

BRITISH STANDARD

Strata reinforcement support system components used in coal mines –

Part 1: Specification for rockbolting

ICS 73.100.10



NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

Publishing and copyright information

The BSI copyright notice displayed in this document indicates when the document was last issued.

© BSI 2007

ISBN 978 0 580 58550 0

The following BSI references relate to the work on this standard:

Committee reference MRE/1

Draft for comment 07/30163374 DC

Publication history

First published October 1996

Second edition, October 2007

Amendments issued since publication

Amd. no.	Date	Text affected
-----------------	-------------	----------------------

Contents

Foreword *iii*

1	Scope	<i>1</i>
2	Normative references	<i>1</i>
3	Terms and definitions	<i>2</i>
4	Steel rockbolts and components	<i>4</i>
5	Glass fibre reinforced plastic (GRP) rockbolts and components for use in the sides	<i>6</i>
6	Resins and capsules	<i>9</i>
7	System type tests – Steel rockbolts	<i>10</i>
8	System type tests – GRP rockbolts	<i>11</i>

Annexes

Annex A (normative)	Tensile test on steel bar	<i>12</i>
Annex B (normative)	Resistance to brittle fracture	<i>12</i>
Annex C (normative)	Breakout facility torque test	<i>14</i>
Annex D (normative)	Tensile test to establish flattening and pull through loads of steel domed washer plate assemblies	<i>15</i>
Annex E (normative)	Alignment test	<i>17</i>
Annex F (normative)	Fire resistance test on non-metallic components	<i>18</i>
Annex G (normative)	Torsional strength test on GRP bar	<i>20</i>
Annex H (normative)	Tensile strength test on GRP bar	<i>21</i>
Annex I (normative)	Minimum tensile strength of GRP rockbolt bar	<i>23</i>
Annex J (normative)	Flexural strength tests on GRP rockbolt bar	<i>25</i>
Annex K (normative)	Tensile test to establish GRP bolt assembly failure load	<i>26</i>
Annex L (normative)	Determination of uniaxial compressive strength (UCS) of resin	<i>28</i>
Annex M (normative)	Determination of elastic modulus of resin	<i>29</i>
Annex N (normative)	Determination of creep of resin	<i>31</i>
Annex O (normative)	Tensile test on rockbolt threaded end	<i>33</i>
Annex P (normative)	Shear test on rockbolt/resin system	<i>34</i>
Annex Q (normative)	Determination of bond strength and system stiffness	<i>36</i>

Bibliography *44*

List of figures

Figure 1	– Example of a steel rockbolt assembly in situ	<i>3</i>
Figure B.1	– Charpy impact specimen – machining from bar details	<i>13</i>
Figure C.1	– Arrangement for nut breakout torque test for GRP rockbolts	<i>15</i>
Figure D.1	– Load test arrangement for tensile test flattening and pull through loads of steel domed washer plate	<i>16</i>
Figure E.1	– Alignment capacity of conical seat and domed washer plate assembly	<i>17</i>
Figure F.1	– Draught-free cabinet for flame test	<i>19</i>
Figure G.1	– Arrangement for torsional strength test on GRP bar	<i>20</i>
Figure H.1	– Arrangement for tensile test on GRP bar	<i>22</i>
Figure I.1	– Double embedment tensile test – schematic diagram	<i>24</i>
Figure J.1	– Arrangement for flexural strength test on GRP bar	<i>25</i>

Figure K.1 – Load test arrangement for GRP components	27
Figure M.1 – Arrangement for elastic modulus test and creep test: machine platen	31
Figure O.1 – Arrangement for tensile test on rockbolt threaded end	33
Figure P.1 – Sectional diagram of shear frame	34
Figure Q.1 – General arrangement of lathe-based pull test apparatus	37
Figure Q.2 – General arrangement of hydraulic pull test apparatus	38
Figure Q.3 – Hydraulic biaxial pressure cell	39
Figure Q.4 – Rock core performance envelope	43
List of tables	
Table 1 – Colour coding of rockbolt length	5
Table 2 – Resin setting times at 27 °C	10
Table Q.1 – Standard consumables and criteria for rock core performance testing	42

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iii, a blank page, pages 1 to 43, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 7861 is published by BSI and came into effect on 31 October 2007. It was prepared by Subcommittee MRE/1/1/1, *Roof supports and strata reinforcements*, under the authority of Technical Committee MRE/1, *Mining mechanical equipment and machinery*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 7861 supersedes BS 7861-1:1996, which is withdrawn.

