BS 4659:1989

Specification for

Tool and die steels

UDC 669.14.018.25:621.73.073:621.7.016.2

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/31, upon which the following bodies were represented:

British Chain Manufacturers' Association
British Coal Corporation
British Forging Industry Association
British Industrial Fasteners' Federation
British Steel Industry
Cold Rolled Sections Association
Department of Trade and Industry (National Physical Laboratory)
Engineering Industries Association
Federation of British Engineers' Tool Manufacturers
Institution of Production Engineers
Lloyds Register of Shipping
Ministry of Defence
National Association of Steel Stockholders
Road Vehicle Spring Society
Society of Motor Manufacturers and Traders Limited
Stainless Steel Fabricators' Association of Great Britain

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Contents

Foreword

This British Standard has been prepared under the direction of the Iron and Steel Standards Policy Committee and is a combination and revision of BS 4659:1971 and BS 224:1938 which are withdrawn.

This revision retains one die steel (BH224/5) from BS 224:1938 and introduces two grades of steel for plastics moulding. The dimensional and decarburization requirements have been revised as a result of experience gained in the application of BS 4659:1971.

The tool steels have been grouped into three types, i.e. high speed, hot work and cold work. The designations adopted for the various types of tool steel are those adopted by the American Iron and Steel Institute, except that in all cases this letter has been preceded by the letter B. Thus, BT designates high speed tool steels of tungsten grades. The grades standardized are those which are most commonly used.

In the case of high speed steel and high carbon high chromium cold work tool steel, photomicrographs illustrate typical carbide distribution. These photomicrographs may be used to define the degree of permissible carbide segregation.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies chemical composition, tolerances on dimensions and maximum depths of functional decarburization and recommends heat treatment temperature ranges for tool and die steels in the form of:

a) hot-rolled rounds and flats;

b) coiled rod;

c) machined, ground or drawn rounds or coiled rod;

d) sheet and strip;

e) forgings;

f) forged bar.

NOTE 1 The term "hot-rolled coil" used in BS 4659:1971 has been replaced by "coiled rod".

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definition

For the purposes of this British Standard the following definition applies.

functional decarburization

the functional depth of decarburization is the last depth at which the hardness is not less than the minimum value specified in the hardened and tempered condition

3 Information to be supplied by the purchaser

3.1 General

The purchaser shall state the grade and form of steel required at the time of enquiry and order.

3.2 Options

A number of options are specified in Appendix A. In the event that the purchaser does not indicate his wish to implement any of these options and specify his requirements at the time of the enquiry and order, the manufacturer shall supply in accordance with the base specification.

4 Chemical composition

4.1 Composition ranges

The chemical composition of the steel, based on cast analysis, shall comply with the appropriate grade of material in Table 1.

4.2 Residual elements

Elements not quoted in the relevant steel composition shall not be intentionally added to the steel.

4.3 Product analysis and permitted deviations

NOTE The product analysis may differ from the cast analysis due to heterogeneity arising during casting and solidification.

The permitted deviations from the specified range on product analysis shall be as given in Table 2.

The deviation may occur either above or below the individual element ranges but shall not apply both above and below the specified range for any one element in any one cast of steel.

Test specimens for product analysis shall be taken in accordance with the appropriate method of BS 6200-3 or Handbook 19.

4.4 Dispute

Where results are disputed, samples shall be taken and tested in accordance with the appropriate Parts of BS 6200 or Handbook 19.

5 Freedom from defects

The steel shall be free from harmful defects such as piping, bursts, excessive porosity, gross inclusions from laps or other surface or subsurface defects and from ingotism and excessive banding. Carbides shall be spherodized and continuous carbide networks shall be absent.

See also the options listed in **A.4**, **A.5**, **A.6**, **A.7** and **A.8**.

6 Depth of functional decarburization for tool steels

The depth of functional decarburization shall comply with Table 3 (see Figure 1) for hot-rolled rounds and flats, Table 4 for hot-rolled sheet and strip and Table 5 (see Figure 2) for forged rounds and flats when measured in accordance with BS 6617-1 or BS 6617-2.

Steel ordered with a machined or ground finish shall be free from decarburization.

Where no value is specified the hardness at the functional depth of decarburization shall be within 5 % of the hardness midway between the axis and the surface of the section.

In cases of dispute, the sample shall be hardened and tempered in a neutral salt bath in accordance with the temperature ranges given in Appendix B and shall meet the hardness requirements given in Table 1.

7 Dimensional tolerances

7.1 Hot-rolled rounds and flats

The dimensional tolerances shall be as given in Table 3. Ovality shall be within dimensional tolerances.

7.2 Coiled rod

The dimensional tolerances shall be $^{+\ 0.30}_{-\ 0.15}$ mm for coiled rod 3 mm to 14 mm diameter.

7.3 Machined ground or drawn rounds and coiled rod

The dimensional tolerances shall be as given in Table 6.

Ground bar and drawn coiled rod shall be supplied to class 1 and machined to class 2 (see Table 6) dimensional tolerances. See also **A.9**.

7.4 Hot rolled sheet and strip

The dimensional tolerances shall be as given in Table 4.

7.5 Forged rounds and flats

The dimensional tolerances shall be as given in Table 5.

8 Hardness

8.1 Annealed hardness

The hardness of the steel after annealing shall not exceed the maximum requirement for the appropriate grade given in Table 1 when measured in accordance with BS 240.

8.2 Hardness after hardening and tempering of the steel

When subjected to hardening and tempering by heat treatment the hardness of the steel shall achieve the minimum requirement for the appropriate grade given in Table 1 when measured in accordance with BS 427.

NOTE Recommended temperatures for annealing, hardening and tempering and recommended quenching media are given in Appendix B.

9 Metallurgical condition of steel on delivery

The steel shall be in the annealed condition with the exception of BP20 which is normally delivered in the hardened and tempered condition.

NOTE Drawn rod or bar can be expected to have received a certain amount of cold work and the hardness will become greater as the size becomes smaller. The hardness of steel in this form can be expected to be up to 45 HB numbers higher than the maximum annealed hardness values given in Table 1.

10 Marking

Bars shall be marked either individually or, when the bars are securely bundled, on a metal tag attached to each bundle with the following information.

a) The number of this British Standard, i.e. BS 4659:1989[1)].

b) The grade of steel, e.g. BM1.

