



Designation: F2459 – 18

Standard Test Method for Extracting Residue from Metallic Medical Components and Quantifying via Gravimetric Analysis¹

This standard is issued under the fixed designation F2459; 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 test method covers the quantitative assessment of the amount of residue obtained from metallic medical components when extracted with aqueous or organic solvents.

1.2 This test method does not advocate an acceptable level of cleanliness. It identifies two techniques to quantify extractable residue on metallic medical components. In addition, it is recognized that this test method may not be the only method to determine and quantify extractables.

1.3 Although these methods may give the investigator a means to compare the relative levels of component cleanliness, it is recognized that some forms of component residue may not be accounted for by these methods.

1.4 The applicability of these general gravimetric methods have been demonstrated by many literature reports; however, the specific suitability for applications to all-metal medical components will be validated by an Interlaboratory Study (ILS) conducted according to Practice E691.

1.5 This test method is not intended to evaluate the residue level in medical components that have been cleaned for reuse. This test method is also not intended to extract residue for use in biocompatibility testing.

NOTE 1—For extraction of samples intended for the biological evaluation of devices or materials, refer to ISO 10993–12.

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

1.7 This standard may involve hazardous or environmentally-restricted materials, operations, and equipment. *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

¹ This test method is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.15 on Material Test Methods.

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1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G121 Practice for Preparation of Contaminated Test Coupons for the Evaluation of Cleaning Agents

G131 Practice for Cleaning of Materials and Components by Ultrasonic Techniques

G136 Practice for Determination of Soluble Residual Contaminants in Materials by Ultrasonic Extraction

2.2 ISO Standard:³

ISO 10993–12 Biological Evaluation—Sample Preparation and Reference Materials

3. Terminology

3.1 Definitions:

3.1.1 *ionic compounds/water soluble residue*—residue that is soluble in water, including surfactants and salts.

3.1.2 *non-soluble debris*—residue including metals, organic solids, inorganic solids, and ceramics.

3.1.3 *non-water soluble residue*—residue soluble in solvents other than water. Inclusive in this are oils, greases, hydrocarbons, and low molecular weight polymers. Typical solvents used to dissolve these residues include chlorinated or fluorinated solvents, or low molecular weight hydrocarbons.

3.1.4 *reflux system*—an apparatus containing an extraction vessel and a solvent return system. It is designed to allow

² 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.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

boiling of the solvent in the extraction vessel and to return any vaporized solvent to the extraction vessel.

3.1.5 *reuse*—the repeated or multiple use of any medical component (whether labeled SUD or reusable) with reprocessing (cleaning, disinfection, or sterilization, or combination thereof) between patient uses.

3.1.6 *single use device (SUD)*—a disposable component that is intended to be used on one patient during a single procedure.

3.1.7 *surface area*—the projected surface area of a part. This area does not include the internal porosity of parts with cancellous, porous, or wire structure.

3.2 Symbols:

- m_1 = weight of extraction vessel, foil, and component before extraction
- m_2 = weight of extraction vessel, component, foil, and solvent after extraction
- m_3 = mass of clean beaker and foil used to hold removed aliquot of extracted solution
- m_4 = mass of beaker, foil, and aliquot of solution before drying
- m_5 = mass of beaker, foil, and residue after evaporating solvent
- m_6 = mass of new filter
- m_7 = mass of filter following filtration and drying
- m_8 = mass of pre-dried sample specimen prior to extraction
- m_9 = mass of pre-dried sample specimen after extraction
- m_a = mass of residue in removed aliquot
- c_r = concentration of residue in solution
- c_b = concentration of residue in blank solutions
- m_r = mass of soluble residue in the overall extract, corrected for the blank runs
- m_i = weight of insoluble debris
- m_t = mass of soluble and insoluble residue
- E = extraction efficiency

4. Summary of Test Method

4.1 This test method describes the extraction and quantitative analysis procedures used to detect and quantify the total amount of extractable residue from metallic medical components. The residues are grouped into three categories: (1) water-soluble extractables; (2) non-water soluble extractables; and (3) non-soluble debris.

5. Significance and Use

5.1 This test method is suitable for determination of the total amount of extractable residue in metallic medical components. Extractable residue includes aqueous and non-aqueous residue, as well as non-soluble residue.

5.2 This test method recommends the use of a sonication technique to extract residue from the medical component. Other techniques, such as solvent reflux extraction, could be used but have been shown to be less efficient in some tests, as discussed in X1.2.

5.3 This test method is not applicable for evaluating the extractable residue for the reuse of a single-use component (SUD).