Assessed capability. Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

Product certification/inspection/testing

Users of this British Standard are advised to consider the desirability of third-party certification/inspection/testing of product conformity with this British Standard. Appropriate conformity attestation arrangements are described in BS EN ISO/IEC 17025. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the following statutory regulations.

The Health and Safety at Work etc. Act 1974 [1]

The Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 [2]

The Control of Substances Hazardous to Health Regulations 1995 [3]

1 Scope

This Part of BS 7861 specifies dimensional, material and performance requirements for rockbolting support system components used in coal mines. Components included are steel rockbolts, glass reinforced plastics (GRP) rockbolts, resins, nuts, conical seats and domed washer plates.

This British Standard does not cover the assembly or installation of these components to form a rockbolting support system on site.

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.

BS 6319-1:1983, *Testing of resin compositions for use in construction – Part 1: Method for preparation of test specimens*

BS 6319-2:1983, *Testing of resin compositions for use in construction – Part 2: Method for measurement of compressive strength*

BS EN 837-1, 1998, *Pressure gauges – Part 1: Bourdon tube pressure gauges – Dimensions, metrology, requirements and testing*

BS EN 10002-1:2001, *Metallic materials – Tensile testing – Part 1: Method of test at ambient temperature*

BS EN 10045-1:1990, *Charpy impact test on metallic materials – Part 1: Test method (V- and U-notches)*

BS EN 13463-1, *Non-electrical equipment for potentially explosive atmospheres – Part 1: Basic method and requirements*

BS EN ISO 527-1, *Plastics – Determination of tensile properties – Part 1: General principles*

BS EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*

BS EN ISO 4034, *Hexagon nuts – Product grade C*

BS EN ISO 6789, *Assembly tools for screws and nuts – Hand torque tools – Requirements and test methods for design conformance testing, quality conformance testing and recalibration procedure*

BS EN ISO 7500-1:2004, *Metallic materials – Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Verification and calibration of the force-measuring system*

BS EN ISO 9513:2002, *Metallic materials – Calibration of extensometers used in uniaxial testing*

3 Terms and definitions

For the purposes of this Part of BS 7861, the following terms and definitions apply.

3.1 bond strength

load in a rockbolt/resin/rock system at which the system stiffness falls below 20 kN/mm, when measured by pull testing, for a given bond length

3.2 breakout facility

facility whereby the nut is held in position on the thread of the rockbolt, enabling mixing of the resin to take place during rockbolt installation, but which allows the nut to be spun up the thread to tighten on the domed washer plate when a predetermined torque value is reached

3.3 brittle fracture

failure of a steel rockbolt without plastic deformation

3.4 conical seat

accessory which, when used in conjunction with a rockbolt, nut and domed washer plate, accommodates a degree of misalignment between the rockbolt and the strata surface

3.5 domed washer plate

accessory which, when used in conjunction with a rockbolt, nut and conical seat, facilitates load distribution, ensures correct alignment and reduces weathering around the mouth of the rockbolt hole

3.6 equivalent diameter

diameter of an equivalent circular bar calculated from the weight and density of a 150 mm long sample of actual bar

NOTE For steel rockbolts that are to be galvanized, the equivalent diameter is determined from a sample of un-galvanized bar.

3.7 flexural strength

maximum flexural stress occurring at the surfaces of the test specimen during a bending test, based on the maximum load sustained during the test and assuming that the neutral axis is through the middle of the section

3.8 gel time

period during which a resin can be mixed with no appreciable change in viscosity, i.e. before it begins to turn from fluid to solid state

