INTERNATIONAL STANDARD

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Dentistry — Casting investments and refractory die materials

Art dentaire — Revêtements et matériaux pour modèles réfractaires

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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15912 was prepared by Technical Committee ISO/TC 106, *Dentistry*, Subcommittee SC 2, *Prosthodontic materials*.

This first edition of ISO 15912 contains the requirements and test methods for dental casting, brazing and refractory investment and die materials. It cancels and replaces ISO 7490:2000, ISO 9694:1996, ISO 11244:1999, ISO 11245:1999 and ISO 11246:1996.

In general, this International Standard contains the same or similar requirements to those contained in the five International Standards it replaces. An exception is the requirement for setting expansion, which has been removed due to the continuing inability to find a suitably reliable and reproducible test method for all binder chemistries.

Introduction

Dental investment and other refractory materials are used for a variety of applications within the dental laboratory. Historically, standards were developed on the basis of the chemistry of the binding system used or specific type of application, resulting in five separate International Standards. This single International Standard gives the requirements and test methods for dental casting, brazing and refractory investments and refractory die materials, regardless of the nature of the binding system or the particular application.

This International Standard classifies investments into types according to their intended use and classes according to the recommended burn-out procedure.

A specific quantitative requirement for setting expansion is not included in this International Standard. However, if the setting expansion of a gypsum-bonded investment is measured, use of the procedure contained in ISO 6873:1998 should be considered. This procedure is not recommended for phosphate-bonded products.

Dentistry — Casting investments and refractory die materials

1 Scope

This International Standard is applicable to dental casting, brazing and refractory investments and refractory die materials, regardless of the nature of the binding system or the particular application.

This International Standard classifies investments into types according to their intended use and classes according to the burn-out procedure recommended by the manufacturer.

This International Standard specifies requirements for the essential physical and mechanical properties of the materials and the test methods used to determine them.

This International Standard also includes requirements for the information and instructions which accompany each package.

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 3696:1987, *Water for analytical laboratory use — Specification and test methods*

ISO 1942, *Dentistry — Vocabulary*

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

3 Terms and definitions

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

3.1
dental casting investment material
refractory filler powder and binder system which, mixed with a specified liquid, hardens to form the mould for casting dental restorations

NOTE Generally, the refractory powder consists of oxides such as silica. Depending upon its chemistry, all the components of the binder can be in the liquid, or some can be dispersed (as a powder) in the refractory powder. The liquid can be pure water or a special liquid, as required by the chemistry of the binding system.

3.2
refractory die material
powder mixture of a refractory filler and binder system designed, specifically (when mixed with a particular liquid) to allow the formation of a hardened die suitable for the production of dental ceramic restorations using the sintering technique

3.3
brazing investment material
powder mixture of a refractory filler and binder system, designed specifically (when mixed with a particular liquid) to allow the formation of a cast upon which components are held in place while they are being joined by brazing

NOTE The cast can be referred to as the model, even though this is a deprecated term.

3.4
special liquid
liquid, other than water, supplied by the manufacturer or distributor for mixing with the investment powder

3.5
slow- or step-heating method
heating method in which the burn-out furnace is initially at room temperature, then its temperature is increased to the end temperature at a programmed rate

NOTE After a time recommended by the manufacturer, the set investment is placed in the burn-out furnace, which is set at room temperature. The temperature of the furnace is then increased to the end temperature in a series of stages and at a rate recommended by the manufacturer.

3.6
quick-heating method
heating method in which the burn-out furnace is set initially at the recommended final burn-out temperature

NOTE At a time recommended by the manufacturer, the set investment is placed directly in the heated furnace. The furnace is maintained at this temperature,

4 Classification

For purposes of this International Standard, investments and refractory die materials are categorized by the following types.

— Type 1: for the construction of inlays, crowns and other fixed restorations;

— Type 2: for the construction of complete or partial dentures or other removable appliances;

— Type 3: for the construction of casts used in brazing procedures;

— Type 4: for the construction of refractory dies.

There are two classes of casting investment and refractory die material:

— Class 1: recommended for burn-out by a slow- or step-heating method;

— Class 2: recommended for burn-out by a quick-heating method.

