



BS 4402:1982

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Specification for

Safety requirements for laboratory centrifuges

Spécification pour les impératifs de sécurité concernant les centrifugeuses de laboratoire

Spezifikation für die Sicherheitsanforderungen an Labor-Zentrifugen



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British Standards Institution

BS 4402 : 1982

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Foreword

This British Standard has been prepared under the direction of the Laboratory Apparatus Standards Committee. It was first published in 1969 with the title 'Mechanical safety requirements for laboratory centrifuges' and covered only mechanical safety requirements. Subsequent experience in using the standard brought to light certain difficulties and in 1972 the Scientific Instrument Manufacturers' Association showed that centrifuge manufacturers were unable to comply unambiguously with the requirements as formulated in the specification. The Quality Assurance Department (now the Certification and Assessment Department) of the British Standards Institution also experienced difficulties in connection with licences under its certification mark scheme, and with the added impetus of the expected Health and Safety at Work Act, subsequently enacted in 1974, work on this revised edition was started in 1973.

This revision supersedes the previous edition published in 1969, which is therefore now withdrawn.

When IEC 'Safety requirements for measuring, control and associated equipment' (provisional title) now in preparation in Technical Committee 66 of the International Electrotechnical Commission is published, it is intended to implement it as a British Standard. Clause 10 of this standard will then be amended to replace the references to BS 3456 : Part 101 with references to the corresponding new British Standard.

The 1969 edition of BS 4402 has been enlarged and divided into the following sections:

Section one	General
Section two	Mechanical safety requirements
Section three	Electrical safety requirements
Section four	Requirements for additional safety features of centrifuges for use with flammable materials and in flammable atmospheres
Section five	Accessories for use with potentially biologically hazardous materials and potentially chemically hazardous materials

With the exception of Gerber centrifuges and basket centrifuges, the standard covers all centrifuges of current design which are likely to be used in a laboratory. Performance requirements are stated only where these have a bearing on safety.

The introduction which follows this foreword outlines the technical problems of centrifuge design which were encountered during the preparation of the present revision.

Appendix A gives information to be supplied with the centrifuge.

Appendix B gives recommendations on the use of centrifuges.

Appendix C gives type tests on centrifuge casings.

Appendix D gives type test methods for sealed buckets and sealed heads.

British Standard Specification for

Safety requirements for laboratory centrifuges

Section one. General

0. Introduction

The most important safety requirement for a centrifuge is the provision of a strong guard barrier surrounding the rotation assembly to prevent any debris, resulting from disruption, being projected into the laboratory. Accidents caused by the breaking-up of centrifuge heads often have explosive violence. The guard barrier of an ultracentrifuge may for example be required to contain an energy release equivalent to the head-on collision of a car having a mass of 1 tonne (1000 kg) travelling at 160 km/h, and the design has to provide for the absorption of all the kinetic energy contained in the disrupted parts. There are simple theoretical equations for calculating the required thickness and strength of guard barriers for rotating machinery other than laboratory centrifuges, but they are based on simple shear processes unrepresentative of the many energy absorption modes which occur during centrifuge disruption and are not generally accepted by centrifuge manufacturers.

In the 1969 edition of BS 4402, the only method of specifying the strength of the centrifuge casing was by requiring compliance with type tests carried out on typical production models. In these tests, a rotation assembly was caused to break and the containment or otherwise of the fragments was determined. These tests are very costly, and the Technical Committee which undertook this revision decided to introduce a non-destructive method of specifying guard barriers as an alternative to type tests. This alternative method specifies the thickness and strength of guard barriers by an equation which represents a consensus of current design practice among leading manufacturers in the United Kingdom and some other countries.

This consensus involved a survey of 13 types of centrifuge having long established sales histories and for most of which there was a wealth of data from destructive tests. It was notable that in the survey a correlation factor of 0.97 was obtained for the inequality given in 6.2 in spite of a very wide range of design practice among the participating manufacturers.

The 1969 edition of BS 4402 gave methods for testing the strength of centrifuge heads and specified the maximum permitted elongation in their critical sections. These tests were difficult to carry out, and the associated specifications for the quality of the materials of construction proved to be ambiguous. Accordingly, the Technical Committee considered specifying the strength of centrifuge heads in terms of type tests involving fatigue testing. This was intended as an alternative that the manufacturer could adopt and which would permit the use of a casing having a strength less than that given by the equation in 6.2.

