



American National Standard/
American Dental Association
Standard No. 139

Dental Base Polymers

Modified adoption of ISO 20795-1:2008, *Dentistry — Base polymers - Part 1: Denture base polymers*; ISO 20795-1:2008, *Technical Corrigendum (2009)*; and ISO 20795-2:2010, *Dentistry – Base polymers - Part 2: Orthodontic base polymers*

ADA American
Dental
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Council on
Scientific Affairs

2012

AMERICAN NATIONAL STANDARD/AMERICAN DENTAL ASSOCIATION STANDARD NO. 139 FOR DENTAL BASE POLYMERS

The Council on Scientific Affairs of the American Dental Association has approved American Dental Association Standard No. 139 for Dental Base Polymers. This and other standards for dental materials, instruments and equipment are being formulated by working groups of the ADA Standards Committee on Dental Products (formerly Accredited Standards Committee MD156 for Dental Materials, Instruments and Equipment). The Committee has representation from all interests in the United States in the standardization of materials, instruments and equipment in dentistry. The Council has adopted the standards, showing professional recognition of their usefulness in dentistry, and has forwarded them to the American National Standards Institute with a recommendation that the standards be approved as American National Standards. The American National Standards Institute granted approval of ADA Standard No. 139 as an American National Standard on June 6, 2012.

The ADA Standards Committee on Dental Products thanks the members of Working Group 2.15 on Denture Base Resin and Resilient Liners and the organizations with which they were affiliated at the time the standard was developed:

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AMERICAN NATIONAL STANDARD/AMERICAN DENTAL ASSOCIATION STANDARD NO. 139 FOR DENTAL BASE POLYMERS**FOREWORD**

(This Foreword does not form a part of the ANSI/ADA Standard No. 139 for Dental Base Polymers).

This standard is an adoption of ISO 20795-1:2008, Dentistry – Base polymers – Part 1: Denture base polymers; and ISO 20795-2:2010, Dentistry – Base polymers – Part 2: Orthodontic base polymers. ADA SCDP Working Group 2.15 on Denture Base Resin and Resilient Liners examined the international standards and found them acceptable as a modified adoption for ANSI/ADA Standard No. 139.

ANSI/ADA Standard No. 139 incorporates ISO 20795-1:2008, Technical Corrigendum 1. The corrections contained therein are the only modifications made to ISO 20795-1:2008 and ISO 20795-2:2010 beyond combining them to form ANSI/ADA Standard No. 139. This standard is presented in two parts: 1). Denture-base polymers; and 2). Orthodontic-base polymers.

ANSI/ADA Standard No. 139 replaces ANSI/ADA Standard No. 12-2002, Denture Base Polymers.

Specific qualitative and quantitative requirements for freedom from biological hazard are not included in this standard. In assessing possible biological or toxicological hazards, reference should be made to ANSI/ADA Standard No. 41, ISO 7405 and ISO 10993-1.

AMERICAN NATIONAL STANDARD/AMERICAN DENTAL ASSOCIATION STANDARD NO. 139 FOR DENTAL BASE POLYMERS

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PART 1:

DENTURE BASE POLYMERS

1 SCOPE

1.1 This part of ANSI/ADA Standard No. 139 classifies denture base polymers and copolymers and specifies their requirements. It also specifies the test methods to be used in determining compliance with these requirements. It further specifies requirements with respect to packaging and marking the products and to the instructions to be supplied for use of these materials. Furthermore it applies to denture base polymers for which the manufacturer claims that the material has improved impact resistance. It also specifies the respective requirement and the test method to be used.

1.2 Although this part of ANSI/ADA Standard No. 139 does not require manufacturers to declare details of the composition, attention is drawn to the fact that some national or international authorities require such details to be provided.

1.3 This part of ANSI/ADA Standard No. 139 applies to denture base polymers such as those listed below:

- a) poly(acrylic acid esters);
- b) poly(substituted acrylic acid esters);
- c) poly(vinyl esters);
- d) polystyrene;
- e) rubber modified poly(methacrylic acid esters);
- f) polycarbonates;
- g) polysulfones;
- h) poly(dimethacrylic acid esters);
- i) polyacetals (polyoxymethylene);
- j) copolymers or mixtures of the polymers listed in a) to i).

2 NORMATIVE REFERENCES

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

ISO 463:2006, *Geometrical Product Standards (GPS) — Dimensional measuring equipment — Design and metrological characteristics of mechanical dial gauges*

ISO 1942, *Dentistry — Vocabulary*

ISO 3696, *Water for analytical laboratory use — Standard and test methods*

ISO 8601, *Data elements and interchange formats — Information interchange — Representation of dates and times*



Documents

Document Sharing Hub

ANSI/ADA Standard No. 15 — *Artificial teeth for dental prostheses*

ANSI/ADA Standard No. 80 — *Determination of color stability*

(ANSI/ADA standards and ISO standards for dentistry are available from the American Dental Association, Department of Standards, 211 E. Chicago Ave., Chicago, IL 60611 or <http://catalog.ada.org>. Other ISO standards are available from the American National Standards Institute, 25 W. 43rd St., New York, NY 10036 or www.ansi.org).

