Designation: C 788 – 9803

Standard Specification for Nuclear-Grade Uranyl Nitrate Solution or Crystals[1]

This standard is issued under the fixed designation C 788; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification applies to nuclear-grade aqueous uranyl nitrate solution or crystals not exceeding 5 % ^{235}U intended for subsequent manufacture into either UF_6 (for feed to an enrichment plant) or direct conversion to uranium oxide (for use in reactors).

1.2 This specification is intended to provide the nuclear industry with a general standard for aqueous uranyl nitrate solution or crystals. It recognizes the diversity of manufacturing methods and the processes to which it is subsequently to be subjected. It is therefore anticipated that it may be necessary to include supplementary specification limits by agreement between purchaser and manufacturer. Different limits are appropriate depending on whether or not the uranyl nitrate is to be converted to UF_6 for subsequent processing.

1.3 The purpose of this specification is: (a) to define the impurity and uranium isotope limits for commercial standard uranyl nitrate, and (b) to define additional limits for reprocessed uranyl nitrate (or any mixture of reprocessed and commercial standard uranyl nitrate). For such uranyl nitrates, special provisions may need to be made to ensure that no extra hazard arises to the employees, the process equipment, or the environment.

1.4 The scope of this specification does not comprehensively cover all provisions for preventing criticality accidents, for health and safety, or for shipping. Observance of this standard does not relieve the user of the obligation to conform to all international, federal, state and local regulations for processing, shipping, or any other way of using the uranyl nitrate. An example of a U.S.

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[1] This specification is under the jurisdiction of ASTM Committee C-26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.02 on Fuel and Fertile Material Specifications.

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Government Document is the Code of Federal Regulations (latest edition), Title 10, Part 50.[2]

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 787 Specification for Uranium Hexafluoride for Enrichment[3]

C 799 Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Nuclear-Grade Uranyl Nitrate Solutions[3]

C 859 Terminology Relating to Nuclear Materials[3]

C 996 Specification for Uranium Hexafluoride Enriched to Less Than 5 % ^{235}U[3]

C 1233 Practice for Determining Equivalent Boron Contents of Nuclear Materials[3]

C 1295 Test Method for Gamma Energy Emission from Fission Products in Uranium Hexafluoride and Uranyl Nitrate Solution[3]

2.2 *ANSI Standard:*[4]

ANSI/ASME NQA-1 Quality ~~Assurance Program,~~ Assurance, Requirements for Nuclear Facility Applie~~c~~ations

2.3 *U.S. Government Document:*

Code of Federal Regulations, Title 10, (Energy), Part 50, Domestic Licensing of Production and Utilization Facilities

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.
[3] *Annual Book of ASTM Standards*, Vol 12.01.
[4] Available from the American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

~~2.4 *Other Document:*[5]~~

~~Davies, B. S. J. and Tobias, A., *A Summary of the Data Available in ENDF 1B* Format, CEGB Report RD/B/5095 N81 (November 1981)~~

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 Terms shall be defined in accordance with Terminology C 859, except for the following:

3.1.1.1 *commercial standard uranyl nitrate*—refers to uranyl nitrate made from unirradiated uranium. However, it is recognized that some contamination with reprocessed uranium may occur during routine processing; this is acceptable, provided that the product meets the specification for commercial standard uranyl nitrate as defined in 4.2.

3.1.1.2 *reprocessed uranyl nitrate* —refers to any uranyl nitrate made from uranium that has been exposed in a neutron irradiation facility and subsequently chemically separated from the fission products and transuranic isotopes so generated. The limits given in this specification are intended to be typical of reprocessed spent fuel having achieved burn-up levels of up to 50 000 megawatt day per ton of uranium in light water reactors and cooling for 10 years after discharge. It is recognized that different ~~limits~~ values would be necessary to accommodate different fuel histories.

4. Radionuclide Content

4.1 The ^{235}U content shall be reported as g/100 g U.

4.2 For commercial standard uranyl nitrate, the concentration of ^{99}Tc, ^{232}U, ^{234}U and ^{236}U shall be as specified in Specifications C 787 or C 996, as appropriate, unless otherwise agreed upon between purchaser and manufacturer. For ^{99}Tc and ^{232}U, the specific isotopic measuremetns required by the appropriate specifiation may be waived, provided that the manufacturer can demonstrate compliance, for instance, through the manufacturer's quality assurance records.

4.3 For reprocessed uranyl nitrate, the concentrations of ^{99}Tc, ^{232}U, ^{234}U and ^{236}U shall be as specified in Specifications C 787 or C 996, as appropriate, unless otherwise agreed between purchaser and manufacturer.

4.4 For reprocessed uranyl nitrate, the total of the products of each specific mean gamma decay rate multiplied by each specific mean gamma energy per disintegration arising from fission products shall not exceed 3×10^5 MeV-Bq/~~d~~ Kg U. The radionuclides to be determined by the gamma spectrometer method of Methods C 799, C 1295, or equivalent.

~~The presence of any other detectable gamma emitting fission product isotope shall be recorded and its contribution included in the total (see section 2.4).~~

4.5 For reprocessed uranyl nitrate that is to be converted to UF_6, the maximum alpha activity due to transuranic alpha emitters shall be 250 Bq/g U (15 000 dpm/g U); the maximum alpha activity due to neptunium shall be 125 Bq/g U (7500 dpm/g U). For reprocessed uranyl nitrate that is to be converted directly into UO_2 fuel, the transuranic alpha emitter specification limits of Specification C 996 shall apply unless otherwise agreed upon between purchaser and manufacturer.

