

Recommended materials to be used in replacement and re-construction

1. INTRODUCTION

This manual is provided as a guide to the properties, selection and use of materials to be employed in the replacement and repair of components for "Thoroughbred Grand Prix racing cars". The aim is to ensure that the cars are maintained in as safe a manner as is. The document is set out in 3 sections:

1. Introduction
2. Short list of materials
3. Design data sheets.

Wherever possible it is recommended that a specification from the short list be used. This gives a range of materials to cope with virtually all applications on the cars. The third section comprises data sheets to cover the overwhelming majority of uses on the cars or ancillaries. Each of the materials is presented in the condition in which it is most regularly along with its purchase condition. Metal alloys are defined in the heat treatment condition in which they will be most commonly used.

A great number of problems are incurred in the specification of materials due to the myriad of systems of nomenclature employed and the different units used to present data. To that end each of the materials is given a "drawing reference", and "purchase condition". This consists of a standardised code for the material and, where appropriate, a condition descriptor. It is intended to provide a quick, unambiguous delineation of the material requirements. All mechanical properties are given in SI units and hardness in the Vickers system. Impact properties of the various metals have all been evaluated using the "Charpy" test to allow for ease of comparison.

It is preferable to request heat treatments in terms of final property requirements rather than specifying the complete treatment, which is included as a guide. This then puts the quality emphasis on the heat treater rather than the designer and makes control easier. Despite advances in technology, much heat treatment of metals remains a "black art". Please ensure that a test piece is included with each batch of components to be heat treated so that it can be subsequently checked.

2. MATERIALS SHORT LIST

2.1 Ferrous alloys

2.1.1 Fabricating steels

- AISI/SAE 4130 stressed steel fabrications (suspension uprights, etc.).
- EN3- general purpose fabricating steel.
- 15 CDV 6.
- T45.

2.1.2 Through-hardening steels

- VAR 300M machined components requiring very high strength (axles, drive shafts etc.).

2.1.3 Carburising steels

- EN 36C for components requiring case hardening (gears etc.).

2.1.4 Free cutting steels

- EN1 A For rapid production of non-stressed pieces (jigs and fixtures etc.)
- EN 16T Medium strength machined parts (shafts, crankshafts connecting rods etc.).

- EN 24T high strength monolithic components and studs etc.

2.2 Aluminium alloys

- 2014 A T6 general high strength aluminium alloy for machined components.
- 5251-H3 work hardening alloy for sheet fabrications.
- 6082 T6 weldable heat treatable alloy.

2.3 Titanium alloys

- Commercially pure Ti (grade 2) for light weight fabrications.
- Ti 6Al 4V machined components requiring high specific strength.

2.4 Magnesium alloys

- ZE 41 A T5 for lightweight castings.

2.5 Copper alloys

- Phosphor bronze, PB1 for bearings and bushings.

3. DESIGN DATA SHEETS

Recommended materials

Steel, AISI/SAE 4130

Drawing reference:

Steel, 4130 stress relieved, hardened and tempered to (286-318)Hv

Purchase condition:

Normalised (condition N) or annealed (condition A).

Product forms:

Billet, bar, rod, forgings, sheet, plate, tubing and castings.

Applications:

High strength machined and fabricated components, stress relieved and heat treated to achieve strength at optimum toughness.

Chemical composition:

| | |
|----|------------|
| C | 0.28-0.33% |
| Mn | 0.40-0.60% |
| Si | 0.20-0.35% |
| Cr | 0.80-1.10% |
| Mo | 0.15-0.25% |
| P | 0.035max |
| S | 0.040max |
| Fe | remainder |

Heat treatment:

Stress relieve, quench and temper to (286-318)Hv.

1. De-scale after welding
2. Stress relieve at 600°C for 1 hr,
3. Air cool,
4. Normalise at 900°C for 1 hr,
5. Air cool ,
6. Austenitise at 840°C,
7. Oil quench , double temper at 565°C for 4hrs.
8. Air cool.