5 Requirements

5.1 General

If a manufacturer claims that a given product is suitable for both classes, the material must satisfy the requirements for both classes.

5.2 Material consistency

When examined in accordance with 7.1, the powder shall be uniform and free from lumps and foreign matter. If a special liquid is supplied, it shall be free of sediment.

5.3 Fluidity

When measured in accordance with 7.2, the fluidity shall not vary by more than 30 % from the value stated by the manufacturer.

This requirement shall not apply to silica bonded investments (i.e. products in which an alcoholic solution of ethyl silicate is used in the binding system).

5.4 Initial setting time

When measured in accordance with 7.3, the initial setting time shall not vary by more than 30 % from that stated by the manufacturer. If the manufacturer gives a range for the initial setting time, the measured initial setting time shall not vary by more than 30 % from the mid-point of this range.

5.5 Compressive strength

When measured in accordance with 7.4, the compressive strength shall not vary by more than 30 % from that stated by the manufacturer and in no case shall be lower than 2 MPa.

5.6 Linear thermal dimensional change

When measured in accordance with 7.5, the linear thermal expansion for all four types shall not vary by more than 20 % from the value stated by the manufacturer. If the manufacturer gives a range for the linear thermal expansion, the measured linear thermal expansion shall not vary by more than 20 % from the mid-point of this range.

When measured in accordance with 7.5, the linear firing shrinkage for Type 4 shall not vary by more than 15 % from the value stated by the manufacturer. If the manufacturer gives a range for the linear firing shrinkage, the measured linear firing shrinkage shall not vary by more than 15 % from the mid-point of this range.

5.7 Setting expansion

See the Introduction for guidance on setting expansion.

6 Sampling, test conditions and mixing

6.1 Sampling

Use material from a single lot. Use only sealed, undamaged packages that are within the “use before” date.

If a special liquid is recommended by the manufacturer, use liquid from a single lot that is within the “use before” date.

6.2 Test conditions

Carry out all testing under controlled conditions of temperature (23 ± 1) °C and relative humidity (50 ± 10) % in a room free from obvious draughts.

Hold all materials and test equipment under these controlled conditions for a minimum period of 16 hours prior to testing.

6.3 Mixing

Mix according to the manufacturer's instructions. If a range is given for the powder to liquid ratio, use the midpoint of this range. When a special liquid is supplied, use at the manufacturer’s recommended dilution in accordance with 8.1 c). If a range of dilutions is given, use the mid-point of this range. If water is required, use water that complies with grade 3 in accordance with ISO 3696:1987.

6.3.1 Apparatus

The following items may be needed, depending on the manufacturer's instructions.

6.3.1.1 Clean, dry flexible **mixing bowl** and rigid **spatula** for hand mixing.

6.3.1.2 **Mechanical/vacuum mixer** with an appropriate clean and dry mixing bowl.

6.3.1.3 **Timer** capable of measuring time to an accuracy of 1 s.

6.3.2 Procedure

Measure the required mass of powder and the recommended volume of liquid to an accuracy of 1 %.

Pour the liquid into the mixing bowl (6.3.1.1) and add the powder. Commence timing when liquid and powder make first contact.

Hand spatulate (6.3.1.1) and/or mix mechanically (6.3.1.2) (with a vacuum, if specified) for the appropriate length of time, according to manufacturer's instructions. If the manufacturer recommends a range of mixing times, the mid-point of the range shall be used.

7 Test methods

7.1 Material consistency

7.1.1 Testing procedure

Examine the material, as received, visually without the aid of magnification. Use eyesight of nominally normal visual acuity. Corrective (non-magnifying) lenses may be worn.

7.1.2 Test report

Report whether the product meets or does not meet the requirement for material consistency (5.2). If it does not meet the requirement for material consistency, state the reason.

7.2 Fluidity

7.2.1 Material and apparatus

7.2.1.1 **Clean dry cylindrical ring mould**, of length (50 ± 1) mm, of inside diameter (35 ± 1) mm and constructed from a corrosion-resistant, non-absorbent material.

7.2.1.2 **Flat square glass plate**, measuring at least 150 mm × 150 mm.