[1)] Marking BS 4659:1989 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Table 1 — Chemical composition, annealed hardness and hardness after heat treatment

Designation	C		Si		Mn		P		A		Cr		Mo		Ni		Co		Cu		Sn		V		W		Annealed hardness (max.)[a]	Hardness after heat treatment (min.)
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.		
High speed tool steels	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	HB	HV
BM1	0.75	0.85	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	8.0	9.0	—	0.40	—	1.0[b]	—	0.20	—	0.05	1.0	1.25	1.0	2.0	241	823
BM2	0.82	0.92	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	4.75	5.5	—	0.40	—	1.0[b]	—	0.20	—	0.05	1.75	2.05	6.0	6.75	248	836
BM4	1.25	1.40	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	4.25	5.0	—	0.40	—	1.0[b]	—	0.20	—	0.05	3.75	4.25	5.75	6.5	255	849
BM15	1.45	1.60	—	0.40	—	0.40	—	0.035	—	0.035	4.5	5.0	2.75	3.25	—	0.40	4.5	5.5	—	0.20	—	0.05	4.75	5.25	6.25	7.0	277	869
BM35	0.85	0.95	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	4.75	5.25	—	0.40	4.60	5.20	—	0.20	—	0.05	1.75	2.15	6.0	6.75	269	869
BM42	1.0	1.10	—	0.40	—	0.40	—	0.035	—	0.035	3.5	4.25	9.0	10.0	—	0.40	7.5	8.5	—	0.20	—	0.05	1.0	1.3	1.0	2.0	269	897
BT1	0.70	0.80	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	—	0.70	—	0.40	—	1.0[b]	—	0.20	—	0.05	1.0	1.25	17.5	18.5	255	823
BT4	0.70	0.80	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	—	1.0	—	0.40	4.5	5.5	—	0.20	—	0.05	1.0	1.25	17.5	18.5	277	849
BT5	0.75	0.85	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	—	1.0	—	0.40	9.0	10.0	—	0.20	—	0.05	1.75	2.05	18.5	19.5	290	869
BT6	0.75	0.85	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	—	1.0	—	0.40	11.25	12.25	—	0.20	—	0.05	1.25	1.75	20.0	21.0	302	869
BT15	1.40	1.60	—	0.40	—	0.40	—	0.035	—	0.035	4.25	5.0	—	1.0	—	0.40	4.5	5.5	—	0.20	—	0.05	4.75	5.25	12.0	13.0	290	890
BT21	0.60	0.70	—	0.40	—	0.40	—	0.035	—	0.035	3.5	4.25	—	0.7	—	0.40	—	1.0[b]	—	0.20	—	0.05	0.40	0.60	13.5	14.5	255	798
BT42	1.25	1.40	—	0.40	—	0.40	—	0.035	—	0.035	3.75	4.5	2.75	3.50	—	0.40	9.0	10.0	—	0.20	—	0.05	2.75	3.25	8.5	9.5	277	912
Hot work tool steels																												
BH10	0.30	0.40	0.75	1.10	—	0.40	—	0.035	—	0.035	2.8	3.2	2.65	2.95	—	0.40	—	—	—	0.20	—	0.05	0.30	0.50	—	—	229	—
BH10A	0.30	0.40	0.75	1.10	—	0.40	—	0.035	—	0.035	2.8	3.2	2.65	2.95	—	0.40	2.8	3.2	—	0.20	—	0.05	0.30	1.10	—	—	241	—
BH11	0.32	0.42	0.85	1.15	—	0.40	—	0.035	—	0.035	4.75	5.25	1.25	1.75	—	0.40	—	—	—	0.20	—	0.05	0.30	0.50	—	—	229	—
BH12	0.30	0.40	0.85	1.15	—	0.40	—	0.035	—	0.035	4.75	5.25	1.25	1.75	—	0.40	—	—	—	0.20	—	0.05	—	0.50	1.25	1.75	229	—
BH13	0.32	0.42	0.85	1.15	—	0.40	—	0.035	—	0.035	4.75	5.25	1.25	1.75	—	0.40	—	—	—	0.20	—	0.05	0.90	1.10	—	—	229	—
BH19	0.35	0.45	—	0.40	—	0.40	—	0.035	—	0.035	4.0	4.5	—	0.45	—	0.40	4.0	4.5	—	0.20	—	0.05	2.0	2.4	4.0	4.5	248	—
BH21	0.25	0.35	—	0.40	—	0.40	—	0.035	—	0.035	2.25	3.25	—	0.60	—	0.40	—	—	—	0.20	—	0.05	—	0.40	8.5	10.0	235	—
BH21A	0.20	0.30	—	0.40	—	0.40	—	0.035	—	0.035	2.25	3.25	—	0.60	2.0	2.5	—	—	—	0.20	—	0.05	—	0.50	8.5	10.0	255	—
Hammer die steel																											A[b] 444/447 A 401/429 B 363/388 C 331/352	
BH224/5	0.49	0.57	—	0.35	0.70	1.00	—	0.030	—	0.025	0.70	1.10	0.25	0.40	1.25	1.80	—	—	—	0.20	—	0.05	—	—	—	—	D 302/321 E 269/293	—

Table 1 — Chemical composition, annealed hardness and hardness after heat treatment

