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CETAMA  
Métrologie et Analyses Chimiques

# REFERENCE MATERIALS

## *Catalogue*



Commissariat à l'énergie atomique et aux énergies alternatives

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## 1. Foreword

In nuclear research and industry, particularly in the fuel cycle as well as for safeguards, the accuracy of analyses is a primordial factor:





- To optimize the operation of facilities;
- To prepare accurate reports concerning the movements of fissile materials;
- To enable sure, efficient monitoring of nuclear matter accounting;
- To characterize nuclear waste and orient it towards suitable treatment and storage routes;
- To monitor releases into the environment, which must meet increasingly strict regulatory requirements.

As part of its missions within the French CEA, the CETAMA participates in the improvement of analysis quality through the organization of interlaboratory comparisons (especially the EQRAIN interlaboratory comparisons – known in French as “Circuits d’Evaluation de la Qualité du Résultat d’Analyse dans l’Industrie Nucléaire”) and in the production of reference materials which are often certified (CRMs).

These CRMs can be used for :


- The calibration of measurement systems ;
- The validation of analytical methods ;
- The preparation of secondary reference materials.

The CETAMA’s CRMs are presented according to the following categories:

- Reference materials with a certified elemental content 
- Reference materials with a certified isotopic composition 
- Reference materials with a certified impurity content 
- Reference materials with a certified specific surface area 

It is worth noting that certain CRMs can be found in more than one category. For example:

- The MP2 material is certified for its elemental content, its isotopic composition, and its mass;
- The STAM material is certified for both its elemental content and its isotopic composition.

The CETAMA also provides non-certified reference materials (RMs). 



## 2. Production of reference materials

The CETAMA prepares these materials in accordance with the objectives and needs of the nuclear industry: better accuracy for analysis results, new materials to analyze, new specifications to check, as well as preventing any shortages in the CRM stocks available.

All the CRM production operations, carried out according to the principles of the NF EN ISO 17034 Standard "General requirements for the competence of reference material producers", are managed and coordinated by the CETAMA: recording of needs, lot size, choice and supply of the material implemented, purification, verification of homogeneity and stability, packaging, certification (measurement data processing, determination of the characterization's uncertainty value, determination of the uncertainties related to homogeneity and to stability, issue of the certificate).

These operations are distributed among different French and international expert laboratories, depending on their specialized skills.

## 3. Certificate

Each CRM is accompanied by a certificate specifying (at a minimum) the certified values with their associated uncertainty, the instructions for appropriate use and storage, the certification date, the validity period of the certificate, the analytical methods used for the certification, and metrological traceability information concerning the certified values.

The certificates are available on request.

The non-certified Reference Materials are accompanied by a product information sheet specifying (at a minimum) the measurand values, the instructions for appropriate use and storage, the the validity period for the information sheet, and the analysis methods used. Additional analytical data may be supplied as indications.

## 4. Dual use goods

Certain materials sold by the CETAMA are classified as dual use items, and as such require a customs export authorization. A request for an export license may thus be necessary in order to ship the materials internationally. The codes of the harmonized customs system (called HS codes) are indicated in the comments section for each material.

## 5. Availability and ordering

For information regarding the availability and the prices of these CRMs, please address your request to:

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## 6. Reference Materials with a certified elemental content

### 6.1. Americium materials

Reference	Matrix	Certified amounts		Packaging	Comments
<b>STAM</b>	Nitric solution approx. 1M	<b><sup>243</sup>Am</b>	(5.696 ± 0.011) nmol.g <sup>-1</sup> (1.3845 ± 0.0026) µg.g <sup>-1</sup>	5.5 µg of americium in 3.5 ml of nitric acid solution (glass ampoule)	Certified value on 1 <sup>st</sup> January 2017  Certified isotopic composition (cf. § 7.1)  (HS 2844 432000)
		<b><sup>241</sup>Am</b>	(0.7754 ± 0.0015) nmol.g <sup>-1</sup> (0.18692 ± 0.0036) µg.g <sup>-1</sup>		
		<b>Am</b>	(6.472 ± 0.012) nmol.g <sup>-1</sup> (1.5716 ± 0.0030) µg.g <sup>-1</sup>		
		<b>M(Am)</b>	(242.821094 ± 0.000085) g.mol <sup>-1</sup>		