6. Apparatus

6.1 *Ultrasonic Bath*, for extraction. The bath must be large enough to hold an extraction beaker containing the medical component. This apparatus is used with the technique described in 11.5. Alternatively, an ultrasonic probe can be used with a bath.

6.2 *Solvent Reflux Extraction Assembly*, shown in Fig. 1. This assembly is composed of a vessel large enough to hold the medical component, and a water-cooled refluxing column. A heating manifold or hotplate stirrer capable of reaching the boiling point of the solvent is also included. This apparatus is used in the procedure described in 11.3. A Soxhlet extractor, as shown in Fig. 2, could be used as well using the procedure described in 11.3.

6.3 *Analytical Balance*, with 0.1 mg accuracy or better.

6.4 *Balance*, with accuracy of 10 mg or better and sufficient capacity to weigh the extraction beaker with the medical component and solvent combined.

6.5 *Glass Beaker and Extraction Vessel*, large enough to hold sufficient solvent to cover the medical component in the extraction vessel. Additionally, metal beakers could be used. Plastic beakers should not be used as low molecular weight residues could be extracted from the beakers.

6.6 *Desiccator*.

6.7 *Pipets*, for transferring liquid. Some solvents can leach extractable compounds from plastic pipets. Glass or metallic pipets are recommended for organic solvents.

6.8 *Aluminum Foil*, degreased in extraction solvent.

6.9 *Forceps, Tweezers, or Tongs*, cleaned with acetone or extraction solvent.

6.10 *Filtration Apparatus*, containing a removable 0.2 μm filter medium that is non-soluble in the extraction solvent.

6.11 *Non-Corrosive (Glass or Non-Corrosive Metal) Trays*.

6.12 *Laboratory Oven* or rotary evaporator.

7. Reagents and Materials

7.1 Each user needs to demonstrate solubility of all of their suspect sources of residue in the solvent(s) of choice. Several solvents may be required if more than one type of residue may be present on the component. The selected solvent shall not dissolve or change the implant material.

7.2 Spectroscopy or ACS-grade solvents should be used.

7.3 High purity, deionized, or equivalent water should be used.

8. Hazards

8.1 Many organic solvents are toxic, flammable, or explosive and should be handled only with chemically protective laboratory gloves and used in a fume hood.

8.2 If sonication is used, the user should make sure that the solvent is not heated, directly or through sonication, to a temperature above the flash point of the solvent.

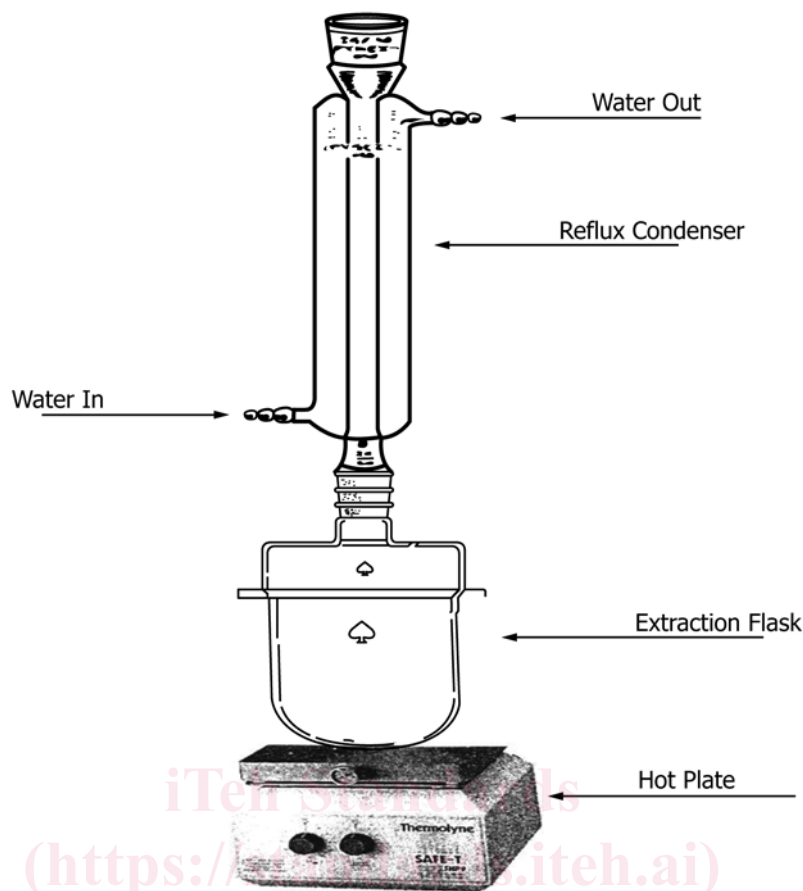


FIG. 1 Sample Solvent Reflux Extractor Assembly

9. Sampling, Test Specimens, and Test Units

9.1 Metallic medical components should be taken in random groupings from different lots if available.

9.2 It is up to the user to determine the number of medical components that need to be used to establish known reproducibility.

