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**Grout for prestressing tendons —  
Part 3:  
Test methods**

*Coulis pour câbles de précontrainte —  
Partie 3: Méthodes d'essai*



Reference number  
ISO 14824-3:2012(E)



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## 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.

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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 14824-3 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and prestressed concrete*, Subcommittee SC 3, *Concrete production and execution of concrete structures*.

ISO 14824 consists of the following parts, under the general title *Grout for prestressing tendons*:

- *Part 1: Basic requirements*
- *Part 2: Grouting procedures*
- *Part 3: Test methods*

## Introduction

In post-tensioned prestressed concrete construction, the grouting of tendons is an important operation. The intention of this part of ISO 14824 is to provide a specification for grouting, compliance with which will satisfy the requirements in ISO 22966.

The testing regimes anticipated by this part of ISO 14824 include three levels:

- (1) initial type and audit testing in accordance with ISO 14824-1;
- (2) suitability testing for confirmation of the selected grout for a specific project in accordance with ISO 14824-2;
- (3) inspection during the production of grout on a specific project in accordance with ISO 14824-2.

The test methods for each of the regimes are given in this part of ISO 14824. Some tests given herein are alternatives and it will be necessary to relate the chosen test method to the specified requirements. The tests are reference tests for checking suitability of grout for use with any type of tensile steel element.

Where the suitability of high viscosity grouts has been proven by full scale trials, alternative appropriate test methods can be adopted provided a correlation or safe relationship with these test methods has been established.

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# Grout for prestressing tendons —

## Part 3: Test methods

### 1 Scope

This part of ISO 14824 describes the test methods for grout specified in ISO 14824-1. The test methods are applicable to grout for all types of structures, including bridges and buildings.

### 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 679, *Cement — Test methods — Determination of strength*

ISO 14824-1, *Grout for prestressing tendons — Part 1: Basic requirements*

### 3 Terms and definitions

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

#### 3.1

##### **grout**

homogeneous mixture of cement and water, which may contain admixtures and additions

### 4 Testing of grout

#### 4.1 General

##### 4.1.1 Personnel

The grouts shall be tested by competent personnel experienced in the subject.

##### 4.1.2 Test conditions

Testing shall be carried out at temperatures specified in accordance with ISO 14824-1. The temperature of constituent materials should be as recommended by the manufacturer in order to attain grout of the required temperature.

The grout for the tests shall be made from materials specified in ISO 14824-1 and mixed in accordance with ISO 14824-1.

NOTE ISO 14824-2 requires suitability testing to be carried out using the same type of mixing equipment as is used for the actual site operations, hence it is preferable to also use the same type of equipment for all testing.

##### 4.1.3 Test reports

All test reports shall include the following information as a minimum:

- a) reference to this part of ISO 14824;

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- b) name and address of the testing laboratory;
- c) identification number of the test report;
- d) name and address of the organization or person who ordered the test;
- e) name and address of the manufacturer or supplier of the product(s);
- f) name or other identification mark of the product;
- g) date of fabrication, and if relevant, supply of the product;
- h) date of manufacture of test specimens;
- i) date of test;
- j) temperature of the fresh grout and ambient temperature;
- k) batching and mixing procedures used;
- l) specification of the grout mixer used;
- m) identification of test equipment used, including, where appropriate, calibration details;
- n) individual results for the required test;
- o) any inaccuracies or uncertainty of test results;
- p) date and signature of the person responsible for the tests.

### 4.2 Sieve test

#### 4.2.1 Principle of test

The test consists of pouring a quantity of grout through a sieve to check for the absence of lumps on the sieve.

The test may be omitted where all grout used in the project automatically passes through a sieve with an aperture  $\leq 2$  mm within the supply equipment.

#### 4.2.2 Apparatus

A 150 mm diameter sieve with an aperture  $\leq 2$  mm.

#### 4.2.3 Procedure

Pour a minimum of 1 l of freshly mixed grout through the sieve.