Designation	C		Si		Mn		P		S		Cr		Mo		Ni		Co		Cu		Sn		V		W		Annealed hardness	Hardness after heat treatment
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	(max.)[a]	(min.)
Cold work tool steels	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	HB	HV
BD2	1.40	1.60	—	0.60	—	0.60	—	0.035	—	0.035	11.5	12.5	0.70	1.20	—	0.40	—	—	—	0.20	—	0.05	0.25	1.00	—	—	255	735
BD2A	1.60	1.90	—	0.60	—	0.60	—	0.035	—	0.035	12.0	13.0	0.70	0.90	—	0.40	—	—	—	0.20	—	0.05	0.25	1.00	—	—	255	763
BD3	1.90	2.30	—	0.60	—	0.60	—	0.035	—	0.035	12.0	13.0	—	—	—	0.40	—	—	—	0.20	—	0.05	—	0.50	—	—	255	763
BA2	0.95	1.05	—	0.40	0.30	0.70	—	0.035	—	0.035	4.75	5.25	0.90	1.1	—	0.40	—	—	—	0.20	—	0.05	0.15	0.40	—	—	241	735
BA6	0.65	0.75	—	0.40	1.8	2.1	—	0.035	—	0.035	0.85	1.15	1.2	1.6	—	0.40	—	—	—	0.20	—	0.05	—	—	—	—	241	735
B01	0.85	1.0	—	0.40	1.1	1.35	—	0.035	—	0.035	0.40	0.60	—	—	—	0.40	—	—	—	0.20	—	0.05	—	0.25	0.40	0.60	229	735
B02	0.85	0.95	—	0.40	1.5	1.8	—	0.035	—	0.035	—	—	—	—	—	0.40	—	—	—	0.20	—	0.05	—	0.25	—	—	229	735
BS1	0.48	0.55	0.70	1.0	0.30	0.70	—	0.035	—	0.035	1.2	1.7	—	—	—	0.40	—	—	—	0.20	—	0.05	0.10	0.30	2.0	2.5	229	600
BL1	0.95	1.10	—	0.40	0.40	0.70	—	0.035	—	0.035	1.20	1.60	—	—	—	0.40	—	—	—	0.20	—	0.05	—	—	—	—	229	735
BW2	0.95	1.1	—	0.30	—	0.35	—	0.035	—	0.035	—	0.15	—	0.10	—	0.20	—	—	—	0.20	—	0.05	0.15	0.35	—	—	207	790
Plastics Moulding steel																												
BP20	0.28	0.40	0.40	0.60	0.65	0.95	—	0.025	—	0.025	1.50	1.80	0.35	0.55	—	0.40	—	—	—	0.25	—	0.05					[c]	[c]
BP30	0.26	0.34	—	0.40	0.45	0.70	—	0.025	—	0.025	1.10	1.40	0.20	0.35	3.9	4.3	—	—	—	0.20	—	0.05	—	—	—	—	[c]	[c]

[a] The hardness values for BH224/5 are for hardened and tempered steel.

[b] The maximum cobalt levels for BM1, BM2, BM4, BT1 and BT21 have been increased because of the level of cobalt in the scrap used for manufacture is increased.

[c] BP20 and BP30 are supplied to a wide range of hardness.

Table 2 — Permitted deviations in chemical composition on product analysis (see **4.3**)

Element	Range in which specified maximum falls	Permitted deviation from specified range on product analysis	
		Over max.	Under min.
Carbon	Greater than 0.25 less than or equal to 0.50 Greater than 0.50 less than or equal to 1.5 Greater than 1.5 less than or equal to 2.3	0.03 0.04 0.05	0.03 0.04 0.05
Silicon	Less than or equal to 0.40 Greater than 0.40 less than or equal to 1.0 Greater than 1.0	0.03 0.05 0.07	0.03 0.05 0.07
Manganese	Less than or equal to 1.0 Greater than 1.0 less than or equal to 1.5 Greater than 1.5	0.04 0.08 0.10	0.04 0.08 —
Phosphorus	Less than or equal to 0.025 Greater than 0.025 less than or equal to 0.040	0.005 0.006	— —
Sulphur	Less than or equal to 0.025 Greater than 0.025 less than or equal to 0.040 Greater than 0.09 less than or equal to 0.15	0.005 0.006 0.01	— — 0.01
Chromium	Less than or equal to 0.60 Greater than 0.60 less than or equal to 1.25 Greater than 1.25 less than or equal to 2.50 Greater than 2.50 less than or equal to 10.0 Greater than 10.0 less than or equal to 15.0	0.03 0.04 0.05 0.10 0.15	0.03 0.04 0.05 0.10 0.15
Molybdenum	Less than or equal to 1.0 Greater than 1.0 less than or equal to 2.0 Greater than 2.0 less than or equal to 3.0 Greater than 3.0 less than or equal to 10.0	0.03 0.05 0.08 0.10	0.03 0.05 0.08 0.10
Nickel	Less than or equal to 1.0 Greater than 1.0 less than or equal to 3.0 Greater than 3.0 less than or equal to 5.0	0.03 0.05 0.07	0.03 0.05 0.07
Cobalt	Less than or equal to 4.0 Greater than 4.0 less than or equal to 8.0 Greater than 8.0	0.08 0.10 0.15	0.08 0.10 0.15
Vanadium	Less than or equal to 0.5 Greater than 0.3 less than or equal to 1.0 Greater than 1.0 less than or equal to 2.5 Greater than 2.5	0.02 0.04 0.07 0.10	0.02 0.04 0.07 0.10
Tungsten	Less than or equal to 2.0 Greater than 2.0 less than or equal to 7.0 Greater than 7.0 less than or equal to 10.0 Greater than 10.0	0.07 0.10 0.15 0.20	0.07 0.10 0.15 0.20

Table 3 — Dimensional tolerances and maximum depth of functional decarburization for hot-rolled rounds and flats (see Figure 1)

Diameter or dimension across flats	Dimensional tolerance (max.)	Maximum depth of functional decarburization
mm	mm	mm
Up to and including 10	+0.4 −0	0.45
Over 10 up to and including 24	+0.6 −0	0.55
Over 24 up to and including 40	+0.8 −0	0.70
Over 40 up to and including 65	+1.2 − 0	0.95
Over 65 up to and including 80	+1.4 −0	1.10
Over 80 up to and including 100	+1.6 −0	1.30
Over 100 up to and including 120	+2.0 −0	1.50

Table 4 — Dimensional tolerances and maximum depth of functional decarburization for hot-rolled sheet and strip

Thickness	Dimensional tolerances	Maximum depth of functional decarburization per side
mm	mm	mm
Up to and including 0.6	± 0.04	0.03
Over 0.6 up to and including 0.8	± 0.05	0.03
Over 0.8 up to and including 1.2	± 0.08	0.03
Over 1.2 up to and including 1.6	± 0.07	0.05
Over 1.6 up to and including 2.0	± 0.08	0.08
Over 2.0 up to and including 2.5	± 0.09	0.10
Over 2.5 up to and including 3.0	± 0.11	0.13
Over 3.0 up to and including 4.0	± 0.13	0.13
Over 4.0 up to and including 5.0	± 0.14	0.18
Over 5.0 up to and including 6.0	± 0.16	0.20
Over 6.0 up to and including 8.0	± 0.25	0.25

