

ROLLS-ROYCE

AERO
ENGINES

MATERIAL
SPECS



ROLLS-ROYCE LIMITED.

Specification No. 201 D.

(Cancelling Specification 201 C. of 29.9.33.)

MATERIAL. "30" Carbon Steel for general use.
(NOT suitable for Carburising and not to be specified for hexagon bars for nuts.)

R.R. SYMBOL. S/M. S.77.

DISTINGUISHING MARKING. One 3" band of white paint on each end of every bar or billet.

<u>CHEMICAL COMPOSITION.</u>	Carbon	0.26% to 0.34%
	Manganese	0.60% to 0.90%
	Sulphur	Not more than 0.045%
	Phosphorus	" " " 0.045%
	Silicon	" " " 0.30%
	Nickel *	" " " 0.10%
	Chromium *	" " " 0.20%

* It is preferred that these constituents shall not be present, but in any case they must not exceed the percentage stated.

HARDNESS NUMBER. The hardness number shall be determined by the formula $7C + 2(MN + CR) + NI$ (if any).

GRADING OF CASTS. Casts shall be graded according to the hardness numbers as follows :-

Bar or billet up to and including $\frac{5}{8}$ "	2.9 to 3.3
" " " $\frac{3}{4}$ " to 2"	3.1 to 3.7
" " " $2\frac{1}{8}$ " and above	3.6 to 4.2

TEST PIECES. The requisite physical tests shall be obtained from test pieces $1\frac{1}{8}$ " dia. when heat treated.

HEAT TREATMENT. Heat to 880/900°C and quench in water.
Temper at 620/650°C. and cool in air.

PHYSICAL TESTS. Brinell Hardness. 187/247.
Tensile. Maximum Stress not less than 35 tons per square inch.

Elongation on 2" not less than 22%
Reduction in Area " " " 47%

IZOD. Not less than 20 ft. lbs.
The Izod Test is chiefly applicable to bright drawn bars and if required will be specified on our orders.

GENERAL CONDITIONS.

- (1) The chemical analysis of every cast must be submitted to and approved by us before the steel is rolled.
- (2) The cast number must be stamped on all billet or rough rolled bar supplied to this specification. In the case of finished rolled bar and bright drawn bars, this is not necessary, but we must be advised of the cast number from which such bars are rolled.

8th April, 1940.

ROLLS-ROYCE LIMITED.

Specification No. 2031 A.

(Cancelling Specification of same No. dated
14th November, 1922).

MATERIAL. MILD STEEL TUBE (for general use).

ANALYSIS. Carbon 0.25% to 0.35%
Manganese.. .. 0.40% to 0.75%
Sulphur maximum 0.04%
Phosphorus " 0.04%
Silicon " 0.25%

{ T. I.
S.I.D.
—

NOTE. This specification is intended to cover "A"
Quality Commercial Mild Steel Tubing.

DISTINGUISHING

MARKING. Tubes supplied to this specification shall be
bundled together, each bundle bearing a metal
tally showing the specification number. The
tubes shall also be painted at the end with a
3" band of Grey Paint.

MANUFACTURE. Tubes are to be seamless and cold drawn. They
should be thoroughly annealed at a suitable
temperature before the final pass, and the Tubes
should be reduced as little as possible in that
pass.

GENERAL TUBES must be free from longitudinal seaminess
CONDITIONS. and to our entire satisfaction.

TESTS. Tubes may be flattened at the end or at any
point where faulty material is suspected by a
few blows (not more than six) delivered until
the sides are not more than three times the
thickness of the metal apart. They must stand
this treatment without cracking.

TOLERANCES. No Plus Tolerance on Outside Diameter is
permissible.
All Tolerances to be minus and in accordance
with the following scale :-

Up to $\frac{1}{2}$ " outside diameter	..	Minus .003"
From $\frac{1}{2}$ " to 1" outside diameter		Minus .005"
From 1" to 3" outside diameter		Minus .007"
Above 3" outside diameter		Minus .010"

ROTUNDITY. The permissible limits of out-of-
round on outside diameter to be as follows :-

Up to $\frac{1}{2}$ " outside diameter	..	.004"
From $\frac{1}{2}$ " to 1" outside diameter		.005"
From 1" to 2" outside diameter		.008"
Over 2" outside diameter		.010"

ECCENTRICITY. The eccentricity of the inside diameter in relation to the outside diameter shall not exceed 10% of the wall thickness of the tube.

OILING. All Tubes must be oiled inside and outside with a suitable non-acid oil to prevent rust.

April 6th, 1940.

ROLLS-ROYCE LIMITED.

Specification No. 2031 B.

(Cancelling Specification of same number dated 14th November, 1922).

T.26
S/D.

MATERIAL. MILD STEEL TUBE (for special purposes where strength is not of importance).

ANALYSIS.	Carbon	..	..	..	0.08% tp	0.20%
	Manganese	..	..	..	0.40% to	0.75%
	Sulphur	..	..	..	maximum	0.04%
	Phosphorus	..	..	..	"	0.04%
	Silicon	..	..	..	"	0.25%

NOTE This specification is intended to cover "B" Quality Commercial Mild Steel Tubing.

DISTINGUISHING MARKING. Tubes supplied to this specification shall be bundled together, each bundle bearing a metal tally showing the specification number. The tubes shall also be painted at the end with a 3" band of White Paint.

MANUFACTURE. Tubes are to be seamless and cold drawn. They should be thoroughly annealed at a suitable temperature before the final pass, and the tubes should be reduced as little as possible in that pass.

GENERAL CONDITION. Tubes must be free from longitudinal seaminess and to our entire satisfaction.

TESTS. Tubes may be flattened at the end or at any point where faulty material is suspected by a few blows (not more than six) delivered until the sides are not more than three times the thickness of the metal apart. They must stand this treatment without cracking.

TOLERANCES. NO PLUS TOLERANCE ON OUTSIDE DIAMETER IS PERMISSIBLE.

All tolerances must be minus and in accordance with the following scale :-

Up to 1/2" outside diameter	..	Minus .003"
from 1/2" to 1" outside diameter		Minus .005"
From 1" to 3" outside diameter		Minus .007"
Above 3" outside diameter		Minus .010"

ROTUNDITY. The permissible limits of out-of-round on outside diameter to be as follows :-

Up to 1/2" outside diameter	..	.004"
From 1/2" to 1" outside diameter		.005"
From 1" to 2" outside diameter		.008"
Over 2" outside diameter		.010"

ECCENTRICITY. The eccentricity of the inside diameter in relation to the outside diameter shall not exceed 10% of the Wall Thickness of the tube.

OILING. All Tubes must be oiled inside and outside with a suitable non-acid oil to prevent rust.

8th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 2052.

(Cancelling Specification No. 2051 of May 1st. 1939)

MATERIAL. .55 to .65 Carbon Steel.

{ S. 79.
S./HC.

MATERIAL SYMBOL. S/HC.

ANALYSIS. Carbon 0.55% to 0.65%
Manganese 0.6% to 0.75%
Silicon not more than 0.3%
Sulphur " " " 0.05%
Phosphorus " " " 0.05%
* Nickel " " " 0.3%
* Chromium " " " 0.3%

* Nickel and Chromium must not exceed the limits stated as they are impurities, and their absence is preferred.

NOTES. This specification is primarily intended for steel cylinder forgings. All forgings delivered to this specification must be supplied in the normalised condition and we will carry out any further heat treatment necessary.

The analysis of all casts must be submitted to and approved by us before work is commenced.

HEAT TREATMENT. For purposes of acceptance of material to this specification test pieces $1\frac{1}{2}$ " Dia. should be heat treated as follows :-

- (1) Heat to 840/850°C. and quench in oil.
- (2) Temper at 580/620°C. and cool in air.

Physical Properties must conform to those given in Section I.

MECHANICAL TESTS.

SECTION I. (for general use)

Brinell 237 - 285.

Maximum Stress not less than 56.0 tons per sq. inch.
Elongation on 2" - Not less than 14%
Reduction in Area " " " 32%

SECTION II. (Cylinder Liners of Intermediate Hardness).

Brinell 321 - 352.

Maximum Stress not less than 68.0 tons per sq. inch.
Elongation on 2" - Not less than 11%

8th April, 1940.

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SECTION III. (Cylinder Liners of Maximum Hardness).

Brinell 360 - 400.

Maximum Stress not less than 76.0 tons per sq. inch.
Elongation on 2" - Not less than 7%

Material heat-treated to this high brinell must also conform to the following bend test :-

Sample, which may be a portion of the broken tensile specimen, must be capable of being bent through an angle of 75° over a radius of .100" without showing signs of fracture.

If a separate sample is preferred it must be round and of .250 or .312" diameter.

Subsequent fracture of the bend specimen must show no signs of coarse crystallinity.

8th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO, 2061a.

(Cancelling Specification No. 206A of December 4th, 1918).

MATERIAL. Mild Nickel Steel (Suitable for Chassis Frames, Strip or Sheet for pressings for frame parts, and also for Seamless Tube).

S/NS.

ANALYSIS.	Carbon.....	0.25% to 0.3%
	Manganese.....	0.48% to 0.58%
	Silicon.....	Maximum 0.20%
	Sulphur.....	" 0.04%
	Phosphorus.....	" 0.04%
	Nickel.....	3.0% to 3.3%

T. 50
S/NS

NOTE. We only agree to 0.20% Silicon on the understanding that it is in solution in the steel, and not present as inclusions.

