It is most important that the objectives and potential uses of an AAMI product standard or recommended practice are clearly understood. The objectives of AAMI's technical development program derive from AAMI's overall mission: the advancement of medical instrumentation. Essential to such advancement are (1) a continued increase in the safe and effective application of current technologies to patient care, and (2) the encouragement of new technologies. It is AAMI's view that standards and recommended practices can contribute significantly to the advancement of medical instrumentation, provided that they are drafted with attention to these objectives and provided that arbitrary and restrictive uses are avoided.

A voluntary standard for a medical device recommends to the manufacturer the information that should be provided with or on the product, basic safety and performance criteria that should be considered in qualifying the device for clinical use, and the measurement techniques that can be used to determine whether the device conforms with the safety and performance criteria and/or to compare the performance characteristics of different products. Some standards emphasize the information that should be provided with the device, including performance characteristics, instructions for use, warnings and precautions, and other data considered important in ensuring the safe and effective use of the device in the clinical environment. Recommending the disclosure of performance characteristics often necessitates the development of specialized test methods to facilitate uniformity in reporting; reaching consensus on these tests can represent a considerable part of committee work. When a drafting committee determines that clinical concerns warrant the establishment of minimum safety and performance criteria, referee tests must be provided and the reasons for establishing the criteria must be documented in the rationale.

A recommended practice provides guidelines for the use, care, and/or processing of a medical device or system. A recommended practice does not address device performance per se, but rather procedures and practices that will help ensure that a device is used safely and effectively and that its performance will be maintained.

Although a device standard is primarily directed to the manufacturer, it may also be of value to the potential purchaser or user of the device as a frame of reference for device evaluation. Similarly, even though a recommended practice is usually oriented towards healthcare professionals, it may be useful to the manufacturer in better understanding the environment in which a medical device will be used. Also, some recommended practices, while not addressing device performance criteria, provide guidelines to industrial personnel on such subjects as sterilization processing, methods of collecting data to establish safety and efficacy, human engineering, and other processing or evaluation techniques; such guidelines may be useful to health care professionals in understanding industrial practices.

In determining whether an AAMI standard or recommended practice is relevant to the specific needs of a potential user of the document, several important concepts must be recognized:

All AAMI standards and recommended practices are voluntary (unless, of course, they are adopted by government regulatory or procurement authorities). The application of a standard or recommended practice is solely within the discretion and professional judgment of the user of the document.

Each AAMI standard or recommended practice reflects the collective expertise of a committee of health care professionals and industrial representatives, whose work has been reviewed nationally (and sometimes internationally). As such, the consensus recommendations embodied in a standard or recommended practice are intended to respond to clinical needs and, ultimately, to help ensure patient safety. A standard or recommended practice is limited, however, in the sense that it responds generally to perceived risks and conditions that may not always be relevant to specific situations. A standard or recommended practice is an important reference in responsible decision-making, but it should never replace responsible decision-making.

Despite periodic review and revision (at least once every five years), a standard or recommended practice is necessarily a static document applied to a dynamic technology. Therefore, a standards user must carefully review the reasons why the document was initially developed and the specific rationale for each of its provisions. This review will reveal whether the document remains relevant to the specific needs of the user.

Particular care should be taken in applying a product standard to existing devices and equipment, and in applying a recommended practice to current procedures and practices. While observed or potential risks with existing equipment typically form the basis for the safety and performance criteria defined in a standard, professional judgment must be used in applying these criteria to existing equipment. No single source of information will serve to identify a particular product as unsafe. A voluntary standard can be used as one resource, but the ultimate decision as to product safety and efficacy must take into account the specifics of its utilization and, of course, cost-benefit considerations. Similarly, a recommended practice should be analyzed in the context of the specific needs and resources of the individual institution or firm. Again, the rationale accompanying each AAMI standard and recommended practice is an excellent guide to the reasoning and data underlying its provision.

In summary, a standard or recommended practice is truly useful only when it is used in conjunction with other sources of information and policy guidance and in the context of professional experience and judgment.

INTERPRETATIONS OF AAMI STANDARDS AND RECOMMENDED PRACTICES

Requests for interpretations of AAMI standards and recommended practices must be made in writing, to the AAMI Vice President, Standards Policy and Programs. An official interpretation must be approved by letter ballot of the originating committee and subsequently reviewed and approved by the AAMI Standards Board. The interpretation will become official and representation of the Association only upon exhaustion of any appeals and upon publication of notice of interpretation in the "Standards Monitor" section of the AAMI News. The Association for the Advancement of Medical Instrumentation disclaims responsibility for any characterization or explanation of a standard or recommended practice which has not been developed and communicated in accordance with this procedure and which is not published, by appropriate notice, as an official interpretation in the AAMI News.
Cardiovascular implants—Cardiac valve prostheses—Part 2: Surgically implanted heart valve substitutes

Developed by
Association for the Advancement of Medical Instrumentation

Approved 16 November 2015 by
American National Standards Institute, Inc.

