of uranium)													
	Ag	Al	B	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Si	Sn	Zr
Bleuet	<0.5	40	≤0.2	4	5	12	70	6	7	24	1,5	70	≤2	25
Capucine	0.5	40	0.55	4	32	55	140	25	20	190	5	22	4	55
Dahlia	0.6	90	0.8	8	140	72	450	32	30	290	2	40	7	70
Eglantine	1.2	120	0.25	15	15	7	38	4	50	50	15	13	20	110
Fuschia	1.3	150	0.35	26	17	23	200	60	95	110	25	110	20	150

Reference	Impurity content (mg kg^{-1} of uranium)																
	Al	B	Be	Bi	Ca	Cr	Cu	Fe	In	Mn	Nb	Ni	Si	Th	Ti	V	W
Hortensia	60	1	<0.1	<1	≤2	140	80	460	1	15	≤5	340	34	5	5	4	<5
Iris	100	/	0.2	≤1	4	27	35	130	6	6	≤10	115	13	<5	10	3	≤5
Kentia	120	1.3	/	/	5	9	130	110	/	12	20	480	40	<5	40	3	5

Reference	Impurity content (mg kg^{-1} of uranium)												
	Al	B	Co	Cr	Cu	Fe	Mn	Mo	Ni	Si	Sn	Th	Zr
Romarin	270	≤0.1	2.5	7	8	95	5	25	6	40	25	<50	30
Sauge	465	0.2	5	12	13	200	10	51	13	40	50	<50	50