Properties:

| | | |
|---|--|----------|
| Tensile strength | 926Mpa | (830MPa) |
| Tensile modulus | 205GPa | |
| Yield strength | 834Mpa | (670MPa) |
| Elongation | 18% | (24%) |
| Hardness | 286-318Hv | (250Hv) |
| Fatigue strength (@ 10 ⁶ cycles) | 550MPa | |
| Charpy impact | 96.4J | (135J) |
| Density | 7.8gcm ⁻³ | |
| Linear expansion coef. | 12.2x10 ⁻⁶ °C ⁻¹ | |

(normalised properties in brackets)

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor, must be protected by painting. Recommend "Kephos black" as this permits crack testing without needing to be removed.

Machinability: good.

Welding: readily arc welded but **must** be stress relieved and normalised, may subsequently be hardened and tempered if so required.

Adhesive bonding: very good.

Notes

1. This material can also be used for studs or heat treated to provide higher strength in machined components. To achieve this the tempering temperature is reduced to 260°C

| | | |
|-------------|------------------|--------------|
| Properties: | Tensile strength | 1220-1405MPa |
| | Yield strength | 1080-1235MPa |
| | Elongation | 11% |
| | Hardness | 372-440Hv |
| | Charpy impact | 17J |

2. For fabricated components which require sheet bent into very tight radii, it may be necessary to use material in the **annealed** condition (217Hv), see section 5.1.1.c) for details.

3. Slender components such as suspension members will be prone to distortion during heat treatment but may be straightened by shot peening.

4. Shot peening should be specified for all highly stressed components to improve fatigue life.

5. Where ultimate strength is not required, fabricated components may be specified with stress relieving only following welding (assume "normalised" properties in any stress calculations.

Recommended materials

Steel, EN 3

Drawing reference:
Steel, EN3, stress relieved.

Purchase condition:
Normalised.

Product forms:
Bar, rod, sheet, plate

Applications:
A general purpose, free-cutting mild steel suitable for welded structures. Useful for the rapid production of fabricated components which will not be subjected to high stresses in service, particularly jiggig etc.

Chemical composition:

| | |
|----|------------|
| C | 0.25%max |
| Si | 0.05-0.35% |
| Mn | 1.0%max |
| S | 0.060%max |
| P | 0.060% |
| Fe | remainder |

Heat treatment:
Normalised

1. Heat to 880-910°C
2. Air cool.

Properties:

| | |
|------------------------|--|
| Tensile strength | 386-540MPa |
| Tensile modulus | 208GPa |
| Yield strength | 300MPa |
| Elongation | 25% |
| Hardness | 145Hv |
| Charpy Impact | 75.4J |
| Density | 7.86gcm ⁻³ |
| Linear expansion coef. | 12.4x10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:
Resistance to atmospheric attack: poor, requires protection.
Machinability: very good.
Welding: readily weldable by any of the commercial techniques.
Adhesive bonding: good.

Steel, 15 CDV 6

Drawing reference:
Steel, 15 CDV 6 stress relieved, hardened and tempered to (286-318)Hv

Purchase condition:
Heat treated (condition T) or annealed (condition A).

Product forms:
Billet, bar, rod, forgings, sheet, plate, tubing and castings.

Applications:
High strength machined and fabricated components, stress relieved and heat treated to achieve strength at optimum toughness.

Chemical composition:

| | |
|----|-----------|
| C | 0.15% |
| Mo | 0.90% |
| Cr | 1.25% |
| V | 0.25% |
| P | 0.035max |
| S | 0.040max |
| Fe | remainder |

Heat treatment:
Stress relieve, quench and temper to T condition (286-318)Hv

1. De-scale after welding
2. Stress relieve at 650°C for 1 hr,
3. Air cool,
4. Normalise at 975°C for 1 hr,
5. Oil quench , double temper at 625°C for 4hrs.
6. Air cool.