7.2.1.3 **Dental vibrator**.

7.2.1.4 **Scale or rule**, graduated in millimetres.

7.2.1.5 **Mould-release agent**, such as silicone spray or silicone grease.

7.2.2 Number of specimens

Make 2 specimens from separate mixes of investment.

NOTE Three more specimens (from three mixes of investment) are required if one specimen meets the requirement of 5.4 and the other does not.

7.2.3 Testing procedure

Coat the inside of the ring mould (7.2.1.1) with a thin layer of mould release agent (7.2.1.5).

Mix the investment according to 6.3, using a mass of powder with the appropriate volume of liquid that will produce a workable mix sufficient to fill the mould. Centre the mould base on the glass plate and place the plate on the dental vibrator platform. Vibrate the investment mix into the mould until it is slightly overfilled. Vibrate for (20 ± 2) s. Level the mix flush with the top of the mould. 2 min after the first contact of powder and liquid, lift the mould vertically from the plate in a smooth action over a period of 5 s, to allow the mix to slump onto the plate. As soon as the mixed investment has set, measure the largest and smallest diameters of the set investment base, and record the average value.

Repeat the test and record this second value, the average of the two measurements made on the second specimen.

7.2.4 Evaluation of results

If both results meet the requirement of 5.3, the product complies.

If neither result meets the requirement of 5.3, the product fails to comply.

If one test result meets this requirement and one fails to do so, repeat the test three more times.

If the results of all three of these additional tests meet the requirement of 5.3, the product complies. Otherwise, it fails to comply.

7.2.5 Test report

The test report shall contain the following information:

a) the average value for every test conducted in accordance with 7.2.3 and 7.2.4;

b) the value for the fluidity given by the manufacturer in accordance with 8.3.2 a);

c) a statement that the product meets or does not meet the requirement for fluidity of 5.3.

7.3 Initial setting time

7.3.1 Material and apparatus

7.3.1.1 Needle penetrometer apparatus, an example of which is shown in Figure 1, and which meets the following requirements:

a) needle, 50 mm long, of circular cross section and with a diameter of (1,00 ± 0,01) mm;

b) rod of approximate dimensions 270 mm in length and 10 mm in diameter;

c) total mass of the needle, rod and compensating weight of (300 ± 1) g;

d) scale graduated in millimetres;

e) base plate of plate glass, measuring about 100 mm × 100 mm.