### 6.2. Neptunium materials

Reference	Matrix	Certified neptunium content (g.l <sup>-1</sup> at 20°C)	Packaging	Comments
<b><sup>237</sup>Np sol 99</b>	Nitric solution	1.0210 ± 0.0052	5 ml of solution (sealed glass ampoule)	(HS 2844 432000)
<b><sup>237</sup>Np sol 05</b>	Nitric solution	1.0140 ± 0.0090	5 ml of solution (sealed glass ampoule)	(HS 2844 432000)
<b><sup>237</sup>Np sol 07</b>	Nitric solution	1.0080 ± 0.0060	5 ml of solution (sealed glass ampoule)	(HS 2844 432000)

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6.3. Plutonium materials

Reference	Matrix	Certified plutonium content (g.kg <sup>-1</sup> )	Packaging	Comments
<b>MP2</b>	Plutonium metal	999.0 ± 0.4	0.4 to 0.7 g (sealed double glass ampoules)	Certified value on 12 <sup>th</sup> March 2001  Certified isotopic composition (cf. §7.2)  Certified mass ±12µg  (HS 2844 209900)
<b>MP4</b>	Plutonium metal	998.06 ± 0.38	0.3 to 0.5 g (sealed double glass ampoules)	Certified value on 30 <sup>th</sup> June 2023  Certified isotopic composition (cf. §7.2)  Certified impurities content (cf§8.1)  Certified mass ±20µg  (HS 2844 209900)
<b>EQRAIN Pu15</b>	Nitric solution	1.2411 ± 0.0015	10 ml of solution (sealed glass ampoule)	Certified value on 21 <sup>st</sup> June 2019  Certified isotopic composition (cf. §7.2)  (HS 2844 209900)

6.4. Uranium materials

Reference	Matrix	Certified uranium content (g.kg <sup>-1</sup> )	Packaging	Comments
<b>MU2</b>	Uranium metal	999.85 ± 0.05	0.4 to 1.5 g (sealed glass ampoule)	Natural Uranium (HS 2844100900)
<b>OU1</b>	UO <sub>2</sub>	881.22 ± 0.90	10 sintered pellets, 0.4 g unitary mass (sealed glass ampoule)	Natural Uranium (HS 2844109000)
<b>OTU1</b>	U <sub>3</sub> O <sub>8</sub>	847.74 ± 0.82	25 g (plastic vial)	Natural Uranium (HS 2844109000)
<b>MIN A</b>	Ore	3.214 ± 0.042	200 g (plastic vial)	Illite pitchblende, at radioactive equilibrium (HS 2844100900)
<b>MIN B</b>	Ore	1.639 ± 0.016	200 g (plastic vial)	Granite pitchblende, at radioactive equilibrium (HS 2844100900)
<b>MIN C</b>	Ore	40.43 ± 0.21	100 g (plastic vial)	Autunite granite, at radioactive equilibrium (HS 2844100900)
<b>MIN D</b>	Ore	0.650 ± 0.016	100 g or 200 g (plastic vial)	Pyrite pitchblende, at radioactive equilibrium (HS 2844100900)
<b>MIN E</b>	Ore	4.343 ± 0.052	100 g (plastic vial)	Sandstone pitchblende, at radioactive equilibrium (HS 2844100900)
<b>MIN F</b>	Ore	0.140 ± 0.006	100 g or 200 g (plastic vial)	Colophanite, at radioactive equilibrium (HS 2844100900)

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Reference	Matrix	Certified uranium content (g.kg <sup>-1</sup> )	Packaging	Comments
<b>EQRAIN U15 sol 61</b>	Nitric solution	196.21 ± 0.20	10 ml of solution (sealed glass ampoule)	Natural Uranium (HS 2844109000)
<b>EQRAIN U15 sol 62</b>	Nitric solution	122.58 ± 0.13	10 ml of solution (sealed glass ampoule)	Natural Uranium (HS 2844109000)
<b>EQRAIN U16 sol 63</b>	Nitric solution	196.61 ± 0.20	10 ml of solution (sealed glass ampoule)	Natural Uranium (HS 2844109000)
<b>EQRAIN U16 sol 64</b>	Nitric solution	51.747 ± 0.052	10 ml of solution (sealed glass ampoule)	Natural Uranium (HS 2844109000)