However, it was decided not to permit this option in the present edition because the extensive studies necessary to formulate the precise requirements would have unduly delayed publication.

The 1969 edition classified centrifuges according to the operating pressure in the chamber. This has now been omitted since the distinction serves no purpose in the new approach to the containment of debris during disruption.

Subject to the exceptions mentioned in 1.3 and 1.4, this British Standard covers all laboratory centrifuges, but the Technical Committee considered that non-electrical means of motive power (e.g. turbine and manual drives) were insufficiently widespread for the specification of any additional safety features for them. It also decided not to cover non-metallic (e.g. concrete) guard barriers which might be developed in the future. At the time of preparation of this British Standard, design data for the use of plastics in centrifuge casings and in access covers was not available, and market experience was limited to only a few years with small bench centrifuges. The Technical Committee was therefore unable to include the use of plastics in this edition.

It was foreseen that access covers might in future be built into the guard barrier, but this arrangement has been excluded for the time being on account of the hazard such a feature would constitute if incorporated into conventional designs.

In the standard, centrifuges are classified in terms of $E_{\max}$ the highest rotational energy of the head, and table 1 is given to help the reader relate this energy to more familiar descriptions.

Table 1. Typical values of $E_{\max}$

Type of centrifuge	Type of head	Maximum speed	$E_{\max}$ typical value
		r/min	kJ
Small bench top	4 x 15 ml swing-out	2400	0.1
Bench top	8 x 15 ml swing-out	3200	1.0
Large capacity floor standing	6 x 1000 ml fixed	5200	73
High speed	6 x 300 ml fixed	14 000	150
Ultracentrifuge	8 x 35 ml fixed	60 000	1000



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1. Scope

1.1 This British Standard specifies safety requirements for electrically driven laboratory centrifuges in which the rotation assembly is surrounded by a metallic casing.

1.2 This British Standard specifies safety requirements for centrifuges designed for use with rotation assemblies in which the samples are contained in a number of discrete containers.

1.3 This British Standard does not cover centrifugal machines designed for use solely with rotation assemblies which allow continuous flow of sample in and removal of separated components out of the centrifuge (see BS 767), but if a continuous flow rotation assembly (e.g. a zonal head) or a basket head is provided by the manufacturer as an accessory additional to the rotation assemblies described in 1.2, then the centrifuge is covered by this British Standard.

1.4 This British Standard is not applicable to centrifuges used in the Gerber method for the determination of fat in milk and milk products (BS 696)*.

1.5 Sections two and three specify, respectively, mechanical and electrical requirements for laboratory centrifuges, designated and marked 'D' or 'T'† by the manufacturer, according to which of the requirements of section two are complied with.

Section four specifies additional safety requirements for laboratory centrifuges designated and marked 'SC' or 'EP'‡, as appropriate, by the manufacturer.

Section five specifies safety requirements for accessories designated and marked 'A' by the manufacturer.

2. References

The titles of the standards publications referred to in this standard are listed on page 13.

3. Definitions

For the purposes of this British Standard the following definitions apply.

3.1 laboratory centrifuge. An apparatus used in the laboratory for separating substances of different density or particle size, when suspended in a liquid, by spinning them about an axis.

3.2 centrifuge head (also known as a centrifuge rotor). The rotated component of the centrifuge to which the accessories are attached.

3.3 sealed head. A head with a lid secured against a seal which prevents leakage of liquid or gas from the head.

3.4 angle head (also known as a fixed head). A centrifuge head in which the sample containers are supported at a fixed angle to the spin axis.

3.5 swing-out head. A centrifuge head in which the sample containers change their angle in relation to the spin axis.

3.6 head accessory. An article, other than a sample container, that is designed to fit on or in the centrifuge head, and to rotate with it. It may either be attached directly to the centrifuge head or it may be positioned inside another accessory, e.g. an adaptor inside a bucket.

3.7 bucket. A head accessory designed to support one or more sample containers.