3 TERMS AND DEFINITIONS

For the purposes of this document the terms and definitions given in ISO 1942 and the following apply.

3.1

autopolymerizable materials

products having polymerization initiated by chemical means and not requiring application of temperatures above 65 °C to complete the polymerization

3.2

capsulated material

material consisting of two or more components supplied in a container that keeps them separated until the time they are mixed together and dispensed for use directly from the container

3.3

denture

artificial substitute for missing natural teeth and adjacent tissues, to also include any additions needed for optimum function

3.4

denture base

that part of a denture which rests on soft tissue foundations and to which artificial teeth are added

3.5

heat-polymerizable materials

products requiring application of temperatures above 65 °C to complete polymerization

3.6

immediate container

container that is in direct contact with the denture base materials

3.7

liquid

monomeric liquid to be mixed with polymeric particles to form a moldable dough or fluid resin mixture used for forming denture bases

3.8

powder

polymeric particles to be mixed with monomeric liquid to form a moldable dough or fluid resin mixture used for forming denture bases

3.9

outer packaging

labelled container or wrapping within which other containers are packed

3.10

packing

⟨of a denture⟩ act of filling a denture base mold with a material (using a compression, pour or injection technique) to form a denture base

3.11**initial packing time**

time after mixing, or other preparation, when a denture base material mixture first reaches packing consistency

3.12**final packing time**

last time, after achievement of the initial packing time, at which a denture base material mixture retains packing consistency

3.13**processing**

procedure of preparing a solid denture base polymer plate and/or specimen by polymerization or injection molding

3.14**thermoplastic, adj**

characteristic of a hard polymeric material that allows it to be softened by application of heat to make it moldable, and then return to the hardened state upon cooling

3.15**translucency**

capacity of a body of material to allow the passage of light, yet diffusing the light so as not to render objects lying beyond the body clearly visible

4 CLASSIFICATION

Denture base polymers covered by this part of ANSI/ADA Standard No. 139 are categorized into the following types and classes:

- Type 1: Heat-polymerizable materials
 - Class 1: Powder and liquid
 - Class 2: Plastic cake
- Type 2: Autopolymerizable Materials
 - Class 1: Powder and liquid
 - Class 2: Powder and liquid for pour-type resins
- Type 3: Thermoplastic blank or powder
- Type 4: Light-activated materials
- Type 5: Microwave cured materials

5 REQUIREMENTS**5.1 Unpolymerized material****5.1.1 Liquid component****5.1.1.1 General**

The liquid shall consist essentially of monomeric material compatible with the powder.

5.1.1.2 Homogeneity

The liquid shall be free of deposit or sediment that can be observed by visual inspection (see 8.1.1).

5.1.2 Solid components

The solid or semi-solid components shall be free of extraneous material that can be observed by visual inspection (see 8.1.1).

5.1.3 Packing plasticity

When Type 1 Class 1 and Type 2 Class 1 materials are tested in accordance with 8.2, at the initial packing time recommended by the manufacturer, they shall be capable of being intruded into at least two holes in the die (8.2.2.1) to a depth of not less than 0.5 mm (see 8.2.4.2). Type 1 Class 1, Type 1 Class 2, and Type 5 materials shall meet the requirements when tested at the final packing time (see 8.2.4.3).

5.2 Polymerized material

5.2.1 Biocompatibility

Specific qualitative requirements for freedom from biological hazard are not included in this part of ANSI/ADA Standard No. 139, but it is recommended that, in assessing possible biological or toxicological hazards, reference be made to ANSI/ADA Standard No. 41, ISO 10993-1 and ISO 7405.

5.2.2 Surface characteristics

5.2.2.1 When processed in the manner recommended by the manufacturer and in contact with materials recommended by the manufacturer, denture base specimens prepared in accordance with 8.4.3, 8.8.2.2 and 8.9.3 shall have a smooth, hard and glossy surface (see 8.1.1).

5.2.2.2 The specimens for color stability, the specimens for residual methyl methacrylate monomer and the specimens for sorption and solubility testing shall retain their form without visible distortion after processing (see 8.1.1).

5.2.2.3 When polished in accordance with 8.5.1.4, the specimen plates shall present a smooth surface with a high gloss (see 8.1.1).

5.2.3 Shape capability

When prepared in accordance with the manufacturer's instructions, all types of denture base polymers shall produce a test specimen plate (8.5.1.4) with defined edges after deflasking (see 8.5.1.4).

5.2.4 Color

The color of a specimen strip shall be as stated by the manufacturer when tested in accordance with 8.3 and inspected in accordance with 8.1.1.

The manufacturer shall provide a shade guide on request.

Colored denture base polymers shall be translucent (see 5.2.6 and 8.5.2) and pigment and fibres shall be evenly distributed.