Table 5 — Dimensional tolerances and maximum depth of functional decarburization for forged rounds and flats

Dimension diameter or width across flats	Dimensional tolerance (max.)	Maximum depth of functional decarburization
mm	mm	mm
Over 10 up to and including 20	+2 −0	1.3
Over 20 up to and including 100	+3 −0	2.5
Over 100 up to and including 150	+4.5 −0	3.5

Table 6 — Dimensional tolerances for machined, ground or drawn rounds and coiled rod

Diameter	Dimensional tolerance	
	Class 1	Class 2
mm	mm	mm
Over 1 up to and including 3	+0 −0.025	+0 −0.06
Over 3 up to and including 6	+0 −0.030	+0 −0.075
Over 6 up to and including 10	+0 −0.036	+0 −0.090
Over 10 up to and including 18	+0 −0.043	+ 0 −0.110
Over 18 up to and including 30	+0 −0.052	+0 −0.130
Over 30 up to and including 50	+0 −0.062	+0 −0.160
Over 50 up to and including 80	+0 −0.074	+0 −0.190

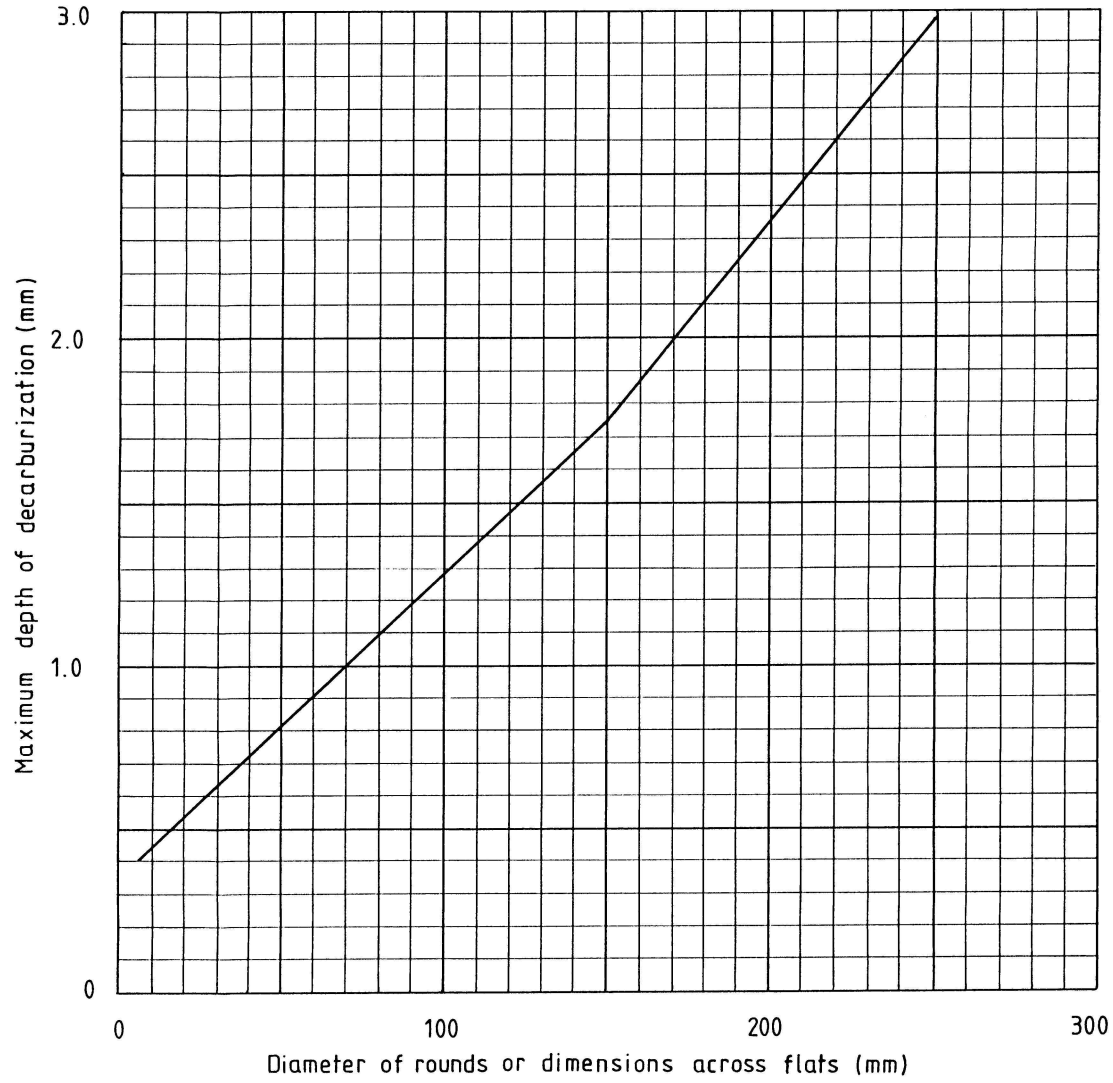

Figure 1 — Maximum depth of decarburization for hot-rolled rounds and flats

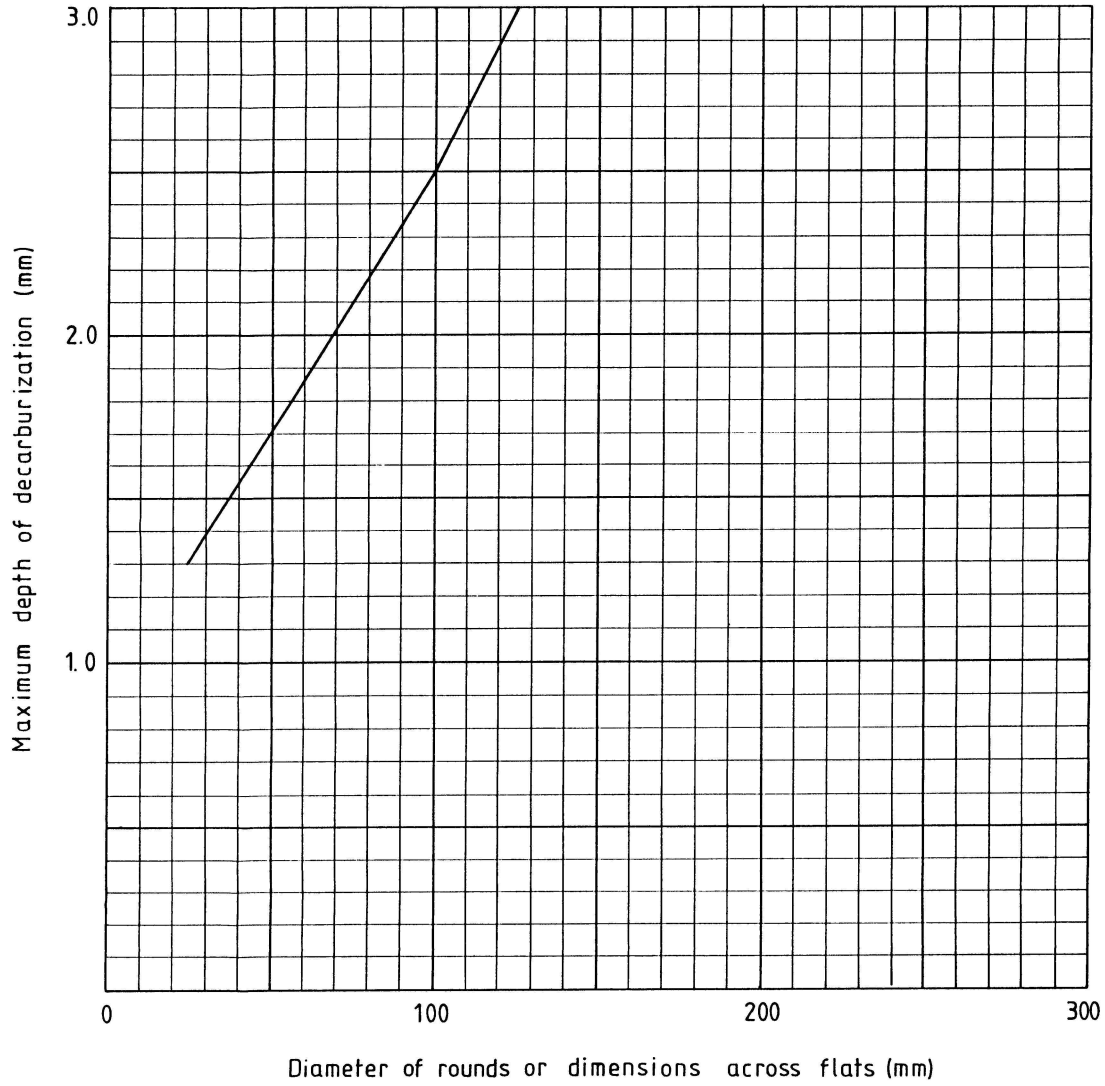

Figure 2 — Maximum depth of decarburization for forged rounds and flats

Appendix A Options (see 3.2)

A.1 Cast composition

The manufacturer shall supply a test certificate confirming the cast composition.

A.2 Chemical composition: sulphur

The steel shall contain either:

a) 0.09 to 0.15 % sulphur; or

b) 0.02 to 0.045 % sulphur.

A.3 Magnetic particle flaw detection

The steel shall be subjected to magnetic particle flaw detection in accordance with BS 6072.

A.4 Ultrasonic detection of imperfections

The steel shall be subjected to ultrasonic flaw detection in accordance with BS 4124.

A.5 Carbide distribution

The steel shall be tested to reveal the carbide distribution. The degree of permissible carbide segregation shall be agreed between purchaser and supplier.

NOTE Typical carbide distributions are shown for reference purposes in Appendix C.

A.6 Grain size

The grain size shall be measured in accordance with the Snyder-Graf method given in BS 4490.

A.7 Inclusion content

The inclusion content shall be assessed in accordance with ASTM E45-81, method A.

