American National Standards Institute/ American Dental Association Specification No. 52* for Uranium Content in Dental Porcelain and Porcelain Teeth

Council on Dental Materials and Devices

American Dental Association Specification No. 52 for Uranium Content in Dental Porcelain and Porcelain Teeth has been approved by the Council on Dental Materials and Devices of the American Dental Association. The formulation of this and other specifications for dental materials and devices is being carried on through subcommittees of the American National Standards Committee MD156 for Dental Materials and Devices. The Council on Dental Materials and Devices acts as the administrative sponsor of that committee, which has representation from all interests in the United States in the standardization of materials, equipment, and instruments in dentistry. The Council has adopted the specifications showing professional recognition of their usefulness in dentistry and has forwarded them to the American National Standards Institute with a recommendation that the specifications be approved as American National Standards. Approval of ADA Specification No. 52 as an American National Standard was granted by the American National Standards Institute on Sept 8, 1978. This specification will become effective one year from date of publication in The Journal of the American Dental Association.

The Council acknowledges, with thanks, the work of the subcommittee members who formulated the standard:

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It is the understanding of the Council that manufacturers have voluntarily accepted this standard subsequent to Jan 1, 1977.

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Foreword: (This foreword does not form a part of ANSI/ADA Specification No. 52 for Uranium Content in Dental Porcelain and Porcelain Teeth.)

Uranium shall be taken to mean natural uranium as it exists in secular equilibrium with its daughter products and depleted uranium which is uranium from which certain isotopes of uranium have been removed or reduced in concentra-
tion. This specification does not include enriched uranium.

Dental porcelain is a powdered ceramic material which can be fabricated into a shape that, when fused, simulates the form and function of the whole or part of the clinical crown of a natural tooth.

Porcelain teeth are prefabricated artificial teeth prepared from porcelain of approximately those of human teeth.

Uranium has been used in dental porcelains and artificial porcelain teeth since before 1935 to impart the fluorescent color of natural teeth. To date, ongoing research has not yet produced a satisfactory fluorescent substitute.

With the establishment of the Atomic Energy Commission in 1946, the dental industry sought advice as to whether the concentrations of uranium contained in dental porcelain and porcelain teeth might pose radiation hazards. Conferences were held between the dental industry and AEC during the 1950s. AEC's conclusion at that time was that concentrations of uranium constituting not more than 0.05% by weight could be used without danger. This proposed standard establishes a 40% reduction in the permissible amount since no more than 0.03% by weight is necessary to achieve the intended purpose.

1. Scope and classification
   1.1 Scope. This standard is to establish a maximum for the uranium content of dental porcelain and porcelain teeth.

   1.2 Forms. The standard is limited to defining the uranium content in dental porcelain in two forms:
   A. Prefabricated artificial teeth made from fused porcelain.
   B. Porcelain powders for use in making custom crowns and bridges.

   1.3 Date of manufacture. For purposes of this standard, the date of manufacture shall be considered to be the date upon which the uranium is added to the porcelain.

2. Applicable documents
   2.1 Code of Federal Regulations, Title 10, Chapter 1, Part 40.

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X-ray spectrum of (500 ng) standard after four hours of irradiation at 1017 almin^-2-sec, 48-hour decay, and a 1,200-second count on 16-mm Ortec LEPD. The figure shows the spectra of Np-239. All six photons are clearly defined but only four are abundant enough for quantitative analysis at ppb levels. The photopeaks used were 14.28, 18.29, 106.10 keV. Hence, ratios between these photopeaks were used for ruling out interferences from other isotopes present in the sample, thus providing a very accurate means of analysis. The figure clearly illustrates the fine resolution of the LEPD detector and the sensitivity with which it detects low energy photons. In the porcelain samples, only the 106.10-keV photopeak exhibited interferences while the other three main peaks showed the correct half-life and internal ratios as the uranium standard.

3. Requirements
   3.1 Uranium content. The maximum content of uranium in porcelain teeth or dental porcelains shall be 0.03% by weight as determined by the procedure described in paragraph 4.

4. Methods of testing
   4.1 Uranium determination, introduction. The procedure described here represents a rapid instrumental method of neutron activation analysis of uranium in concentrations above 50 ppb, utilizing only a multichannel analyzer coupled to the Low Energy Photon Detector (LEPD). This procedure readily adapts to the typical scheme of a neutron activation analysis laboratory where irradiation, decay, and counting of the samples fit an efficient schedule, and it uses a detector (LEPD) which has broad capabilities other than uranium analysis [1,2].