Clear (transparent) denture base polymers shall be clear and colorless.

5.2.5 Color stability

When tested in accordance with 8.4 and inspected in accordance with 8.1.1, test specimens shall not show more than a slight change in color.

5.2.6 Translucency

When tested in accordance with 8.5.2.3 the shadow of the illuminated opaque disc shall be visible from the opposite side of the test specimen plate.

5.2.7 Freedom from porosity

When prepared in accordance with 8.5.3.3, a specimen's strips shall not show voids that can be observed by visual inspection (see 8.1.1).

5.2.8 Ultimate flexural strength

When determined in accordance with 8.5.3.5, the ultimate flexural strength shall be not less than 65 MPa for Type 1, Type 3, Type 4 and Type 5 polymers and not less than 60 MPa for Type 2 polymers (see Table 1).

5.2.9 Flexural modulus

When determined in accordance with 8.5.3.5, the flexural modulus of the processed polymer shall be at least 2 000 MPa for Type 1, Type 3, Type 4 and Type 5 polymers and at least 1 500 MPa for Type 2 polymers (see Table 1).

5.2.10 Maximum stress intensity factor for materials with improved impact resistance

Where a manufacturer claims a material with improved impact resistance, the maximum stress intensity factor shall be at least $1.9 \text{ MPa m}^{1/2}$ when tested in accordance with 8.6 (see Table 2).

5.2.11 Total fracture work

Where a manufacturer claims a material with improved impact resistance, the total fracture work shall be at least 900 J/m^2 when tested in accordance with 8.6 (see Table 2).

5.2.12 Bonding to synthetic polymer teeth

Denture base polymers intended for use with synthetic polymer teeth shall meet one of the following requirements.

- a) The polymer shall, when tested in accordance with 8.7, be capable of bonding to polymer teeth complying with the bonding requirements of ISO 22112.
- b) If there are problems of achieving bonding, the manufacturer's instructions shall contain information about special treatments necessary to achieve bonding [see 9.3 k)].

5.2.13 Residual methyl methacrylate monomer

When prepared and tested in accordance with 8.8 the following shall apply (see Table 1).

The upper limit (maximum) for residual methyl methacrylate is 2.2 % mass fraction for denture base polymers of Type 1, Type 3, Type 4 and Type 5.

The upper limit (maximum) for residual methyl methacrylate is 4.5 % mass fraction for denture base polymers of Type 2.

If lower percentages of residual methyl methacrylate monomer are claimed by the manufacturer [see 9.3 m)], the content shall not be more than 0.2 % mass fraction higher than that stated by the manufacturer.

5.2.14 Sorption

When the processed polymer is tested in accordance with 8.9, the increase in mass per volume (water sorption) shall not exceed $32 \text{ } \mu\text{g/mm}^3$ (see Table 1).

5.2.15 Solubility

When the processed polymer is tested in accordance with 8.9, the loss in mass (soluble matter) per volume shall not exceed $1.6 \mu\text{g}/\text{mm}^3$ for Type 1, Type 3, Type 4 and Type 5 polymers, and shall not exceed $8.0 \mu\text{g}/\text{mm}^3$ for Type 2 polymers (see Table 1).

Table 1 — Summary of requirements described in 5.2.8, 5.2.9, 5.2.13, 5.2.14 and 5.2.15

Requirements	Flexural properties		Residual methyl methacrylate monomer Percent mass fraction max.	Sorption w_{sp} $\mu\text{g}/\text{mm}^3$ max.	Solubility w_{sl} $\mu\text{g}/\text{mm}^3$ max.
	Ultimate flexural strength σ MPa min.	Flexural modulus E MPa min.			
Types 1, 3, 4, 5	65	2 000	2.2	32	1.6
Type 2	60	1 500	4.5	32	8.0

Table 2 — Additional requirements for materials with improved impact resistance described in 5.2.10 and 5.2.11

Requirements	Fracture toughness	
	Maximum stress intensity factor K_{max} MPa $\text{m}^{1/2}$ min.	Total fracture work W_f J/m ² min.
Materials with improved impact resistance	1.9	900

6 SAMPLING

The test sample shall consist of a retail package or packages, containing sufficient material to carry out the specified tests, plus an allowance for any necessary repetition of the tests. If more than one package is required, all material shall be of the same batch.

7 PREPARATION OF TEST SPECIMENS

7.1 Laboratory environment

Prepare and test specimens at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \%$ relative humidity, unless otherwise specified in this part of ANSI/ADA Standard No. 139 or in the manufacturer's instructions.

7.2 Procedures

Prepare, manipulate and process materials for making the specimens using the equipment and procedures recommended in the manufacturer's instructions (see 9.3), unless otherwise specified in this International Standard.

From materials requiring a mixture of two or more ingredients, prepare separate mixes for each specimen or specimen plate.

7.3 Special equipment

Any special equipment specified by the manufacturer for processing a material shall be made available by the manufacturer.