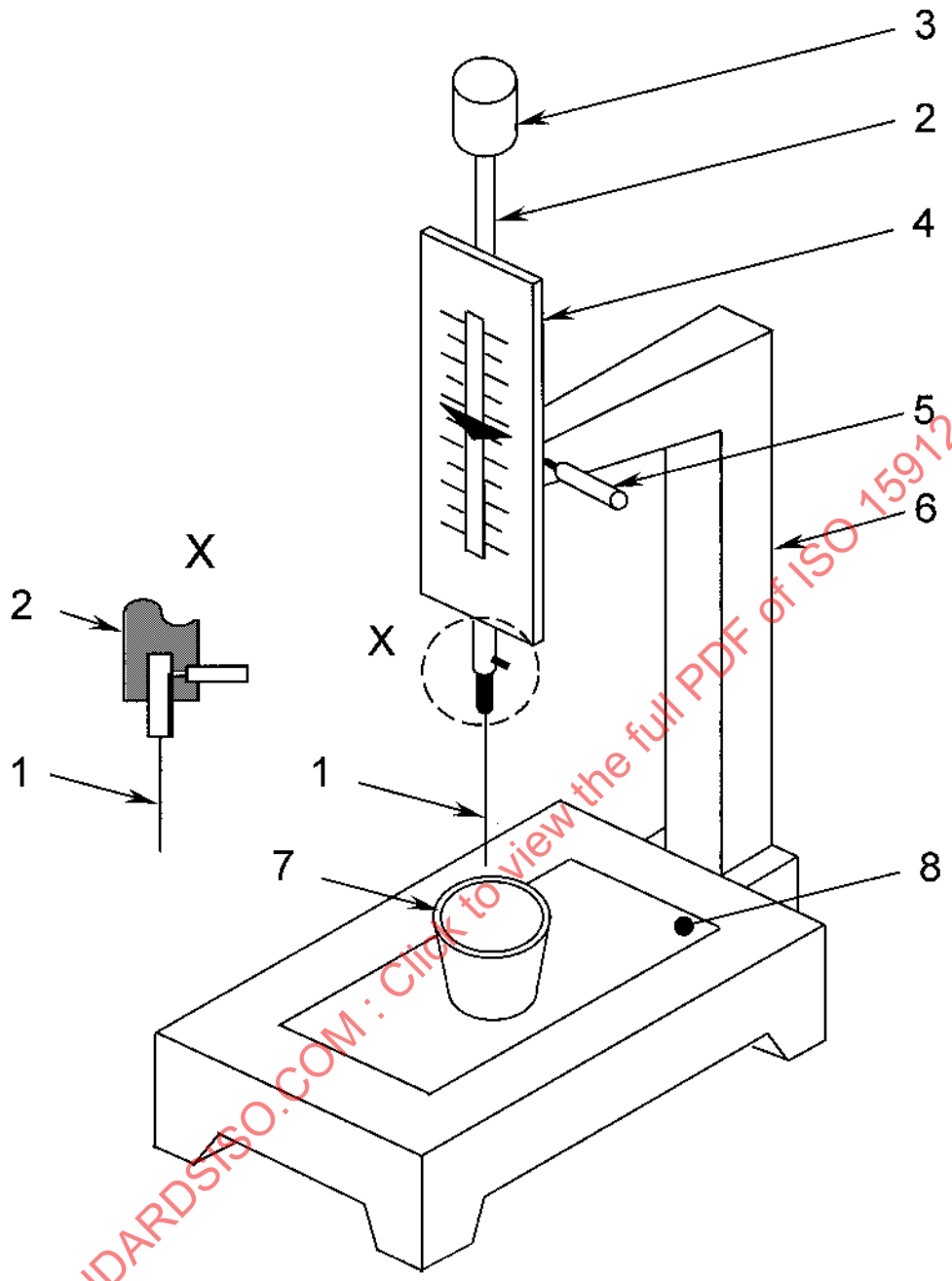
7.3.1.2 Clean, dry conical ring mould, constructed from a corrosion-resistant, non-absorbent material, with an inside diameter of 70 mm at the top and 60 mm at the base, and a height of 40 mm.

7.3.1.3 Mould release agent, such as silicone spray or silicone grease.

7.3.2 Number of specimens

Make two specimens from separate mixes of investment.

NOTE Three more specimens (from three mixes of investment) are required if one specimen meets the requirement of 5.4 and the other does not.



Key

1 needle
2 rod
3 compensating weight (to make up to 300 g)
4 scale
5 scale adjustment locking screw
6 stand
7 conical ring mould
8 base plate

Figure 1 — Example of the needle penetrometer apparatus

7.3.3 Testing procedure

Coat the inside of the ring mould with a thin layer of mould release agent and place on the base plate.

Adjust the scale of the penetrometer apparatus to read zero when the needle is in contact with the base plate. Mix the investment according to 6.3, using a mass of powder with the appropriate volume of liquid that will produce a workable mix sufficient to fill the mould. Overfill the ring mould with the mix and then level the surface. Before 50 % of the initial setting time indicated by the manufacturer elapses, lower the needle until it touches the surface and then release it gently, allowing it to sink into the mix under its own mass. Repeat this procedure at 15 s intervals, wiping the needle clean after each penetration and moving the sample at least 5 mm, so that the needle does not enter the same place twice. Avoid making any penetration closer than 5 mm to the mould walls. Record the initial setting time as the time from the start of mixing (see 6.3.2) until the moment when the needle fails to penetrate the investment to a point within 5 mm of the mould bottom.

Repeat this procedure, using a fresh mix of investment.

7.3.4 Evaluation of results

If both results meet the requirement of 5.4, the product complies.

If neither result meets this requirement, the product fails to comply.

If one result meets the requirement and one fails to do so, repeat the test three more times.