PART I. APPLICABLE TO TUBE MADE TO THIS SPECIFICATION ONLY.

MECHANICAL TESTS. Tensile - Maximum Stress not less than 38 tons per square inch.

Elastic Ratio, 65%.

Elongation per cent on 2" 25%.

Tests should be carried out on a normalised test piece.

GENERAL CONDITIONS. Tube should be supplied to us in the normalised test condition, unless otherwise specified on our orders.

Tube must be free from longitudinal seaminess, and to our entire satisfaction.

TOLERANCES. No plus tolerances are permissible on the outside diameter of any tube supplied to this Specification.

The following MINUS tolerances only are allowed:

Up to and including 1/2" outside diameter	Minus .003"
Above 1/2" and 1" outside diameter	" .005"
Above 1" Outside diameter	.007"

OILING. Tubes must be treated with a suitable non-acid oil inside and outside to prevent rust.

PART II. APPLICABLE TO STRIP OR SHEET FOR PRESSINGS FOR FRAME PARTS.

MECHANICAL TESTS. Tensile - Maximum Stress not less than 38 tons per square inch.
Elastic Ratio 65% Minimum.
Brinell - 149 - 183.

These tests figures must be obtained on a normalised test piece.

GENERAL CONDITIONS All Strip or sheet to this specification must be delivered in the normalised condition.

PART II.
GENERAL
CONDITIONS

Cont'd.

Sheet or strip must be sound, homogeneous and free from blisters or limitation, and special precautions must be taken to avoid surface defects due to the rolling in of loose scale.

TOLERANCES.

The following tolerances on thickness are permissible :-

From 3 I.W.G. to 5 I.W.G.	plus .007	minus .007
From 6 I.W.G. to 13 I.W.G.	plus .006	minus .006
From 14 I.W.G. to 18 I.W.G.	" .004	" .004
From 19 I.W.G. to 22 I.W.G.	" .002	" .003
Less than 22 I.W.G.	" .001	" .002

PART III.

APPLICABLE TO PLATE FOR FRAME PRESSINGS ONLY.

MECHANICAL
TESTS.

Tests should be carried out on a normalised test piece, and must give the following results :-

Tensile :- Maximum Stress not less than 36 tons per square inch.

Elastic Ratio :- 60% minimum.

Brinell :- 143 - 170.

TOLERANCES.

A tolerance of plus or minus 5% of the nominal thickness of the plate is permissible.

GENERAL
CONDITIONS.

Applicable to all parts of this specification.

The analysis of the cast it is proposed to use for any orders to this specification must be submitted to and accepted by us **before** the steel is rolled.

August 18th, 1920.

R.R. MATERIAL SPECIFICATION.

SPECIFICATION NO. 206-B. SYMBOL S/N.

MATERIAL. Nickel Steel for forging Pendulum Levers only.

ANALYSIS. Carbon..... .37 to .45
Silicon..... Max. .30
Manganese..... .50 to .80
Sulphur..... Max. .05
Phosphorus..... Max. .05
Nickel..... 3.0 to 3.3
Chromium..... Nil.

HARDNESS. The hardness number as calculated by formula
7C + 2Mn. + Ni. must be within the limits
7.0 to 7.7

HEAT-TREATMENT. (1) Heat to 820°C. to 840°C. quench in oil,
(2) Temper 520°C. to 540°C. Cool in air.

TESTS.

- a. Brinell. 286 to 311.
- b. Izod. (for Brinell 302-321) 30-22 ft.lbs.
- c. Stanton. 4000 blows. minimum.
- d. Tensile. ult. yield. elong.% RA%
55 tons. 47 tons. 16% 40%
per sq.
in.

NOTE.

Any material supplied to this specification should bear a special distinguishing mark, to be painted on each billet, to distinguish from material to Specification 206.

8th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 2063.

MATERIAL. $3\frac{1}{2}\%$ Nickel Steel. { S 69
S/N. S.A.F. 2340.
S.M.M.T. 15

DISTINGUISHING MARKING. One band of Brown Paint 3" wide on each end of every bar or billet.

R.R. SYMBOL. S/N.

ANALYSIS. Carbon 0.32% to 0.42%
Silicon Not more than 0.30%
Manganese 0.50% to 0.75%
Sulphur Not more than 0.04%
Phosphorus " " " 0.04%
Nickel 3.25% to 3.75%
Chromium 0.15% to 0.30%

On bars 1" diameter or width across the flats and under we are prepared to accept casts which do not contain chromium.

HARDNESS NUMBER. The hardness number shall be graded by the following formula :-

$$7.C + 2 (MN + CR) + Ni.$$

GRADING OF CASTS. Casts shall be graded according to their hardness number in accordance with the following scale :-

<u>Dia. or Width Across Flats.</u>	<u>Finished Bars.</u>	<u>Rough Rolled Bar or Billet for Stpg.</u>
Up to and including $\frac{1}{2}$ "	6.8 to 7.3	7.0 to 7.5
$\frac{9}{16}$ " to 1"	7.2 to 7.6	7.3 to 7.7
$1\frac{1}{16}$ " to $1\frac{1}{2}$ "	7.4 to 7.9	7.4 to 7.9
$1\frac{9}{16}$ " to 2"	7.6 to 8.1	7.6 to 8.1
$2\frac{1}{16}$ " to 3"	7.8 to 8.3	7.9 to 8.4
$3\frac{1}{16}$ " and over.	8.0 to 8.5	8.2 to 8.6

- GENERAL CONDITIONS
- (1) All finished bars above $\frac{5}{8}$ " dia. and less than 3" dia. shall be reeled. Bars delivered as reeled.
 - (2) Analysis of all casts must be submitted to and approved by us before steel is rolled.
 - (3) Casts which fall just outside our limits may be submitted to us and we may apply for a sample, but we do not undertake to accept such casts.
 - (4) All billets for stamping must have the cast number stamped on. In the case of finished bars this is not necessary, but we must be advised of the cast numbers from which they are produced.

8th April, 1940

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**HEAT TREATMENT
OF BARS BEFORE
DELIVERY.**

Machining Bars. All finished bars for machining shall be brinelled and if over 269 Brinell they must be softened.

Forging Bars or Billets. All Bars or billets for forging must be delivered in the normalised condition.

Bars for Bright Drawing. All bars intended for bright drawing shall be delivered in the "as rolled" condition and the drawers will be responsible for normalising such bars before they commence drawing operations.

Bright Drawn Bars. Bright drawn bars shall be normalised after the final pass and then repolished. Hexagon and square Bars shall be normalised immediately before the final pass which should be cleaning and sizing pass only.

**HEAT TREATMENT
OF TEST PIECES.**

Test pieces shall be forged or rough ^{ed} machining to $1\frac{1}{8}$ " dia. and then heat treated as follows :-

- (1) Heat to 820/840°C and quench in oil.
- (2) Temper at 540/570°C and cool in air.

**MECHANICAL
TESTS.**

The following tests results must be obtained on samples heat treated in accordance with the foregoing :-

- (a) Brinell Hardness. 286 - 321
Tensile.
Ultimate Stress Not less than 60 tons per square inch.
Yield Not less than 50 tons per square inch.
Elongation on 2" Not less than 18%
Red. in Area " " " 50%
- (b) Izod. Not less than 30 foot lbs.

NOTE:

In actual practice the tempering heat will be modified to give the various ranges of Brinell Hardness specified on our detail drawings.

For test purposes the treatment given above should be strictly adhered to.

10th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 207C.

MATERIAL. 5% Nickel Case Hardening Steel (High Nickel Content). S60.
S/ZNX.

ANALYSIS. Carbon 0.10% to 0.15%
Manganese 0.30% to 0.40%
Silicon Not more than 0.30%
Sulphur " " " 0.04%
Phosphorus " " " 0.04%
Nickel 5.0% to 5.5%
Chromium Not more than 0.30%

S.A.E. 2515.

GENERAL CONDITIONS. (1) Analysis of all casts must be submitted to and accepted by us before steel is rolled.

(2) Casts which fall just outside our limits may be submitted to us ~~if~~ we may apply for a sample, but we do not undertake to accept such casts.

(3) All billet for stamping must have the cast number stamped on. In the case of finished rolled bars this is not necessary, but we must be advised of the cast number from which they are made.

(4) All finished bars above $\frac{3}{8}$ " dia. and less than 3" dia. shall be reeled. Bars to be delivered as reeled.

PREPARATION OF TEST PIECES. (1) Test Piece should be turned down to 0.750" dia.
(2) Carburise at 900°C for four hours and cool in air.
(3) Reduce on test length to 0.575" dia.
(4) Heat to 820/830°C. Soak for 15 minutes and quench in thin oil.
(5) Heat to 730/750°C. and quench in thin oil.
(6) Grind on test length to 0.564" dia.

MECHANICAL TESTS. Brinell 302 - 341
Tensile Ult. Stress - Not less than 65 tons per sq. in.
Elongation on 2" - Not less than 13%
Red. in Area. - Not less than 35%
Izod Not less than 30 ft. lbs.

8th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 2072.

(Cancelling Specification No. 2071A of 12.9.23)

MATERIAL. 5% Nickel Case Hardening Steel. { S.67
SIZN S.M.M.T. 10
SAE. 2512.