8 TEST METHODS

8.1 Inspection for compliance determination

8.1.1 Visual inspection

Observe the test samples by visual inspection to determine compliance with the requirements laid down in 5.1.1.2, 5.1.2, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7 and Clause 9. [Inspect for color (5.2.4) and color stability (5.2.5) in accordance with ISO 7491].

8.1.2 Expression of results

Report whether the liquid components pass or fail (see 5.1.1.2).

Report whether the solid components pass or fail (see 5.1.2).

Report whether the surfaces of the denture base specimens have a smooth, hard and glossy surface (see 5.2.2.1), and whether the specimens pass or fail.

Report whether the form of specimens is retained without distortion and whether the specimens pass or fail (see 5.2.2.2).

Report whether the specimen plates have a smooth surface with a high gloss after polishing, and whether the specimen plate passes or fails (see 5.2.2.3).

Report whether the specimen plate has defined edges, and whether the specimen plate passes or fails (see 5.2.3).

Report whether the material passes or fails the requirements for labelling, marking, packaging and instructions (see Clause 9).

8.2 Packing plasticity

8.2.1 Materials

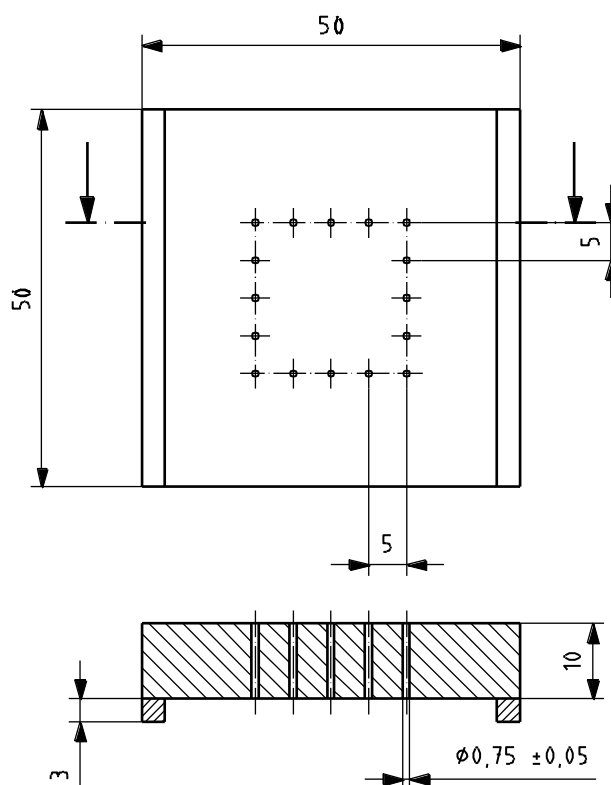
8.2.1.1 Polyethylene or polyester film, 0.035 mm to 0.050 mm thick and approximately 50 mm × 50 mm.

8.2.1.2 Glass plate, (60 ± 5) mm × (60 ± 5) mm × (5 ± 1) mm.

8.2.2 Apparatus

8.2.2.1 Perforated brass die, having the dimensions shown in Figure 1, with perforations having a diameter of (0.75 ± 0.05) mm.

Dimensions in millimeters



Dimensional tolerances not specified shall be ± 1 mm.

Figure 1 — Perforated brass die for packing plasticity test

8.2.2.2 Weight, capable of exerting a force of (50 ± 1) N.

8.2.2.3 Dial gauge, complying with ISO 463, or linear gauge accurate to 0.01 mm, equipped with a probe capable of entering holes in the brass die for measuring depth of penetration of the material into the die.

8.2.3 Test conditions

Maintain the perforated brass die (8.2.2.1) and glass plate (8.2.1.2) at conditions specified in 7.1, except where otherwise specified by the manufacturer.

8.2.4 Procedure

8.2.4.1 General

The materials are tested at the times following mixing as shown in Table 3. See 3.11 and 3.12 for packing time definitions.

Table 3 — Testing procedure

	Type 1 Class 1	Type 1 Class 2	Type 2 Class 1	Type 2 Class 2	Type 3	Type 5
Initial packing time	×	—	×	—	—	—
Final packing time	×	×	—	—	—	×

8.2.4.2 Initial packing time for Type 1 Class 1 and Type 2 Class 1

Prepare a sample of the material having a mass of 16 g to 20 g. Immediately prior to the recommended initial packing time [see 9.3 e)], immediately shape one-half of the sample into a cake approximately

5 mm thick, place it on the upper surface of the brass die (8.2.2.1) and cover it with a plastic film (8.2.1.1). At the recommended initial packing time, place the glass plate (8.2.1.2) and the weight (8.2.2.2) on the plastic-covered resin cake. After $10 \text{ min} \pm 30 \text{ s}$, remove the weight. When the material is firm, introduce the measuring instrument probe (8.2.2.3) into each hole from the other side of the brass die, to contact the penetrating material to determine the unpenetrated depth in the hole.