#### 6.5. Uranium and plutonium materials

Reference	Matrix	Certified content (g.kg <sup>-1</sup> )		Packaging	Comments
<b>EQRAIN (U+Pu)2</b>	Nitric solution	<b>U</b>	106.52 ± 0.13	10 ml of solution (sealed glass ampoule)	Plutonium certified value on 26 <sup>th</sup> April 2018 Certified Pu isotopic composition (cf. §7.2) Natural Uranium (HS 2844205900)
		<b>Pu</b>	1.1192 ± 0.0013		
<b>EQRAIN (U+Pu)3</b>	Nitric solution	<b>U</b>	116.580 ± 0.058	10 ml of solution (sealed glass ampoule)	Plutonium certified value on 26 <sup>th</sup> October 2021 Certified Pu isotopic composition (cf. §7.2) Natural Uranium (HS 2844205900)
		<b>Pu</b>	5.9700 ± 0.0036		



## 7. Reference materials with a certified isotopic composition

### 7.1. Americium materials

Reference	Matrix	Certified isotopic ratios (atomic fraction) (mol.mol <sup>-1</sup> )		Packaging	Comments	
STAM	Nitric solution approx. 1M	Certified values	$\frac{n(^{241}\text{Am})}{n(^{243}\text{Am})}$	$0.136138 \pm 0.000054$	5.5µg of americium in 3.5ml of nitric acid solution (glass ampoule)	Certified concentration (cf. §5.1)  Certified value on 1 <sup>st</sup> January 2017  (HS 2844 432000)
			$\frac{n(^{243}\text{Am})}{n(\text{Am})}$	$0.880069 \pm 0.000042$		
			$\frac{n(^{241}\text{Am})}{n(\text{Am})}$	$0.119810 \pm 0.000042$		
		Indicative values	$\frac{n(^{242}\text{Am})}{n(^{243}\text{Am})}$	$1.373.10^{-4} \pm 0.024.10^{-4}$		
			$\frac{n(^{242}\text{Am})}{n(\text{Am})}$	$1.208.10^{-4} \pm 0.021.10^{-4}$		

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7.2. Plutonium materials

Reference	Matrix	Certified isotopic ratios (atomic fraction) (mol.mol <sup>-1</sup> )		Packaging	Comments
<b>MIRF 01</b>	Plutonium nitrate	<b>n(239Pu)/n(242Pu)</b>	0.9783 ± 0.0005	100 µg of Pu in dry extract form (glass vial)	Certified value on 1 <sup>st</sup> January 2000  Isotopic composition given as an indication  (HS 2844 209900)
<b>242Pu</b>	Nitric solution	<b>n(238Pu)/n(242Pu)</b>	0.23603 ± 0.00042	10 ml of solution (sealed glass ampoule)	Certified value on 1 <sup>st</sup> January 2023  Two Pu concentration levels: C1≈0.9g.kg <sup>-1</sup> C2≈4.5mg.kg <sup>-1</sup>  (HS 2844 209900)
		<b>n(239Pu)/n(242Pu)</b>	0.2704 ± 0.0018		
		<b>n(240Pu)/n(242Pu)</b>	0.57100 ± 0.00028		
		<b>n(241Pu)/n(242Pu)</b>	0.1992 ± 0.0014		
		<b>n(244Pu)/n(242Pu)</b>	0.03831 ± 0.00012		

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Reference	Matrix	Certified isotopic ratios (atomic fraction) (mol.mol <sup>-1</sup> )		Packaging	Comments
MP2	Plutonium metal	$n(^{238}\text{Pu})/n(^{239}\text{Pu})$	$3.083.10^{-5} \pm 0.029.10^{-5}$	0.4 to 0.7 g (sealed double glass ampoule)	Certified values on 7 <sup>th</sup> November 2006 Plutonium certified content (cf. §6.3) Certified Mass $\pm 12\mu\text{g}$ (HS 2844 209900)
		$n(^{240}\text{Pu})/n(^{239}\text{Pu})$	$2.24324.10^{-2} \pm 0.00051.10^{-2}$		
		$n(^{241}\text{Pu})/n(^{239}\text{Pu})$	$2.378.10^{-4} \pm 0.031.10^{-4}$		
		$n(^{242}\text{Pu})/n(^{239}\text{Pu})$	$7.570.10^{-5} \pm 0.078.10^{-5}$		
MP4	Plutonium metal	$n(^{238}\text{Pu})/n(^{239}\text{Pu})$	$1.37.10^{-5} \pm 0.12.10^{-5}$	0.3 to 0.5 g (sealed double glass ampoule)	Certified values on 30 <sup>th</sup> June 2023 Plutonium certified content (cf. §6.3) Certified Mass $\pm 20\mu\text{g}$ (HS 2844 209900)
		$n(^{240}\text{Pu})/n(^{239}\text{Pu})$	$1.68114.10^{-2} \pm 0.00023.10^{-2}$		
		$n(^{241}\text{Pu})/n(^{239}\text{Pu})$	$2.796.10^{-5} \pm 0.046.10^{-5}$		
		$n(^{242}\text{Pu})/n(^{239}\text{Pu})$	$6.16.10^{-6} \pm 0.19.10^{-6}$		