DISTINGUISHING MARKING. One azure blue band, 3" wide, on both ends of every bar or billet.

ANALYSIS.

Carbon	0.09% to 0.14%
Silicon	0.10% to 0.25%
Manganese	0.25% to 0.40%
Sulphur	Maximum 0.04%
Phosphorus	Maximum 0.04%
Nickel	4.6% to 5.0%
Chromium	Maximum 0.10%

HARDNESS NUMBER. The hardness number to be determined by the following formula :-

$$7C + 2 (Mn + Cr) + Ni.$$

GRADING. Casts to be graded according to their hardness number in accordance with the following scale.

<u>Dia. or Width Across Flats, Bar or Billets.</u>	<u>Hardness Number.</u>
Under 1"	5.9 to 6.3
1" up to 1½"	6.0 to 6.4
1½" up to 2½"	6.1 to 6.6
2½" up to 5"	6.2 to 6.7

Occasionally we may require for special purposes material which does not conform to the above hardness scale. This is made clear on our orders, and any material delivered to us where the hardness is varied from the above scale must be painted with a broad vermilion band round the centre of the bar or billet to distinguish same from standard material.

- GENERAL CONDITIONS.
- (1) Analysis of all casts must be submitted to and accepted by us before steel is rolled.
 - (2) Casts which fall just outside our limits may be submitted to us, and we may apply for a sample, but we do not undertake to accept such casts.
 - (3) All billet for stamping must have the cast number stamped on. In the case of finished rolled bars this is not necessary, but we must be advised of the cast number from which they are made.

GENERAL CONDITIONS Cont'd.

- (4) All finished bars above $\frac{5}{8}$ " diameter and less than 3" diameter shall be reeled. Bars to be delivered as reeled.

PREPARATION

- OF TEST PIECES. (1) Test Piece should be turned down to 0.750" diameter.
- (2) Carburise at 900-920°C. for 4 hours and cool in air.
- (3) Reduce on test length to 0.575" diameter.
- (4) Heat to 840°C. Soak for 15 minutes and quench in thin oil.
- (5) Heat to 740°C. and quench in thin oil.
- (6) Grind on Test length to 0.564" diameter.

MECHANICAL TESTS.

Treated as above, the material must give the following mechanical test results :-

- (a) Brinell Hardness : 200 - 300 (on core).
- (b) Tensile :

Ult. Stress.	Yield.	Elong. 2"	R. in A%
45 MIN.	28 MIN.	18% MIN.	45% Min.

Izod. 50 ft. lbs.

February 22nd, 1926.

ROLLS-ROYCE LIMITED.

Specification No. 208a.

(Cancelling Specification of the same number dated November 26th, 1918).

MATERIAL.	NICKEL CHROME STEEL (for Front Axles, etc.).				<u>SINCR.</u>
ANALYSIS.	Carbon	0.18%	to	0.25%	
	Manganese	0.25%	to	0.55%	
	Silicon	Maximum		0.30%	
	Sulphur .. .. .	..		0.04%	
	Phosphorus .. .. .	..		0.04%	
	Nickel	3.25%	to	4.00%	
	Chromium .. .. .	.40%	to	.80%	
NOTE.	(1) Analysis of all casts must be submitted to and accepted by us before the steel is worked.				
	(2) Casts which fall just outside our limits may be submitted, and we may apply for a sample, but we do not undertake to accept such casts.				
HEAT TREATMENT.	(1) Heat to 825°C. and quench in oil.				
	(2) Temper to give required brinell and quench in oil.				
MECHANICAL TESTS.	(a) BRINELL : 255-286.				
	(b) TENSILE :				
	Max. Stress.	Yield Point.	Elong. on	R.A. %.	
	55-60 tons	45-53 tons	2" %.	50% min.	
	per sq. inch.	per sq. inch.	18% min.		
	(c) IZOD : Not less than 35 ft. lbs.				
	(d) STANTON (if required) : 4,000 blows with 4½-lbs. hammer falling 2.000".				

10th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 2082.

(Cancelling Specification 2081 of Feb.22/1926)

{ 4.5.11
S/NCR.

SAE 3435 (no no.)
SMMT 21.

MATERIAL. Nickel Chrome Steel.

ANALYSIS.	Carbon	0.30% to 0.36%
	Manganese	0.45% to 0.65%
	Silicon	Maximum 0.30%
	Sulphur	" 0.04%
	Phosphorus	" 0.04%
	Nickel	3.20% to 3.70%
	Chromium	0.60% to 0.70%
	Molybdenum	0.15% to 0.25%

GENERAL CONDITIONS

- (1) Analysis of all casts must be submitted to and accepted by us before the steel is worked.
- (2) Casts which fall just outside our limits may be submitted to us, and we may apply for a sample, but we do not undertake to accept such casts.
- (3) All billets for stamping must have the cast number stamped on. In the case of finished rolled bars this is not necessary but we must be advised of the cast from which they are made.
- (4) All forgings delivered to this specification (Crankshafts, Propeller Shafts, etc.) must be delivered in the normalised condition, unless otherwise specified on our orders.

HEAT TREATMENT.

Heat to 820/840°C and quench in oil.
Temper at 570/590°C and quench in oil.

MECHANICAL TESTS.

<u>Brinell</u>	286 - 321
<u>Tensile</u>	Maximum Stress 60 - 68 tons per sq.in.
	Yield 50 - 60 " " " "
	Elongation % on 2" Not less than 18%
	R.A.%
<u>Izod.</u>	Not less than 40 ft. lbs.

10th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 209C.

(Cancelling Specification No. 209B of Oct. 14th, 1925)

MATERIAL.	Chrome Vanadium Steel (for wire for valve springs).	} <u>S/CV.</u> <u>D.T.D 4A.</u>
ANALYSIS.	Carbon 0.42% to 0.47% Manganese..... 0.50% to 0.70% Silicon..... 0.2% to 0.4% Sulphur..... Maximum 0.03% Phosphorus..... " 0.03% Chromium..... 1.1% to 1.4% Vanadium..... 0.15% to 0.25% Nickel..... Maximum 0.3% Copper..... Not more than 0.15%	

The carbon content on the annealed and heat-treated springs must not be less than 0.40%.

GENERAL CONDITIONS.

- (1) Casts shall be electrically melted and shall not exceed 8 tons in weight.
- (2) Casts shall be made into the special type of ingots.
- (3) Analysis of every cast must be submitted to and approved by us before any work is done upon same.
- (4) A test bar 4 feet long and 13/16" diameter must be submitted to us before final approval of any cast can be given.
- (5) The ingots shall be machined all over before rolling. They shall be cogged down and rolled WITHOUT quartering.
- (6) The material may be required either in the form of 9/16" diameter or 13/32" diameter rods, or else as 2 inch square billets with corners removed, of 60 lbs weight approximately.

HEAT TREATMENT.

FOR AERO VALVE SPRINGS ONLY.

- (1) Heat to 880°C and quench in oil.
- (2) Preheat to 450/500°C and transfer to final Hardening Furnace.
- (3) Heat to 860°C and quench in oil.
- (4) Temper at 430/460°C and hold at the temperature for 1 to 2 hours according to size of wire. Allow to cool in air.

FOR CHASSIS VALVE SPRINGS.

- (1) Heat to 870°C and quench in oil.
- (2) Temper at 430/460°C and hold at the temperature for 1 to 2 hours according to size of wire. Allow to cool in air.

MECHANICAL TESTS.

- (1) BRINELL : 401 - 440.
- (2) TENSILE :

Ult. Stress.	Yield.	Elong.	R.A.
Not less than 95 tons	90 tons	12%	35%

12th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 210 A.

MATERIAL. High Carbon Chromium Steel (for Ball Races and Ball Thrusts.)

ANALYSIS.

Carbon	.80%	to	1.05%
Chromium	1.20%	to	1.5%
Manganese	.30%	to	.55%
Silicon	maximum		.30%
Sulphur	"		.04%
Phosphorus	"		.04%

HARDNESS SCALE. The hardness figure is calculated by the formula $10C. + 2 CR. + 5 MN.$, and to obtain the best results from this Steel the hardness when calculated by this formula should be within the limits 13 to 15.5.

HEAT TREATMENT.

- (1) Normalising. After rough machining the pieces should be normalised by heating in a salt bath to $840^{\circ}C.$ and allowed to remain at that temperature for 20 minutes. They should then be cooled in air.
- (2) Hardening. Heat in salt bath to $820^{\circ}C.$ and soak for 10 minutes. Quench in thin cold oil.
- (3) Temper. Temper in oil at $150^{\circ}C.$ for 10 minutes.

TESTS. Scleroscope 85 to 100.

SPECIAL NOTE. The Hardness Scale given above is of the utmost importance, and must be carefully worked to if satisfactory results are to be obtained from this Steel.

May 7th, 1918.

ROLLS-ROYCE LIMITED.

Specification No. 211.

MATERIAL.

CHROMIUM STEEL FOR VALVES.

ANALYSIS.

Carbon	..	..	..	.40%	to	.47%
Chromium	..	..	..	6.5%	to	7.5%
Manganese	..	..	..	.40%	to	.60%
Silicon	..	..	..	.60%	to	1.00%
Sulphur	..	..	..	Max.		.04%
Phosphorus	..	..	..	Max.		.04%

HEAT TREATMENT.