Calculate the depth of penetration for each hole according to the following formula:

$$D_P = d - d'$$

where

D_P is the depth of penetration, in millimeters;

d is the thickness of the brass die, in millimeters;

d' is the depth not penetrated, in millimeters.

8.2.4.3 Final packing time for Type 1 Class 1, Type 1 Class 2 and Type 5

Immediately before the final packing time [see 9.3 e)] recommended by the manufacturer, immediately shape the second half of the sample into a cake and test this portion in accordance with 8.2.4.2.

8.2.5 Pass/fail determinations

If the first sample fails to comply with the requirement stated in 5.1.3 test two additional samples. If the second and third samples comply with the requirement, the product passes.

8.2.6 Expression of results

Report the number of holes penetrated to a depth of not less than 0.5 mm by each sample and whether the material passes or fails.

8.3 Color

8.3.1 General

Compare a specimen strip prepared in accordance with 8.5.3.3, and inspected in accordance with 8.1.1, with the shade guide, for compliance with 5.2.4.

8.3.2 Expression of results

Report whether the material passes or fails in accordance with ISO 7491.

8.4 Color stability

8.4.1 Materials

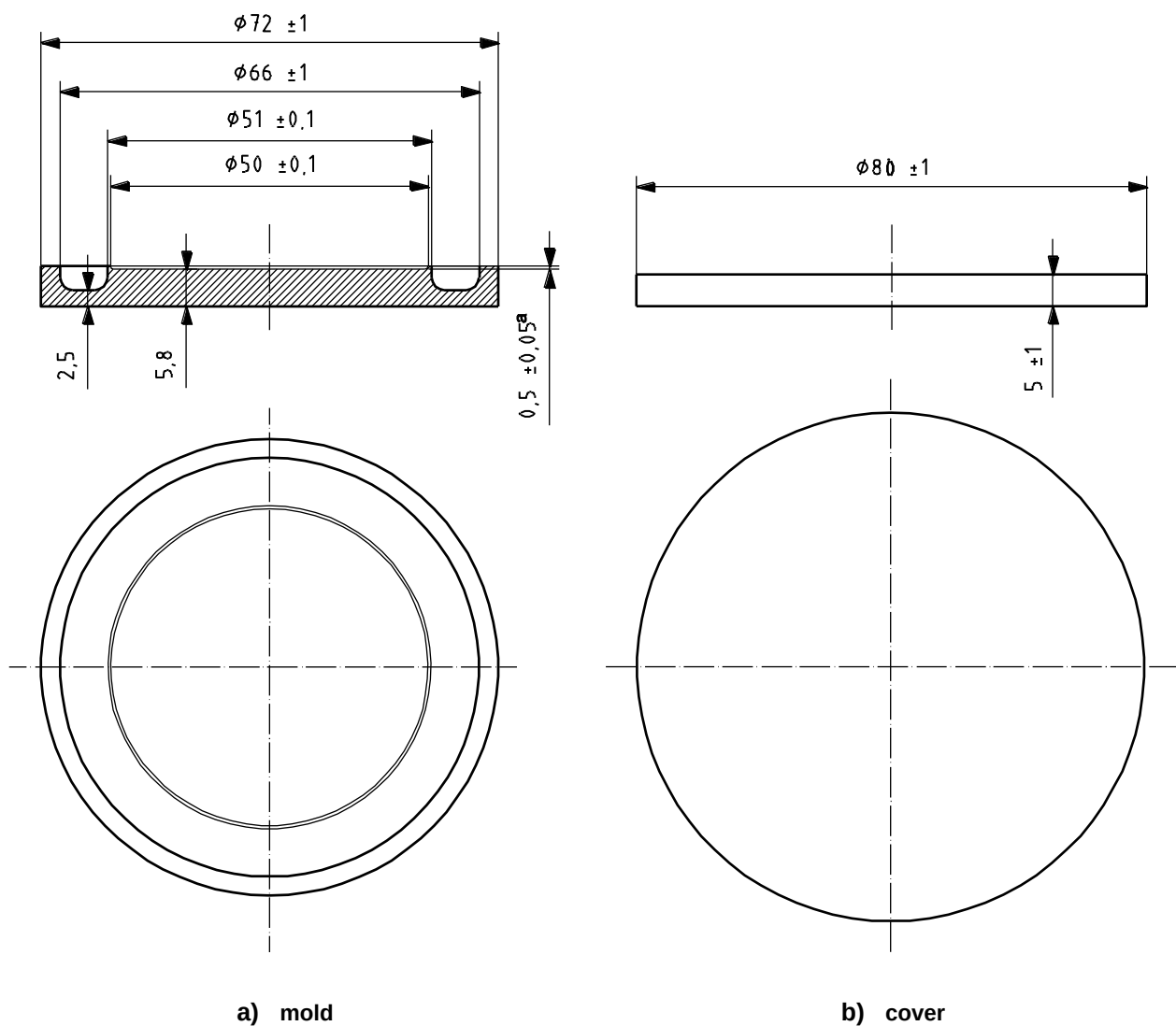
8.4.1.1 Sheet of polyester film, having a thickness of $(50 \pm 25) \mu\text{m}$ to cover the steel mold (8.4.2.1).