3.9 hand held machine

drilling machine where the drill thrust is provided solely by human power

3.10 resin

encapsulating material used to achieve a bond between rockbolt and strata

3.11 rockbolt

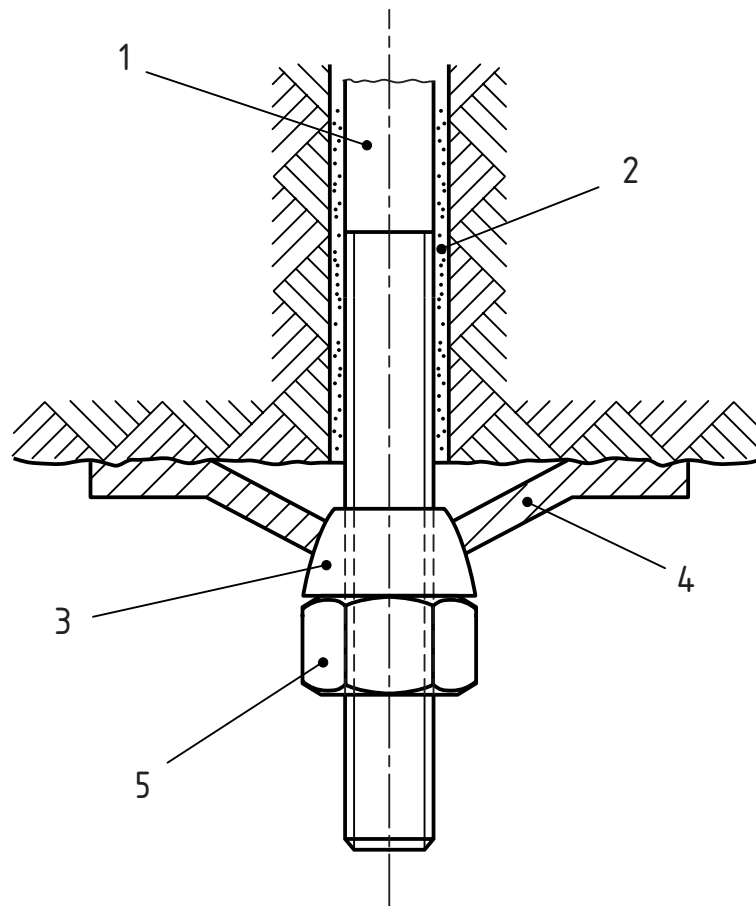
bar inserted into the roof or side of a roadway, used with fully encapsulating resin as part of a rockbolting support system

3.12 rockbolt assembly

rockbolt complete with appropriate end fittings

NOTE An example of a steel rockbolt assembly is given in Figure 1.

Figure 1 Example of a steel rockbolt assembly in situ

**Key**

- 1 Rockbolt
- 2 Resin
- 3 Conical seat

- 4 Domed washer plate
- 5 Nut

3.13 rockbolting support system

rockbolt assemblies installed systematically to provide principal roof and/or side support for mine roadways

3.14 setting time

period following the gel time required for the resin to attain enough strength to resist the pull exerted on the rockbolt when the nut is tightened

3.15 system stiffness

stiffness of the rockbolt/resin/rock system for a given bond length in load per unit displacement (kN/mm), when measured by pull testing

4 Steel rockbolts and components

4.1 Rockbolt

4.1.1 Rockbolt bar

4.1.1.1 Composition

The bar of a rockbolt shall be made from steel with a homogenous structure having a chemical composition of carbon 0.3% max., manganese 1.6% max., sulfur 0.05% max. and phosphorus 0.05% max.

4.1.1.2 Profile

The bar of a rockbolt shall be of rolled circular section and may be ribbed or threaded.

4.1.1.3 Diameter

The minimum equivalent diameter of the bar of a rockbolt shall be not less than 21.5 mm. The minimum measurement across the minor axis of the bar shall be not less than 20 mm.

4.1.1.4 Straightness

Straightness shall be within 0.4% of the length of the rockbolt bar.

4.1.1.5 Tensile properties

When tested in accordance with Annex A:

- a) the minimum yield strength shall be 640 N/mm²;
- b) the tensile strength shall be at least 20% greater than the yield strength on each tensile test;
- c) the elongation after fracture (A) shall be a minimum of 18% and the elongation at maximum force (A_{gt}) shall be a minimum of 8%.

4.1.1.6 Resistance to brittle fracture

NOTE The bar of a rockbolt should be tough enough to resist brittle fracture at the lowest expected operating temperature.

When tested in accordance with Annex B:

- a) no more than two of the individual values shall be lower than 27 J;
- b) no more than one individual value shall be lower than 19 J;
- c) the average value of all tests shall be no lower than 27 J.

4.1.2 Manufacture

4.1.2.1 Proximal end

The minimum length of the thread at the proximal end of the rockbolt shall be 150 mm. The thread shall be compatible with the nut.

4.1.2.2 Distal end

The distal end of the rockbolt shall be capable of passing through a 450 mm long cylinder gauge with a diameter not more than 1.5 mm greater than the maximum diameter of the rockbolt bar.

4.1.2.3 Length

The tolerance on the manufactured length of the rockbolt shall be ± 5 mm.

Colour coding on the proximal end in accordance with Table 1 shall identify rockbolt length. Rockbolt lengths other than those listed in Table 1 shall be identified by colour(s) other than those listed in Table 1.

Table 1 **Colour coding of rockbolt length**

Nominal rockbolt length m	Colour code
3.0	Brown
2.4	Red
2.1	Green
1.8	Yellow
1.5	White
1.2	Blue

4.1.2.4 Corrosion protection

Where corrosion protection is required rockbolts shall be hot dipped galvanized in accordance with BS EN ISO 1461 with a minimum coating thickness of 85 μm . Rockbolts shall not be passivated after galvanizing as this can affect the resin bond strength.