Abstract: Outlines an approach for qualifying the design and manufacture of a surgical heart valve substitute through risk management. The selection of appropriate qualification tests and methods are derived from the risk assessment. The tests may include those to assess the physical, chemical, biological, and mechanical properties of surgical heart valve substitutes and of their materials and components. The tests may also include those for pre-clinical in vivo evaluation and clinical evaluation of the finished surgical heart valve substitute.

Keywords: assessment, clinical, design, input, operational, output, performance, risk, test, use
AAMI Standard

This Association for the Advancement of Medical Instrumentation (AAMI) standard implies a consensus of those substantially concerned with its scope and provisions. The existence of an AAMI standard does not in any respect preclude anyone, whether they have approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. AAMI standards are subject to periodic review, and users are cautioned to obtain the latest editions.

CAUTION NOTICE: This AAMI standard may be revised or withdrawn at any time. AAMI procedures require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Interested parties may obtain current information on all AAMI standards by calling or writing AAMI.

All AAMI standards, recommended practices, technical information reports, and other types of technical documents developed by AAMI are voluntary, and their application is solely within the discretion and professional judgment of the user of the document. Occasionally, voluntary technical documents are adopted by government regulatory agencies or procurement authorities, in which case the adopting agency is responsible for enforcement of its rules and regulations.
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glossary of equivalent standards</td>
<td>v</td>
</tr>
<tr>
<td>Committee representation</td>
<td>vi</td>
</tr>
<tr>
<td>Background on AAMI adoption of ISO 5840-2:2015</td>
<td>vii</td>
</tr>
<tr>
<td>Foreword</td>
<td>viii</td>
</tr>
<tr>
<td>Introduction</td>
<td>ix</td>
</tr>
<tr>
<td>1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>2 Normative references</td>
<td>1</td>
</tr>
<tr>
<td>3 Terms and definitions</td>
<td>2</td>
</tr>
<tr>
<td>4 Abbreviations</td>
<td>4</td>
</tr>
<tr>
<td>5 Fundamental requirements</td>
<td>5</td>
</tr>
<tr>
<td>6 Device description</td>
<td>5</td>
</tr>
<tr>
<td>6.1 Intended use</td>
<td>5</td>
</tr>
<tr>
<td>6.2 Design inputs</td>
<td>5</td>
</tr>
<tr>
<td>6.2.1 Operational specifications</td>
<td>5</td>
</tr>
<tr>
<td>6.2.2 Performance specifications</td>
<td>5</td>
</tr>
<tr>
<td>6.2.3 Packaging, labelling, and sterilization</td>
<td>6</td>
</tr>
<tr>
<td>6.3 Design outputs</td>
<td>6</td>
</tr>
<tr>
<td>6.3.1 General</td>
<td>6</td>
</tr>
<tr>
<td>6.4 Design transfer (manufacturing qualification)</td>
<td>6</td>
</tr>
<tr>
<td>6.5 Risk management</td>
<td>6</td>
</tr>
<tr>
<td>7 Design verification testing and analysis/design validation</td>
<td>6</td>
</tr>
<tr>
<td>7.1 General requirements</td>
<td>6</td>
</tr>
<tr>
<td>7.2 In vitro assessment</td>
<td>7</td>
</tr>
<tr>
<td>7.2.1 Test conditions, sample selection, and reporting requirements</td>
<td>7</td>
</tr>
<tr>
<td>7.2.2 Material property assessment</td>
<td>8</td>
</tr>
<tr>
<td>7.2.3 Hydrodynamic performance assessment</td>
<td>8</td>
</tr>
<tr>
<td>7.2.4 Structural performance assessment</td>
<td>10</td>
</tr>
<tr>
<td>7.2.5 Device MRI safety</td>
<td>11</td>
</tr>
<tr>
<td>7.2.6 Additional implant design evaluation requirements</td>
<td>11</td>
</tr>
<tr>
<td>7.2.7 Design specific testing</td>
<td>11</td>
</tr>
<tr>
<td>7.2.8 Simulated use</td>
<td>12</td>
</tr>
<tr>
<td>7.2.9 Human factors/usability assessment</td>
<td>12</td>
</tr>
<tr>
<td>7.3 Preclinical in vivo evaluation</td>
<td>12</td>
</tr>
<tr>
<td>7.3.1 Overall requirements</td>
<td>12</td>
</tr>
<tr>
<td>7.3.2 Methods</td>
<td>13</td>
</tr>
<tr>
<td>7.3.3 Test report</td>
<td>14</td>
</tr>
<tr>
<td>7.4 Clinical investigation</td>
<td>14</td>
</tr>
<tr>
<td>7.4.1 General</td>
<td>14</td>
</tr>
<tr>
<td>7.4.2 Statistical considerations</td>
<td>15</td>
</tr>
<tr>
<td>7.4.3 Distribution of subjects and investigators</td>
<td>15</td>
</tr>
<tr>
<td>7.4.4 Sample size</td>
<td>15</td>
</tr>
<tr>
<td>7.4.5 Entry criteria</td>
<td>15</td>
</tr>
<tr>
<td>7.4.6 Duration of the study</td>
<td>16</td>
</tr>
<tr>
<td>7.4.7 Clinical data requirements</td>
<td>16</td>
</tr>
<tr>
<td>7.4.8 Clinical investigation report</td>
<td>18</td>
</tr>
</tbody>
</table>
Glossary of equivalent standards