NOTE This can be carried out while filling the fluidity test cone.

#### 4.2.4 Reporting

Report the absence of lumps on the sieve.

### 4.3 Fluidity test

Two test methods are described. Only one is to be performed as appropriate for the type or characteristics of the grout.

#### 4.3.1 Cone method

##### 4.3.1.1 Principle of test

The fluidity of grout, expressed in seconds, is measured by the time necessary for a stated quantity of grout (1 l) to pass through the orifice of the cone, under stated conditions.



#### 4.3.1.2 Apparatus

The following apparatus is required for the test:

- a) Cone of the dimensions given in Figure 1. The cone shall be of smooth non-absorbent material. The volume of the cone (excluding the cylindrical portions at top and bottom) shall be  $(1,7 \pm 0,17)$  l.
- b) Stopwatch showing time to 0,1 s.
- c) Graduated cylinder of minimum 1 l capacity and with a diameter of approximately 60 mm.
- d) Thermometer.

NOTE The cone in Figure 1 is available in plastic.

#### 4.3.1.3 Test procedure

##### 4.3.1.3.1 Preparation

Mount the cone with its axis vertical and its largest diameter uppermost and support firmly in position. During the test prevent the cone from vibrating. Place the cylinder under the cone outlet. All surfaces of the cone shall be clean and shall be dampened so that the surfaces are moist but without free water. Close the lower cone orifice.

##### 4.3.1.3.2 Procedure

Pour the grout to fill the conical section of the cone. The grout shall be poured sufficiently slowly to prevent a build-up of air. Open the lower cone orifice and at the same time start the stopwatch. Measure the time taken to the nearest 0,5 s, for 1 l of grout to run into the cylinder. The grout shall be kept agitated while waiting further testing if required.

##### 4.3.1.4 Reporting of results

Report the time measured.

Dimensions in millimetres  
Dimensions are internal

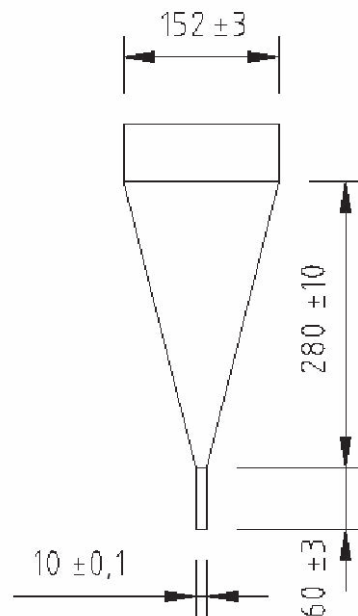


Figure 1 — Cone for fluidity test

#### 4.3.2 Grout spread method

##### 4.3.2.1 Principle of test

The grout spread test measures the fluidity of thixotropic grouts. The fluidity is measured by the diameter of the circle of grout spread on a smooth plate after a fixed period.

##### 4.3.2.2 Apparatus

The following apparatus is required for the test:

- a) Glass or polished steel plate with a minimum diameter of  $\varnothing$  300 mm.
- b) Stiff mould made of steel or plastic with an internal diameter of  $\varnothing$  39 mm and a height of 60 mm.
- c) Stopwatch showing time to 0,1 s.
- d) Thermometer.
- e) Ruler with a minimum length of 300 mm and a 1 mm graduation.

##### 4.3.2.3 Test procedure

###### 4.3.2.3.1 Preparation

The spread test is carried out on the horizontal plate. Ensure that the surfaces of the mould and plate are clean and slightly moistened. If necessary apply a thin film of petroleum jelly (e.g. Vaseline<sup>1)</sup>) to the brim of the mould in contact with the plate to prevent the mould from leaking during filling with grout.

