

BRITISH STANDARD 4582 : Part 1 : 1970

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METRIC UNITS

SPECIFICATION FOR
FINE PITCH GEARS
(metric module)

Part 1. Involute Spur and Helical Gears

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*Incorporating amendments issued September 1978 (AMD 2723) and
May 1980 (AMD 3304)*

BRITISH STANDARDS INSTITUTION

Incorporated by Royal Charter

THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the Executive Board on 27 March, 1970.

SBN: 580 05988 X

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

A complete list of British Standards, numbering over 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 308. Engineering drawing practice.

BS 978. Fine pitch gears.

Part 1. Involute spur and helical gears.

Part 2. Cycloidal type gears.

BS 4500. ISO limits and fits.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

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The following BSI references relate to the work on this standard
Committee reference MEE/17 and MEE/17/4
Draft for approval 69/3766

CO-OPERATING ORGANIZATIONS

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- | | |
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| Associated Offices' Technical Committee | *Institute of Marine Engineers |
| *Association of Consulting Engineers | Institution of Civil Engineers |
| Association of Mining Electrical and Mechanical Engineers | Institution of Gas Engineers |
| *Board of Trade | Institution of Heating and Ventilating Engineers |
| British Chemical Plant Manufacturers' Association | *Institution of Mechanical Engineers |
| British Compressed Air Society | Institution of Mechanical Engineers (Automobile Division) |
| *British Electrical and Allied Manufacturers' Association | *Institution of Production Engineers |
| *British Gear Manufacturers' Association | Locomotive and Allied Manufacturers' Association of Great Britain |
| British Internal Combustion Engine Manufacturers' Association | London Transport Board |
| *British Mechanical Engineering Confederation | *Machine Tool Trades Association |
| British Pump Manufacturers' Association | Ministry of Defence |
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| Gas Council | National Coal Board |
| | National Physical Laboratory (Ministry of Technology) |
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The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- | | |
|---|--|
| British Ship Research Association | Milling, Cutter and Reamer Association |
| British Horological Institute | Ministry of Defence (Navy) |
| Electronic Engineering Association | Navy and Gearing Research Association |
| Institute of British Foundrymen | North East Coast Institution of Engineers and Shipbuilders |
| Institution of Engineers and Shipbuilders in Scotland | Society of Motor Manufacturers and Traders Ltd. |
| Institution of Engineering Inspection | |

BRITISH STANDARD SPECIFICATION FOR FINE PITCH GEARS (metric module)

Part 1. Involute Spur and Helical Gears

FOREWORD

This British Standard, which is a companion work to BS 978, Part 1*, has been prepared under the authority of the Mechanical Engineering Industry Standards Committee.

Whereas BS 978, Part 1*, is primarily concerned with the requirements for tooth form, diametral pitches, accuracy and accuracy testing procedures, etc., in the inch system, this standard provides similar information centred around metric modules. This enables the two standards to be used in parallel during the period of the changeover to the metric system in the United Kingdom.

SPECIFICATION

1. GENERAL

1.1 SCOPE

This British Standard relates to involute spur, helical and crossed helical gears, having modules of one millimetre and finer, in four accuracy grades. Examples of application are:

Class A. Astronomical apparatus and scientific instruments; colour printing machinery; control systems (when multiple trains of gears are involved this grade would generally be used for low speed components where the effect of positional accuracy is important).

Class B. Navigational instruments; high speed components of control systems where quietness and smooth running are essential; machine tool speed control; photographic instruments.

Class C. General purpose instruments; accounting and calculating machinery; counters; clockwork mechanisms.

Class D. Textile machinery; switch operating gear; clockwork mechanisms where accuracy is not the primary consideration.

It is recommended that all spur, helical and crossed helical gears for use in horology should be produced to this British Standard, with the possible exception of gears for weight or spring-driven mechanisms in which the pinion is the driven member and has 12 or fewer teeth. In such cases it may be preferable to use cycloidal type spur gears, conforming to BS 978, Part 2†.

Examples of calculation are given in Appendix B.

1.2 TERMINOLOGY AND NOTATION

As the first step towards achieving international understanding of gears terminology, the terms and definitions of Draft ISO Recommendation No. 888‡, 'International vocabulary of gears', have been applied, together with corresponding notation derived from ISO Recommendation No. 701, 'International gear notation, symbols for geometrical data'‡.