4.1.3 Supplier identification

Either the nut or conical seat supplied with the rockbolt shall be marked with the identity of the supplier.

4.2 Nut

4.2.1 General

The nut shall be manufactured from black hexagon steel grade 8 conforming to BS EN ISO 4034, except that its thickness shall be not less than 26 mm. The nut shall be compatible with the bar thread and conform to 7.1.

The nut shall have a breakout facility, unless it is intended for installation in the side with a hand held machine; in which case a breakout facility is optional.

4.2.2 Nut breakout type test

When tested in accordance with C.1, the nut breakout facility shall operate at torques in the following ranges:

- a) high torque range 100 Nm to 185 Nm;
- b) low torque range 35 Nm to 80 Nm.

4.3 Domed washer plate/conical seat

4.3.1 Material

The domed washer plate and conical seat shall be manufactured from steel.

4.3.2 Form

The form of the domed washer plate and conical seat shall be as shown in Figure 1 and be compatible with other components of the rock bolt assembly.

4.3.3 Supplier identification

Each domed washer plate shall be marked with a unique supplier identification mark.

4.3.4 Performance requirements

4.3.4.1 Assembly load

When tested in accordance with Annex D, the steel domed washer plate shall:

- a) flatten under a load of 50% to 70% of the nominal breaking load of the bar, based on the equivalent diameter and a stress of 770 N/mm²;
- b) allow pull-through of the rockbolt, nut and conical seat assembly under a load (the maximum tensile load or pull-through load) of 70% to 95% of the breaking load of the bar, based on the equivalent diameter and a stress of 770 N/mm².

NOTE Failure of the domed washer plate and conical seat might occur in a ductile manner. Brittle fracture in either component is not acceptable.

4.3.4.2 Alignment

When tested in accordance with Annex E, the conical seat shall allow a minimum misalignment of 18° between the rockbolt and the domed washer plate.

5 Glass fibre reinforced plastic (GRP) rockbolts and components for use in the sides

5.1 Rockbolt

5.1.1 Rockbolt bar

5.1.1.1 Composition

The bar of the GRP rockbolt shall be made from a polymer resin matrix with a minimum glass content of 75% by weight.

5.1.1.2 Profile

The bar of the GRP rockbolt shall be of circular section and may have a rough or threaded surface.

5.1.1.3 Diameter

The minimum equivalent diameter of the GRP rockbolt bar shall be not less than 21.5 mm. The minimum measurement across the minor axis shall be not less than 20 mm.

5.1.1.4 Straightness

Straightness shall be within 0.4% of the length of the GRP rockbolt bar.

5.1.1.5 Electrical resistance

The antistatic properties of the GRP rockbolt bar shall be in accordance with BS EN 13463-1.

5.1.1.6 Fire resistance

When tested in accordance with Annex F, the persistence of flame time of the GRP rockbolt bar shall be less than 10 s.

5.1.1.7 Torsional strength

When tested in accordance with Annex G, the minimum torsional strength of the GRP rockbolt bar shall be 100 Nm in both directions.

5.1.2 Manufacture**5.1.2.1 Proximal end**

The minimum length of the thread of the GRP rockbolt bar shall be 150 mm. The thread shall be compatible with the nut.

5.1.2.2 Distal end

The distal end the GRP rockbolt bar shall be machined and free from burrs or edges which protrude beyond the profile of the rockbolt.

5.1.2.3 Length

The tolerance on the manufactured length of the GRP rockbolt bar shall be ± 5 mm.

Rockbolt lengths shall be identified by colour coding on the proximal end as specified in Table 1. Rockbolt lengths other than those listed in Table 1 shall be identified as such by colour(s) other than those listed in Table 1.

5.1.3 Type tests**5.1.3.1 Tensile strength**

When tested in accordance with Annex H and BS EN ISO 527-1, the GRP rockbolt bar shall have a tensile strength of not less than 850 N/mm².

When tested in accordance with Annex I the peak load shall be at least 320 kN.

5.1.3.2 Flexural strength

When tested in accordance with Annex J, the material shall have a flexural strength of not less than 750 N/mm² based on the maximum load recorded during the test.

5.2 Nut, conical seat and domed washer plate

5.2.1 Material properties

5.2.1.1 Electrical resistance of the nut, conical seat and domed washer plate

The antistatic properties of the nut, conical seat and domed washer plate shall be in accordance with BS EN 13463-1.

