INTERNATIONAL STANDARD

ISO 14949

First edition
2001-10-15

Implants for surgery — Two-part addition-cure silicone elastomers

Implants chirurgicaux — Élastomères de silicone à deux composants à réticulation par réaction d'addition

Reference number
ISO 14949:2001(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14949 was prepared by Technical Committee ISO/TC 150, *Implants for surgery*, Subcommittee SC 1, *Materials*.

Annexes A and B form a normative part of this International Standard.

Introduction

Silicones are commercially available in a variety of physical forms and formulations. Silicone-cure products often employ cure mechanisms that utilize metals, free radicals and/or atmospheric moisture. This International Standard was undertaken to describe a subset of silicones with a successful history of use in implant applications; namely, those utilizing two-part addition-cure (platinum-based) chemistry. It was developed in response to a need to standardize the raw materials, formulation, processing, characterization testing and documentation of two-part addition-cure silicone elastomers targeted as implants for surgery.

Two-part addition-cure silicone elastomer is a thermoset elastomer and is commercialized as a two-part (non-crosslinked) product. The two parts should be thoroughly mixed in a fixed ratio before shaping by extrusion, press- or injection-moulding and crosslinking at elevated temperatures.

Implants for surgery — Two-part addition-cure silicone elastomers

1 Scope

This International Standard specifies the characteristics of, and corresponding test methods for, the two-part addition-cure high consistency or liquid silicone elastomer for use in the manufacture (partially or totally) of surgical implants.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 34-1:1994, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*

ISO 48:1994, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 527-2:1993, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 3417:1991, *Rubber — Measurement of vulcanization characteristics with the oscillating disc curemeter*

ISO 6502:1999, *Rubber — Guide to the use of curemeters*

ISO 10993-1:1997, *Biological evaluation of medical devices — Part 1: Evaluation and testing*

ISO 10993-5:1999, *Biological evaluation of medical devices — Part 5: Tests for in vitro cytotoxicity*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
catalyst
organometallic complex, typically containing platinum substituted by ligands made of any suitable combination of the elements carbon, hydrogen, oxygen, chlorine or silicon (with the exclusion of aromatic rings), which initiates a chemical reaction between a polymer and crosslinking agent

NOTE The catalyst may be dispersed in a silicone oligomer, polymer or mixture of these, such as $RMe_2SiO(SiMe_2O)_x(SiMeR'O)_ySiMe_2R$ where R and R′ are methyl or vinyl groups.

3.2
crosslinking agent
monomer, polymer, silicate or any combination of these, typically of the structure $R''Me_2SiO(SiMe_2O)_x(SiRMeO)_ySiMe_2R''$ where R″ is typically a methyl group or hydrogen, that on curing provides a crosswise connection to parallel polymer chains

NOTE Excess SiH is recommended (not required) before curing to ensure that the cure is total and that no residual Si-vinyl reactive entities exist, thus providing better elastomer stability.

3.3
filler
reinforcing agent
〈for the purposes of this International Standard〉 silicate or high purity amorphous silica

NOTE 1 Such agents are commercially known as fumed or precipitated silica.

NOTE 2 Silica can be treated with silylating agents, for example, those of the formula Me_3SiX or Me_2SiX_2 where X is a hydrolysable group, or polysiloxane oligomer of the formula $HOMe_2SiO(SiMe_2O)_p(SiMeRO)_qSiMe_2OH$ where R is a methyl or a vinyl group.

NOTE 3 Agents that impart radiopacity to the elastomer (e.g. $BaSO_4$) may have reinforcing properties.

3.4
inhibitor
compound or material that has the effect of slowing down or stopping a chemical reaction such as crosslinking

3.5
lot
batch
defined quantity of material manufactured in a single or multi-step process such that the material obtained can be considered as homogeneous

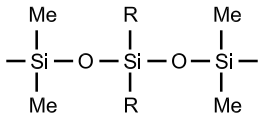
NOTE in the case of a continuous process, the term corresponds to a defined fraction of the production, characterized by its intended homogeneity.

3.6
manufacturer
company who manufactures the final medical device in question

3.7
raw materials
materials from which two-part addition-cure silicone elastomer is manufactured

3.8
silicone elastomer
synthetic rubber obtained by the crosslinking of silicone polymer chains essentially made of repeat siloxane units

EXAMPLE



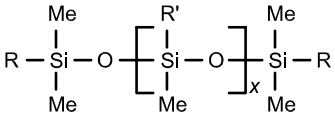
where

R is a phenyl, fluoro, hydroxyl, alkyl or other suitable organic group,

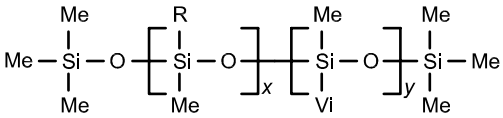
Me is $-CH_3$

3.9
silicone polymer
any polymer or combination of polymers of medium or high molecular mass of the structure $RMe_2SiO(SiMe_2O)_x(SiMeR'O)_ySiMe_2R$, where R is typically a methyl, vinyl or hydroxyl group but might also be a fluoro, phenyl or other group and where R′ is typically a methyl or vinyl group but might also be a fluoro, phenyl or other group

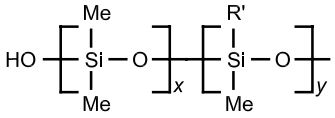
EXAMPLE 1



EXAMPLE 2



EXAMPLE 3



where

Vi is $-CH=CH_2$,

Me is $-CH_3$

both R and R′ are methyl, phenyl, fluoro or other suitable organic groups.

