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Grout for prestressing tendons —

Part 2: Grouting procedures

Coulis pour câbles de précontrainte —

Partie 2: Modes opératoires de gobetage

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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.org
Web www.iso.org

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Foreword

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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 14824-2 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed 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 main function of grouting is to:

— protect the prestressing steel against corrosion;

— provide a bond between the prestressing steel and the ducts where required for the design of the structure;

— allow the transfer of compressive stresses in the structure in a direction transverse to the internal tendons;

— fill all voids where water may accumulate and cause frost damage.

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 this part of ISO 14824;

(3) inspection during the production of grout on a specific project in accordance with this part of ISO 14824.

The test methods for each of the regimes are given in ISO 14824-3.

In some countries requirements exist for independent third-party certification of grout and grouting procedures which should be set out in national requirements to supplement ISO 22966.

Where the suitability of high viscosity grouts has been proven by full scale trials, any amendments or alternatives to the procedures in this part of ISO 14824 need to be incorporated in the execution specification (see 4.1). This also applies to certain special structures or tendon configurations which require grouts with enhanced performance.

Grout for prestressing tendons —

Part 2: Grouting procedures

1 Scope

This part of ISO 14824 gives the procedures to be used for grouting of tendons in post-tensioned prestressed concrete. It is applicable to all types of structures, including bridges and buildings.

This part of ISO 14824 also covers suitability testing and inspection testing for grouts and their component materials used on a project.

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

ISO 14824-3, *Grout for prestressing tendons — Part 3: Test methods*

ISO 22966, *Execution of concrete structures*

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

3.2
grouting
injection of grout into ducts in a continuous operation

3.3
tendon
assembly of prestressing steel and sheath with anchorages and all necessary auxiliary components to permit grouting, either placed internally or externally to the concrete structure

3.4
specialist contractor
contractor or construction enterprise which carries out grouting of tendons

4 Documentation

4.1 Execution specification

Before starting any part of the grouting works, the execution specification relevant to that part of the works shall be complete and available.

The following items shall be included in the execution specification:

— reference to this part of ISO 14824;

— reference to other relevant International or national standards;

— reference to international or national approvals for the post-tensioning kit;

— reference to other relevant national regulations and standards;

— information and requirements for the particular project prepared to supplement and qualify the requirements of the above listed documents;

— drawings and other technical documents needed for the execution.

In addition, where relevant, procedures shall be established for:

— making alterations to previously agreed requirements;

— distribution, the filing and recording of technical documents used for the works.

4.2 Quality plan

If a quality control procedure for grouting works is required by the execution specification, it shall be available at the site.

4.3 Execution documentation

The specialist contractor shall keep available on site written method statements covering materials, equipment, grouting procedures and inspection all adapted to the extent and complexity of the project. Provisions for the case of unusually low or high temperatures or delayed grouting, if likely to occur during the project duration, shall be specified.

The specialist contractor shall have shop drawings showing the position and details of the inlets and outlets, and the details of the sealing of the tendon anchorages.

The specialist contractor shall keep available on site documented records of:

— materials and grout used;

— initial type testing according to ISO 14824-1;

— suitability testing according to this part of ISO 14824;

— results of the project specific grouting tests, if specified.

The specialist contractor shall keep documented records of the conformity of the materials, equipment, grout, grouting operations, and inspection with this standard and the execution specification according to Table 2, Table 3 and Table 4. These records shall be kept for the duration required by national provisions.

Any eventual corrective actions taken shall also be recorded.

If special documentation beyond the requirements of this part of ISO 14824 is required for grouting works, the type and extent of the documentation shall be stated in the execution specification.

5 Materials

The individual materials and the grout to be used shall comply with ISO 14824-1.

6 Grout assessment

6.1 Suitability testing

The suitability of the grout shall be assessed for each project sufficiently in advance of grouting operations, to enable any necessary adjustments to be made in the use of the materials, equipment or personnel. The extent of suitability testing and number of tests shall be in accordance with Table 1.