(1) Heat up to 900°C. and soak 15 minutes.

(2) Cool out in air.

The valve forging should drop to black heat in less than three minutes at head.

(3) Temper.

Heat up to 700°C.

(4) Cool out in air.

Brinell : 255 - 277.

August 21st, 1925.

ROLLS ROYCE LIMITED.

SPECIFICATION NO. 212A.

(Cancelling specification 2121 of June 2nd 1919).

MATERIAL.

Cast Iron (suitable for Cylinders and similar parts, but not suitable for parts where a harder material is necessary such as Brake Shoe Castings.)

K.11 Valve Guide
K.6 Rings.
I/C.

ANALYSIS.

- (a) Carbon combined .. .40% to .60%
- (b) " graphite .. . (c) less (a)
- (c) " total .. .maximum 3.20%
- Silicon1.60% to 2.3%
- Sulphur05% to .11%
- Phosphorus..... .70% to .90%
- Manganese..... .70% to 1.3%
- Titanium.....maximum .25%

TREATMENT.

ANNEALING. It should be understood that two separate and distinct treatments may be conveyed by the term "Annealing" which are as follows :-

- (a) STRESS RELIEVING. For the purpose of removing casting stresses only. For this purpose the castings should be raised to a temperature not exceeding 520°C. and maintained at that temperature for 30 min. This treatment will relieve casting stresses but will not affect the Brinell Hardness of the casting.
- (b) SOFTENING FOR MACHINING PURPOSES. Castings should not be softened by Heat Treatment unless machining difficulties render this necessary. For this treatment the castings should be raised to 675 - 700°C. and maintained at that temperature for 30 min. In any case the softening treatment must not reduce the Brinell Hardness figure below 202.

MECHANICAL TESTS.

- (a) BRINELL. (as cast) 202 - 241.
- (b) TRANSVERSE. Taken on 1.000 square bar as cast with skin of the metal remaining on the bar. 12" centres.
Load 25 cwts.minimum.
Deflection .15" minimum.
- (c) TENSILE. (If required). Not less than 12 tons per square inch ultimate stress.

All test pieces must be in the same condition
as when severed from the rods or bars they represent.

12th April, 1940.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 214.

MATERIAL. Phosphor Bronze (Cast.)

{ B. 8
BZ/PC }

ANALYSIS. Tin 9.00% to 10.7%
Zinc20% to .50%
Lead Max. .70%
Phosphorus60% to .90%
Arsenic Max. .10%

C - 90%

NOTE -

Great care should be taken to prevent overheating in casting. A casting temperature of 950°C - 980°C is recommended.

TESTS. BRINELL: Sand Cast 80 to 98
Chill Cast 101 to 121

TENSILE (not chilled):

M.S.	Y.P.	Elong. in 2".	R.A.
16	13	6	8%

NOTE : If preferred material to Specification 2.B.8 may be supplied against this specification.

5th December, 1918.

ROLLE ROYCE LIMITED.

SPECIFICATION NO. 214a.

MATERIAL.

HIGH LEAD PHOSPHOR BRONZE.

BZ/PL.

ANALYSIS.

Copper	.....	79 to 82%
Tin	.....	8.5 to 10%
Zinc	.....	Maximum .5%
Lead	.....	9.0 to 10.5%
Phosphorus	.....	.6 to .9%
Other impurities	...	Maximum .5%

This is to be made and cast with the usual precautions to be taken in preparation of High Lead Bronzes.

TESTS.

BRINELL : 70-90 (Chill Cast).

TENSILE	: M.S.	Y.P.	Elong.	R.A.
	13 tons	9 tons	8%	8%

ROLLS-ROYCE LIMITED.

Specification Number 214B.

MATERIAL. DRAWN PHOSPHOR BRONZE BAR.

D.T.D. 78A.
BZ/PD.

ANALYSIS.	Tin	..	..	..	..	..	2.7 to 5.0%
	Phosphorus	..	..	..	..	..	.10 to .3%
	Zinc	..	..	..	..	..	Maximum .1%
	Arsenic	..	..	..	..	"	.3%
	Lead	..	..	..	..	"	.2%
	Iron	..	..	..	..	"	.2%

NOTE. This specification is also to be used to replace No. 217 (Braze Metal for bar work).

TESTS.	Bars up to 1"		Max. Stress.	Elong.
		Not less than	20 tons.	22%
	Bars over 1"	" " "	20 tons.	24%

BRINELL. 101 - 130.

November 5th 1925.

ROLLS - ROYCE, LIMITED.

SPECIFICATION NO. 2151.
(Cancelling Specification No.215 of
May 7th, 1918).

MATERIAL. BRASS - ROLLED, Drawn or extruded.

$\left\{ \begin{array}{l} \underline{\underline{B13.}} \text{ Bar.} \\ \underline{\underline{265.}} \text{ Sht.} \\ \underline{\underline{B}} \end{array} \right.$

ANALYSIS. Copper 60% to 62%
Tin *Not more than 1%
Material other than Copper, Tin and
Zinc Not more than 0.75%
Zinc Remainder.

*The presence of Tin up to 1.0% is desired in Rolled or Drawn Bars. In the case of Extruded Bars however, Tin may be omitted if the suppliers consider it desirable to do so.

MECHANICAL TESTS. Tensile; Ult. Stress- Not less than 26 tons per sq. in. Elongation - 20%.

TOLERANCES OF MANUFACTURE Round Bars special sections may be produced by the Extruding process, and the following tolerances are permissible :-

	Up to and including 7/16"	..	Size to plus or minus	.002"
	1/2" to and including 7/8"	..	Size to plus or minus	.003"
	1" to and including 1 3/8"	..	" " " "	.004"
	1 1/2" to and including 1 3/4"	..	" " " "	.005"
	1 7/8" to and including 2"	..	" " " "	.006"
	Above 2"	..	" " " "	.008"

Hexagon and Square Bars must be drawn, and the following minus limits only are acceptable :-

	Up to and including 3/4"	..	Size to minus	.002"
	7/8" up to and including 1 3/8"	..	" " " "	.003"
	1 1/2" up to and including 2"	..	" " " "	.004"

19th May, 1919.

ROLLS ROYCE LIMITED.

SPECIFICATION NO. 215a.

MATERIAL. CAST BRASS (for general casting work). B/C

ANALYSIS.

Copper	65.0 to 69.0%
Zinc	30.0 to 34.0%
Lead	Maximum 1.2%
Tin .....	.5%
Other impurities .....	.3%

TESTS. Test piece to be cast in sand 1.000 dia. and machined down to .564.

(a) BRINELL : 55-72 (as sand cast).

(b) TENSILE : M.S. Y.P. E. R.A.
16 tons. 11 tons. 15% 32%

October 14th, 1925.

ROLLS ROYCE LIMITED.

SPECIFICATION NO. 2151B.

(Cancelling Specification 215 B.)

MATERIAL. HARD DRAWN BRASS TUBE.

ANALYSIS. Copper.....minimum 70%
Material other than
Copper and Zinc.....maximum 0.75%
Zinc.....Balance.

T8. Sept.
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B1D.
Revised
26 1885

FREEDOM FROM DEFECTS. Tubing delivered in accordance with this specification must be clean, smooth and free from cracks, lamination, surface defects or longitudinal grooving and drawing marks, both internally and externally, and must be straight, cylindrical and of uniform thickness.

- TESTS.
- (1) TENSILE. Ultimate stress not less than 25 tons per square inch. Samples for Tensile Test shall not be annealed or treated in any way before testing.
 - (2) FLATTENING AND DOUBLING OVER. A sample of the tube which has previously been annealed must withstand the following test without showing either crack or flaw. The tube must be flattened down until the interior surfaces meet, and then be doubled over on itself (i.e.) through an angle of 180°, the bend being at right angles to the length of the tube.
 - (3) DRIFTING TEST. A sample of the tube which has previously been annealed must withstand drifting until the drifted end measures at least 25% greater than the original diameter without showing signs of crack or flaw.

TOLERANCES. No plus tolerance on outside diameter is permissible. All tolerances must be minus and in accordance with the following scale :

Up to and including	$\frac{1}{2}$ " outside diameter
	Minus .003"
Above $\frac{1}{2}$ " up to and including	1" outside diameter
	Minus .005"
Above	1" outside diameter
	Minus .007"

May 7th, 1918.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER. 216.

MATERIAL.

Delta Metal.

{ B1.
DM.

ANALYSIS.

Tin	Up to 1.00%
Zinc	36.00% to 40.00%
Lead	Max. 1.00%
Copper	59.00% to 63.00%
Iron .. .. .	.70% to 1.50%
Manganese .. .. .	.30% to .70%

TENSILE
TEST.

M.S.	Y.P.	Elong. in 2"	R.A.
34 tons per sq. in.	20-24 tons per sq. in.	16-17%.	32-40%.

BENDING
TEST.

1.00" dia. bar turned down to .500 dia. should bend double over its own diameter.

May 7th, 1918.

R O L L S - R O Y C E L I M I T E D .

SPECIFICATION No. 218.

MATERIAL.

Gun Metal.

(B 2 .
B 2 1 G .

ANALYSIS.