The plutonium certified isotopic ratios of EQRAIN Pu and EQRAIN (U+Pu) solutions are identical of those of MP2.

7.3. Uranium materials

Reference	Matrix	Certified isotopic ratios (atomic fraction) (mol.mol <sup>-1</sup> )		Packaging	Comments
MIRF 02	Uranyl nitrate	$n(^{233}\text{U})/n(^{236}\text{U})$	$0.9681 \pm 0.0010$	200µg of U in dry extract form (glass vial)	Certified value on 1 <sup>st</sup> January 2000 Isotopic composition given as an indication (HS 2844 431000)
CETAMIR 1	U <sub>3</sub> O <sub>8</sub>	$n(^{233}\text{U})/n(^{238}\text{U})$	$2.881.10^{-4} \pm 0.011.10^{-4}$	1 g of U <sub>3</sub> O <sub>8</sub> (sealed glass vial)	Certified value on 1 <sup>st</sup> January 1996 (HS 2844 203500)
		$n(^{235}\text{U})/n(^{238}\text{U})$	$1.1152.10^{-2} \pm 0.0010.10^{-2}$		
		$n(^{236}\text{U})/n(^{238}\text{U})$	$4.098.10^{-3} \pm 0.006.10^{-3}$		
CETAMIR 2	U <sub>3</sub> O <sub>8</sub>	$n(^{233}\text{U})/n(^{238}\text{U})$	$1.038.10^{-3} \pm 0.005.10^{-3}$	1 g of U <sub>3</sub> O <sub>8</sub> (sealed glass vial)	Certified value on 1 <sup>st</sup> January 1996 (HS 2844 203500)
		$n(^{235}\text{U})/n(^{238}\text{U})$	$4.7746.10^{-2} \pm 0.0045.10^{-2}$		
		$n(^{236}\text{U})/n(^{238}\text{U})$	$1.255.10^{-2} \pm 0.001.10^{-2}$		

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## 8. Reference materials with a certified impurity content

### 8.1. Plutonium metal matrix

Reference	Matrix	Certified content (mg.kg <sup>-1</sup> )		Packaging	Comments
<b>MP4</b>	Plutonium metal	<b>Uranium</b>	896 ± 53	0.3 to 0.5 g (sealed double glass ampoule)	Certified values on 30 <sup>th</sup> June 2023 Plutonium certified content (cf. §6.3) Certified isotopic composition (cf. §7.2) Certified Mass ±20µg (HS 2844 209900)
		<b>Americium</b>	99.3 ± 3.3		
		<b>Carbon</b>	48 ± 11		

### 8.2. Uranium metal matrix

Reference	Matrix	Certified content (mg.kg <sup>-1</sup> )		Packaging	Comments
<b>OPERA 103</b>	Uranium metal	<b>Carbon</b>	226 ± 11	50 samples with 1g unitary mass (stainless steel vial)	Slightly depleted Uranium Uranium/Vanadium Alloy (0.2% Vanadium) (HS 2844301900)
<b>OPERA 104</b>	Uranium metal	<b>Carbon</b>	58 ± 7	50 samples with 1g unitary mass (stainless steel vial)	Depleted Uranium (HS 2844301900)

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## 8.3. Uranium oxide matrix

Reference	Matrix	Certified content (mg.kg <sup>-1</sup> of UO <sub>2</sub> )		Packaging	Comments	
VIOGNIER	UO <sub>2</sub>	Certified values	Cl	17.9 ± 1.0	100g of UO <sub>2</sub> powder (plastic vial)	(HS 2844 301900)
			F	32.7 ± 1.1		
			N	45.2 ± 3.3		
			P	43.2 ± 1.8		
		Indicative value	Br	4.4		