9.3 It is up to the user to determine the number of test blanks that need to be used to establish known reproducibility.

9.4 Separate components should be tested for organic and aqueous extractions.

9.5 If a long medical component is cut, it is recommended that the original length and the cut lengths be recorded before the final cleaning operation for validation purposes. Individual cut lengths may be separately extracted and the results combined to provide a total residue value for the medical component. Cutting lubricants must be avoided in this procedure.

10. Limits of Detection and Recovery Efficiency

10.1 Standardized test coupons can be prepared according to Practice G121. Limits of detection for the two extraction techniques described in Section 11 can be assessed by placing known amounts of residues on the test coupons, and performing the extraction and analyses described in Section 11.

10.2 *Recovery Efficiency*—The recovery efficiency of the selected extraction technique can be determined by doping

pre-cleaned medical components with known amounts of the target residue, then extracting and quantifying the target residue. When using this method, the extraction efficiency E is the ratio of the amount of recovered residue to the doped amount of residue. Recovery efficiency may also be determined by exhaustive extraction. The exhaustive extraction technique uses medical components which have not been cleaned and contain unknown amounts of the target residue(s). These components should be extracted using the selected extraction technique until no significant increase in the cumulative residue level is detected upon re-extraction, or until the incremental amount extracted is less than 10 % of what was detected in the first extraction. When using this approach, the extraction efficiency E is the ratio of the amount of recovered residue from the first extraction to the total amount of recovered residue from all extractions performed.

10.3 The user should adjust the extraction parameters in 11.3.11, 11.5.8, or 11.7.12, and/or select the appropriate solvent, in order to achieve an extraction efficiency of $E > 75\%$. This step should be performed if target residues are known a priori. In the case of mixed residues, extraction efficiency may not be able to be determined and the exhaustive extraction of the test specimen may be performed.

11. Procedure

11.1 If more than one specimen is to be extracted collectively, record the number of specimens.



FIG. 2 Sample Soxhlet Extractor Assembly

11.2 If multiple specimens are to be extracted collectively, they must be of the same type and size.

11.3 *Reflux Extraction by Extract Mass:*

11.3.1 Equipment may need to be cleaned with nitric acid or other appropriate means prior to solvent cleaning.

11.3.2 Clean the extraction equipment by rinsing at least three times with spectroscopy-grade hexane or another suitable solvent. The extraction solvent may be used.

11.3.3 Air or oven dry all beakers and glassware at room temperature in a fume hood and store in a desiccator prior to use.

11.3.4 Assemble the extraction apparatus as shown in Fig. 1.

11.3.5 Do not use any type of joint grease on the extraction assembly. It can dissolve in the solvent and contaminate the solution. Polytetrafluoroethylene (PTFE) sleeves or tape can be used to seal the joints if necessary.

11.3.6 Place the sample component in the extractor vessel and add a magnetic stirring bar or PTFE boiling stones to reduce the potential for boiling retardation in the system during reflux. The stir bar or boiling stones, or both, should be carefully cleaned in a suitable solvent prior to use.

11.3.7 Weigh the extractor vessel with the component on a balance and record the weight, m_1 .

11.3.8 Charge the flask with enough solvent to completely cover the component(s) and assemble the reflux system.

11.3.9 Start flow of cooling water through the condenser.

11.3.10 Adjust the hotplate stirrer or heating manifold to maintain the solvent at a brisk boil with moderate constant stirring.

11.3.11 Extract the component(s) for 4 h or for approximately 10 cycles if using a Soxhlet extractor, or the amount of time needed to achieve an extraction efficiency greater than 75 %. The extraction time or number of cycles can be adjusted by the user based on internal. The extraction time or number of cycles can be adjusted by the user based on internal validation of their target residue.

11.3.12 After the extraction period is complete, turn off the hot plate and allow the system to cool. Carefully open the apparatus. If a Soxhlet extractor is used, heavy debris may stay in the top part of the extractor. This debris can be washed down into the collection vessel with fresh extraction solvent.

11.3.13 Weigh the extraction vessel, component, and solvent, and record the weight as m_2 .

11.3.14 Weigh an aliquot beaker large enough to hold an aliquot of the extraction vessel along with a clean piece of foil and record the weight as m_3 . The beaker should be weighed to a resolution of at least 0.1 mg.