Tin	.. ..	7.00% to 8.00%
Zinc	.. ..	6.00% to 8.00%
Lead	.. ..	Max. .20%
Copper	.. ..	Min. 85.00%

TENSILE TESTS.

M.S.	Y.P.	Elong. in 2"
17 tons.	10 tons.	7%

Note:-

If preferred, we accept:-

Air Board Specification B.2 May, 1917, in lieu of above, as below:-

Analysis.

Tin	.. ..	10.00% to 12.00%
Zinc	.. ..	Max. 2.05%
Lead	.. ..	" .5%
Copper	.. ..	Min. 86.00%

Tests.

M.S.	Y.P.	Elong. in 2"
14 tons per sq. in.	7.5 tons per sq. in.	10%

November 6th, 1925.

ROLLS-ROYCE LIMITED.

Specification No. 219 C.

CANCELLING ALL PREVIOUS SPECIFICATIONS FOR VIRGIN ALUMINIUM
(NOTCHED BARS).

MATERIAL

VIRGIN ALUMINIUM (NOTCHED BARS).

ANALYSIS.

Aluminium	..	..	98% to 99%
Iron	..	..	.6% to .8%
Silicon	..	..	Maximum .45%
Zinc	..	..	.. .10%
Tin	..	..	.. .10%
Oxide of Aluminium	..	..	.. .10%

May 7th, 1918.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 220.

MATERIAL.

ALUMINIUM ALLOY. (Crankcase Metal).

ANALYSIS.

Copper	,.	..	..	1.5%	to	2.05%
Zinc	..	..	..	9.0%	to	12.00%
Tin	..	..	..		Max.	.50%
Silicon	..	..	..		"	.50%
Iron	..	..	..		"	.80%
Manganese	..	..	..		"	.20%
Magnesium	..	..	..		"	.20%

The composition of alloy must be such that

Copper+3(Iron+Manganese+Magnesium) must not exceed 5.5.

TESTS.

(a) BRINELL.

(1) Brinell: 55-80.

Taken .125 below surface of 1.000 dia cast bar run in sand mould.

(2) Brinell: 70-97.

When taken on 1.000 dia. round bar cast in metal mould kept at temperature of 350°C.

(b) TENSILE. (Taken on chill cast bar).

M.S.	Y.P.	Elong.in2"	R.A.
11.0 tons.	7.5 tons.	3.2%	3.5%
"	"	"	"

(c) STANTON. 2,000 blows.

Taken with 4.5 lb hammer falling .312".

May 7th, 1918.

ROLLS- ROYCE LIMITED.

SPECIFICATION NUMBER 221.

MATERIAL. ALUMINIUM ALLOY. (Piston Metal).

ANALYSIS.

Copper	..	..	..	6.50% to 8.00%
Zinc	..	..	..	Max. .50%
Tin	..	..	..	" .20%
Iron	..	..	..	" .80%
Silicon	..	..	..	" .50%
Manganese	..	..	..	" .25%
Magnesium	..	..	..	" .25%

There should only be "traces" of other elements.

TESTS. (a) Brinell Figure: 52-72.

Note.-The figure given is taken .125 below surface on 1.000" dia. bar cast in sand mould.

(b) Tensile.

M.S.	Y.P.	Elong.in 2".	R.A.
10 tons	8 tons	2.5%	2.5%
"	"	"	"

(c) Stanton. Minimum 250 blows. Lift of hammer of 4.5 lbs. being .312 inches.

NOTE.- Tensile and Stanton Tests to be taken on "Chill" cast bars.

20th August, 1920.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 2221.

MATERIAL. ALUMINIUM ALLOY (Die Casting Metal)--for highly stressed parts.

ANALYSIS.	Copper	..	..	..	..	5.5 to 7.5%
	Tin	..	..	..	..	Maximum 1.0%
	Nickel	..	..	..	..	" .5%
	Zinc	..	..	..	..	" .2%
	Iron	..	..	..	..	" .6%
	Silicon	..	..	..	..	" .4%
	Manganese	..	..	..	..	" .2%
	Magnesium	..	..	..	..	" .2%

- NOTE.
- (1) It is most important that the iron content should not exceed that figure quoted above.
 - (2) It is considered that the addition of the nickel content will be found necessary in order to obtain the mechanical test results called for. If, however, the makers are of opinion that they can obtain the results without the addition of nickel, it may be omitted.

TESTS.

(a) BRINELL: 60-80.

(b) TENSILE: Max. Yield. Elong. RA.

 11.0 tons " 8.5 tons " 2.0% 2.0%

NOTE. Test Bars must be chill cast in 1" metal moulds previously heated to 350-450°C.

February 19th, 1926.

ROLLS ROYCE LIMITED.

SPECIFICATION No. 237.

MATERIAL.

ALUMINIUM BRONZE.

BZ/A

ANALYSIS.

Aluminium.....6.5% to 7.2%
Silicon.....1.4% to 1.9%
Zinc.....0.6% to 1.0%
Iron.....2.0% to 3.0%
Copper.....Balance.

MECHANICAL
TESTS.

Carried out on a Sand Cast Bar of
1.000" dia.

(A) Brinell 130 - 150.

(B) Tensile Max. Stress.
Not less than 28
tons per square inch.

Elong.
15%

November 25th, 1920.

ROLLS-ROYCE LIMITED.

Specification No. 217A.

MATERIAL.	BRAZING METAL. (For Castings).	<u>BIM.</u>
ANALYSIS.	Zinc	9.0% to 12.0%
	Tin	Maximum 1.0%
	Lead .. .. .	.. .5%
	Arsenic .. .. .	.. .2%
	Other harmless minor constituents	.. .3%
	Copper	Balance.

NOTE 1. The presence of arsenic in this alloy is not considered desirable, but if it is thought necessary to introduce this constituent to increase the strength of the castings, it must not exceed 0.2%.

NOTE 2. For Induction Pipes we prefer an alloy containing 90% copper, 10% zinc.

TESTS.	M.S.	Y.P.	E.	R.A.
TENSILE.	11.0 tons.	5 tons.	20%	35%
BRINELL.	56 minimum.			

17.3.26.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER. 2191.

MATERIAL. Aluminium Virgin Metal Notched Bars.

<u>ANALYSIS.</u>	Iron	..	..	..	..	..	..	1.3% to 1.5%
	Silicon	..	..	..	..	..	..	Maximum 0.4%
	Zinc	..	..	..	..	..	..	" 0.1%
	Oxide of Aluminium			..	..	..	..	" 0.1%
	Tin	..	..	..	..	..	..	" 0.05%
	Magnesium	..	..	..	..	..	..	traces only.
	Aluminium	..	..	..	..	..	..	not less than 98%

NOTE. This material with high iron content is for special purposes only.

May 7th, 1918.

ROLLS ROYCE LIMITED.

=====
SPECIFICATION NO. 223.
=====

{ T.9
A

MATERIAL.

Aluminium Tube.

ANALYSIS.

Aluminium not less than 98%.

TENSILE TEST.

Max. stress not less than 10 tons.

Elongation in 2" not less than 2.5%.

The above agrees with Air Board

Specification T9

June, 1918

which fully meets our requirements.

SPECIFICATION NO. 223A.

MATERIAL. Aluminium Sheet or strip.

ANALYSIS. Aluminium not less than 98%

}

L. 16.
L. 17.
A

- MANUFACTURE.
- (1) All strip or sheet must have bright clear and smooth surfaces free from discolouration, blisters, lamination or surface defects of any kind.
 - (2) Strip or Sheets must be longitudinally straight and the edges parallel. They must not be bowed in length nor taper in width.
 - (3) All strip or sheet must be supplied in the half-hard condition unless otherwise specified on our orders.

TOLERANCES OF MANUFACTURE. (1) THICKNESS. The thickness must not differ from the thickness specified by more than the following tolerances:-

		Up to 48" wide.		Above 48" wide.	
		Plus or minus .007		Plus or minus .012	
6 S.W.G. to 9 S.W.G.					
10 " to 15 "	" " "	.005	" " "	.008"	
16 " to 20 "	" " "	.003	" " "	.006"	
21 " to 25 "	" " "	.002	" " "	.004"	
26 S.W.G. and thinner	" " "	.001	" " "	.003"	

(2) WIDTH. The width must not differ from the width specified by more than the following tolerances:-

Up to and including 6½" wide.	Plus or minus	.031"
Above 6½" to 9½" wide.	" " "	.062"
Above 9½" wide.	" " "	.125"

MECHANICAL TESTS. (1) TENSILE. The ultimate tensile strength shall be between 7 and 8½ tons per sq. inch.

(2) BEND. Sheets or Strip must withstand bending either longitudinally or transversely over a radius equal to half the specified thickness without shewing signs of fracture.

19th January, 1928.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER. 223.B.

{ L. 32
A

MATERIAL. Aluminium Bar (Rolled Drawn or Extruded.)

ANALYSIS.

Copper.....	2.0% to 2.5%
Zinc.....	4.5% to 5.0%
Iron.....	Not more than 1.0%
Silicon.....	" " " 1.0%
(Iron plus Silicon Other Metallic Impurities)	" " " 1.75%
excluding copper & Zinc)	" " " 0.25%
Aluminium	Remainder.

NOTE. The above composition agrees with British Engineering Standards Association Specification No. L.32 which fully meets our requirements for Aluminium Bar.