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Reference	Matrix	Certified content (mg.kg <sup>-1</sup> of U)		Packaging	Comments
<b>AGARIC</b>	U <sub>3</sub> O <sub>8</sub>	<b>Ag</b>	0.07 ± 0.04	25 g of U <sub>3</sub> O <sub>8</sub> powder (plastic vial)	Natural Uranium isotopic composition  Total impurities: <45 mg.kg <sup>-1</sup> of uranium  (HS 2844109000)
		<b>Al</b>	9.1 ± 2.8		
		<b>Ba</b>	0.56 ± 0.24		
		<b>Be</b>	< 0.2		
		<b>Bi</b>	< 0.2		
		<b>Ca</b>	6 ± 2		
		<b>Cd</b>	< 0.15		
		<b>Co</b>	< 0.25		
		<b>Cr</b>	1.04 ± 0.49		
		<b>Cu</b>	< 0.36		
		<b>Dy</b>	< 0.13		
		<b>Eu</b>	<0.02		
		<b>Fe</b>	11.7 ± 7.1		
		<b>Ga</b>	< 0.40		
		<b>Gd</b>	< 0.05		
		<b>In</b>	< 0.06		
		<b>Li</b>	< 0.24		
		<b>Mg</b>	1.2 ± 1.1		
		<b>Mn</b>	< 0.22		
		<b>Mo</b>	< 0.5		
		<b>Pb</b>	0.21 ± 0.01		
		<b>Si</b>	5 ± 2		
		<b>Sm</b>	< 0.14		
<b>Sn</b>	<0.40				
<b>Th</b>	1.34 ± 0.18				
<b>Ti</b>	< 0.35				
<b>V</b>	<0.05				
<b>W</b>	< 0.20				
<b>Zn</b>	0.73 ± 0.11				
<b>Zr</b>	1.71 ± 0.19				

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Reference	Matrix	Certified content (mg.kg <sup>-1</sup> of U)		Packaging	Comments
<b>BOLET</b>	U <sub>3</sub> O <sub>8</sub>	<b>Ag</b>	2.09 ± 0.46	25 g of U <sub>3</sub> O <sub>8</sub> powder (plastic vial)	Natural Uranium isotopic composition  Total impurities: 245 mg.kg <sup>-1</sup> of uranium  (HS 2844109000)
		<b>Al</b>	22.7 ± 2.9		
		<b>Ba</b>	1.09 ± 0.12		
		<b>Be</b>	5.4 ± 1.0		
		<b>Bi</b>	0.52 ± 0.82		
		<b>Ca</b>	3.95 ± 0.71		
		<b>Cd</b>	12.4 ± 1.3		
		<b>Co</b>	0.53 ± 0.09		
		<b>Cr</b>	1.02 ± 0.11		
		<b>Cu</b>	9.37 ± 0.55		
		<b>Dy</b>	10.36 ± 0.77		
		<b>Eu</b>	0.20 ± 0.07		
		<b>Fe</b>	0.21 ± 0.05		
		<b>Ga</b>	54.8 ± 1.9		
		<b>Gd</b>	2.05 ± 0.38		
		<b>In</b>	2.11 ± 0.39		
		<b>Li</b>	5.75 ± 0.77		
		<b>Mg</b>	4.66 ± 0.37		
		<b>Mn</b>	4.88 ± 0.49		
		<b>Mo</b>	18.2 ± 1.1		
		<b>Pb</b>	6.61 ± 0.80		
<b>Si</b>	28.6 ± 5.1				
<b>Sm</b>	0.23 ± 0.06				
<b>Sn</b>	4.38 ± 0.88				
<b>Th</b>	2.90 ± 0.89				
<b>Ti</b>	5.09 ± 0.64				
<b>V</b>	4.55 ± 0.33				
<b>W</b>	9.3 ± 1.5				
<b>Zn</b>	9.6 ± 2.6				
<b>Zr</b>	9.7 ± 2.0				