5. Chemical Requirements

5.1 The limits of uranium concentration and the free nitric acid concentration of the aqueous uranyl nitrate solution shall be agreed between purchaser and manufacturer.

5.2 The uranyl nitrate solution shall contain no more than 0.5 volume% of entrained organic materials.

5.3 When the uranyl nitrate is intended as feed material for conversion to uranium hexafluoride, the following shall apply:

5.3.1 The impurity limit of each element~~s~~ listed ~~below~~ in Table 1 shall not exceed ~~the values shown:~~ its designated maximum.

~~µg/g U~~

~~Antimony~~

~~1~~

~~Arsenic~~

~~3~~

~~Boron~~

~~1~~

~~Bromine~~

~~5~~

~~Chlorine~~

~~100~~

~~Chromium~~

~~10~~

~~Fluorine~~

~~25~~

~~Molybdenum~~

~~1.4~~

~~Niobium~~

~~1~~

TABLE 1 Impurity Limits in Uranyl Nitrate for Direct Conversion to O Uranium Hexafluoride

Element	Maximum Concentration Limit, µg/g U
Aluminum150	
Maximum Concentration Limit, µg/g U	
Calcium + Magnesium	150
Antimony	1
Chlorine + Fluorine	350
Arsenic	3
Chromium	150
Boron	1
Cobalt	80
Bromine	5
Copper	200
Chlorine	100
Iron	200
Chromium	10
Lead	200
Fluorine	25
Manganese	200
Molybdenum	200
Molybdenum	1.4
Nickel	150
Niobium	1
Phosphorus	200
Phosphorus	50
Silicon	200
Ruthenium	1
Tantalum	200
Silicon	100
Thorium	10
Sulphur	400
Tin	200
Tantalum	1
Titanium	200
Titanium	1
Tungsten	200
Tungsten	1.4
Vanadium	200
Zinc	200
Zinc	2001.4

Phosphorus
50
Ruthenium
1
Silicon
100
Sulphur
400
Tantalum
1
Titanium
1
Tungsten
1.4
Vanadium

1.4

5.3.2 The specification limits listed in 5.3.1 are appropriate to a ^{235}U concentration at natural concentration, for example, 0.711 ± 0.004 g ^{235}U/100 g. If the ^{235}U is outside this range, then some modification of these limits may be appropriate, depending on the corresponding UF6 specification and subject to agreement between purchaser and manufacturer.

5.3.3 The sum of concentrations of the following elements (which do not form volatile fluorides) shall not exceed 500 µg/g U:

Aluminum Iron Silver

Barium	Lead	Sodium
Bismuth	Lithium	Strontium
Cadmium	Magnesium	Thorium
Calcium	Manganese	Tin
Copper	Nickel	Zinc
	Potassium	Zirconium

5.4 When the uranyl nitrate is intended for direct conversion to an oxide (not through the hexafluoride), the following clauses shall apply:

5.4.1 The impurity limit of each element listed in Table ~~1~~ 2 shall not exceed its designated maximum. The total of all elements listed in this table shall not exceed 1500 µg/g of uranium.

5.4.2 The total equivalent boron content (EBC) shall not exceed 4.0 µg/g U. The total EBC ~~is the sum of the individual EBC values.~~ shall be determined per Practice C 1233. For fast reactor use the ~~above~~ limitation on EBC does not apply.

~~5.4.3 The specific elements to be measured and used in calculating the total EBC will be determined by agreement between the purchaser and manufacturer.~~

5.5 If the concentrations of any of the elements used in the calculations in 5.3 and 5.4 are reported as a "less than" value, this "less than" value shall be used for any further calculations involving the concentration of this element.

6. Sampling

6.1 A representative sample of sufficient size to perform the tests prescribed herein shall be taken. Because of the potential presence of several liquid phases (organic materials), careful attention should be taken when sampling and subsampling.

6.2 Because of the potential presence of several liquid phases (organic materials) in uranyl nitrate solution, careful attention should be taken when sampling and subsampling.

6.3 Uranyl nitrate crystals are hygroscopic and retain sufficient water after exposure to a moist atmosphere to cause detectable errors. Sample, weigh, and handle the sample under conditions that will ensure that the sample is representative of the lot. Analytical confirmation of sampling plans shall be documented as part of the manufacturer's quality assurance and nuclear materials control and accountability programs.

6.4 All samples shall be clearly identified, including the manufacturer's lot number.

6.3~~5~~ All containers used for a lot shall be positively identified as containing material from a particular homogeneous lot.

7. Methods of Chemical and Isotopic Analysis

7.1 Methods C 799, or demonstrated equivalent, shall be used as mutually agreed between the purchaser and manufacturers. Methods not currently provided by Methods C 799 shall be as mutually agreed between purchaser and manufacturers.

8. Quality Assurance

8.1 Quality assurance requirements shall be agreed upon between the purchaser and manufacturer when specified in the purchase order. Code of Federal Regulations, Title 10, Part 50, Appendix B and ASME NQA-1 are referenced as guides.

9. Keywords

9.1 uranium isotope limits; uranium solutions; uranyl nitrate

TABLE 2 Impurity Limits in Uranyl Nitrate for Direct Conversion to Oxide

Element	Maximum Concentration Limit, µg/g U
Aluminum	150
Calcium + Magnesium	150
Chlorine + Fluorine	350
Chromium	150
Cobalt	80
Copper	200
Iron	200
Lead	200
Manganese	200
Molybdenum	200
Nickel	150
Phosphorus	200
Silicon	200
Tantalum	200
Thorium	10
Tin	200
Titanium	200
Tungsten	200
Vanadium	200
Zinc	200