1) Vaseline is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

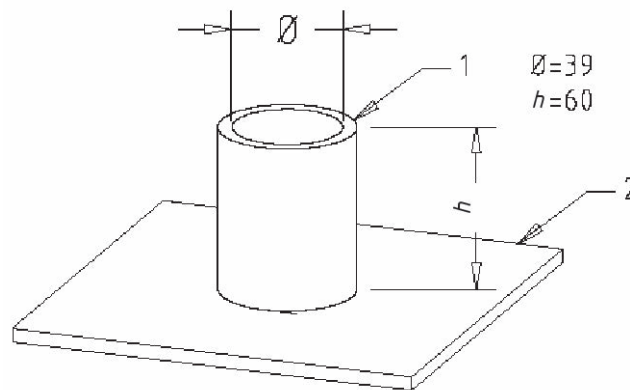
#### 4.3.2.3.2 Procedure

Put the mould on the plate and prevent it from sliding. Pour the grout slowly into the mould until the level of the grout has reached the upper brim. The mould is steadily lifted from the plate and kept above the spread for a maximum of 30 s before it is taken away. The spread is measured in two perpendicular directions at 30 s after the start of lifting the mould.

#### 4.3.2.4 Reporting of results

Report the spread diameter as the average measured in the two perpendicular directions across the grout spread in millimetres.

Dimensions in millimetres



#### Key

- 1 cylinder (steel or plastic tube)
- 2 smooth plate

**Figure 2 — Grout spread test**

### 4.4 Inclined tube test

#### 4.4.1 Principle of test

This test serves to determine the bleed properties and volume stability of grout at full scale and includes the filtering effect of strands. The test consists of measuring the quantity of water and air remaining on the surface of the grout which has been allowed to stand protected from evaporation.

**NOTE** In a first test phase, the bleed water and air accumulated on top of a tube filled with grout is determined. The grout is injected and is allowed to set so that water losses due to evaporation are prevented. In a second phase, the effect of re-grouting of a tube on bleed water and air accumulated can be determined.

#### 4.4.2 Test equipment and set-up

- a) Two transparent tubes, of approximately 80 mm diameter and 5 m long, equipped with caps at each end, including grout inlet at the lower end and grout vent at the top. The tubes and caps shall be able to sustain the proposed grout pressure.
- b) Twelve prestressing strands  $\varnothing$  15-16 mm per tube, i.e. a total of 24, length (approximately 5 m) to just fit between the caps on the tubes.
- c) Thermometer.

### 4.4.3 Test procedure

#### 4.4.3.1 General

The two tubes are fixed on their supports to avoid noticeable deflections, at an inclination of  $(30 \pm 2)^\circ$  against a horizontal reference line. Twelve strands shall be installed in each tube. The caps are subsequently sealed on the tube ends (see Figure 3). The cap shall allow internal inspection for presence of any air or water.

The grout is prepared in accordance with the grouting method statement. Specimens shall be taken from the grout mix to measure its fluidity.

#### 4.4.3.2 Grouting of first tube (Tube 1)

Grout is injected into Tube 1 from the bottom end. When the grout exits from the vent at the top with the same consistency as it enters at the bottom, the valve shall be closed. Subsequently, the grout inlet is closed, and grouting of Tube 1 is complete.

The level of air, water, and any other resulting liquid on top of the grout shall be measured (see details in Figure 3). A minimum of four measurements of levels shall be made between 0 h and 24 h after completing grouting, with one measurement just before the re-grouting of Tube 2 is started (see 4.4.3.3).

NOTE 1 Liquid on top of the grout can be distinguished from the grout by its whitish to yellowish colour, usually clearer than the grout.

NOTE 2 The following four measuring intervals are suggested: 30 min, 1 h, 3 h and 24 h after grouting.

#### 4.4.3.3 Grouting of second tube (Tube 2)

Grout Tube 2 simultaneously with Tube 1 using the same procedure and mix. At a time specified in the method statement for re-grouting, or 30 min, if not stated, the valves of inlet and vent of Tube 2 are opened, the grout pump is started again, and the flow time of the grout is measured again.

This will allow any liquid accumulated on top to be replaced by grout. When grout exits from the vent on top, the valve is closed. Subsequently, the valve at the bottom is closed, and re-grouting of Tube 2 is complete.