Table 1 — Extent of suitability testing[a]

Test in accordance with ISO 14824-3 [b]	Suitability testing	Number of tests
Sieve	Yes	1 test
Fluidity	Yes	1 test immediately after mixing 2 tests 30 min after mixing
Inclined tube	Only required if not already subject to initial type testing with the same type of mixer intended to be used on the project	1 test if required
Wick-induced bleed [c]	Yes	3 tests
Volume change [c]	Yes	3 tests
Compressive strength [d]	Yes	3 tests
Density	Yes	1 test

[a] Suitability testing may be waived for structures in Inspection Class 2 subject to there being satisfactory evidence from previous similar projects of full compliance of the grout with the requirements of ISO 14824-1 and documented testing during production in accordance with ISO 14824-1.

[b] Other test methods may be used if the correlation or safe relationship between the results of these test methods and the reference methods in ISO 14824-3 have been established.

[c] Tests for bleeding and volume change are performed on the same sample.

[d] The number of compressive tests may be reduced to one where there is documented evidence from previous projects of full compliance of the grout with the requirements of ISO 14824-1.

The grout assessment shall consist of the preparation of the grout using the materials, equipment and personnel proposed for the project, and testing in accordance with ISO 14824-3. The preparation of the grout shall be carried out under the conditions expected on site for the project. The assessed grout properties shall comply with ISO 14824-1. The range of acceptable temperatures specified for the particular grout shall be compatible with the expected conditions of the project.

6.2 Project specific grouting tests

If required by the execution specification, project specific grouting tests on tendons in representative forms of the project shall be performed. Such tests should be planned and carried out well in advance of the site operations.

NOTE Such project specific grouting tests can be advisable, e.g. when tendon geometry and details are specified on the project for which no prior experience for successful grouting is available. Experience has shown that full-scale tests of grout and grouting procedures can be valuable to prove adequacy.

7 Equipment

7.1 General

Grouting equipment shall consist of a mixer and a pump with all the necessary connection hoses, valves, measuring devices for water, cement, admixtures and additions, and testing equipment as required to perform the grouting of the project.

The grouting equipment shall be such that the ducts can be filled without interruption and at the anticipated speed.

Grouting equipment shall include a storage reservoir if required for continuous filling of the tendons on the project. Such storage reservoirs shall have an agitator to keep the grout moving continually before it is pumped into the ducts.

The grouting equipment shall be compatible with the post-tensioning kit provided for the project.

7.2 Mixer

The mixing equipment shall be capable of producing grout, which possesses an even distribution of cement, and an even dispersal of admixtures, additions, if any, and water. The mixed grout shall contain no cement lumps as confirmed with the sieve test of ISO 14824-3. The mixed grout shall comply with the requirements of ISO 14824-1.

7.3 Pump

The pump shall be capable of providing a continuous flow of grout and maintaining the anticipated pressure for grouting. It shall be equipped with a pressure gauge and means to prevent unsafe pressure during grouting.

The pump shall be constructed in such a way as to prevent introduction of air, oil or other foreign substances into the grout.

NOTE 1 Limiting the grout pressure serves to: (a) prevent blow-outs of hoses, inlets and outlets; (b) prevent damage to the concrete structure; (c) protect the equipment and valves from damage; (d) protect the operators.

NOTE 2 The use of a pump with a variable output gives the advantage that it can be adapted to the requirements of ducts of different diameters.

7.4 Hoses

The diameter and rated pressure capacity of the grout hoses shall be compatible with the pump output, the assumed maximum pressure and the length needed.

7.5 Inlet connections

The connections of the grout hoses to the inlets of the ducts shall be leak tight. Narrow openings in hose connectors or inlet connections through which the grout must pass, should be avoided. A pressure gauge should be mounted at the grout inlet if the hose length is greater than 30 m.

NOTE 1 Narrow openings cause resulting pressure build-up which can increase the risk of bleeding and in turn can lead to blockage.

NOTE 2 In the event of sudden and abnormal pressure increase, an additional pressure gauge located at the grout inlet will indicate whether the reason for the pressure build-up lies within the tendon ducts or in the grout hoses.

7.6 Stand-by and emergency equipment

If required, stand-by and emergency equipment shall be provided in the execution specification.

8 Grouting procedures

8.1 Inlets, outlets and tendon anchorages

Tendon anchorages or tendon anchorage recesses shall be sealed with a temporary or permanent cover which is compatible with the post-tensioning kit and which can be removed after grouting for inspection of the quality of grouting.