International Standards adopted in the United States may include normative references to other International Standards. AAMI maintains a current list of each International Standard that has been adopted by AAMI (and ANSI). Available on the AAMI website at the address below, this list gives the corresponding U.S. designation and level of equivalency to the International Standard.

www.aami.org/standards/glossary.pdf
Committee representation

Association for the Advancement of Medical Instrumentation
Cardiac Valve Committee

The adoption of ISO 5840-2:2015 as an American National Standard was initiated by the AAMI Cardiac Valve Committee. The AAMI Cardiac Valve Committee also functions as a U.S. Technical Advisory Group to the relevant work in the International Organization for Sterilization (ISO). U.S. representatives from the AAMI Cardiac Valve Committee (U.S. Sub-TAG for ISO/TC 150/SC 2/WG 1, Cardiac valves) played an active part in developing the ISO standard.

At the time this document was published, the AAMI Cardiac Valve Committee had the following members:

Cochairs:
- Ann M. Graves
- Changfu Wu, PhD

Members:
- Devesh Amatya, PhD, Colibri Heart Valve
- Richard W. Bianco, University of Minnesota
- Jeffrey Borer, MD, Weill Cornell Medical College of Cornell University
- James C. Conti, PhD, Dynatek Labs
- Joanna Develter, Abbott Vascular Structural Heart
- Francis Duhay, MD, Univ of California Irvine Medical Center
- Robert W.M. Frater, MD, Bronxville, NY
- Xiao-Yan Gong, PhD, Medical Implant Mechanics
- Ann M. Graves, St. Jude Medical
- Rebecca Tung Hahn, MD, Columbia University Presbyterian Hospital
- Stephen Hilbert, PhD MD, Children's Mercy Hospital/Ward Family Center for Congenital Heart Disease
- Salvador Marquez, Edwards LifeSciences
- David Mester, W.L. Gore & Associates
- John Morriss, Twelve
- Sunoj Narayanan, Bose Corporation – Electroforce System Group
- Ning Pan, Boston Scientific
- Carlos Ruiz, PhD FACC FESC MSCAI, Hackensack University Medical Center/The Joseph M. Sanzari Children’s Hospital
- Jonas Runquist, HLT Inc.
- Ryan Siskey, Exponent
- Wei Sun, PhD, Georgia Institute of Technology/Emory University
- Julie A. Swain, MD, Mount Sinai Hospital
- Craig Weinberg, PhD, Biomedical Device Consultants & Laboratories
- Changfu Wu, FDA/Center for Devices and Radiological Health
- Ajit Yoganathan, PhD, Georgia Institute of Technology
- Julie Zaha, RN Southeastern Regional Medical Center

Alternates:
- Lori Adels, BA PhD, Edwards LifeSciences
- Nandini Duraiswamy, FDA/Center for Devices and Radiological Health
- Carol E. Eberhart, Medtronic, Inc.
- Neelakantan Saikrishnan, St. Jude Medical
- Helen Scotch, Sadra Medical/Boston Scientific
- Elaine, Strope, PhD, Dynatek Labs
- Matthew Thompson, Bose Corporation – Electroforce System Group
- Steven L. Weinberg, PhD, Biomedical Device Consultants & Laboratories
- David Williams, RN MSN, W.L. Gore & Associates

NOTE—Participation by federal agency representatives in the development of this standard does not constitute endorsement by the federal government or any of its agencies.
Background on AAMI adoption of ISO 5840-2:2015

As indicated in the foreword to the main body of this document (page viii), the International Organization for Standardization (ISO) is a worldwide federation of national standards bodies. The United States is one of the ISO members that took an active role in the development of this standard, which was developed by ISO Technical Subcommittee 150/SC 2, Cardiovascular implants and extracorporeal systems, to fill a need for standardization in the field of cardiac valve prostheses.