   The LEPD detector operates on the principle that a thin wafer crystal of lithium-drifted germanium is highly sensitive to the X-rays and low energy gammas from reactor-irradiated materials, and it is basically insensitive to the usual interferences from higher energy gammas that are experienced with large volume Ge(Li) detectors typically used in neutron activation analysis.

   Considering the analysis for uranium by NAA, one of the activation products produced from the bombardment of U-238 by thermal neutrons is Np-239. This activation product has a half-life of 2.35 days and X-rays and low energy gammas at 14.28, 18.29, 21.40, 99.46, 103.65, and 106.10 keV (Illustration).

   The analysis of uranium in dental porcelains and artificial teeth using the LEPD method offers significant improvements over other methods. These are: (1) no chemical dissolutions are required as is the case with many other methods when applied to solid samples; (2) chemical separations which can give technique and recovery errors are unnecessary.
either liquids or solids can be analyzed because of direct measurement of the X-rays emitted after irradiation in the reactor; (4) the analysis can be performed by a technician at less expense rather than by a highly trained chemist.

4.1.1 Apparatus. The apparatus used consisted of a 16-mm Ortec (LEPD) Low Energy Photon Detector and an ND2200 MCA coupled to a Hewlett-Packard computerized data retrieval system. This detector and its dewar are very similar in dimensions to a standard large volume Ge(Li) detector except in the actual construction of the germanium crystal itself. The windowless (less than 1 μm) lithium-drifted germanium crystal wafer has a standard end cap window of a 5-ml thickness of beryllium. The detector is liquid nitrogen dewar cooled. The LEPD, when coupled with a 1024 or greater multichannel analyzer, has a useful range from 3 to approximately 600 keV. However, for practical purposes sensitivity-wise, it is best below 300 keV. Typical resolution is 225 eV at 5.9 keV, 600 eV at 122 keV, and 750 eV at 270 keV.

4.1.2 Reagent preparation. Weigh approximately 1 gm of freeze-dried uranyl nitrate in 1 liter of distilled water and 0.1N nitric acid. Micropipetting shall be used to reduce standards to 1.0, 10.0, and 100.0 μg dried concentrations mixed and dried with 0.1-gm samples of dental porcelains containing less than 0.1 μg per gram uranium. These shall be sealed in poly irradiation vials.

As a check on the uranium standards, three (0.10 gm) samples of an NBS Reference Coal containing 1.35 ppm U shall be also heat-sealed in poly vials and shall be used as uranium reference standards.

4.1.3 Sample preparation. Dental porcelains shall be prepared by thoroughly shaking each in a vibrator shaker for two minutes to remix the constituents of each porcelain bottle. The factory seals shall then be broken on each bottle and a 0.1-gm sample of each porcelain powder shall be transferred to poly irradiation vials and heat-sealed.

Porcelain teeth samples shall be prepared by cleansing thoroughly to remove carding wax, by crushing to remove metal pins, and then by grinding to blend the total tooth to the mesh of the standard powder. Blank teeth containing no uranium shall be put through the same process to check for contamination possibilities. A 0.1-gm sample of each ground tooth shall be weighed and sealed in poly irradiation vials.

4.1.4 Irradiation procedure. Both samples and standards with flux monitors attached shall be irradiated for two hours in a flux of $1 \times 10^{13}$ n/cm²-sec. The irradiated samples shall then be allowed to decay for 48 hours before counting the Np-239 activity. A decay of 40 to 50 hours provides the best decay time in a trade of Np-239 decay versus the background decay of other isotopes in the sample. The solids shall be placed in a special counting vial which provides duplicate counting conditions for both standard and unknown on the LEPD detector.

The standards and porcelain powders shall be counted (decay monitored) on the 16-mm Ortec LEPD for approximately 400 to 1,000 seconds at a calibration 0–125 keV (Illustration).

Data analysis may be performed by the Covell [4] method, by a computerized Hewlett-Packard, APT, and Nuclear Data ND2200 system, by a computerized ND4420, or by other similar MCA systems.

An alternative equivalent method for determination of uranium content that is calibrated by use of National Bureau of Standards Uranium Content Reference Standards may be used.

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