



Designation: **F1581–08 (Reapproved 2012) F1581 – 08 (Reapproved 2016)**

Standard Specification for Composition of Anorganic Bone for Surgical Implants¹

This standard is issued under the fixed designation F1581; 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 covers material requirements for anorganic xenogenic or allogeneic bone (apatite) intended for surgical implants. For a material to be called anorganic or deorganified bone, it must conform to this specification (see [Appendix X1](#)).

1.2 The biological response to apatite in soft tissue and bone has been characterized by a history of clinical use and by laboratory studies (**1, 2, 3**).² Xenogenic bone, with organic components present, has been shown to be antigenic in the human host (**4**) whereas the same material that has been completely deorganified has been shown to elicit no inflammatory or foreign body reactions in human clinical use (**5, 6, 7**).

1.3 This specification specifically excludes synthetic hydroxylapatite, hydroxylapatite coatings, ceramic glasses, tribasic calcium phosphate, whitlockite, and alpha- and beta-tricalcium phosphate.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 **Warning**—Mercury has been designated by EPA and many state agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Material Safety Data Sheet (MSDS)(DS) for details and EPA's website (<http://www.epa.gov/mercury/faq.htm>) for additional information. Users should be aware that selling mercury or mercury-containing products, or both, in your state may be prohibited by state law.

1.6 *This standard does not purport to address all of the safety concerns, such as health concerns due to the presence of transmissible disease, 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.* (See [Appendix X2](#)).

2. Referenced Documents

2.1 ASTM Standards:³

[D513 Test Methods for Total and Dissolved Carbon Dioxide in Water](#)

[D1688 Test Methods for Copper in Water](#)

[D2972 Test Methods for Arsenic in Water](#)

[D3557 Test Methods for Cadmium in Water](#)

[D3559 Test Methods for Lead in Water](#)

[D3919 Practice for Measuring Trace Elements in Water by Graphite Furnace Atomic Absorption Spectrophotometry](#)

[D4129 Test Method for Total and Organic Carbon in Water by High Temperature Oxidation and by Coulometric Detection](#)

[E1184 Practice for Determination of Elements by Graphite Furnace Atomic Absorption Spectrometry](#)

[F748 Practice for Selecting Generic Biological Test Methods for Materials and Devices](#)

[F1185 Specification for Composition of Hydroxylapatite for Surgical Implants](#)

2.2 Code of Federal Regulations:⁴

[Title 21, Part 820](#)

¹ This specification is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is under the direct responsibility of Subcommittee F04.13 on Ceramic Materials.

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² The boldface numbers in parentheses refer to the list of references at the end of this specification.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

⁴ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

2.3 *National Formulary*:⁵

Tribasic Calcium Phosphate

2.4 *United States Pharmacopeia*:⁶

Identification Tests for Calcium and Phosphate <191>

Lead <251><251>

Mercury <261>

Cadmium <461>

Arsenic <211>

Heavy Metals <231> Method 1

Nitrogen Determination <4617>

2.5 *U.S. Geological Survey Method*:⁷

Cadmium

3. Terminology

3.1 *Definitions*:

3.1.1 *allogeneic, adj*—derived from different individuals of the same species.

3.1.2 *anorganic, adj*—denoting tissue (for example, bone) from which the organic material has been totally removed. Also referred to as *deorganified, deproteinized* or *deproteinated*.

3.1.3 *apatite, n*—the mineral substance having the molecular formula $\text{Ca}_{10}(\text{X})_2(\text{PO}_4)_6$ where X = OH (hydroxyapatite or hydroxylapatite), CO_3 (carbonated apatite), F (fluorine), or Cl (chlorine) (8).

3.1.4 *xenogeneic, adj*—derived from individuals of a different, specified species. For example, bovine bone, when used as an implant material in humans, is xenogeneic.

4. Chemical Requirements

4.1 Elemental analysis for calcium and phosphorus shall be consistent with the expected composition of the source of the biologically-derived bone mineral (9).

4.2 An X-ray diffraction analysis of the material shall be consistent with PDF card #9-432 for hydroxyapatite (10) or PDF card #35-180 for calcium phosphate carbonate (carbonated apatite). Analysis of relative peak intensities shall be consistent with published data.⁸

4.3 The crystal size of the anorganic bone shall be determined from the X-ray diffraction data using the well-known Scherrer formula (11).

4.4 The concentration of trace elements in the anorganic bone shall be limited as follows:

Element	ppm, max
arsenic	3
cadmium	5
mercury	5
lead	30
total heavy metals (as lead)	50

For referee purposes, use either inductively coupled plasma/mass spectroscopy (ICP/MS) (12) or the USP methods <191>, <251>, <261>, <211>, <231> Method 1, <4617>; and for cadmium, use either <461> or the U.S. Geological Survey Method on cadmium. (See 2.4 and 2.5.) Graphite furnace atomic absorption spectrophotometry may also be used for analysis of trace elements using for arsenic (Test Methods D2972), copper (Test Methods D1688), cadmium (Test Methods D3557), lead (Test Methods D3559) with 1 g anorganic bone/100mL water samples. General guides for the application of the graphite furnace are given in Practices D3919 and E1184.

4.5 The maximum allowable limit of all heavy metals determined as lead shall be 50 ppm as described in 2.4 or equivalent. Sample preparation shall be identical to that for tribasic calcium phosphate as specified in the National Formulary (see 2.3), except that approximately 1 g of material shall be dissolved in approximately 30 mL of 5 % HCl and boiled.

⁵ National Formulary 25. Available from U.S. Pharmacopeia (USP), 12601 Twinbrook Pkwy., Rockville, MD 20852-1790, <http://www.usp.org>. Succeeding USP editions may alternatively be referenced.

⁶ United States Pharmacopeia 30. Available from U.S. Pharmacopeia (USP), 12601 Twinbrook Pkwy., Rockville, MD 20852-1790, <http://www.usp.org>. Succeeding USP editions may alternatively be referenced.

⁷ Crock, J. G., Felichte, F. E., and Briggs, P. H., "Determination of Elements in National Bureau of Standards Geological Reference Materials SRM 278 Obsidian and SRM 688 Basalt by Inductively Coupled Argon Plasma—Atomic Emission Spectrometry," *Geostandards Newsletter*, Vol 7, 1983, pp. 335–340. Crock, J. G., Felichte, F. E., and Briggs, P. H., "Determination of Elements in National Bureau of Standards Geological Reference Materials SRM 278 Obsidian and SRM 688 Basalt by Inductively Coupled Argon Plasma—Atomic Emission Spectrometry," *Geostandards Newsletter*, Vol 7, 1983, pp. 335–340.

⁸ The Joint Committee on Powdered Diffraction Standards has established a Powder Diffraction File. The Committee operates on an international basis and cooperates closely with the Data Commission of the International Union of Crystallography and ASTM. Hydroxylapatite data can be found on file card number 9-432 and is available from the Joint Committee on Powder Diffraction Standards, 1600 Park Lane, Swarthmore, PA 19801.