ROLLS ROYCE LIMITED.

SPECIFICATION NO. 224.

MATERIAL.

White Metal (Tin Alloy).

B.21
WM/T.

ANALYSIS.

Copper	..	3.50	..	4.20%
Antimony	..	8.00	..	9.50%
Zinc	..	max.	..	.05%
Lead	..	"	..	.25%
Tin	..	85.5	..	88.5%
Arsenic	..	Traces only		

TEST RESULTS.

(a) Cast in chill at 350°C.
A 1,000 dia. bar should
give a Brinell figure of 30.

TENSILE TESTS.

(b) Cast as above metal should
stand max. stress of 5.5
tons.

NOTES -

- (1) The alloy should not be allowed to stand for long periods in a molten condition.
 - (2) It should not be melted in large quantities as it is liable to separate into layers of varying composition.
 - (3) We prefer that suppliers should aim at the mean composition and should avoid getting both the Copper and Antimony on the upper limit.
-

19th. May, 1919.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 226.

MATERIAL.

LOW CARBON CASE HARDENING STEEL.

$\left\{ \begin{array}{l} \underline{S.14} \\ \underline{S/2} \end{array} \right.$

ANALYSIS.

Carbon .. .. .	.1 to .16%
Manganese .. .. .	.7 to 1.00%
Silicon	Maximum .15%
Sulphur	" .045%
Phosphorus	" .045%

EAT TREATMENT. The test piece should be machined 1" dia. bar treated as under :-

- (1) Reduce for a test length of 2.500" to a dia. of .700.
- (2) Carburise at 930°C. for 4 hours and cool in air.
- (3) Reduce on test length to .575 dia.
- (4) Heat up to 920°C. and quench in water.
- (5) Heat up to 760°C. and quench in water.
- (6) Grind test length to .564 dia.

TESTS.

- (a) BRINELL: 167 minimum (on the core).
- (b) TENSILE: As treated above.

M.S.	Y.P.	E.	R.A.
27 tons.	20 tons	30%	56%

March 18th. 1929.

ROLLS - ROYCE LTD.

SPECIFICATION NUMBER 229B.

(Cancelling Specification No. 229A of
March 3rd. 1924.)

MATERIAL. Stainless Steel. 3/8. s.62.

DISTINGUISH- ING MARKING. One green and yellow band (each 3" wide) on both ends of each bar or billet.

<u>ANALYSIS.</u>	Carbon.....	0.22% to 0.32%
	Chromium.....	12.5% to 14.5%
	Manganese.....	Not more than 0.5%
	Silicon.....	" " " 0.5%
	Sulphur.....	" " " 0.04%
	Phosphorus.....	" " " 0.04%
	Nickel.....	" " " 1.00%

BARS FOR GENERAL PURPOSES. For general purposee this material will be required in the fully heat treated condition.

It must comply with the following mechanical test requirements.

- (1) Brinell. 207 - 235.
- (2) Tansile. Max. Stress 46 - 52 tons pr.sq.in.
Elong. on 2" not less than 20%
Red. in aera " " " 45%
- (3) Izod. Bars up to 2" dia. or width across flats not less than 35 ft. lbx.
Over 2" " " " 20 ft. lbs.

FORGING BARS. Bars or billets which are required for forging or stamping (which will be so specified on our order) must be supplied in the softened sondissement.

BARS FOR BRIGHT DRAWING. Bars required for bright drawing shall be supplied by the steel makers in the annealed condition They shall be suitably annealed by the drawers as required between the various passes. They shall again be annealed immediately before the final pass which should be a cleaning and sizing pass only.

HEAT TREATMENT. (Required for forgings only).

- (1) Heat to 940/960°C. and quench in oil.
- (2) Temper to give the Brinell Hardness Specified in our drawings. If this material is tempered at 960 to 750°C and quenched in oil, the Brinell Range is 207 - 235.

March 18th. 1929.

ROLLS - ROYCE LTD.

SPECIFICATION NUMBER 229B.

(Cancelling Specification No. 229A of
March 3rd. 1924.)

MATERIAL. Stainless Steel.

{ 3.62
S/S.

DISTINGUISHING MARKING. One green and yellow band (each 3" wide) on both ends of each bar or billet.

<u>ANALYSIS.</u>	Carbon.....	0.22%	to	0.32%
	Chromium.....	12.5%	to	14.5%
	Manganese.....	Not more than 0.5%		
	Silicon.....	"	"	" 0.5%
	Sulphur.....	"	"	" 0.04%
	Phosphorus.....	"	"	" 0.04%
	Nickel.....	"	"	" 1.00%

BARS FOR GENERAL PURPOSES.

For general purposes this material will be required in the fully heat treated condition.

It must comply with the following mechanical test requirements.

- (1) Brinell. 207 - 235.
- (2) Tensile. Max. Stress 46 - 52 tons pr.sq.in.
Elong. on 2" not less than 20%
Red. in area " " " 45%
- (3) Izod. Bars up to 2" dia. or width across flats not less than 35 ft. lbx.
Over 2" " " " 20 ft. lbs.

FORGING BARS. Bars or billets which are required for forging or stamping (which will be so specified on our order) must be supplied in the softened condition.

BARS FOR BRIGHT DRAWING.

Bars required for bright drawing shall be supplied by the steel makers in the annealed condition They shall be suitably annealed by the drawers as required between the various passes. They shall again be annealed immediately before the final pass which should be a cleaning and sizing pass only.

HEAT TREATMENT.

(Required for forgings only).

- (1) Heat to 940/960°C. and quench in oil.
- (2) Temper to give the Brinell Hardness Specified in our drawings. If this material is tempered at 960 to 750°C and quenched in oil, the Brinell Range is 207 - 235.

SPECIFICATION NO. 234A.

MATERIAL. 20% NICKEL SILVER ROLLED OR DRAWN. (Sheet or Bar). N/SLD.

ANALYSIS.	Copper	.. .. .	60.0%	to	64.0%
	Nickel	.. .. .	19.0%	to	21.0%
	Iron	.. .. .	maximum		.7%
	Tin	.. .. .	"		.1%
	Lead	.. .. .	"		1.0%
	Zinc	.. .. .		Balance.	

NOTE. We have no objection to the presence of 1% Lead in Drawn Bar if the Suppliers are of opinion that the machining qualities will be improved by the addition.

GENERAL CONDITIONS. Bar material must be delivered to us in a condition suitable for High Speed machining. Sheet must be delivered in a suitable condition for cold working, and must be capable of being bent through an angle of 180° without cracking.

MECHANICAL TESTS. Material treated in the manner laid down in the foregoing clauses should give the following mechanical test results:-

	M.S.	Y.	E. on 2".	R. in A.
TENSILE.	25 tons per sq. in.	13 tons per sq. in.	30%	45%

May 29th, 1919.

ROLLS-ROYCE LIMITED.

Specification Number 235.

MATERIAL.	NICKEL SILVER (Cast)					<u>N|SLC.</u>	
ANALYSIS.	Copper	..	..	..	..	49.0 to 53.0%
	Zinc.	..	..	..	..	31.0 to 34.0%
	Nickel.	..	..	..	..	14.0 to 16.0%
	Iron.	..	..	..	..	Maximum 1.2%
	Aluminium.	..	..	..	..	" 1.0%
	Tin.	..	..	..	..	" 1%
TESTS.	(a)	BRINELL. Minimum 76.					
	(b)	TENSILE.	M.S.	Y.	E.	R.A.	
			20.0	11.0	16%	30% min.	
			tons.	tons.			

NOTE.

Cupro Silicon and Phosphor Copper can be used as deoxidisers with advantage, but the Silicon and Phosphorus in the final alloy must not be together than .1%.

ROLLS-ROYCE LIMITED.

Specification No. 236.

MATERIAL. LOW CARBON AIR HARDENING NICKEL CHROME STEEL (for Carburising). { S.82
S/ZNC

ANALYSIS.

Carbon14% to .18%	<i>Krupp</i>
Silicon (maximum)	.. .. .	.30%
Manganese	.. .. .	.35% to .45%
Nickel	.. .. .	4.0 % to 4.5 %
Chromium	.. .. .	1.0 % to 1.30%

HARDNESS FORMULA. Hardness Figure is calculated by the following formula:- 7C. plus 2 (MN.plus Cr.) plus Ni.

GRADING.

Bar or Billet up to 15/16"	..	Hardness Figure, 7.7 to 8.3
" " " 1" to 2"	..	8.1 to 8.6
" " " 2.1/16" to 3"	..	8.5 to 8.9
" " " above 3"	..	8.9 to 9.4

TESTS. HEAT TREATMENT OF TEST PIECES.

- (1) Test Piece should be an integral part of the forging it represents if this is possible, in any case the dia. of the Test Piece as treated should not be less than 1 1/8" dia.
- (2) Heat to 900°C. in sand for 4 hours.
- (3) Heat to 820°C. and quench in oil.
- (4) Heat to 800-810°C. and cool in air (see also Section 5 below).
- (5) Alternative to Section 4 above. Where this material is required for Aero Engine work, the final heat should be 760°C. and quench in oil.
- (6) Machine test bar in accordance with Drawing Requirements.