NOTE 1 Similar to Tube 1, the measurements of levels are done between 0 h and 24 h after completion of the initial grouting. One of the measurements is made just prior to re-grouting Tube 2 followed by measurements suggested at 30 min, 1 h and 3 h after completion of re-grouting, with a final measurement at 24 h.

NOTE 2 The re-grouting of Tube 2 is carried out in the test even if re-grouting is not envisaged as part of the site procedures. If no liquid accumulates on top of the grout, report results as zero and terminate the test.

### 4.4.4 Reporting of results

The following results and observations shall be recorded:

- Description of test set-up.
- Grout mix design, origin and certificates of all grout constituents.
- Mixing procedure of grout.
- Fluidity of grout mix before initial grouting, and before re-grouting.
- Method statement for grouting, including pressurization details.
- Measurements of levels (or reasonable estimation) of air, water (and any residual liquid) on top of the grout.
- Any observation and comment on the formation of bleed or liquid within or on top of the grout, or on difficulties encountered during the test.

- Any observation and comment on cracks of the grout, with location, orientation and approximate width.
- Development of ambient temperature during the entire test period.
- Photos illustrating test set-up, and details of the top end of the tube with air, water and residual liquid.

Bleeding is expressed as

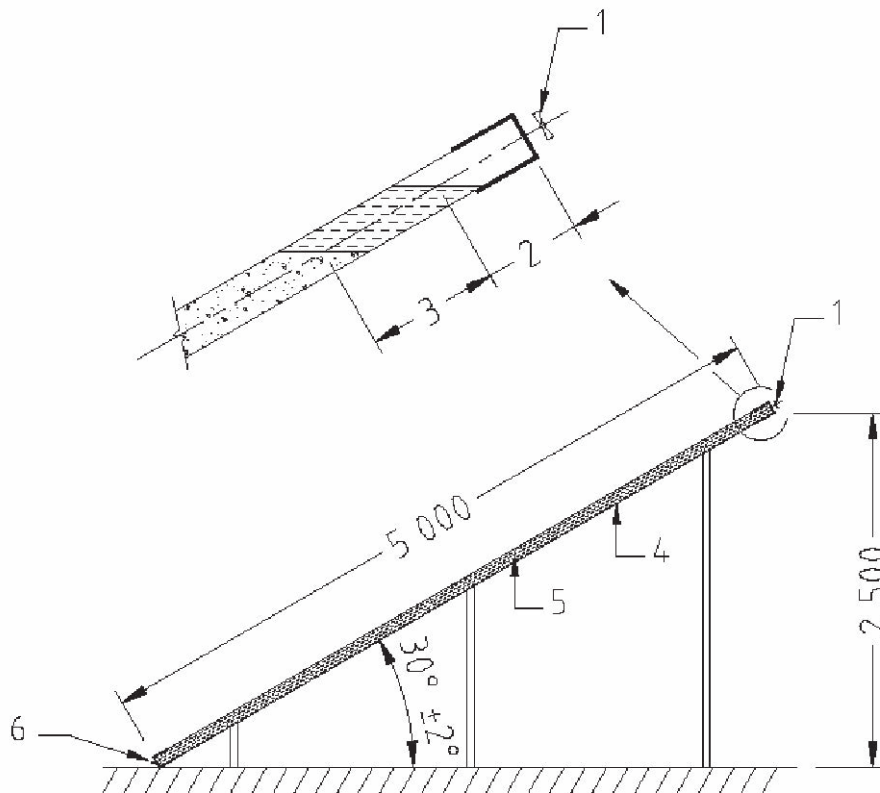
$$h_w / (5\,000 - h_w - h_a) \times 100 \%$$

Volume change (if negative) is

$$-(h_a + h_w) / 5\,000 \times 100 \%$$

NOTE This test will not measure a positive volume change.