If all three of these additional results meet the requirement of 5.4, the product complies. Otherwise, it fails to comply.

7.3.5 Test report

The test report shall contain the following information:

a) the value for every test conducted in accordance with 7.3.3 and 7.3.4;

b) the initial setting time or setting-time range, given by the manufacturer in accordance with 8.3.2 b);

c) a statement that the product meets or does not meet the requirement for initial setting time (see 5.4);

7.4 Compressive strength

7.4.1 Materials and apparatus

7.4.1.1 **One or more sectional or split moulds**, to produce cylindrical specimens with a diameter of (20,0 ± 0,2) mm and a length of (40,0 ± 0,4) mm. Make the mould from a corrosion-resistant material. The ends of the mould shall be parallel to within 0,05 mm.

7.4.1.2 **One or more sectional or split mould extensions**, with a diameter of (20,0 ± 0,2) mm and a length of (20,0 ± 0,4) mm, to produce a cylindrical specimen with a diameter of (20,0 ± 0,2) mm and a length of (60,0 ± 0,4) mm, when the extension is added to the mould top surface. Make the extension from a corrosion-resistant material.

NOTE These extensions are required for silica bonded products only.

7.4.1.3 **Wax**: sticky wax and sheet moulding wax, to be used as appropriate.

7.4.1.4 **Flat glass plates**, sufficient in size and number to cover both ends of all moulds.

7.4.1.5 **Dental vibrator**.

7.4.1.6 **Compression testing machine**, adjusted to a loading rate of (5 ± 2) kN/min and capable of measuring a force to an accuracy of ± 0,5 N

7.4.1.7 **Mould release agent**, such as silicone spray or silicone grease.

7.4.1.8 **Micrometer screw gauge or similar measuring instrument**, with the capacity of measuring to an accuracy of ± 0,02 mm specimen diameters of up to 25,00 mm.

7.4.1.9 **Dental trimmer**, for use with silica bonded products.

7.4.2 Number of specimens

If a sufficient number of moulds (and if required, mould extensions) are available, more than one specimen may be made from a single mix. Prepare five specimens from at least two mixes of investment. Make a maximum of three specimens from a single mix.

NOTE A second set of five specimens will be required if three specimens meet the requirement of 5.5 and two do not.

7.4.3 Preparation of specimens

7.4.3.1 Products other than silica bonded

Coat the inside surface of each mould with a thin layer of the mould release agent. Place each mould on a glass plate.

Mix the investment according to 6.3, using a mass of powder with the appropriate volume of liquid that will produce a workable mix sufficient to fill a minimum of one mould. Slightly overfill the mould with the investment mix, while applying slight vibration using the dental vibrator. Stop vibration before the glossy surface has disappeared from the mix. As soon as the glossy surface has completely disappeared from the mix, place a second glass plate on the top of the mould and press it down until the glass contacts the mould. Remove the specimen from the mould (60 ± 5) min after the start of mixing (see 6.3.2).

7.4.3.2 Silica bonded products

Coat the inside surface of the mould and the mould extension with a thin layer of the mould release agent. Place the mould on a glass plate. Add the mould extension to the top mould surface and attach with wax.

Mix the investment according to 6.3, using a mass of powder with the appropriate volume of liquid that will produce a workable mix sufficient to fill a minimum of one mould and mould extension. Slightly overfill the mould and mould extension with the investment mix, while applying slight vibration using the dental vibrator. Stop vibration before the glossy surface has disappeared from the mix. Remove the mould extension from the mould at the initial setting time indicated by the manufacturer [see 8.3.2 b)]. Using the dental trimmer, trim down the specimen flush with the top of the mould. Use the trimming technique recommended by the manufacturer in the product information. The top surface is to be flat and parallel with the bottom surface.

Remove the specimen from the mould (60 ± 5) min after the start of mixing (see 6.3.2).

If given, follow the manufacturer's instructions on the treatment of the material following setting and prior to casting.

NOTE For example, immersion in a resin or drying in an oven are treatments that may be advised following setting.

7.4.4 Testing procedure

Prior to testing, measure the diameter, d, of each specimen to an accuracy of ± 0,02 mm. Begin the compression testing of each specimen (120 ± 5) min from the start of mixing.