8.4.1.2 Aluminum foil.

8.4.2 Apparatus

8.4.2.1 Circular stainless steel mold and cover (for Type 1 and Type 2 Class 1 materials), having the dimensions shown in Figure 2, mounted in gypsum in separate halves of a denture flask.

Dimensions in millimeters



^a mold depth to form specimen

Dimensional tolerances not specified shall be ± 0.2 mm

Figure 2 — Stainless steel mold and cover for specimen preparation of color stability sorption and solubility (see 8.4 and 8.9)

8.4.2.2 Molds and/or equipment (for Type 2 Class 2, Type 3, Type 4, Type 5 and capsulated materials) recommended by the manufacturer to produce specimens with the dimensions specified in 8.4.3.

8.4.2.3 Hydraulic or hand press and clamp, where applicable.

8.4.2.4 Water bath, capable of maintaining constant temperatures, where applicable.

8.4.2.5 Micrometer screw gauge or dial calliper, accurate to 0.01 mm and fitted with parallel anvils.

8.4.2.6 Oven, capable of being maintained at $(37 \pm 1) ^\circ\text{C}$.

8.4.2.7 Radiation source and test chamber, see 3.1.1 and 3.1.3 of ISO 7491:2000.

8.4.3 Preparation of test specimens

8.4.3.1 Type 1 and Type 2 Class 1 materials

Make two specimens from separate mixes. Mix the resin and pack the mixture into the mold (8.4.2.1) with the polyester film (8.4.1.1) against the steel cover of the mold. Process the mixture in accordance with the manufacturer's instructions (see 9.3), but retain the polyester film during the processing cycle.

Check with a micrometer or dial calliper (8.4.2.5) to ensure that each specimen has a diameter of (50 ± 1) mm and a thickness of (0.5 ± 0.1) mm and that the top and bottom surfaces are flat.

8.4.3.2 Type 2 Class 2, Type 3, Type 4, Type 5 and capsulated materials

Prepare the specimens as described by the manufacturer.

Check with a micrometer or dial calliper (8.4.2.5) to ensure that each specimen has a diameter of (50 ± 1) mm and a thickness of (0.5 ± 0.1) mm and that the top and bottom surfaces are flat.

8.4.4 Procedure

Store the two specimens in the oven (8.4.2.6) for $24 \text{ h} \pm 30 \text{ min}$ at $(37 \pm 1) ^\circ\text{C}$. Then store one specimen in the dark in a laboratory environment (see 7.1) until the color comparison test is made.

Cover half of the second specimen with aluminum foil (8.4.1.2) and transfer it to the radiation source and test chamber (8.4.2.7). Immerse the specimen in water at $(37 \pm 5) ^\circ\text{C}$ when exposed to the radiation for $24 \text{ h} \pm 30 \text{ min}$ in accordance with ISO 7491. After exposure, remove the aluminum foil before color comparison of the specimens including the unexposed specimen.

Carry out the color comparison in accordance with the requirements specified in 5.2.5 and in accordance with the procedure for color comparison laid down in ISO 7491.

For Type 4 materials, store the exposed specimen in a laboratory environment (see 7.1) for $6 \text{ d} \pm 2 \text{ h}$ until the color comparison test is made.

8.4.5 Expression of results

Report whether the material passes or fails in accordance with ISO 7491 and 5.2.5.

8.5 Polishability, translucency, freedom from porosity, ultimate flexural strength and flexural modulus

8.5.1 Polishability

8.5.1.1 Materials

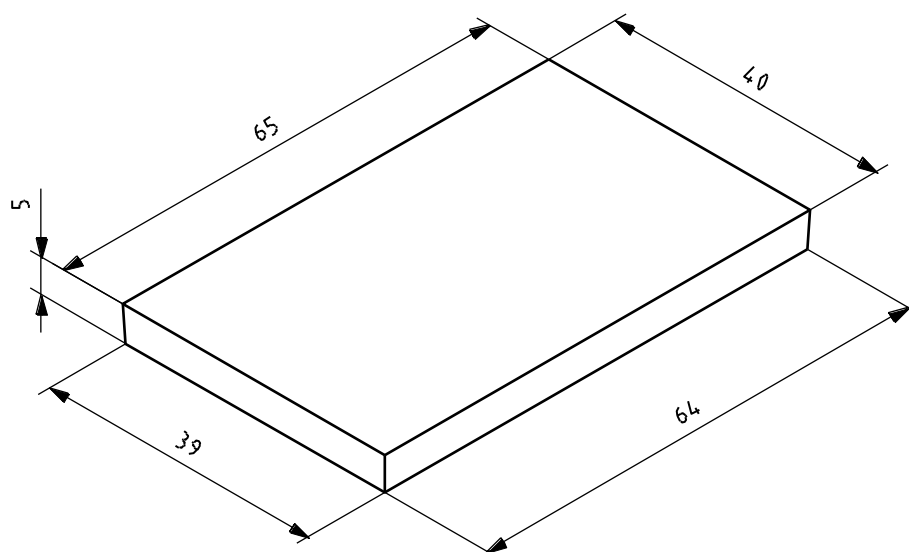
8.5.1.1.1 Polishing compound.