A.8 Dimensional tolerances

The dimensional tolerances for machined, ground or drawn bar and rod shall be agreed between purchaser and supplier.

Appendix B Recommended heat treatment for tool steels

The recommended heat treatment for tool steels is shown in Table 7.

Table 7 — Recommended heat treatment temperatures and cooling media for tool steels

Designation	Treatment				
	Annealing	Pre-heating	Hardening	Cooling medium	Tempering
	°C	°C	°C[d]		°C
HIGH SPEED TOOL STEEL[a]					
BM1	850–870	850	1 190–1 210	Oil	530–550
BM2	850–870	850	1 210–1 230	air	550–570
BM4	850–870	850	1 200–1 220	or	540–560
BM15	870–900	850	1 210–1 230	salt	540–560[b]
BM35	870–900	850	1 215–1 235	bath	530–550[b]
BM42	870–900	850	1 180–1 200	at	520–540[b]
BT1	870–890	850	1 270–1 290	500 °C to	550–570
BT4	880–900	850	1 280–1 300	560 °C	550–570
BT5	880–900	850	1 290–1 310	followed	550–570[b]
BT6	880–900	850	1 290–1 310	by	550–570[b]
BT15	870–890	850	1 230–1 250	cooling	550–570[b]
BT21	850–870	850	1 270–1 290	in air	550–570
BT42	850–870	850	1 220–1 240		550–570[b]
HOT WORK TOOL STEEL[a]					
BH10	850–870	800	1 000–1 060	Oil	530–650
BH10A	850–870	800	1 000–1 060	air	530–650
BH11	850–870	800	1 000–1 030	or	530–650
BH12	850–870	800	1 000–1 030	neutral salt	530–650
BH13	850–870	800	1 000–1 030	bath	530–650
BH19	850–870	800	1 150–1 200		530–650
BH21	870–890	800	1 100–1 180		560–675
BH21A	870–890	800	1 100–1 170		560–675
HAMMER DIE STEEL					
BH224/5	850–870	650	820–840	Water or oil	520–660
COLD WORK TOOL STEEL					
BD2	850–870	800	980–1 030	Air	150–220[c]
				oil	450–550
				or	
BD2A	850–870	800	980–1 030	neutral	150–220[c]
				salt	150–220[c]
				bath	
BD3	850–870	800	950–1 000		150–220[c]
					450–550
BA2	850–870	800	950–980		150–550[d]
BA6	730–750	650	830–850		150–250[d]
B01	760–780	—	780–820		150–300
B02	760–780	—	760–780	Oil	150–300
BS1	780–820	—	870–950		200–650
BL1	780–820	—	800–850	Oil or water	150–300
BW2	740–790	—	780–800	Water or brine	180–350
PLASTICS MOULDING STEELS					
BP20	—	—	850–880[e]	Oil	180–650[e]
BP30	640–660	—	810–830	Air or oil	180–650

[a] These steels are normally double-tempered.