Inlets and outlets shall be provided in general, at both tendon ends and at those points of the tendons where air and water may accumulate.

All inlets and outlets shall be suitably marked to identify the tendon, and their location along the tendon. Drainage outlets should be provided at all low points if freezing temperatures are to be expected before grouting is carried out. These drainage outlets should be left open until shortly before grouting starts.

NOTE Likely points of the tendons where air and water can accumulate are: anchorages, couplers, at high points and in the slope of the duct beyond these.

8.2 Precautions before grouting

During the time before grouting the tendons shall be adequately sealed against an ingress of water.

Ducts in precast segmental construction shall be verified to be sufficiently leak tight to avoid grout migration into adjacent ducts.

Ducts shall be confirmed to be free of debris, water and blockages that could prevent or harm grouting operations as provided in the method statement of the specialist contractor or as required in the execution specification. This may be done by blowing dry air through the tendon ducts. Verification by flushing of water through the tendon ducts shall be prohibited, in general. Any requirements for air pressure tests of ducts should be given in national requirements for the project specification.

Precautions shall be taken for temporary protection of the prestressing steel and post-tensioning kit anchorages if the construction periods recommended in ISO 22966 are likely to be exceeded.

Ducts should be grouted as soon as possible after it is verified that the tensioning of the prestressing steel has been successful. If the delay between inserting the prestressing steel and grouting the ducts is likely to permit corrosion of the prestressing steel, consideration should be given to the use of protective soluble oils on the prestressing steel or circulation of dry air in the ducts. It shall be verified that the use of protective soluble oils will not have an adverse effect upon the prestressing steel or the properties of the grout, and that the bond properties of the prestressing steel with protective soluble oils are acceptable for the design of the structure.

NOTE 1 Ducts in precast segmental construction can be checked for sufficient leak tightness with compressed air. Any leakage of concern can be repaired before grouting.

NOTE 2 For certain types of tendons with filling ratios larger than 0,45, e.g. bar tendons, it can still be considered necessary to flush the tendons with water before grouting.

8.3 Temperature at grouting

Records shall be kept of the maximum and minimum ambient temperatures and the temperature of the structure adjacent to the tendons to be grouted.

No grout shall be placed if the temperature of the structure adjacent to the tendon is, or is likely to become during the 48hrs after grouting, below 5 °C or the minimum temperature declared by the manufacturer, for which he has confirmed compliance of the grout with ISO 14824-1, unless the structure adjacent to the tendons is heated so as to maintain the temperature of the placed grout above 5 °C, or 2 °C above the temperature specified by the manufacturer, for at least 48 h.

No material in which frost, snow or ice is present shall be used. The ducts and equipment shall be free of frost and ice.

No grout shall be placed if the temperature of the grout is above 35 °C or the temperature of the structure adjacent to the tendon is, or is likely to become during the 48hrs after grouting, above 40 °C or the maximum temperature for which the manufacturer has confirmed and documented the grout to satisfy the performance requirements of ISO 14824-1.

8.4 Grouting operations

The grouting procedures shall ensure that ducts are adequately filled with grout.

Grouting shall proceed in one continuous operation for the tendon.

The grouting operations shall be executed in accordance with the method statement of the specialist contractor. Records shall be kept of quantities of materials used.

Grout shall be used within 30 min after mixing or the time limit for which the manufacturer has confirmed the properties specified in ISO 14824-1 to be satisfied at the temperature.

Grouting shall continue until the fluidity of the grout flowing from the outlets is similar to that of the grout being injected, to within the limits specified in ISO 14824-1. The outlets shall be successively closed as the filling of the duct progresses. The grout taken at the outlet at the end of the tendon shall not exhibit variation in liquid density in excess of 3 % compared with the grout taken at the mixer.

When all the outlets are closed, the grout pressure shall be maintained for about one minute to confirm that there is no unintended loss of grout due to leakage. If the pressure cannot be maintained without pumping grout, the leakage shall be located and repaired, and the procedure repeated.

Shortly after grouting, and within the time limit for which properties specified in ISO 14824-1 have been documented to be satisfied, all inlets, outlets and anchorage covers shall be verified to be full, e.g. by light tapping. If any of the inlets, outlets and anchorage covers are not full, remedial action should be considered.