8.5.1.1.2 Wet pumice, having a grain size of approximately $10 \mu\text{m}$ to $20 \mu\text{m}$.

8.5.1.2 Apparatus

8.5.1.2.1 Model of the specimen plate, in metal or polymer (see Figure 3).

Dimensions in millimeters



Dimensional tolerances shall be ± 1 mm.

Figure 3 — Model of the specimen plate

8.5.1.2.2 Denture flask, capable of accommodating the test specimen plate so that the corners are not less than 5 mm from the walls of the flask.

8.5.1.2.3 Equipment for processing the resin, including gypsum or hydrocolloid investment system [see 9.3 f)].

8.5.1.2.4 Standard metallographic grinding paper, with a grain size of approximately $30\ \mu\text{m}$ (P500).

NOTE See ISO 6344-1.

8.5.1.2.5 Muslin wheel, with 16 to 36 ply having a diameter of 70 mm to 95 mm and at least 10 mm between the periphery and the stitching or other reinforcement.

8.5.1.2.6 Unstitched muslin wheel, with 16 to 36 ply having a diameter of 70 mm to 95 mm.

8.5.1.3 Preparation of the mold

For Type 1 and Type 2 Class 1 polymers, invest the model of the specimen plate (8.5.1.2.1) in the denture flask (8.5.1.2.2) in accordance with the manufacturer's instructions. Prepare the mold for Type 2 Class 2, Type 3, Type 4, Type 5 and capsulated materials in accordance with the manufacturer's instructions.

8.5.1.4 Procedure

Form and process, according to the manufacturer's instructions, two specimen plates each from a separate mix. Use the material (8.5.1.1), the apparatus (8.5.1.2) and the mold (8.5.1.3). Grind and polish the surfaces of the specimen plates for no longer than 1 min with pumice (8.5.1.1.2) and with a wet muslin wheel (8.5.1.2.5) at a circumferential speed of (650 ± 350) m/min.

NOTE A wheel with a diameter of 70 mm rotating at $1\ 500\ \text{min}^{-1}$ will have a circumferential speed of 329 m/min and a 100 mm wheel rotating at $3\ 500\ \text{min}^{-1}$ will have a circumferential speed of 1 100 m/min.

Thereafter polish with an unstitched muslin wheel (8.5.1.2.6) using a polishing compound (8.5.1.1.1).

After polishing and cleaning, examine the polished surfaces for compliance with 5.2.2.3.

8.5.1.5 Pass/fail determination

If both specimen plates comply with 5.2.2.3, the material passes.

If both specimen plates fail to comply with 5.2.2.3, the material fails.

If only one of the specimen plates complies, prepare and evaluate three new plates. The material passes only if all three new plates comply.

8.5.1.6 Expression of results

Report the number of specimen plates evaluated, the number complying and whether the material passes.

8.5.2 Translucency

8.5.2.1 Materials

8.5.2.1.1 **Two specimen plates**, prepared and tested according to 8.5.1.

8.5.2.2 Apparatus

8.5.2.2.1 **Electrical light bulb**, frosted 40 W.

NOTE Other frosted electrical light sources of equivalent radiant excitance can be used.

8.5.2.2.2 **Opaque disc**, diameter (10 ± 1) mm and thickness (2 ± 1) mm.

8.5.2.3 Procedure

Examine each of the two specimen plates separately. Position the polished specimen plate approximately 500 mm from the light bulb (8.5.2.2.1) with the opaque disc (8.5.2.2.2) centered in between. Darken the room. View the specimen plate from the side opposite the disc location to determine whether the material complies with 5.2.6.

8.5.2.4 Pass/fail determination

If both specimen plates comply with 5.2.6, the material passes.

If both specimen plates fail, the material fails.

If only one of the specimen plates passes, prepare and evaluate three new plates. The material passes only if all three new plates comply.

8.5.2.5 Expression of results

Report the number of specimen plates evaluated, the number complying and whether the material passes.

8.5.3 Freedom from porosity, ultimate flexural strength and flexural modulus

8.5.3.1 Materials

8.5.3.1.1 **Two specimen plates**, prepared and tested in accordance with 8.5.1 and 8.5.2.

8.5.3.2 Apparatus

8.5.3.2.1 **Motorised saw**, or other cutting device for sectioning the specimen plates.

8.5.3.2.2 **Milling machine**, or other equipment for air- or water-cooled cutting so as not to generate temperatures above 30 °C during shaping of the specimens. (A machine with a milling head and a sharp carbide edge, is suitable.)