3.8 sealed bucket. A bucket with a cap secured against a

seal which prevents leakage of liquid or gas from the bucket.

3.9 inserts. Head accessories such as sleeves, cushions and adaptors that fit between the sample container and its holder, e.g. a bucket, to prevent unnecessary movement and to minimize distortion or breakage of the container.

3.10 rotation assembly. A centrifuge head carrying one combination of head accessories specified by the manufacturer.

3.11 fully loaded rotation assembly. A rotation assembly loaded with the maximum number of sample containers specified by the centrifuge manufacturer, each filled to the indicated maximum capacity with a liquid of density 1200 kg/m³.

3.12 centrifuge chamber. The enclosed space in which the rotation assembly moves.

3.13 centrifuge casing. The protective casing comprising guard barrier, top, access cover and base that completely encloses the rotation assembly. This casing is primarily provided to contain within the apparatus any part of the rotation assembly which may break free while in use. (See figure 1.)

3.14 guard barrier. Part of the casing, that may comprise one or more concentric components, situated around the periphery of the rotation assembly so as to receive the major impact of any part of the rotation assembly or sample containers that may break free while in use.

3.15 guard barrier thicknesses, t_1, t_2, t_3 , etc. The thickness of those parts of the guard barrier, measured normal to their surfaces, that lie between the two cones above and below the head as shown in figure 1. The cones have apex angles of 170°, have axes coincident with the axis of rotation of the centrifuge, and apexes lying in planes, normal to the axis, through the upper and lower extremities of any rotation assembly specified by the manufacturer for use with the centrifuge. In the case of swing-out heads, these extremities may be determined by the disposition of the accessories during rotation at normal running speed.

3.16 rotational energy, E . The kinetic energy, in joules, of a specified rotation assembly during rotation at a specified speed calculated from the equation

$$E = 0.5 I \omega^2$$

where

I is the moment of inertia of the rotation assembly (in kg m²)

ω is the angular velocity (in rad/s).

3.17 maximum angular velocity, $\omega_{\max}$

Where limited by available power. The angular velocity of a fully loaded rotation assembly resulting when the motor is connected to a supply voltage 106 % of the nominal value, with the speed control (if any) disabled so as to override any safety interlocks (thereby applying maximum power to the motor) and when the centrifuge chamber is at the nominal operating pressure.

Where limited by the strength of the head. The angular velocity at which a fully loaded rotation assembly commences to disintegrate.

Where limited by means of a control device. A predetermined angular velocity set by the manufacturer by means of speed limiting devices (3.19).

*However, the revision of BS 696, at present in preparation, will refer to certain of the requirements of this British Standard.

†See note to 6.1.2.

‡See 11.1 and 12.1.

3.18 maximum rotational energy, $E_{\max}$

For rotation assemblies referred to in 1.2. The rotational energy (3.16) of whichever fully loaded rotation assembly develops the highest energy when running at its maximum angular velocity (3.17).

For zonal heads. The rotational energy of the unloaded rotation assembly.

3.19 speed limiting device. A device, independent of the speed control, which limits the angular velocity to a predetermined value according to the particular centrifuge head in use.

3.20 rotational speed. The speed, in r/min, calculated from $30\omega/\pi$.

3.21 access cover. The cover that forms part of the chamber casing and that allows access to the rotation assembly and the centrifuge chamber.

3.22 type test. A test carried out on a model selected at random from production to assess compliance with a requirement.

3.23 perimeter of a centrifuge head, c

For an angle head. The envelope of minimum length measured in a plane that includes the axis of rotation (see figures 2(a) and 2(d)).

For a swing-out head where the fixed portion of the head

contributes more than 75 % of the moment of inertia of the fully loaded rotation assembly. As for an angle head (see figure 2(b)).

For a swing-out head where the fixed portion of the head contributes less than 75 % of the moment of inertia of the fully loaded head. The envelope of minimum length of each bucket (or carrier) multiplied by the number of buckets (or carriers). The envelope of minimum length of each bucket (or carrier) is measured in a plane perpendicular to its axis of symmetry at a distance from its outer end equal to 25 % of the length of the bucket (or carrier) (see figure 2(c)).