PHYSICAL PROPERTIES. Should the material be finally heated to 800-810°C. and cooled in air, the following minimum figures should be obtained :-

	M.S.	Y.P.	E.	R.A.
(1) TENSILE.	68 tons sq. in.	-	18.5%	50%
(2) STANTON.	6,500 blows.			
(3) BRINELL.	302-341.			
(4) IZOD.	40 ft. lbs. (if required).			

If the material has been finally quenched in oil from 760°C. the Tensile strength should be :-

	M.S.	Y.P.	E.	R.A.
MINIMUM	85 tons per sq. in.	75 tons per sq.in.	12%	35%

July 20th, 1933.

R O L L S - R O Y C E L T D.

SPECIFICATION NUMBER 238B.

(Cancelling Specification No. 238A of Jan. 8th 1925.)

MATERIAL. Silicon Chromium Steel for Valves

D.T.D. 138.

S/SLV.

ANALYSIS.

Carbon	0.40	to	0.50%
Silicon	3.25	to	3.75%
Manganese	0.40	to	0.60%
Sulphur	Not more than 0.03%		
Phosphorus	"	"	" 0.03%
Chromium	7.5	to	8.5%
Nickel	Not more than 0.5%		

FORGING. The valves must be forged at a temperature between 900°C. and 1100°C. On no account must any latitude be permitted in respect to these temperatures.

HEAT TREATMENT. A double heat treatment is considered essential in case of valve forgings, where the stem is forged exceeds $\frac{1}{2}$ " diameter. The first treatment should be given to the forgings prior to machining and the second after rough machining as specified hereunder :-

- (1) Heat to 950°C. and quench in oil.
- (2) Temper at 650/700°C. and quench in water.

TESTS. Brinell Hardness. 255 - 286

Bend. Valves after complete heat treatment should bend through an angle of 45° over a radius of .100" before fracture.

SPECIFICATION NO.239A.

(Cancelling Specification 239 of July 18th 1924)

MATERIAL. MILD STEEL FOR PRESSINGS.
This is not suitable for deep drawing for which purpose specification No.202A must be used.

S.3.
S/MD.

ANALYSIS.

Carbon.....	0.18% to 0.27%
Manganese.....	0.50% to 0.80%
Silicon.....	0.1% to 0.25%
Sulphur.....	Maximum 0.04%
Phosphorus.....	" 0.04%

NOTE. Sheets must be supplied in the C.R.C.A. condition and suitable for pressing.

LIMITS OF MANUFACTURE. 1. THICKNESS.
The thickness is not to differ from the thickness specified by more than the following tolerances:-

6 Imp. W.G. to 13 Imp. W.G.	plus or minus .006"
14 " " 18 " " "	.004"
19 " " 22 " " "	.003"
23 " or thinner	.002"

2. WIDTH.
Sheets or strip must be longitudinally straight and the edges parallel. They shall not be bowed in length nor taper in width, and must not differ from the thickness specified by more than the following tolerances.

Up to and including 6½" wide.	Plus or minus .031"
Above 6½" wide and including 9½" wide	" " " .062"
Above 9½" wide	" " " .125"

MECHANICAL TESTS. BEND TEST.
The material must withstand a close bend test each way of the grain without cracking.

FREEDOM FROM DEFECTS. Sheets must be sound, homogenous and free from blisters and surface defects of any kind.

PROTECTION FROM CORROSION. All sheet or strip must be protected by means of a suitable rust preventative before despatch.

February 17th, 1925.

ROLLS-ROYCE LIMITED.

=====
Specification Number 245.
=====

MATERIAL.

SPECIAL PHOSPHOR BRONZE FOR CAM CASINGS.

ANALYSIS.

Tin	..	..	..	..	9.0 to 10.5%
Lead	..	..	..	..	Maximum 1.0%
Phosphor	..	..	..	..	" .10%
Copper	..	..	..	..	" Balance.

NOTE.

To obtain the results we require, it is essential that not more than .1% of Phosphorus is present in the final alloy.

TESTS.

(1) BRINELL. (Sand Cast) 69 minimum.

(2) TENSILE. M.S. Y. Y. E. RA.
 15 tons per 8 tons per 14% 15%
 sq.in. sq.in.

December 12th, 1924.

ROLLS-ROYCE LIMITED.

Specification Number 247.

MATERIAL. MEDIUM CARBON STEEL FOR BRAKE DRUMS (more suitable for pressings than Spec.205). SINC.

A ANALYSIS.	Carbon	..	..	..	..	0.45% to 0.54%
	Manganese	..	..	..	..	0.5 % to 0.75%
	Silicon	..	..	..	..	maximum .25%
	Sulphur	..	..	..	..	" .04%
	Phosphorus	..	..	..	..	" .04%

GENERAL CONDITIONS, Analysis of all casts must be submitted to us in writing and be accepted by us. When submitting casts the name of the Steel Maker and the identifying number of the cast should be given. Casts which fall just outside our limits may be submitted to us, and we may apply for a sample, but we do not undertake to accept such casts.

HEAT TREATMENT.

- (1) Heat to 850°C. and quench in oil.
- (2) Temper to give the Brinell Hardness as specified on our drawings.

TESTS.

- (1) A Brinell Hardness Test after heat treatment must be taken on each pressing, and must give a result within the range specified on our drawings.

August 16th, 1928.

ROLLS-ROYCE LIMITED.

SPECIFICATION NO. 401.

MATERIAL. "45" Carbon Steel.

S.L.
S/MC.

NOTE. This material is intended solely for the manufacture of bright drawn Hexagon bars for nuts and similar parts. It is to be used for this purpose in place of mild steel to Specification 201.D.

DISTINGUISHING MARKING. One white and one red band each 3" wide to be painted round the centre of every bar.

ANALYSIS. Table with 4 columns: Element, Range 1, Range 2, Range 3. Rows include Carbon, Manganese, Silicon, Sulphur, and Phosphorus.

MANUFACTURE. Bars shall be bright drawn to within .020" to .040" of finished size (at the discretion of the drawers). They shall then be normalised and afterwards given a final sizing and cleaning pass.

HEAT TREATMENT. Normalise at 870°C. and allow to cool in air.

- PHYSICAL TESTS. (a) Brinell 187 - 247. (b) Tensile. Maximum stress 42 to 52 tons per sq" Yield Not less than 26 " " " Elong% on 2" " " 20% Red.in Area% Not less than 45% (c) Izod (if required) Not less than 20 ft.lbs.

- GENERAL CONDITIONS. (1) Analysis of all casts must be submitted to and accepted by us before steel is rolled. (2) With each consignment of bars we must be advised of the cast number or numbers from which the bars have been produced. (3) Casts which fall just outside this specification may be submitted to us, and we may apply for a sample though we do not undertake to accept such casts. (4) Bars must be sound, straight, free from cracks, laps, seams, twists or damaged ends. They must be of a proper finish and delivered in a condition suitable for use in Automatic machines.

TOLERANCES OF MANUFACTURE. Minus tolerances only are permissible and must conform to the following scale Width across flats.

TOLERANCES OF MANUFACTURE CONT'D.

Up to and including .709"	minus	.002"
Above .709" and " 1.301"	"	.003"
Above .301" " " 1.860"	"	.004"
Over 1.860" " "	"	.005"

ROLLS - ROYCE LTD.

SPECIFICATION NO. 403.

(L. 40
A/c
A/bc

MATERIAL. LIGHT ALUMINIUM ALLOY FOR SAND OR DIE CASTINGS.
(Not suitable for pistons or other parts
subjected to elevated temperatures).

<u>ANALYSIS.</u>	Copper	0.9% to 2.0%
	Nickel	0.8% to 1.75%
	Magnesium.....	0.05% to 0.30%
	Silicon	Maximum 2.80%
	Iron.....	0.85% to 1.4%
	Titanium.....	0.02% to 0.2%

HEAT TREATMENT. All castings should be heat treated at 155 - 175°C for 8 - 20 hours. The method of cooling after treatment is immaterial. Castings may either be quenched or allowed to cool normally as required.

TEST BARS. Standard Chill Test Bars shall be prepared in duplicate. For larger castings such as crank-cases, Cylinder Blocks etc. test bars must be provided with every casting.

The test bars must be heat treated with the castings they represent.

The Test Bars are to be cast in the standard mould 1" dia. with 1/2" wall thickness and inclined at an angle of 30° whilst pouring.

MECHANICAL TESTS.

Tensile.

Maximum Stress. Not less than 12.5 tons per sq. in.

Elongation on 2" not less than 4.0%

Reduction in Area " " " 4.0%

Brinell. 60 - 80.

ROLS - ROYCE LIMITED.

SPECIFICATION NO.404.

MATERIAL. LIGHT ALUMINIUM ALLOY FOR FORGINGS AND CHILL CASTINGS (for pistons and other purposes where maximum strength at elevated temperatures is required.

R.R. 59.
L. 42.
A/PF.

ANALYSIS. Copper 1.5% to 2.5%
Nickel 0.3% to 1.5%
Magnesium 1.2% to 2.0%
Iron 0.85% to 1.5%
Titanium 0.02% to 0.2%
Silicon Not more than 2.0%

Las Si. RRSQ better for high temp (A/Fls) spec 439

HEAT TREATMENT. All material made in this specification whether forgings or castings shall be given the following treatment.