* BS 978, 'Fine pitch gears', Part 1, 'Involute spur and helical gears'.

† BS 978, 'Fine pitch gears', Part 2, 'Cycloidal type gears'.

‡ To be incorporated in BS 2519, 'Glossary of terms for toothed gearing'.

The notation used is as follows:

a	centre distance
a_v	virtual centre distance
d	reference circle diameter
d_1	reference circle diameter: pinion
d_2	reference circle diameter: wheel
d_a	tip diameter
d_{a1}	tip diameter: pinion
d_{a2}	tip diameter: wheel
d_R	measuring pin diameter
d_b	base circle diameter
j_n	normal backlash
j^*	coefficient for calculation of backlash
l	length of arc
m	module (normal module in millimetres)
s	arc tooth thickness
s_1	arc tooth thickness: pinion
s_2	arc tooth thickness: wheel
x	addendum modification coefficient
x_1	addendum modification coefficient: pinion
x_2	addendum modification coefficient: wheel
Δx_1	secondary addendum modification coefficient: pinion
Δx_2	secondary addendum modification coefficient: wheel
v	centre distance modification coefficient
z	number of teeth
z_1	number of teeth: pinion
z_2	number of teeth: wheel
z_v	virtual number of teeth
α_n	normal pressure angle
α_{nw}	normal pressure angle, operating
α_t	transverse pressure angle
α_{tw}	transverse pressure angle, operating
β	helix angle at reference cylinder
β_b	helix angle at base cylinder.

1.3 STANDARD MODULES

Standard modules should be selected from Table 1. First preference modules are in capital heavy type. Second preference modules are in ordinary type. Non-preferred modules are in italics.

TABLE 1. STANDARD MODULES

mm	mm	mm	mm	mm
	0.10	0.18	0.32	0.58
	<i>0.105</i>	<i>0.19</i>	0.35	0.60
	0.11	0.20	0.38	0.65
	<i>0.115</i>	<i>0.21</i>	0.40	0.70
0.07	0.12	0.22	0.42	0.75
<i>0.075</i>	0.13	0.24	0.45	0.80
0.08	0.14	0.25	0.48	0.85
<i>0.085</i>	0.15	0.26	0.50	0.90
0.09	0.16	0.28	0.52	0.95
<i>0.095</i>	0.17	0.30	0.55	1.00

NOTE. For comparable metric modules and diametral pitches, see Appendix C.

1.4 BASIC RACK TOOTH PROFILE

Fig. 1 shows the basic rack usually employed where it is desired to have minimum backlash, as in servo-mechanisms.

That shown in Fig. 2 is used where it is desired to have backlash to avoid any risk of jamming and where the load is usually uni-directional, for example, in clockwork mechanisms. When non-topping hobs are used it is permissible to use a hob conforming to Fig. 1 basic rack and to cut at greater depth than normal to obtain the required tooth thickness.

For internal gears (Fig. 1 and Fig. 2 basic racks) the

basic rack reference addendum shall normally be 0.850 instead of 1.000. In cases when the tips of the teeth have a radius of 0.25 or greater (up to 0.3 maximum as shown) the 1.000 addendum may be applied.

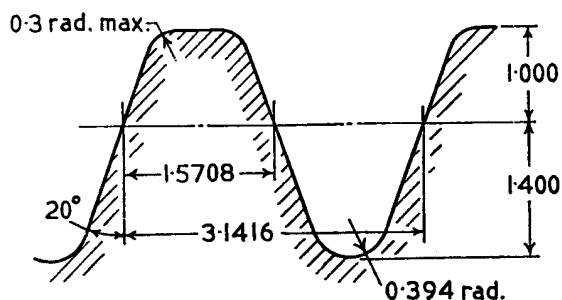


Fig. 1. Basic rack tooth profile for unit normal module

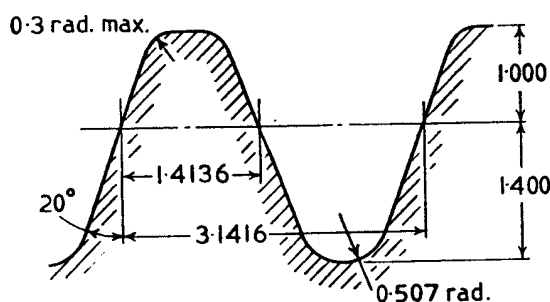


Fig. 2. Basic rack tooth profile for unit normal module with backlash allowance

2. DESIGN DETAILS

2.1 OUTSIDE DIAMETER AND CENTRE DISTANCE

For the normal case when both $z_1 \sec^3 \beta$ and $z_2 \sec^3 \beta$ are greater than 17 the dimensions are as follows:

$$d_1 = m.z_1 \sec \beta \quad (1)$$

$$d_2 = m.z_2 \sec \beta \quad (2)$$

$$d_{a1} = m.(z_1 \sec \beta + 2) \quad (3)$$

$$d_{a2} = m.(z_2 \sec \beta + 2) \quad (4)$$

$$a = \frac{m.(z_1 + z_2) \sec \beta}{2} \quad (5)$$

(For spur gears, $\sec \beta = 1$.)

2.2 MODIFICATION OF ADDENDUM AND CENTRE DISTANCE

2.2.1 For an explanation of the principles followed in connection with addendum modification see Appendix A.

2.2.2 Where no limitations are imposed, the value of x for any gear whose virtual number of teeth z_v is less than 17 is given by the formulae:

$$x = 1 - \frac{z_v \sin^2 \alpha_n}{2} \quad (\text{see Table 2 and Figs. 3 and 4}), \quad (6)$$

$$\text{where } z_v = z \sec \beta \sec^2 \beta_b \approx z \sec^3 \beta. \quad (7)$$

This gives values in accordance with the lower limiting line XX in Fig. 3 and a small and normally negligible amount of undercutting is thereby permitted.

The addendum modification coefficient for helical pinions from 6 to 16 teeth and helix angles up to 45° is shown in Fig. 4.

2.2.3 When the pinion is modified as above and there are no other limitations, the wheel is unmodified and its dimensions are obtained from the formulae in 2.1; but the dimensions of the pinion and centre distance are as follows:

$$d_{a1} = m[z_1 \sec \beta + 2(1 + x_1)] \quad (8)$$

$$s_1 = m(1.5708 + 0.7279x_1) \quad (\text{Fig. 1 type gears}) \quad (9)$$

$$s_1 = m(1.4136 + 0.7279x_1) \quad (\text{Fig. 2 type gears}) \quad (10)$$

$$a = \frac{m[(z_1 + z_2) \sec \beta + 2x_1]}{2} \quad (11)$$

Parallel axis external gear pairs designed as above have backlash at this centre distance. (See Appendix A.)

TABLE 2. DATA FOR SPUR PINIONS OF UNIT MODULE HAVING FEWER THAN 17 TEETH

No. of teeth z_1	Addendum modification coefficient x_1	Tip diameter d_{a1}	Increase in circular tooth thickness at standard pitch diameter	Recommended minimum number of teeth in mating wheel z_2
8*	0.5321	11.0642	0.3874	26
9*	0.4736	11.9472	0.3448	25
10	0.4151	12.8302	0.3022	24
11	0.3566	13.7132	0.2596	23
12	0.2982	14.5963	0.2170	22
13	0.2397	15.4793	0.1744	21
14	0.1812	16.3623	0.1319	20
15	0.1227	17.2453	0.0893	19
16	0.0642	18.1284	0.0467	18

* Pinions having 8 or 9 teeth generated from basic rack Fig. 1 have narrow crest width, as also have pinions of 10 and 11 teeth generated from basic rack Fig. 2. 10 is the smallest number of teeth that can be generated at full depth from basic rack Fig. 2.

2.3 ENLARGED SPUR PINIONS WITH MINIMUM BACKLASH

Spur pinions enlarged according to Table 2 may be engaged with wheels in which x_2 is zero, at centre distance derived from Table 3. Gears derived from Fig. 1 basic rack will have no backlash at this centre distance. A small and negligible reduction of tip-to-root clearance is obtained at this centre distance.

Table 2 is not applicable to helical gears, for which the formulae in Appendix A are required.