Properties:

| | |
|---|--|
| Tensile strength | 1050MPa |
| Tensile modulus | 205GPa |
| Yield strength | 860MPa |
| Elongation | 16% |
| Hardness | 286-318Hv |
| Fatigue strength (@ 10 ⁶ cycles) | 550MPa |
| Density | 7.8gcm ⁻³ |
| Linear expansion coef. | 12.2x10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:
Resistance to atmospheric attack: poor, must be protected by painting. Recommend "Kephos black" as this permits crack testing without needing to be removed.
Machinability: good.
Welding: readily arc welded but **must** be stress relieved This material is roughly equivalent to ASI/SAE 4130 save that it possesses the advantage of being able to be welded in the heat treated (T) condition, requiring only a subsequent stress relieving. Using pre-heat treated material for fabrications will however create difficulties in forming tight radii. Having said that, the manufacturers (Aubert and Duval) do provide a number of pre-formed shapes (aero tubing etc.) off the shelf.
Adhesive bonding: very good.

Recommended materials

Steel, 4T.45

Drawing reference:

Steel, 4T.45 stress relieved, or
Steel, 4T.45 stress relieved, hardened and tempered to
(263±20)Hv

Purchase condition:

Annealed (condition A).

Product forms:

Tubing.

Applications:

Fabricated tubular constructions (roll cages etc.)

Chemical composition:

| | |
|----|------------|
| C | 0.17-0.25% |
| Mn | 1.30-1.70% |
| Si | 0.10-0.35% |
| Cr | 0.25% |
| Mo | 0.10% |
| P | 0.040max |
| Ni | 0.040max |
| Fe | remainder |

Heat treatment:

Stress relieve, quench and temper to (263±20)Hv.

1. De-scale after welding
2. Stress relieve at 600°C for 1 hr,
3. Air cool,
4. Normalise at 900°C for 1 hr,
5. Oil quench & temper at to achieve (263±20)Hv
6. Air cool.

Properties:

| | | |
|---|--|----------|
| Tensile strength | 900Mpa | (700MPa) |
| Tensile modulus | 200GPa | |
| Yield strength | 620Mpa | (670MPa) |
| Elongation | 18% | (24%) |
| Hardness | (263±20)Hv | (203Hv) |
| Fatigue strength (@ 10 ⁶ cycles) | 500MPa | |
| Density | 7.8gcm ⁻³ | |
| Linear expansion coef. | 12.0x10 ⁻⁶ °C ⁻¹ | |

(normalised properties in brackets)

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor, must be protected by painting. Recommend "Kephos black" as this permits crack testing without needing to be removed.

Machinability: good.

Welding: readily arc welded but **must** be stress relieved, may subsequently be hardened and tempered if so required.

Adhesive bonding: very good.

Steel, VAR 300M

Drawing reference:

Steel, 300M quenched and tempered to 580 ±20Hv.

Purchase condition:

Normalised and softened.

Product forms:

Bar.

Applications:

Through hardening steel for high strength machined components. Equivalent to S155.

Chemical composition:

| | |
|----|------------|
| C | 0.4-0.46% |
| Mn | 0.65-0.90% |
| Si | 1.45-1.80% |
| Cr | 0.70-0.95% |
| Ni | 1.65-2.00% |
| V | 0.05%min |
| Fe | remainder |

Heat treatment:

Quenched and tempered to 580Hv.

1. Copper plate (0.075-0.127mm deep) or use vacuum furnace.
2. Normalise at 925±10°C.
3. Austenitise at 860-885°C
4. Oil quench to 25-50°C.
5. Double temper at 300±5°C for 2-4hrs.
6. Air cool to room temperature.

Properties:

| | |
|---|--------------------------------------|
| Tensile strength | 1990Mpa (2000MPa at 200°C) |
| Tensile modulus | 207GPa |
| Yield strength | 1670MPa |
| Elongation | 8% |
| Shear strength | 1200MPa |
| Fatigue strength (@ 10 ⁶ cycles) | 550MPa |
| Hardness | 580Hv |
| Charpy impact | 24.4J |
| Maximum use temperature | 315°C |
| Density | 7.83gcm ⁻³ |
| Linear expansion coef. | 12x10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor (must be well protected with oil)

Machinability: good.

Welding: may be TIG welded but this is generally not recommended.

Adhesive bonding: good

Note:

This steel is very susceptible to hydrogen embrittlement during electro-plating operations and requires a de-embrittlement treatment.

Recommended materials

Steel, EN 36C

Drawing reference:

Steel, EN 36C, fully case hardened.

Purchase condition:

Normalised.