Dimensions in millimetres



**Key**

- |   |                      |
|---|----------------------|
| 1 vent and stop valve                         | 4 transparent tube   |
| 2 height of air, $h_a$ , in mm                | 5 12 strands         |
| 3 height of water/other liquid, $h_w$ , in mm | 6 injection of grout |

**Figure 3 — Inclined tube test set-up**

**4.5 Wick-induced test**

**4.5.1 Principle of test**

This test provides both volume change and bleeding measurements. Bleeding is measured as the volume of water remaining on the surface of the grout which has been allowed to stand protected from evaporation.

The volume change is measured as a difference in percentage of the volume of grout between the start and the end of the test. The test measures mainly the volume change caused by sedimentation or expansion.

#### 4.5.2 Equipment

- a) One transparent tube, of approximately 60 mm to 80 mm internal diameter, and approximately 1 m long, equipped with caps at each end.
- b) One 7-wire strand approximately 900 mm long which fits inside the tube.
- c) Thermometer.

#### 4.5.3 Procedure

Set up tube in a vertical position with its open end at the top. Provide rigid fixing so that no movement or vibration can occur.

Install the strand in the tube, ensuring that it is firmly located on the base, and held centred.

Pour the grout into the tube at a steady flow rate (either from the bottom or using a small diameter tremie tube) to ensure there is no trapped air. Fill the tube to a height,  $h_0$ , about 10 mm above top of the steel. Seal top of tube to minimize evaporation. Record the temperature of the grout and ambient air temperature.

Record starting time  $t_0$  and height  $h_0$  of the grout.

Record height of grout,  $h_g$ , at 15 min intervals for first hour and subsequently at 2h, 3h and 24h. Measurements shall ignore the meniscus on the grout.

Record height of bleed water,  $h_w$ , at the same times as for the grout (see Figure 4).

Record inhomogeneities that may develop in the appearance of the grout as seen through the transparent tube. Examples of inhomogeneities are:

- formation of lenses of bleed water below top of grout;
- segregation leading to areas of different coloured grout.

NOTE The purpose of recording at intervals instead of simply taking the final value is to be able to follow the behaviour of expansive grouts. For small projects the measurement at 24h may be omitted by agreement in the execution documentation.