[b] Triple tempering is recommended.

[c] The lower tempering temperature is used where maximum hardness is required and the higher range where maximum toughness is required.

[d] The temperatures given refer to heating in a neutral salt bath. Where heating is in a muffle furnace, the hardening temperature range should be 20 °C higher.

[e] BP20 is normally supplied in the hardened and tempered condition.

Appendix C Typical carbide distributions

Photomicrographs of typical carbide distributions as seen in longitudinal sections of high speed steel are illustrated in Figure 3 to Figure 6; these may be used to form a basis for agreement. Carbide segregation becomes more severe as the section increases and as the axis of the bar is approached. In reaching agreement it will be necessary to take into account the size of the bar, the position in the bar at which the examination is to be made, the type of high speed steel, and whether it is to be examined in the annealed or hardened and tempered condition.

Photomicrographs of typical carbide distributions as seen in longitudinal sections of cold work tool steels are illustrated in Figure 7 to Figure 10.

Figure 3 — Typical carbide distribution in high speed tool steel (× 100 magnification)

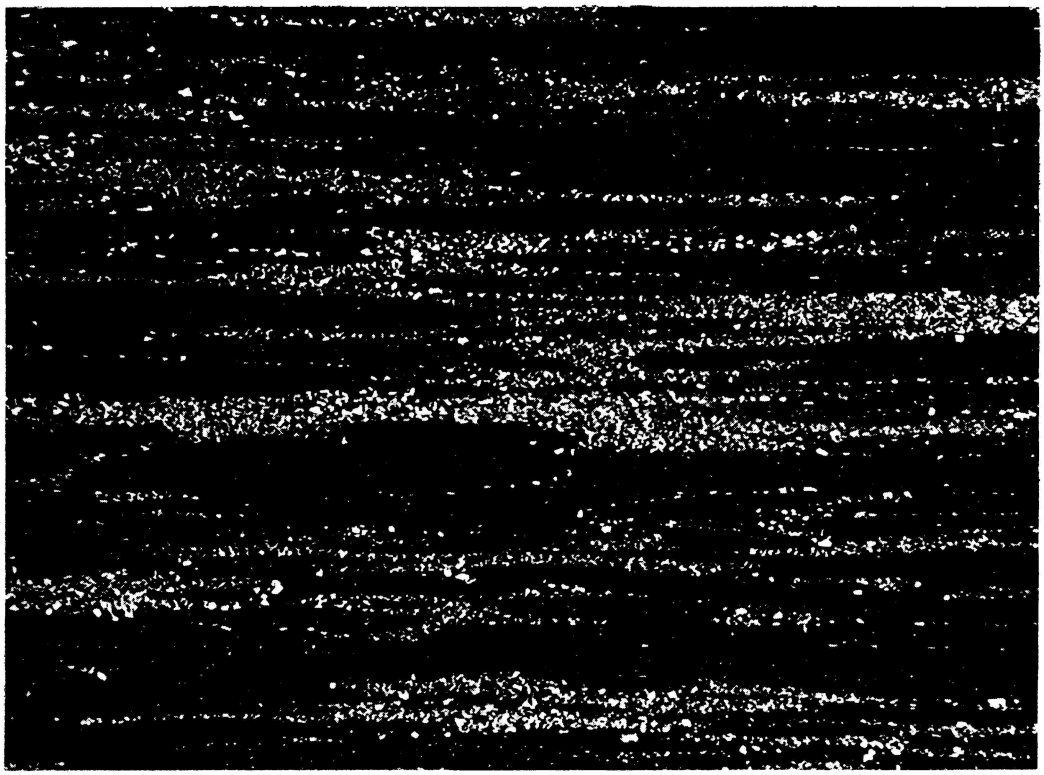

Figure 4 — Typical carbide distribution in high speed tool steel (× 100 magnification)

Figure 5 — Typical carbide distribution in high speed tool steel (× 100 magnification)