NOTE In some countries repeated pumping, called post-grouting, is carried out at this stage. Where such grouting procedure is adopted it can be appropriate to amend grout properties specified in ISO 14824-1 by requirements of the project specification.

8.5 Precautions after grouting

When the grout has set, all inlets, outlets and anchorage covers shall be inspected to confirm adequate filling with grout. If any of the inlets, outlets and anchorage covers are not adequately filled, these voids shall be filled with freshly mixed grout.

All grout inlets and outlets shall be suitably sealed to prevent ingress of water or other aggressive agents into the tendon.

Anchorages, inlets and outlets shall be permanently protected with suitable methods as specified in the method statement of the specialist contractor or as required in the execution specification.

Anchorages, vents and other metallic items that are to remain permanently in place shall be protected against corrosion as required in the execution specification.

9 Quality management

9.1 General

Further detailing of the requirements for the quality management regime in excess of what is given in this part of ISO 14824 may be stated in the execution specification.

9.2 Personnel

Grouting operations shall be under the charge of a supervisor with appropriate knowledge, training and experience in production, testing, injection and inspection; they shall be responsible for the production and injection of the grout. This supervisor, or an appropriately trained representative, shall be present during all grouting procedures and shall be responsible for all safety precautions relating to the preparatory and grouting operations.

Grouting operators shall be suitably trained for the grouting activities they are anticipated to perform on the project.

NOTE 1 In some countries there are special requirements regarding the level of knowledge, training and experience of the supervisor in charge of grouting, and of the operators carrying out the grouting activities. Guidance can be found in specialist literature, or in the CEN Workshop Agreement CWA 14646 which gives guidance for the qualification and acceptance of the supervisor and operators.

NOTE 2 Some countries require inspection of grouting by an independent and competent organization.

9.3 Inspection

Supervision and inspection shall ensure that the grouting works are completed in accordance with this part of ISO 14824 and the provisions of the execution specification.

Inspection refers to verifying conformity of the properties of materials to be used as well as inspection of the execution of the works.

Requirements for inspection shall be specified using one of the following two classes according to ISO 22966:

— inspection class 2;

— inspection class 3.

The inspection class to be used shall be stated in the execution specification.

Inspection shall be carried out by the specialist contractor and shall be recorded.

The scope of inspection of materials, products and execution of works to be performed is given in Table 2.

NOTE 1 Inspection class refers to the grouted tendon or to certain materials and technologies used for the execution. ISO 22966 gives guidance for the selection of the inspection class.

NOTE 2 The two inspection classes give the option to specify the required inspection based on the complexity of the structure and the criticality of the execution for its ability to fulfil its function.

Table 2 — Inspection requirements prior to grouting

Subject	Inspection class 2	Inspection class 3
Incoming grout materials and products	In accordance with ISO 14824-1 and the execution specification according to 4.3 [a]	
Other items [b]	In accordance with the execution specification	
Availability of results of initial type testing according to ISO 14824-1	In accordance with 4.3	
Availability of results of suitability testing according to ISO 14824-2	In accordance with 4.3	
Availability of results of project specific grouting tests	In accordance with 4.3	
Grouting equipment	In accordance with 7.2 and 7.3	
Method statement	In accordance with 4.3	
Grouting supervisor	In accordance with 9.2	
Grouting operators	In accordance with 9.2	
Identification marking of inlets, outlets and anchorages	In accordance with 8.1	
Verification of leak tightness of ducts in precast segmental construction	In accordance with 8.2	
Verification of sheaths to be free for grouting	In accordance with 8.2	
Precautions for temporary protection of prestressing steel and anchorages	In accordance with 8.2	
Temperature of structure adjacent to tendons	In accordance with 8.3	

[a] Products bearing a recognized certification mark or third-party product certification shall be checked against the delivery ticket and visually inspected. In cases of doubt, further inspection shall be undertaken to check that the product complies with its specification. Other products/items shall be subject to inspection and testing as defined in the execution specification.

[b] For example, items like inlets, outlets, mortar for filling of anchorage recesses, etc.