If the manufacturer's instructions on the treatment of the material following setting (i.e. before it is heated to the casting temperature) include an action that leads to a time in excess of (120 + 5) min from the start of mixing before it is possible to apply the compression force, commence the compression test immediately after the treatment has been completed. Record this time.

Position each specimen between the loading platens of the compression testing machine, such that the specimen is loaded in an axial direction. Do not use padding between specimen and platen. Increase the compressive force until fracture occurs. Record the compressive force, F (in newtons), at which fracture occurs, to the nearest Newton.

7.4.5 Expression and evaluation of the results

For each specimen tested, calculate the maximum stress, σ, as follows:

$$\sigma = \frac{4F}{\pi d^2} \quad (1)$$

where

σ is the maximum stress (compressive strength) in MPa;

F is the maximum recorded force in N;

d is the diameter of the specimen in mm.

If four or five specimens meet the requirement for compressive strength (see 5.5), the product complies.

If two or fewer specimens meet the requirement for compressive strength (see 5.5), the product fails to comply.

If only three specimens meet the requirement for compressive strength (see 5.5), make a second set of five specimens.

If all the specimens in this second set meet the requirement for compressive strength, the product complies. Otherwise, the product fails to comply.

7.4.6 Test report

The test report shall contain the following information:

a) the value for every test conducted in accordance with 7.4.4 and 7.4.5;

b) if the post-setting manufacturer's recommended treatment resulted in testing at a time later than (120 + 5) minutes after the start of mixing, give the time at which the specimens were loaded to failure. Give details of procedures that caused this increased time before the application of force.

c) a statement that the product meets or does not meet the requirement for compressive strength (see 5.5).

7.5 Linear thermal dimensional change

7.5.1 Materials and apparatus

7.5.1.1 Vitreous silica dilatometer

7.5.1.1.1 General characteristics: a vitreous silica dilatometer includes a linear inductive transducer instrument or other measuring instrument that exerts a measuring force to produce a stress no greater than 10 kPa, and is capable of measuring the change in length to an accuracy of ± 0,02 % of the measuring length over the temperature range of 23 °C to 700 °C.

7.5.1.1.2 Dilatometers for use with Class 1 materials, capable of heating at a rate of (5 ± 1) °C/min over the range from 23 °C to 700 °C.

7.5.1.1.3 Dilatometers for use with Class 2 materials, capable of heating at a rate of (25 ± 5) °C/min over the range from 23 °C to 700 °C.

7.5.1.2 **Mould**, constructed from a corrosion-resistant material and capable of producing a specimen between 20 mm and 50 mm long, and of uniform cross-section.

7.5.1.3 **Mould extension**, with a cross-section shape and area identical to that of the mould and a length of (20,0 ± 0,4) mm. Make the extension from a corrosion-resistant material.

The extension is required for silica bonded products alone.

7.5.1.4 **Wax**: sticky wax and sheet moulding wax, to be used as appropriate.

7.5.1.5 **Mould release agent**, such as silicone spray or silicone grease.

7.5.1.6 **Micrometer screw gauge or similar measuring instrument**, with the capacity of measuring to an accuracy of ± 0,02 mm for specimen lengths up to 50,00 mm.

7.5.1.7 **Dental trimmer**, for use with silica bonded products.

7.5.1.8 **Burn-out oven**, for use with Type 4 products.

7.5.2 Number of specimens

Make 2 specimens from separate mixes of investment.

NOTE Three more specimens (from 3 mixes of investment) will be required if one specimen meets the requirement (5.6) and other does not.

7.5.3 Preparation of specimens

7.5.3.1 Products other than silica bonded

Coat the inside surface of each mould with a thin layer of the mould release agent. Place each mould on a glass plate.

Mix the investment according to 6.3, using a mass of powder with the appropriate volume of liquid that will produce a workable mix that will fill the mould. Slightly overfill the mould with the investment mix, while applying slight vibration using the dental vibrator. Stop vibration before the glossy surface has disappeared from the mix. As soon as the glossy surface has completely disappeared from the mix, scrape the investment material level with the top of the mould.