- (1) Heat to 510/535°C. for 2 to 4 hours (according to the size of casting or forging) and quench in water.
- (2) Re-heat to 155 - 175°C for 20 hours and cool rapidly by quenching in water. It is essential that the maximum temperature 174°C. given above is not exceeding

TEST BARS. In the case of forgings 2 forged test bars either 1 1/2" dia. or 1 1/2" square must be provided with every 50 forgings.

For chill castings 2 standard chill cast bars of 1" dia. must be provided for every 50 castings. Test bars shall be heat treated with the batches of material they represent, and must give the mechanical test results tabulated below.

MECHANICAL

TESTS. Tensile. Forgings.

Maximum Stress not less than 24 tons per sq. inch.
yield " " " 18 " " " "
Elong% on 2" " " " 6%
R in A% " " " 6%

Brinell 110 - 150

Castings. Tensile.

Maximum Stress not less than 20 tons per sq. inch.
Elong% on 2" " " " 1.0%
R in A% " " " 1.0%

Brinell. 106 - 140.

January 12th 1932.

R O L L S - R O Y C E L T D.

SPECIFICATION NO. 405.

MATERIAL. LIGHT ALUMINIUM ALLOY FOR FORGINGS FOR GENERAL PURPOSES. (For pistons and other parts subjected to elevated temperatures, see specification No. 404.)

R.R. 56.
L. 40.
D. 220 A. 5
J. T. 6. 206 (9)
AIF

ANALYSIS. Copper 1.5% to 3.0%
Nickel 0.3% to 1.5%
Magnesium 0.4% to 1.0%
Iron 0.85% to 1.4%
Titanium 0.02% to 0.2%
Silicon up to 1.00%

L 45

DTD 130
410
G.P.A.
H. 34mm

HEAT TREATMENT. All material produced to this specification must be given the following heat treatment.

- (1) Heat to 510/535°C. for 2 to 4 hours and quench in water.
- (2) Re-heat to 155-175°C. for 20 hours and cool rapidly by quenching in water. It is essential that the maximum temperature of 175°C. is not exceeded.

TEST PIECES. Sufficient material to make two forged test pieces each 12" long and 1 1/8" dia. or 1 1/8" square shall be provided representing each pot of metal cast.

The test pieces shall be forged and heat treated at the same time as the parts they represent and shall exhibit the test results set forth in the table below.

MECHANICAL TESTS.

- (1) Brinell 120 - 160.
- (2) Tensile.

Maximum Stress not less than 27 tons per sq. inch.

Yield " " " 23 " " " "
Elong. on 2" " " " 10%
Reduction in Area " " " 10%

January 13th 1932.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 406.

MATERIAL. LIGHT ALUMINIUM ALLOY FOR SEALING RINGS FOR CYLINDERS.

D.T.D. 128.

A/FS.

ANALYSIS.

Copper.....	2.0%	to	3.0%
Nickel.....	0.5%	to	1.5%
Magnesium.....	0.05%	to	0.15%
Iron.....	0.8%	to	1.4%
Titanium.....	0.02%	to	0.3%
Silicon.....	up to		?.50%

HEAT

TREATMENT. The forged pots or tubes for producing these sealing rings shall be given the following treatment.

(1) Heat to 510/540°C. for two hours and quench in water.

(2) Re-heat to 155/175°C. for 20 hours and cool rapidly by quenching in water. It is essential that the maximum figure of 175°C. is not exceeded.

MECHANICAL

TESTS.

(1) Brinell. Each pot shall be brinelled after treatment, and shall have a brinell hardness between 60 and 85.

September 30th, 1929.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 407.

MATERIAL Special Bronze for Drain Taps etc.

ANALYSIS.

Zinc	10.0%	-	12.0%
Tin	11.75%	-	2.75%
Copper	Not less than 87.0%		

MECHANICAL

TESTS.

(A) Brinell 60 - 80
(B) Tensile. Maximum Stress not less than 14 tons
per sq.in.
Elongation % not less than 20%
R in A % " " " 25%

NOTE.

A mixing of 88% Copper, 10% Zinc and 20% Tin has been found to give excellent results and should be worked to as nearly as possible.

July 19th 1933.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 411.

MATERIAL. Aluminium Bronze Bar for Valve Seats. { D.T.D. 160.
BZ1AD.

ANALYSIS. Aluminium 9.0 to 9.8%
Total Impurities Not more than 0.75%
Lead shall not be more
than 0.15%
Copper The remainder.

MANUFACTURE. The material shall be produced by extrusion and finally cold rolled to finished size.

HEAT TREATMENT. This material must be subsequently heat treated between 600 - 700°C. and quenched in water. It is preferable for the heat treatment to be carried out on rough machined parts and not on bars as drawn.

MECHANICAL TESTS. (a) Brinell. Each bar shall be brinell tested and the hardness number shall not be less than 126 or greater than 160.
(b) Tensile. Ult. Ten. Not less than 35 tons per square inch.
Elongation - Not less than 17%

NOTE. The composition given above conforms to the requirements of D.T.D. Specification No. 160 which is acceptable within the limitations given above especially those of Brinell Hardness.

July 19th 1933.

ROLLS-ROYCE LIMITED.

SPECIFICATION NUMBER 412.

MATERIAL. Aluminium Nickel Bronze Bars forged or extruded for cylinder holding down nuts and propeller shaft Nuts and general forging purposes.

D.T.D. 164
B2/AF

ANALYSIS.

Aluminium	9.0 to 10.0%
Nickel	1.0 to 3.0%
Iron	0.5 to 2.5%
Total Impurities	Not more than 0.75%
Copper	Lead must be nil
	Balance

MANUFACTURE.

Bars for machining shall preferably be supplied in the forged condition and must be heat treated before delivery. Forgings shall be delivered in the heat treated condition.

HEAT TREATMENT. Temper at 350°C. and cool in air.

MECHANICAL TESTS. All Bars shall be brinelled using a ratio of 30 and the Brinell Hardness shall not be less than 135.

Tensile. Max. Stress Not less than 38 tons pr. sq. in
Elongation
on 2" " " " 18%

NOTE.

The chemical composition given above conforms to D.T.D. Specification No. 164 which meets our requirements excepting for Brinell Hardness as specified above.

October 16th, 1933.

ROLLS ROYCE LIMITED.

SPECIFICATION NUMBER 414.

- (1) MATERIAL. High Nickel Chromium Non Corrodible Steel
(Firth's F.D.P.) for Chassis Exhaust Parts.

D.T.D. 171A. (S)
D.T.D. 207. (T)
S/CNT.

- (2) COMPOSITION.
- | | | |
|----------|---------------|-------|
| Nickel | not less than | 6.0% |
| Chromium | " " | 12.0% |
| Titanium | " " | 0.4% |

Molybdenum Tungsten or Vanadium may be added at the discretion of the manufacturers.

- (3) This steel is primarily intended for the manufacture of chassis exhaust parts.
- (4) It must be capable of being heated to a temperature of 750°C. for considerable periods without being subject to the development of crystal growth and subsequent brittleness.
- (5) It must be capable of being welded without being susceptible to attack at the welded joints (weld decay).
- (6) No subsequent heat treatment shall be necessary after welding in order to overcome weld decay.
- (7) This material will be required either in the form of drawn tube or sheet.
- (8) In either case it must be delivered in the fully softened and descaled condition.
-

SPECIFICATION No. 415.

MATERIAL. "10" Carbon Steel.

SYMBOL. S/LC. B.T.D. 299.

ANALYSIS.

Carbon		0.05%	to	0.15%
Manganese		0.25%	to	0.40%
Sulphur	Not more than	0.05%		
Phosphorus	" "	"		0.05%

NOTE. Analysis of all casts must be submitted to and approved by us before any work is commenced.

MANUFACTURE. This material may be required either in form of bars tubes or forgings. In any case the material shall be delivered to us in the normalised condition.

NORMALISING. Normalise at 920°C. and cool in air.

HEAT TREATMENT. Where complete heat treatment is specified it shall be carried out as follows:-

- (1) Heat to 920°C. and quench in water.
- (2) Temper at 650°C. and cool in air.

ACCEPTANCE TEST. The Brinell Hardness of bars, tubes or forgings after normalising shall not be more than 120.

A sample disc .500" thick or other suitable sample shall not shew a brinell Hardness greater than 160 when quenched in oil from 1000°C.

12th March, 1940.

ROLIS -ROYCE LIMITED.

SPECIFICATION NUMBER 425.

MATERIAL. 2% Nickel Steel for Connecting Rod Bearing shells.

SYMBOL. S/ZLN.

<u>CHEMICAL ANALYSIS.</u>	Carbon	0.08	to	0.13%
	Manganese	0.35	to	0.50%
	Nickel	1.8	to	2.25%
	Silicon	Not more than 0.30%		
	Sulphur	"	"	" 0.04%
	Phosphorus	"	"	" 0.04%
	Chromium	"	"	" .15%

- GENERAL CONDITIONS.
- (1) Analysis of all casts must be submitted to and accepted by us before steel is rolled.
 - (2) With each consignment of bars we must be advised of the cast number or numbers from which the bars have been produced.
 - (3) Casts which fall just outside this specification may be submitted to us, and we may apply for a sample though we do not undertake to accept such casts.

TESTS. A sample disc $\frac{3}{8}$ " thick quenched in oil from 1050°C. shall exhibit a Brinell Hardness not greater than 286.