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Reference	Matrix	Certified content (mg.kg <sup>-1</sup> of U)		Packaging	Comments	
<b>CHANTERELLE</b>	U <sub>3</sub> O <sub>8</sub>	<b>Certified values</b>	<b>Ag</b>	5.0 ± 0.6	25 g of U <sub>3</sub> O <sub>8</sub> powder (plastic vial)	Natural Uranium isotopic composition  Total impurities: 642 mg.kg <sup>-1</sup> of uranium  (HS 2844109000)
			<b>Al</b>	51 ± 3		
			<b>B</b>	1.1 ± 0.4		
			<b>Be</b>	0.86 ± 0.10		
			<b>Bi</b>	5.2 ± 0.5		
			<b>Ca</b>	56 ± 7		
			<b>Cd</b>	1.1 ± 0.4		
			<b>Co</b>	5.2 ± 1.1		
			<b>Cr</b>	49.6 ± 4.1		
			<b>Cu</b>	26.4 ± 3.4		
			<b>Fe</b>	122 ± 10		
			<b>Ga</b>	2.8 ± 0.6		
			<b>Mg</b>	11 ± 1		
			<b>Mn</b>	9.9 ± 1.7		
			<b>Mo</b>	54 ± 4		
			<b>Ni</b>	50 ± 3		
			<b>Pb</b>	45 ± 3		
			<b>Si</b>	35 ± 9		
			<b>Ti</b>	9.8 ± 2.1		
		<b>V</b>	9.4 ± 1.3			
<b>W</b>	18.1 ± 2.6					
<b>Zn</b>	44 ± 4					
<b>Zr</b>	24 ± 7					
		<b>Indicative values</b>	<b>Sn</b>	5.3 ± 0.7		

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Reference	Matrix	Certified content (mg.kg <sup>-1</sup> of U)		Packaging	Comments	
<b>MORILLE</b>	U <sub>3</sub> O <sub>8</sub>	<b>Certified values</b>	<b>Ag</b>	10.4 ± 1.6	25 g of U <sub>3</sub> O <sub>8</sub> powder (plastic vial)	Natural Uranium isotopic composition  Total impurities: 1557 mg.kg <sup>-1</sup> of uranium  (HS 2844109000)
			<b>Al</b>	99 ± 6		
			<b>B</b>	3.8 ± 1.6		
			<b>Ba</b>	9.6 ± 0.4		
			<b>Be</b>	5.4 ± 0.6		
			<b>Bi</b>	24.4 ± 1.9		
			<b>Ca</b>	93 ± 8		
			<b>Cd</b>	4.9 ± 0.7		
			<b>Co</b>	9.8 ± 2.0		
			<b>Cr</b>	99 ± 2		
			<b>Cu</b>	50.2 ± 1.0		
			<b>Dy</b>	0.50 ± 0.06		
			<b>Eu</b>	0.52 ± 0.03		
			<b>Fe</b>	211.6 ± 6.5		
			<b>Gd</b>	0.56 ± 0.06		
			<b>In</b>	9.4 ± 1.0		
			<b>Li</b>	5.0 ± 0,2		
			<b>Mg</b>	19.3 ± 1.5		
			<b>Mn</b>	24.5 ± 0.5		
			<b>Mo</b>	147 ± 5		
		<b>Ni</b>	147 ± 3			
		<b>Pb</b>	101 ± 3			
		<b>Si</b>	100 ± 8			
		<b>Sm</b>	0.50 ± 0.12			
		<b>Sn</b>	18.5 ± 5.6			
		<b>Ti</b>	49.2 ± 2.6			
<b>V</b>	48.7 ± 2.8					
<b>W</b>	100 ± 9					
<b>Zn</b>	98.6 ± 5.5					
<b>Indicative values</b>	<b>Th</b>	6.2 ± 0.8				
	<b>Zr</b>	59.9 ± 4.1				

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8.4. Uranate matrix

Reference	Matrix	Certified content		Packaging	Comments	
<b>FELDSPATH</b>	Ammonium uranate	<b>Certified values</b>	<b>U</b>	(746.5 ± 4.1) g.kg <sup>-1</sup> of dry ammonium uranate	20 g of ammonium uranate	(HS 2844 109000)
			<b>Ca</b>	(128.5 ± 3.0) mg.kg <sup>-1</sup> of U		
			<b>Fe</b>	(42.7 ± 3.1) mg.kg <sup>-1</sup> of U		
			<b>Mg</b>	(25.0 ± 1.1) mg.kg <sup>-1</sup> of U		
			<b>Mo</b>	(30.3 ± 2.1) mg.kg <sup>-1</sup> of U		
			<b>Zr</b>	(68.2 ± 6.1) mg.kg <sup>-1</sup> of U		
		<b>Indicative values (mg.kg<sup>-1</sup> of ranium)</b>	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					