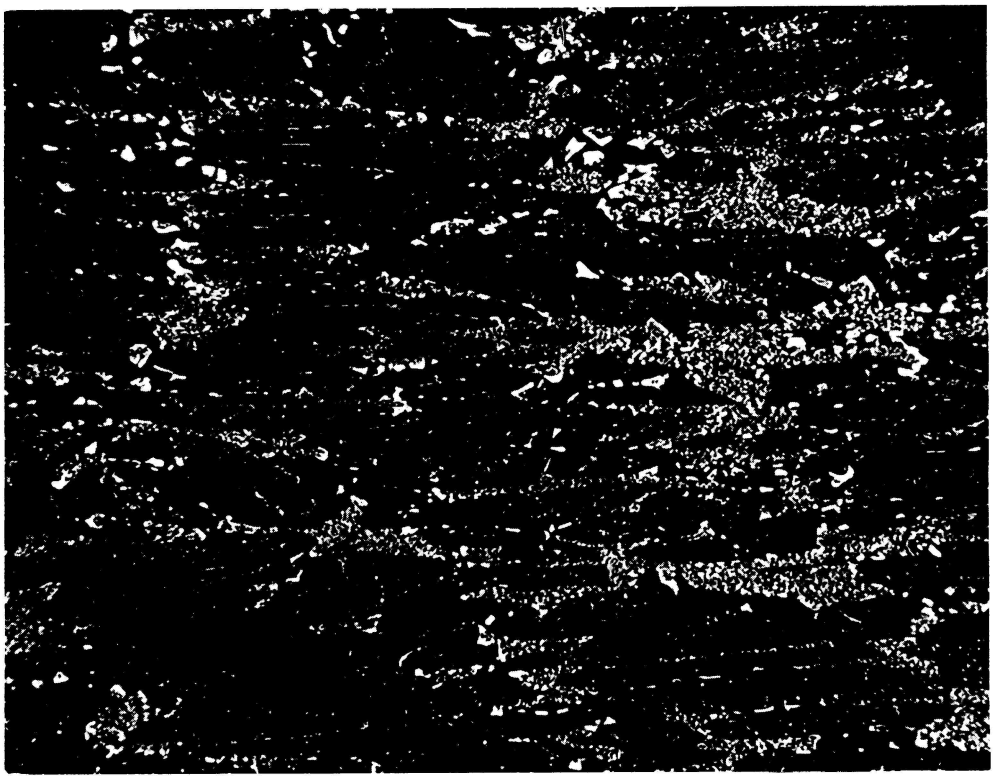

Figure 6 — Typical carbide distribution in high speed tool steel (× 100 magnification)

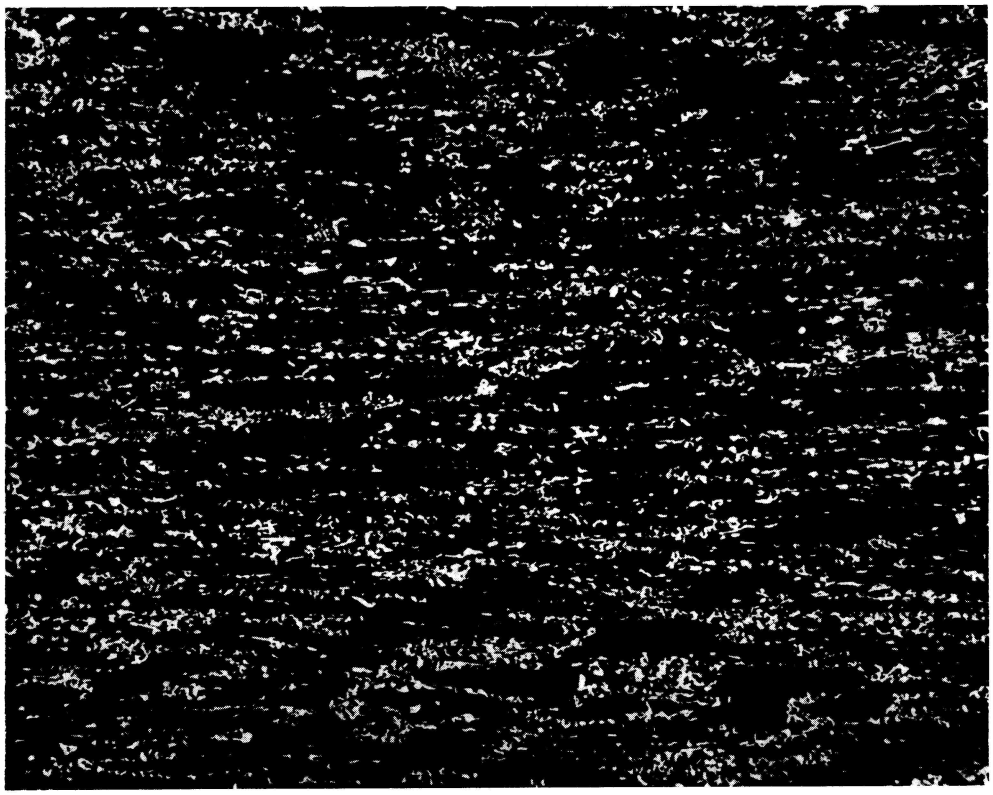

Figure 7 — Typical carbide distribution in high carbon high chromium cold work tool steel (× 100 magnification)

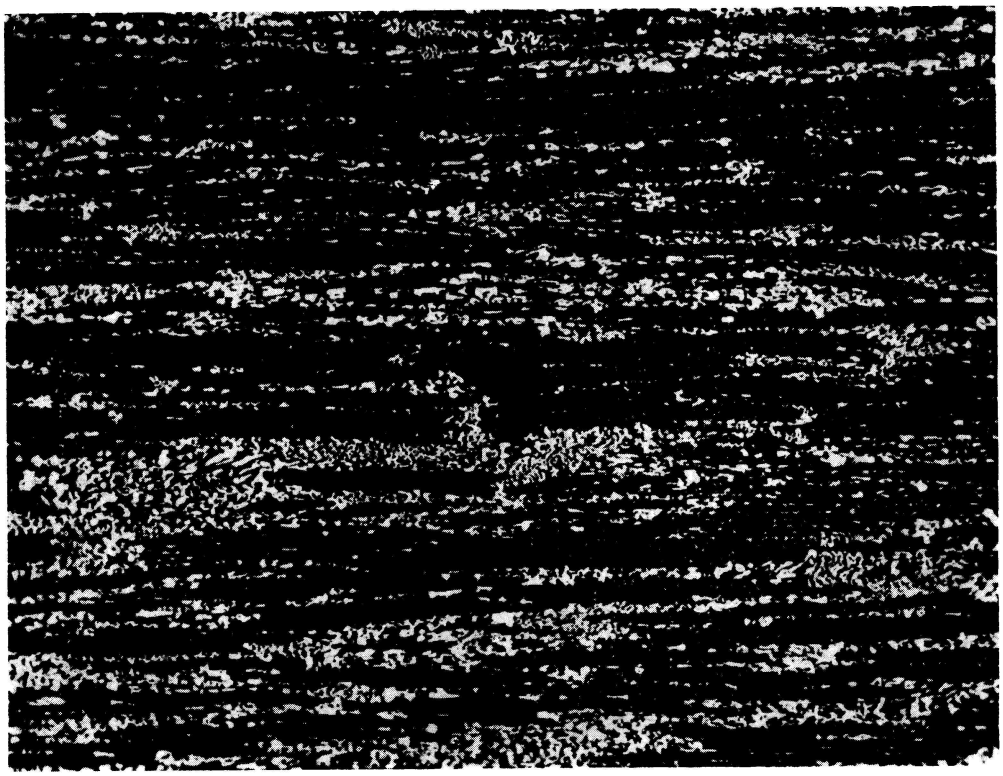

Figure 8 — Typical carbide distribution in high carbon high chromium cold work tool steel (× 100 magnification)