Product forms:

Bar.

Applications:

Machined components requiring case hardening. "Extrac" carburised components are made in their own version of this steel known as "XVAR" essentially this is EN 36C which has been vacuum arc re-melted to improve its quality.

Chemical composition:

| | |
|----|------------|
| C | 0.12-0.18% |
| Si | 0.10-0.35% |
| Mn | 0.30-0.60% |
| S | 0.05%max |
| P | 0.05%max |
| Ni | 3.0-3.75% |
| Cr | 0.6-1.10% |
| Mo | 0.10-0.25% |
| Fe | remainder |

Heat treatment:

Fully carburised.

1. Carburise at 880-950°C for 1 hr minimum.
2. Air cool.
3. Heat to 810-820°C, quench in oil.
4. Temper at 185-195°C for 2hrs minimum.
5. Air cool.

Properties:

| | |
|---|--|
| Tensile strength | 1080MPa |
| Tensile modulus | 200GPa |
| Yield strength | 950MPa |
| Elongation | 8% |
| Fatigue strength (@ 10 ⁶ cycles) | 486MPa |
| Charpy impact | 34J |
| Density | 7.87gcm ⁻³ |
| Linear expansion coef. | 12.3 x 10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:

Resistance to corrosion: poor, must be protected with oil.

Machinability: good.

Welding: may be fabricated by arc welding but EB technique is preferred.

Steel, EN16T

Drawing reference:

Steel, EN16T.

Purchase condition:

Heat treated to "T" condition (261-319)Hv.

Product forms:

Bar, rod, sheet and plate.

Applications:

Free-cutting, medium strength, medium carbon steel for machined components. Similar to BS 970: 1983 606M36T, Hitespeed 55T.

Chemical composition:

| | |
|----|------------|
| C | 0.38-0.43% |
| Si | 0.25%max |
| Mn | 1.5-1.70% |
| P | 0.04%max |
| S | 0.22-0.3% |
| Mo | 0.25-0.35% |
| Fe | remainder |

Heat treatment:

Quenched and tempered to T condition.

1. Heat to 820-870°C for 1hr
2. Oil quench.
3. Temper at 550°C for 2hrs
4. Air cool.

Properties:

| | |
|---|--|
| Tensile strength | 850MPa |
| Tensile modulus | 196GPa |
| Yield strength | 700MPa |
| Elongation | 18% |
| Shear strength | 561MPa |
| Shear modulus | 76GPa |
| Fatigue strength (@ 10 ⁶ cycles) | 430MPa |
| Hardness | 261-319Hv |
| Charpy impact | 55J |
| Density | 7.89gcm ⁻³ |
| Linear expansion coef. | 11.5x10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor, requires protection .

Machinability: good.

Adhesive bonding: good.

Recommended materials

Steel, EN24T

Drawing reference:
Steel, EN 24T

Purchase condition:
T condition (261-319Hv)

Product forms:
Bar, sheet, rod, forgings and plate

Applications:
EN 24 is a high strength alloy steel which is capable of being heat treated to produce a wide range of tensile strengths combined with reasonable ductility and impact resistance. It is equivalent to the American specification AISI/SAE 4340. Also known as S154.

Chemical composition:

| | |
|----|------------|
| C | 0.36-0.44% |
| Mn | 0.45-0.70% |
| P | 0.025%max |
| S | 0.025%max |
| Si | 0.10-0.35% |
| Cr | 1.0-1.40% |
| Ni | 1.30-1.70% |
| Mo | 0.20-0.35% |
| Fe | remainder |

Heat treatment:
Quenched and tempered to T condition.

1. Austenitise at 820-850°C for 1 hr.
2. Oil quench.
3. Temper at 540±10°C for 2-4hrs.
4. Air cool.

Properties:

| | |
|------------------------|--|
| Tensile strength | 850-1000MPa |
| Tensile modulus | 208.5GPa |
| Yield strength | 650MPa |
| 0.2% Proof stress | 635MPa |
| Elongation | 13% |
| Hardness | 261-319Hv |
| Charpy impact | 40.7J |
| Density | 7.84gcm ⁻³ |
| Linear expansion coef. | 12.5x10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:

Machinability: good
Welding: readily TIG welded but must be stress relieved at 630-660°C for 1hr followed by air or oven cooling.
Adhesive bonding: good

Notes:
1. Shot peening is recommended for highly stressed components.