5.2.1.2 Fire resistance of domed washer plate

When the domed washer plate is tested in accordance with Annex F, the persistence of flame time shall be less than 10 s.

5.2.2 Form of the nut, conical seat and domed washer plate

The form of the nut, conical seat and domed washer plate shall be compatible with the other components of the rockbolt assembly.

NOTE An example is shown in Figure 1.

5.2.3 Supplier identification

Either the nut or the conical seat supplied with the GRP rockbolt shall be marked to identify the supplier.

5.2.4 Breakout facility for the nut

The nut shall have a breakout facility, unless it is intended for installation in the side with a hand held machine, in which case a breakout facility is optional.

5.2.5 Type tests

5.2.5.1 Nut breakout test

Where torque nuts are used, they shall enable breakout at a predetermined torque setting in the range of 35 Nm to a maximum of 80% of the maximum torsional strength of the GRP rockbolt bar, when tested in accordance with C.2. The breakout shall function correctly without damaging the rockbolt bar.

5.2.5.2 Assembly load test

When tested in accordance with Annex K the assembly shall fail under a tensile loading of not less than 50 kN.

NOTE Failure of the assembly should occur in a progressive manner.

5.2.5.3 Alignment test

When tested in accordance with Annex E, the conical seat and domed washer plate shall allow a minimum misalignment between the rockbolt and the domed washer plate of:

- 18° when using a steel domed washer plate; and
- 10° when using a non-metallic plate.

6 Resins and capsules

6.1 General

Resins shall be supplied in capsule form and shall achieve full column bonding when used with rockbolts as a means of strata reinforcement.

6.2 Capsule material

The capsules shall contain a filled polyester resin and a catalyst in separate compartments within a frangible sheath.

6.3 Capsule size

Capsules shall be of a diameter and length (dependent on the combination of bolt diameter and length) and hole diameter that permit full encapsulation of the bolt. Capsule tolerances shall be ± 0.5 mm on diameter and $^{+10}_{-5}$ mm on length when measured between the crimped ends.

6.4 Shelf life of resins

Resins shall:

- retain their ability to conform to **6.6** and **6.7**; and
- retain sufficient rigidity to enable insertion using a capsule loading tube

for a minimum period of six months, when stored in accordance with the manufacturer's instructions.

6.5 Packaging of capsules

6.5.1 Capsules shall be supplied in boxes of a size and shape suitable for manual handling in a mining environment and which weigh no more than 25 kg.

6.5.2 The following information shall be displayed on all boxes:

- a) manufacturer's name;
- b) type of resin;
- c) size of capsule;
- d) quantity of capsules;
- e) colour code, as specified in Table 2;
- f) gel and setting time at 27 °C (see **6.6**);
- g) shelf life and storage conditions;
- h) date of manufacture;
- i) weight;
- j) batch or time reference;
- k) manufacturer's identification;
- l) the symbols, risk and safety phrases as required under the current legislation [2];
- m) installation procedure, taking into account the Control of Substances Hazardous to Health Regulations 2002 [3].

6.6 Gel and setting times of mixed resin

The gel and setting times of the mixed resin at a temperature of 27 °C shall be as specified in Table 2.

The manufacturer shall provide information for gel and setting times for an ambient temperature range of 20 °C to 35 °C.

NOTE This information may be provided electronically or on a data sheet.

Table 2 Resin setting times at 27 °C

Resin type (colour)	Gel times s	Setting times s
Fast-set (red)	13–18	7–10
Medium-set (yellow)	40–55	10–15
Slow-set (green)	70–200	30–50
Ultra slow-set (blue)	350–500	80–140

6.7 Mechanical performance criteria for resins

6.7.1 Uniaxial compressive strength (UCS)

The UCS, as determined by the test method in Annex L, shall be greater than 80 MPa.

6.7.2 Elastic modulus

The elastic modulus, as determined by the test method in Annex M, shall be greater than 11 GPa

6.7.3 Resistance to creep

Creep, as determined by the test method in Annex N, shall be no greater than 0.12%.

6.7.4 Re-testing of resin

All resin shall be re-tested when there is a change in constituents or a change in the manufacturer's production process.

7 System type tests – Steel rockbolts

7.1 Tensile test of threads

When tested in accordance with Annex O, the threaded portion of the rockbolt, or the thread of the assembled nut, shall not fail at a load less than the nominal breaking load of the bar based on a stress of 770 N/mm² and the equivalent diameter of the bar.

7.2 Shear test

When tested in accordance with Annex P the shear strength of the rockbolt/resin system shall be at least 640 N/mm².