Before the earliest burn-out time recommended by the manufacturer, remove the specimen from the mould.

7.5.3.2 Silica bonded products

Coat the inside surface of the mould and the mould extension with a thin layer of the mould release agent. Place the mould on a glass plate.

Add the mould extension to the top mould surface and attach with wax.

Mix the investment according to 6.3, using a mass of powder with the appropriate volume of liquid that will produce a workable mix to fill the mould and extension. Slightly overfill the mould and extension with the investment mix, while applying slight vibration using the dental vibrator. Stop vibration before the glossy surface has disappeared from the mix. Remove the mould extension from the mould at the initial setting time indicated by the manufacturer [see 8.3.2 b)]. Using the dental trimmer, trim down the specimen flush with the top of the mould. Use an appropriate scraping or grinding procedure. If given, use the trimming technique recommended by the manufacturer in the product information. The top surface shall be flat and parallel with the bottom surface.

Before the earliest burn-out time recommended by the manufacturer, remove the specimen from the mould.

If given, follow the manufacturer's instructions on the treatment of the material following setting and prior to casting.

NOTE For example, immersion in a resin or drying in an oven are treatments that may be advised following setting.

7.5.4 Testing procedure

7.5.4.1 Linear thermal expansion: Types 1, 2 and 3

Measure the length of the specimen to an accuracy of ± 0,05 mm.

Place the specimen in the dilatometer. At the earliest burn-out time recommended by the manufacturer, raise the dilatometer temperature from its initial temperature (the ambient temperature of the laboratory) to 700 °C at a rate of (5 ± 1) °C/min for Class 1 materials or (25 ± 5) °C/min for Class 2 materials, recording the thermal expansion of the specimen using the recording equipment. Record the values continuously, with accuracies of ± 0,1 % of the specimen length for length and ± 5 °C for the temperature at the position of the specimen. Maintain at end temperature for 15 min, and then determine the change in length with respect to the initial length, to the nearest 0,02 %. Record this as the thermal expansion.

Repeat this procedure once, using freshly-mixed investment to make the specimen.

7.5.4.2 Linear thermal dimensional changes: Type 4

7.5.4.2.1 Linear firing shrinkage

Measure the length of the specimen to an accuracy of ± 0,05 mm.

For Class 1 materials: at the earliest burn-out time recommended by the manufacturer, place the specimen in the burn-out oven (7.5.1.8) and raise the temperature of the oven from its initial temperature (the ambient temperature of the laboratory) to the final burn-out temperature recommended by the manufacturer, at a rate of (5 ± 1) °C/min.

For Class 2 materials: follow the same procedure at a different heating rate, (25 ± 5) °C/min, or alternatively, set the burn-out oven at the recommended burn-out temperature and place the specimen directly into it.

Hold the specimen at recommended burn-out temperature for a time recommended by the manufacturer.

Cool the specimen to room temperature.

Measure the length of the specimen to an accuracy of ± 0,05 mm. Record this value. Calculate the linear firing shrinkage, as the change in length expressed as a percentage of the initial length.

Repeat this procedure once, using freshly-mixed investment to make the specimen.

7.5.4.2.2 Linear thermal expansion

Place the specimens used for 7.5.4.2.1 in the dilatometer. Raise the dilatometer temperature from its initial temperature (the ambient temperature of the laboratory) to 600 °C, at a rate of (5 ± 1) °C/min for Class 1 materials or (25 ± 5) °C/min for Class 2 materials, recording the thermal expansion of the specimen. Record the values continuously with an accuracy of ± 0,1 % of the specimen length for length and ± 5 °C for the temperature at the position of the specimen. When 600 ºC is reached, hold at this temperature for 15 min, and then determine the change in length with respect to the initial length, to the nearest 0,02 %. Record this as the thermal expansion.

NOTE As an alternative, a new specimen can be prepared, followed by firing and measurement.

7.5.5 Evaluation of results

7.5.5.1 Types 1, 2 and 3

If results from both specimens meet the requirement for linear thermal expansion (see 5.6), the product complies.

If neither result meets this requirement, the product fails to comply.