U.S. participation in this ISO subcommittee is organized through the U.S. Technical Advisory Group for ISO/TC 150/SC 2, administered by the Association for the Advancement of Medical Instrumentation (AAMI). The U.S. TAG for ISO/TC 150/SC 2 supports the guidance provided in this document on surgically implanted heart valve substitutes.


AAMI and ANSI procedures require that standards be reviewed and, if necessary, revised every five years to reflect technological advances that may have occurred since publication.

AAMI (and ANSI) have adopted other ISO standards. See the Glossary of Equivalent Standards for a list of ISO standards adopted by AAMI which gives the corresponding U.S. designation and the level of equivalency with the ISO standard.

The concepts incorporated in this standard should not be considered inflexible or static. This standard, like any other, must be reviewed and updated periodically to assimilate progressive technological developments. To remain relevant, it must be modified as technological advances are made and as new data come to light.

Suggestions for improving this standard are invited. Comments and suggested revisions should be sent to Standards Department, AAMI, 4301 N. Fairfax Dr., Ste. 301, Arlington, VA 22203-1633.

NOTE—Beginning with the foreword on page viii, this ANSI/AAMI/ISO standard is identical to ISO 5840-2:2015.
Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO’s adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 150, Implants for surgery, Subcommittee SC 2, Cardiovascular implants and extracorporeal systems.

This first edition of ISO 5840-2, together with ISO 5840-1 and ISO 5840-3, cancels and replaces ISO 5840:2005, which has been technically revised.

ISO 5840 consists of the following parts, under the general title Cardiovascular implants — Cardiac valve prostheses:

— Part 1: General requirements
— Part 2: Surgically implanted heart valve substitutes
— Part 3: Heart valve substitutes implanted by transcatheter techniques
Introduction

This part of ISO 5840 has been prepared for surgical heart valve substitutes with emphasis on specifying types of in vitro testing, preclinical in vivo and clinical evaluations, reporting of all in vitro, preclinical in vivo, and clinical evaluations and labelling and packaging of the device. This process is intended to clarify the required procedures prior to market release and to enable prompt identification and management of any subsequent issues.

This part of ISO 5840 is to be used in conjunction with ISO 5840-1.
This is a preview edition of an AAMI document and is intended to allow potential purchasers to evaluate the content of the document before making a purchasing decision.

For a complete copy of this AAMI document, contact AAMI at 1-877-249-8226 or visit www.aami.org.
Cardiovascular implants—Cardiac valve prostheses—Part 2: Surgically implanted heart valve substitutes

1 Scope

This part of ISO 5840 is applicable to heart valve substitutes intended for implantation in human hearts, generally requiring cardiopulmonary bypass and generally with direct visualization.

This part of ISO 5840 is applicable to both newly developed and modified surgical heart valve substitutes and to the accessories, packaging, and labelling required for their implantation and for determining the appropriate size of the surgical heart valve substitute to be implanted.

This part of ISO 5840 outlines an approach for qualifying the design and manufacture of a surgical heart valve substitute through risk management. The selection of appropriate qualification tests and methods are derived from the risk assessment. The tests may include those to assess the physical, chemical, biological, and mechanical properties of surgical heart valve substitutes and of their materials and components. The tests may also include those for pre-clinical in vivo evaluation and clinical evaluation of the finished surgical heart valve substitute.

This part of ISO 5840 defines performance requirements for surgical heart valve substitutes where adequate scientific and/or clinical evidence exists for their justification.

For novel surgical heart valve substitutes, e.g. sutureless, the requirements of both this International Standard and ISO 5840-3 might be relevant and shall be considered as applicable to the specific device design and shall be based on the results of the risk analysis.

This part of ISO 5840 excludes heart valve substitutes designed for implantation in artificial hearts or heart assist devices.

This part of ISO 5840 excludes homografts.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5840-1:2015, Cardiovascular implants and extracorporeal systems — Cardiac valve prostheses — Part 1: General requirements

ISO 10993-1, Biological evaluation of medical devices — Part 1: Evaluation and testing within a risk management process

ISO 10993-2, Biological evaluation of medical devices — Part 2: Animal welfare requirements

ISO 14155, Clinical investigation of medical devices for human subjects — Good clinical practice

ISO 14630, Non-active surgical implants — General requirements

ISO 14971, Medical devices — Application of risk management to medical devices
ISO 16061, *Instrumentation for use in association with non-active surgical implants – General requirements*

ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

ISO 22442 (all parts), *Medical devices utilizing animal tissues and their derivatives*


ASTM F2213, *Standard Test Method for Measurement of Magnetically Induced Torque on Medical Devices in the Magnetic Resonance Environment*

ASTM F2503, *Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment*

PREVIEW COPY

This is a preview edition of an AAMI document and is intended to allow potential purchasers to evaluate the content of the document before making a purchasing decision.

For a complete copy of this AAMI document, contact AAMI at 1-877-249-8226 or visit www.aami.org.