Reference	Matrix	Certified content (g.kg <sup>-1</sup> of ammonium uranate)		Packaging	Comments
<b>BERYL</b>	Ammonium uranate	<b>Fe</b>	0.108 ± 0.030	50 g of ammonium uranate	(HS 2844 109000)
		<b>Na</b>	0.050 ± 0.010		
		<b>PO<sub>4</sub><sup>3-</sup></b>	0.211 ± 0.036		
		<b>SO<sub>4</sub><sup>2-</sup></b>	20.50 ± 0.06		

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Reference	Matrix	Certified content (g.kg <sup>-1</sup> of magnesium uranate)		Packaging	Comments
<b>AMETHYSTE</b>	Magnesium uranate	<b>Ca</b>	1.29 ± 0.10	50 g of magnesium uranate	(HS 2844 109000)
		<b>Cl</b>	1.92 ± 0.12		
		<b>Fe</b>	2.07 ± 0.06		
		<b>Na</b>	30.8 ± 1.0		
		<b>SiO<sub>2</sub></b>	2.79 ± 0.18		
		<b>SO<sub>4</sub><sup>2-</sup></b>	23.7 ± 1.1		
<b>CALCEDOINE</b>	Magnesium uranate	<b>Fe</b>	4.74 ± 0.05	50 g of magnesium uranate	(HS 2844 109000)
		<b>Mo</b>	1.53 ± 0.09		
		<b>Na</b>	26.2 ± 0.9		
		<b>V</b>	0.684 ± 0.025		
		<b>Zr</b>	2.08 ± 0.09		
		<b>SiO<sub>2</sub></b>	4.76 ± 0.32		
		<b>PO<sub>4</sub><sup>3-</sup></b>	1.25 ± 0.06		
<b>SO<sub>4</sub><sup>2-</sup></b>	12.2 ± 0.9				
<b>DIAMANT</b>	Magnesium uranate	<b>Ca</b>	9,13 ± 0.15	50 g of magnesium uranate	(HS 2844 109000)
		<b>Cl</b>	3.21 ± 0.25		
		<b>Fe</b>	6.39 ± 0.04		
		<b>Na</b>	22.2 ± 0.5		
		<b>SiO<sub>2</sub></b>	29.7 ± 0.6		
		<b>PO<sub>4</sub><sup>3-</sup></b>	5.58 ± 0.29		
<b>SO<sub>4</sub><sup>2-</sup></b>	5.30 ± 0.27				
<b>EMERAUDE</b>	Magnesium uranate	<b>As</b>	1.46 ± 0.12	50 g of magnesium uranate	(HS 2844 109000)
		<b>Ca</b>	17.7 ± 2.1		
		<b>Fe</b>	4.03 ± 0.09		
		<b>Mo</b>	0.38 ± 0.06		
		<b>Zr</b>	9.95 ± 0.26		
		<b>SiO<sub>2</sub></b>	14.3 ± 0.9		
<b>SO<sub>4</sub><sup>2-</sup></b>	14.8 ± 1.2				
<b>HYACINTHE</b>	Magnesium uranate	<b>Ca</b>	1.35 ± 0.12	50 g of magnesium uranate	(HS 2844 109000)
		<b>Fe</b>	2.90 ± 0.06		
		<b>Na</b>	31.6 ± 1.0		
		<b>PO<sub>4</sub><sup>3-</sup></b>	1.22 ± 0.07		
		<b>SO<sub>4</sub><sup>2-</sup></b>	4.31 ± 0.33		

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Reference	Matrix	Certified content (g.kg <sup>-1</sup> of sodium uranate)		Packaging	Comments
<b>GRENAT</b>	Sodium uranate	<b>Fe</b>	0.303 ± 0.019	50 g of sodium uranate	(HS 2844 109000)
		<b>Mo</b>	0.558 ± 0.027		
		<b>Na</b>	81.2 ± 2.3		
		<b>Zr</b>	13.8 ± 0.6		
		<b>SiO<sub>2</sub></b>	1.41 ± 0.10		
		<b>CO<sub>3</sub><sup>2-</sup></b>	21.1 ± 1.8		
		<b>SO<sub>4</sub><sup>2-</sup></b>	8.72 ± 0.14		