NOTE 1. The perimeter does not include contributions from detachable accessories such as covers, lids or handles, nor contributions from separately manufactured fixings and fasteners.

NOTE 2. The perimeter does not include contributions from any re-entrant surfaces.

3.24 sample container. The container and closure (if any) in which the sample is centrifuged.

3.25 speed-limiting final switching device. The final relay, or solid-state equivalent of a speed-limiting device that is responsible for stopping the centrifuge if the maximum angular velocity is exceeded, by interrupting the control supply to the final machine control element (contactor).

3.26 carrier (also known as a trunnion). A head accessory designed to support one or more buckets.

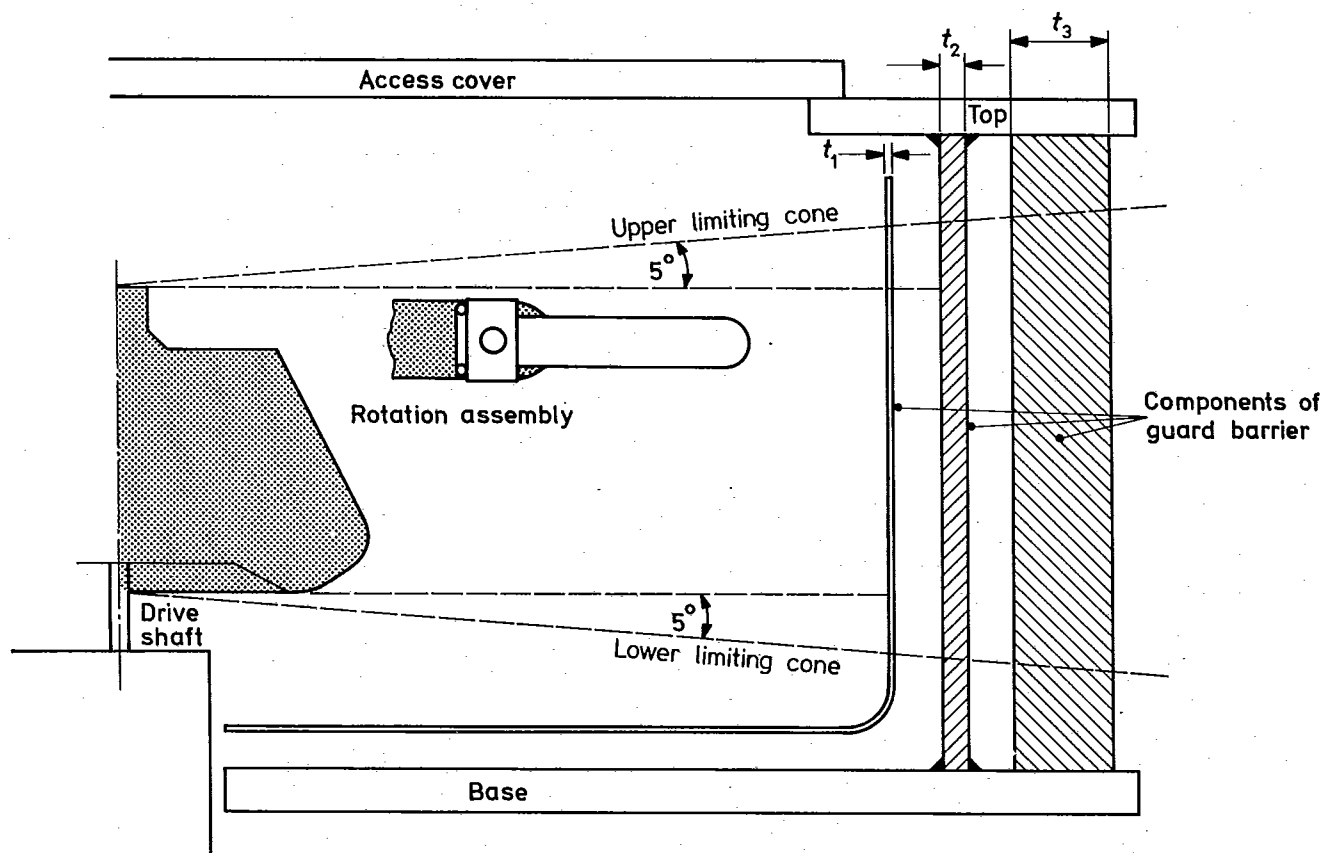
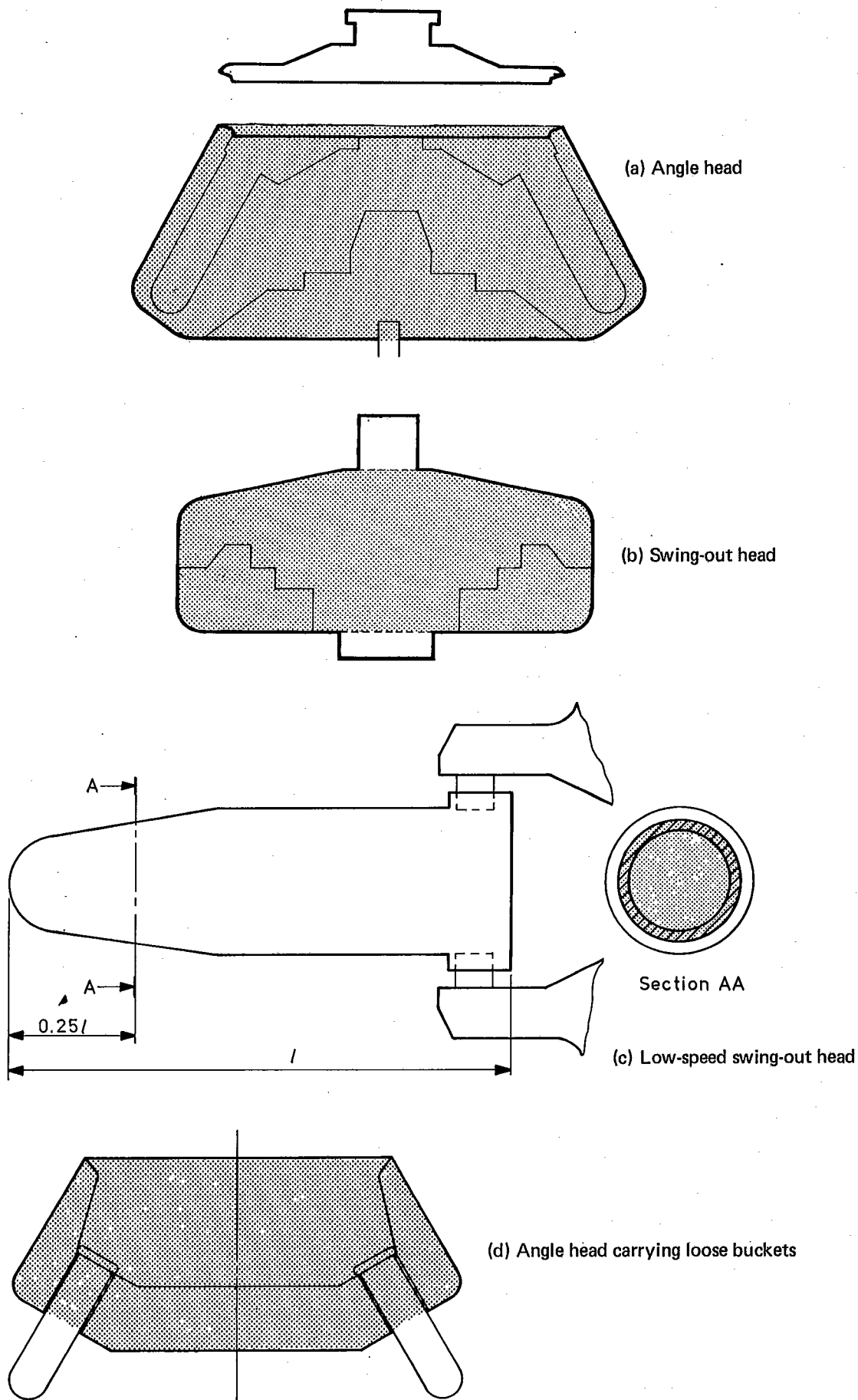


Figure 1. Centrifuge casing, comprising access cover, top, guard barrier and base

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Figure 2. Determination of perimeter c for the purpose of 3.23