Alternatively, spur pinions enlarged according to Table 2 or helical pinions enlarged according to Fig. 4 may be engaged with wheels in which $x_2 = -x_1$, in which case the centre distance is as obtained in 2.1, and

$$s_2 = m(1.5708 - 0.7279x_1) \text{ (Fig. 1 type gears)} \quad (12)$$

$$s_2 = m(1.4136 - 0.7279x_1) \text{ (Fig. 2 type gears)} \quad (13)$$

$$d_{a2} = m[z_2 \sec\beta + 2(1 - x_1)]. \quad (14)$$

Such gears derived from Fig. 1 basic rack will have zero backlash at nominal dimensions.

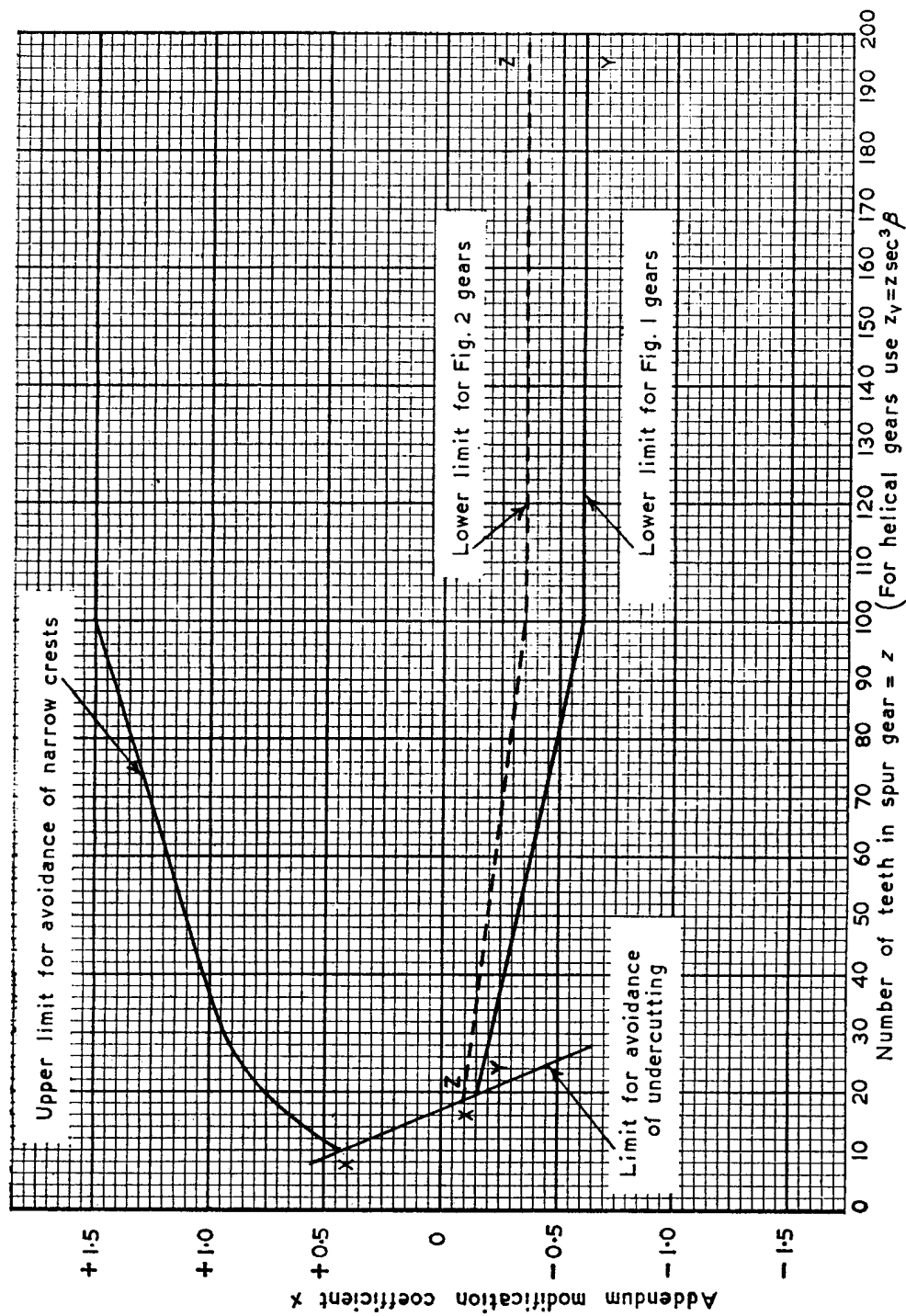


Fig. 3. Limiting values of addendum modification coefficient