NOTE The definition of the polymer and its substituted groups is taken very broadly, as it is not the function of this International Standard to limit the number or the type of substituent groups present; however, for the purposes of this International Standard the definition only relates to materials with available preclinical biocompatibility data (see clause 5) and a well-established history of safe international use in implant applications.

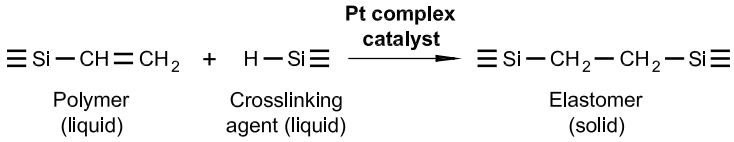
3.10
supplier
company who manufactures and/or supplies the two-part silicone elastomer used for the production of the medical device in question

3.11
treating agent
monomer, oligomer or polymer used to coat the outer surface of silica to reduce the reactivity of the silica

3.12
two-part addition-cure silicone elastomer
elastomer formed by crosslinking silicone polymer chains via an addition reaction between the vinyl functional groups of a vinyl silicone polymer and the silicon hydride of a crosslinking agent containing SiH functions

NOTE The reaction requires the presence of a catalyst, usually an organometallic complex of platinum.

EXAMPLE



where ≡ represents the remaining valencies of the Si

4 Formulation

4.1 Composition

The defined raw materials shall be used in a formulation as defined in Table 1.

Table 1 — General formulation for two-part addition-cure silicone elastomers

Compound	Percentage range (% mass fraction)
Silicone polymer	60 to 80
Reinforcing agent	less than 40
Crosslinking agent	1 to 5
Catalyst	< 0,5
Inhibitor	< 1,0

4.2 Raw materials assessment

Both during product development and on an audit basis (at least once a year or every tenth production lot), the supplier of the two-part addition-cure elastomer shall assess the raw materials (see 3.8) as follows.

a) Structure and functionality of polymer

The structure and functionality of the polymer(s) used shall be determined by a suitable method such as nuclear magnetic resonance spectroscopic analysis (see [2] for further information).

b) Purity of silica

The purity of the silica used shall be assessed by elemental analysis or any other suitable method, and the result should be expressed as (mg Si obtained/theoretical mass) × 100 = % mass fraction Si.

c) Structure and purity of treating agent(s)

The structure and purity of the treating agent(s) used shall be determined by a suitable method such as infrared spectroscopy (see [2] for further information).

d) Structure of the crosslinking agent(s)

The structure of the crosslinking agent(s) used shall be determined by a suitable method such as infrared spectroscopy (see [2] for further information).

e) Purity of the inhibitor

The purity of the inhibitor used shall be determined based on an appropriate analysis and shall be greater than 95 % mass fraction (see [2] for further information).

f) Structure of the inhibitor

The structure of the inhibitor used shall be determined by a suitable method such as infrared spectroscopy (see [2] for further information).

5 Biocompatibility

The biological and physical properties of the cured silicone elastomer depend largely on the formulation as contained in the two-part starting material. Processing conditions to produce silicone parts (extrusion or molding) can also impact biological and physical properties. The validation and consistency of production should be part of the quality system of the supplier. In order to ensure consistent final product properties, the manufacturer should ensure that the supplier has installed measures to control for processing and formulation parameters in accordance with ISO 9001, ISO 14969 and good manufacturing practice. In addition, process validation should include a biological assessment, since production could introduce contaminants, and the functionalities incorporated into silicone elastomers can impart biological activity.

Demonstration of biocompatibility shall be established in accordance with ISO 10993-1. Testing should be carried out at the time of material qualification and then repeated at least every 5 years to 10 years.

6 Characterization and testing

6.1 Test slab preparation

A test slab with a thickness of $(2 \pm 0{,}2)$ mm shall be prepared in accordance with ISO 34-1 and with the recommended cure schedule as well as the post-cure schedule if needed.

6.2 Identification

To analyse the cured elastomer as a silicone, the following test shall be performed on at least an audit basis: examine a slab of elastomer by infrared absorption spectrophotometry, recording the spectrum by the multiple reflection method for solids. There should be absorption maxima at approximately $(2\,962 \pm 5)\ cm^{-1}$, $(2\,906 \pm 5)\ cm^{-1}$, $(1\,260 \pm 5)\ cm^{-1}$ and $(1\,094 \pm 5)\ cm^{-1}$ to $(1\,022 \pm 5)\ cm^{-1}$.

6.3 Purity testing

6.3.1 Metal contamination

Each production lot of two-part addition-cure silicone elastomer shall be tested for metal contamination. The cured elastomer shall be tested and comply with the following specification on metal impurities. If one of these metals comprises part of a formulation component (for example $BaSO_4$), it shall not be tested as an impurity.

— Al $\leqslant 200 \times 10^{-6}$

— P, Ti, Fe $\leqslant 50 \times 10^{-6}$