Table 3 — Inspection requirements during grouting

Subject	Inspection class 2	Inspection class 3
Temperature of structure adjacent to tendons, and of grout.	In accordance with 8.3	
Quantities of materials used in grout preparation.	In accordance with 8.4	
Testing of grout during grouting:	In accordance with ISO 14824-3[d]:	In accordance with ISO14824-3[d]:
— casting of tests for compressive strength testing [a];	— 3 tests per project with samples taken at mixer;	— 3 tests/day with samples taken at mixer;
— wick-induced bleed [b];	— 1 test/day with sample taken at mixer but minimum of 3 tests per project;	—1 test/half day with sample taken at mixer but at least 3 tests per grouting stage[e];
— volume change [b];	— 1 test/day with sample taken at mixer but minimum of 3 tests per project;	— 1 test/half day with sample taken at mixer but at least 3 tests per grouting stage;
— fluidity [c];	— 1 test/half day with sample taken at mixer;	— 3 tests/day or every 4 h with samples taken at mixer;
— density.	— 1 test with sample taken at mixer and 1 test with sample taken at outlet at end of tendon per project (density variation in accordance with 8.4).	— 1 test/half day with 1 sample each taken at mixer and at outlet at end of tendon but at least 2 tests per grouting stage[e] (density variation in accordance with 8.4).
Results of holding pressure when outlets are closed	In accordance with 8.4	
Inspection of all inlets, outlets and anchorage covers	In accordance with 8.4	

[a] The number of compressive tests may be reduced to one where there is documented evidence from previous projects of full compliance of the grout with the requirements of ISO 14824-1

[b] Tests for bleeding and volume change are performed on the same sample.

[c] Fluidity testing by either the cone method or the grout spread method of ISO 14824-3, measured immediately after mixing only.

[d] Other test methods may be used if the correlation or safe relationship between the results of these test methods and the reference methods given in ISO 14824-3 have been established.

[e] A grouting stage is the period of one continuous grouting operation.

Table 4 — Inspection requirements after grouting

Subject	Inspection class 2	Inspection class 3
Inspection of all inlets, outlets and anchorage covers	In accordance with 8.5	
Sealing of inlets, outlets and anchorages	In accordance with 8.5	
Protection of steel parts of anchorages, inlets and outlets	In accordance with 8.5	
Inspection records	Required	

9.4 Conformity criteria

Where testing at the time of preparation of the grout shows results outside the limiting value in fluidity and density, the testing shall be repeated and if confirmed, the particular grout mix shall be rejected.

Conformity assessments for strength, wick-induced bleed, volume change, fluidity and density shall be made on the running production for each project. The assessments shall be based on the method of attributes.

Conformity of strength, wick-induced bleed and volume change, with the required property, is confirmed if the number of results outside the limiting value are not greater than the acceptance number in Table 5. No single result shall be outside the maximum allowed deviation (see Table 6).

Table 5 — Acceptance number for conformity criteria for strength, wick-induced bleed and volume change

Acceptance Quality Limit (AQL) = 4 %	
Number of test results	Acceptance number
1 to 12	0
13 to 19	1
20 to 31	2
32 to 39	3
40 to 49	4
50 to 64	5
65 to 79	6
80 to 94	7
95 to 100	8

NOTE Where the number of test results exceeds 100, the appropriate number may be taken from Table 2-A of ISO 2859-1:1999.

Table 6 — Maximum allowed deviation

Property	**Maximum allowed deviation**
Compressive strength at 28 days	-5 MPa
Compressive strength at 7 days	-3 MPa
Bleed	+0,3 %
Volume change	±0,5 %
Density	±2 %
Fluidity	±5 %

9.5 Action in the event of a non-conformity

Where inspection reveals a non-conformity, appropriate action shall be taken to ensure that the structure remains fit for its intended purpose.

In this case, the following aspects shall be investigated in the order listed:

— implications of the non-conformity on further execution and fitness for intended purpose;

— measures necessary to make the component acceptable;

— necessity of rejection and replacement of the possible non-repairable component.

If required in the execution specification, the rectification of non-conformity shall be in accordance with a procedure stated in the execution specification or a procedure agreed by the parties.

Bibliography

[1] ETAG. 013, *Guideline for the European Technical Approval of post-tensioning kits for prestressing of structures*

[2] ISO 2859-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

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