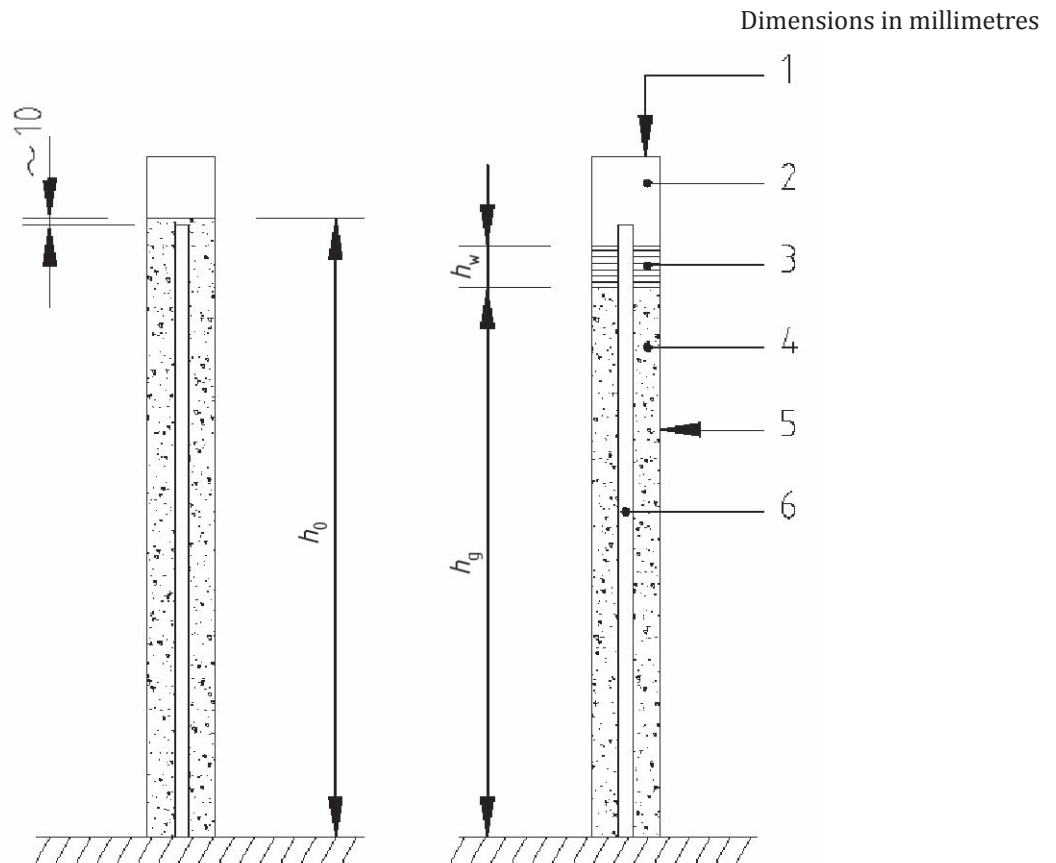
#### 4.5.4 Reporting of results

Bleeding is expressed as

$$h_w/h_0 \times 100 \% \quad (1)$$

Volume change is

$$(h_g - h_0)/h_0 \times 100 \% \quad (2)$$

**Key**

1 seal	4 grout	$h_0$ height at $t_0$
2 air	5 transparent tube	$h_g$ height at $t_n$
3 water	6 strand, wires or bar	$h_w$ height of water/other liquid

**Figure 4 — Wick-induced test set-up****4.6 Compressive strength test****4.6.1 Principle of the test**

The compressive strength of grout in this test (which is an adaption to grout of the mechanical tests described in ISO 679) is determined on the broken halves of prisms.

**4.6.2 Apparatus**

The following apparatus is required for the test.

- a) Mixer for grout in accordance with the requirements of this part of ISO 14824.
- b) Curing equipment in accordance with ISO 679 and an accuracy of  $\pm 2$  °C.
- c) Test machines and devices in accordance with ISO 679.
- d) Metal moulds 40 mm x 40 mm x 160 mm in accordance with ISO 679.
- e) Metal straightedge.

### 4.6.3 Test procedure

#### 4.6.3.1 Preparation

The moulds and accessories shall be prepared and the specimens made in accordance with ISO 679, with the following exception.

Each mould shall be filled with the prepared grout. As an exception to the procedure in ISO 679 (and because of the liquidity of grouts) the test specimens shall not be subject to any vibration or shock.

Immediately strike off the excess grout with the metal straightedge held almost vertically and moved slowly, with a transverse sawing motion once in each direction. Smooth the surface of the specimens using the same straightedge held almost flat. Then cover the specimens with a glass plate. Label or mark moulds to identify specimens.

The test specimens shall be demoulded according to ISO 679.

#### 4.6.3.2 Curing of test specimens

The test specimens shall be submerged in water at the relevant test temperature as defined in 4.1.2 until they are tested.

#### 4.6.3.3 Compressive test

The compressive testing shall be carried out on at least two specimens in accordance with ISO 679.

#### 4.6.3.4 Reporting of results

The report shall provide all results of the compressive strength tests, in N/mm<sup>2</sup>.

The value obtained for each test shall be the mean of the individual results.

### 4.7 Density test

#### 4.7.1 Principle of test

The density is measured as the ratio of mass to volume in the fluid state.

#### 4.7.2 Apparatus

The apparatus comprises calibrated equipment for weight and volume measurement.

Mud balance test equipment is an acceptable alternative.

#### 4.7.3 Reporting of results

The method of sampling, measuring weight and volume, the equipment used and the density determined shall be reported.



## Bibliography

- [1] ISO 14824-2, *Grout for prestressing tendons – Part 2: Grouting procedures*
- [2] ISO 22966, *Execution of concrete structures*