8.5.3.2.3 **Standard metallographic grinding papers**, having a grain size of approximately 30 µm (P500), 18 µm (P1 000) and 15 µm (P1 200).

NOTE See ISO 6344-1.

8.5.3.2.4 **Micrometer screw gauge and/or dial calliper**, accurate to 0.01 mm and fitted with parallel anvils.

8.5.3.2.5 Container containing water, complying with grade 3 of ISO 3696:1987, for storing the specimen strips at $(37 \pm 1)^\circ\text{C}$ for pre-test conditioning.

8.5.3.2.6 Testing machine, calibrated to provide a constant displacement rate of (5 ± 1) mm/min and equipped with instrumentation for measuring the deflection of the specimen to within 0.025 mm.

Take into account any load exerted by the deflection instrument when calibrating the machine.

8.5.3.2.7 Metal flexural test rig, consisting of a central loading plunger and two polished cylindrical supports, 3.2 mm in diameter and at least 10.5 mm long.

The supports shall be parallel to within 0.1 mm and perpendicular to the longitudinal centerline. The distance between centers of the supports shall be (50 ± 0.1) mm, and the loading plunger shall be midway between the supports to within 0.1 mm. Include means in the design, to prevent misalignment of the specimen.

8.5.3.2.8 Water bath, for maintaining the specimens wet and at a temperature of $(37 \pm 1)^\circ\text{C}$, during testing.

8.5.3.3 Procedure

Prepare six specimen strips. Cut each plate lengthways into three equal strips, 64 mm long, (10.0 ± 0.2) mm wide and (3.3 ± 0.2) mm in height. Machine the strips in a milling machine (8.5.3.2.2) on the edges and equally from both molded surfaces so that the dimensions remain slightly oversized. Take care to avoid overheating the specimen. Wet-grind all faces and edges smooth and flat with the metallographic grinding papers (8.5.3.2.3) to the required width and height. Make three measurements of the specimen height along the long axis with an accuracy of ± 0.01 mm using a micrometer, and/or dial calliper (8.5.3.2.4). The deviation between the three measurements along the long axis shall be no more than ± 0.02 mm. The specimen shall be flat and have an even height.

8.5.3.4 Freedom from porosity

8.5.3.4.1 Pass/fail determination

Prepare six test specimen strips in accordance with 8.5.3.3 and examine for compliance with 5.2.7.

The material passes only if at least five out of six specimen strips comply with the requirements given in 5.2.7.

8.5.3.4.2 Expression of results

Report the number of specimen strips complying and whether the material passes.

8.5.3.5 Ultimate flexural strength and flexural modulus

8.5.3.5.1 Procedure

Store five specimen strips [or six in the case of repetition of the test (see 8.5.3.5.2.3 and 8.5.3.5.2.4)], prepared according to 8.5.3.3 and complying with 5.2.7, in water (8.5.3.2.5) at a temperature of $(37 \pm 1)^\circ\text{C}$ for (50 ± 2) h prior to flexural testing. Take a specimen strip from water storage and immediately lay the flat surface symmetrically on the supports of the flexural test rig (8.5.3.2.7) immersed in the water bath (8.5.3.2.8). Allow the specimen to come to equilibrium with the water bath temperature.

Increase the force on the loading plunger from zero, uniformly, using a constant displacement rate of (5 ± 1) mm/min until the specimen breaks.

8.5.3.5.2 Calculation and expression of results

8.5.3.5.2.1 Ultimate flexural strength

Calculate the ultimate flexural strength, σ , in megapascals using the following equation:

$$\sigma = \frac{3Fl}{2bh^2}$$

where

F is the maximum load, in newtons, exerted on the specimen;

l is the distance, in millimeters, between the supports, accurate to $\pm 0,01$ mm;

b is the width, in millimeters, of the specimen measured immediately prior to water storage;

h is the height, in millimeters, of the specimen measured immediately prior to water storage.

8.5.3.5.2.2 Flexural modulus

Calculate the flexural modulus E , in megapascals, using the following equation:

$$E = \frac{F_1 l^3}{4bh^3d}$$

where

F_1 is the load, in newtons, at a point in the straight line portion (with the maximum slope) of the load/deflection curve;

NOTE For greater accuracy, the straight line may be extended.

d is the deflection, in millimeters, at load F_1 ;

l , b and h are as defined in 8.5.3.5.2.1.

8.5.3.5.2.3 Pass/fail determination of ultimate flexural strength

If at least four out of five specimens give results not less than 65 MPa for Type 1, Type 3, Type 4 and Type 5 polymers and not less than 60 MPa for Type 2 polymers, the material is deemed to have complied with the requirements of 5.2.8.

If at least three of the results are less than 65 MPa for Type 1, Type 3, Type 4 and Type 5 polymers and less than 60 MPa for Type 2 polymers, the material is deemed to have failed.