## 8.5. Glass matrix

Reference	Matrix	Certified content (mg.kg <sup>-1</sup> of U)		Packaging	Comments	
<b>VERRE LCV UOX</b>	Ground uranium oxide type glass	<b>Certified values</b>	<b>SiO<sub>2</sub></b>	44.52 ± 0.67	25 g of U <sub>3</sub> O <sub>8</sub> powder (plastic vial)	Natural Uranium isotopic composition  Total impurities: 642 mg.kg <sup>-1</sup> of uranium  (HS 2844 109000)
			<b>B<sub>2</sub>O<sub>3</sub></b>	13.38 ± 0.28		
			<b>Na<sub>2</sub>O</b>	9.23 ± 0.19		
			<b>CaO</b>	3.66 ± 0.19		
			<b>Nd<sub>2</sub>O<sub>3</sub></b>	3.512 ± 0.042		
			<b>Fe<sub>2</sub>O<sub>3</sub></b>	2.921 ± 0.040		
			<b>ZrO<sub>2</sub></b>	2.771 ± 0.035		
			<b>ZnO</b>	2.383 ± 0.032		
			<b>MoO<sub>3</sub></b>	2.221 ± 0.030		
			<b>Li<sub>2</sub>O</b>	1.951 ± 0.034		
			<b>La<sub>2</sub>O<sub>3</sub></b>	1.521 ± 0.034		
			<b>Cs<sub>2</sub>O</b>	1.361 ± 0.019		
			<b>BaO</b>	0.865 ± 0.029		
			<b>RuO<sub>2</sub></b>	0.853 ± 0.016		
			<b>Pd</b>	0.776 ± 0.022		
			<b>Pr<sub>2</sub>O<sub>3</sub></b>	0.660 ± 0.021		
			<b>MnO<sub>2</sub></b>	0.470 ± 0.016		
			<b>SrO</b>	0.402 ± 0.013		
			<b>P<sub>2</sub>O<sub>5</sub></b>	0.220 ± 0.011		
			<b>NiO</b>	0.080 ± 0.010		
			<b>Cr<sub>2</sub>O<sub>3</sub></b>	0.0501 ± 0.0063		
			<b>SnO<sub>2</sub></b>	0.0300 ± 0.0038		
			<b>Indicative values</b>	<b>TeO<sub>2</sub></b>		
<b>Al<sub>2</sub>O<sub>3</sub></b>	4.183 ± 0.072					
<b>Ce<sub>2</sub>O<sub>3</sub></b>	1.221 ± 0.021					

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## 9. Reference materials with a certified specific surface area

Reference	Matrix	Specific surface area certified ( $m^2.g^{-1}$ )	Packaging	Comments
<b>SYRHA</b>	UO <sub>2</sub>	3.41 ± 0.04	100 g of UO <sub>2</sub> powder	(HS 2844 301900)

## 10. Reference materials

The values given in the following tables are indicative only and are given without uncertainty levels.

### 10.1 Organic compound reference materials

Reference	Purity ( $kg.kg^{-1}$ )	Packaging	Comments
<b>DBP</b>	0.991	50 ml of solution	/
<b>H<sub>2</sub>MBP</b>	0.992	50 ml of solution	/

### 10.2. Uranium metal reference material: FLORALIES

The Floralties are natural uranium chips (HS 2844109000) in metallic form, stocked in paraffin oil.

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

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Reference	Packaging	Content (in mg.kg <sup>-1</sup> of uranium)																
		Al	B	Be	Bi	Ca	Cr	Cu	Fe	In	Mn	Nb	Ni	Si	Th	Ti	V	W
<b>Iris</b>	1l or 2l glass vial	100	/	0.2	≤1	4	27	35	130	6	6	≤10	115	13	<5	10	3	≤5
<b>Kentia</b>	0.5l glass vial	120	1,3	/	/	5	9	130	110	/	12	20	480	40	<5	40	3	5

Reference	Packaging	Content (in mg.kg <sup>-1</sup> of uranium)												
		Ag	B	Co	Cr	Cu	Fe	Mn	Mo	Ni	Si	Sn	Th	Zr
<b>Romarin</b>	2l glass vial	270	≤0.1	2,5	7	8	95	5	25	6	40	25	<50	30
<b>Sauge</b>	1l glass vial	465	0.2	5	12	13	200	10	51	13	40	50	<50	50

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