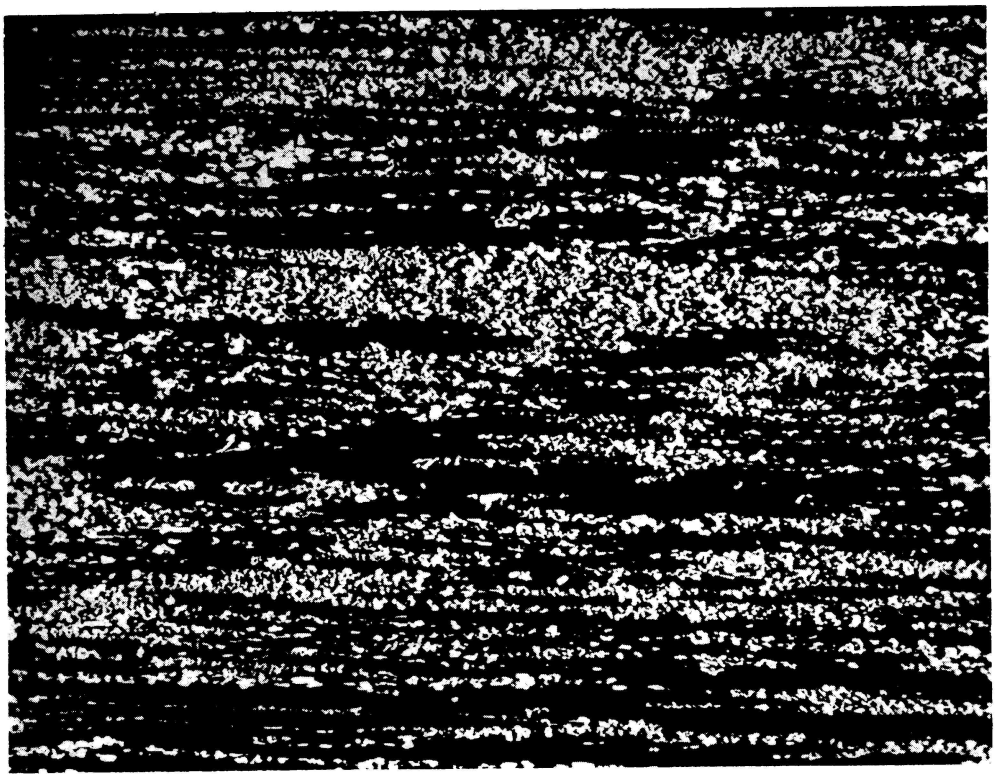

Figure 9 — Typical carbide distrubition in high carbon high chromium cold work tool steel (× 100 magnification)

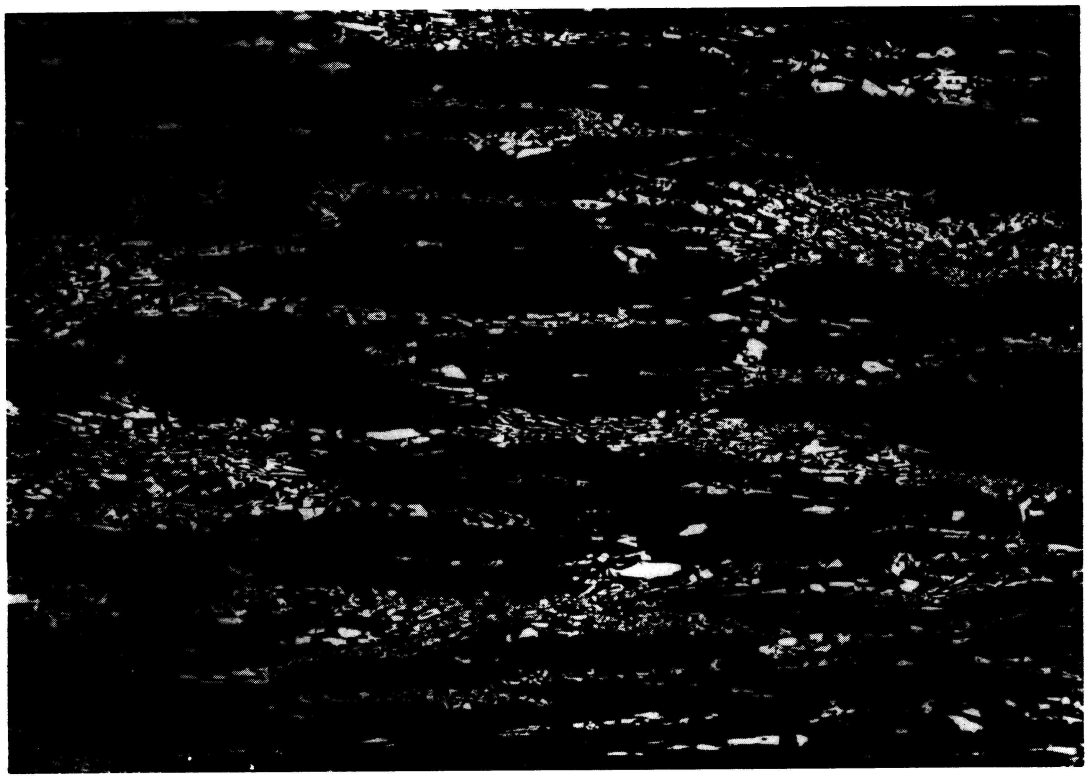

Figure 10 — Typical carbide distribution in high carbon high chromium cold work tool steel (× 100 magnification)

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Publications referred to

BS 240, *Method for Brinell hardness test and for verification of Brinell hardness testing machines.*
BS 427, *Method for Vickers hardness test.*
BS 4124, *Methods for ultrasonic detection of imperfections in steel forgings.*
BS 4490, *Methods for micrographic determination of the grain size of steel.*
BS 6072, *Method for magnetic particle flaw detection.*
BS 6200, *Sampling and analysis of iron, steel and other ferrous metals.*
BS 6617, *Determination of decarburization in steel.*
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ASTM E45-81 Recommended practice for determining the inclusion content of steel.
Handbook 19 Methods for the sampling and analysis of iron, steel and other ferrous metals.

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