Al 2014 A T6

Drawing reference:
Al, 2014 A T6

Purchase condition:
Heat treated to T6 condition.

Product forms:
Plate, sheet, drawn tube and bar, forging stock and tube, bolt and screw stock, rivet stock, wire.

Applications:
General wrought aluminium alloy used primarily for machined components in the solution treated, artificially aged (T6) condition. Formally known as HE 15 TF.

Chemical composition:

| | |
|----|-----------|
| Cu | 3.9-5.0% |
| Si | 0.5-0.9% |
| Fe | 0.5%max |
| Mn | 0.4%max |
| Mg | 0.2-0.8% |
| Cr | 0.1%max |
| Ni | 0.2%max |
| Zn | 0.2%max |
| Al | remainder |

Heat treatment:
T6 condition

1. Solution treated at 505±5°C.
2. Water quench.
3. Age at 155-190°C for 5-20hrs.

Properties:

| | |
|--|--------------------------------------|
| Tensile strength | 470MPa (110 at 200°C) |
| Tensile modulus | 74GPa |
| 0.2% Proof stress | 420MPa |
| Elongation | 7% |
| Shear strength | 293MPa |
| Fatigue strength (@10 ⁶ cycles) | 170MPa |
| Charpy impact | 16.2J |
| Hardness | 153Hv |
| Density | 2.8gcm ⁻³ |
| Melting range | 530-610°C |
| Linear expansion coef. | 22x10 ⁻⁶ °C ⁻¹ |
| Maximum service temperature | 200°C |

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor
Formability: fair.
Machinability: very good.
Welding: TIG not recommended.
Oxy-gas not recommended
resistance, spot, seam excellent
Adhesive bonding: very good
Anodising: protective fair
colour fair (dark colours only)
bright unsuitable
hard good
plating very good.

Recommended materials

Al 5251 H3

Drawing reference:
Al, 5251 H3

Purchase condition:
Half hard.

Product forms:
Plate, sheet and strip, drawn tube, longitudinally welded tube, forging stock and tube, bar, wire.

Applications:
General sheet fabrications such as radiator tanks and swirl pots etc. Formally known as NS 4.

Chemical composition:

| | |
|----|-----------|
| Si | 0.4%max |
| Fe | 0.5%max |
| Cu | 0.15%max |
| Mn | 0.1-0.5% |
| Mg | 1.7-2.4% |
| Cr | 0.15%max |
| Zn | 0.15%max |
| Ti | 0.15%max |
| Al | remainder |

Heat treatment:
Stress relieving after welding.

1. Heat to 210±10°C.
2. Hold for 2hrs in air circulating furnace.
3. Air cool.

Properties:

| | |
|--|--------------------------------------|
| Tensile strength | 200-240MPa |
| Tensile modulus | 70GPa |
| 0.2% Proof stress | 130MPa |
| Elongation | 6% |
| Shear strength | 130MPa |
| Fatigue strength (@10 ⁶ cycles) | 84MPa |
| Charpy impact | 33.2J |
| Hardness | 65Hv |
| Density | 2.69gcm ⁻³ |
| Melting range | 595-560°C |
| Linear expansion coef. | 24x10 ⁻⁶ °C ⁻¹ |
| Maximum service temperature | 150°C |

Characteristics and suitability for processing:

| | |
|--|--------------------------------|
| <u>Resistance to atmospheric attack:</u> | very good |
| <u>Formability:</u> | good |
| <u>Machinability:</u> | good |
| <u>Welding:</u> TIG | very good |
| Oxy-gas | very good |
| resistance, spot etc. | excellent |
| <u>Adhesive bonding:</u> | good |
| <u>Anodising:</u> protective | very good |
| colour | very good |
| bright | good-very good |
| hard | excellent |
| plating | special pre-treatment required |

Al 6082 T6

Drawing reference:
Al, 6082 T6

Purchase condition:
Heat treated to T6 condition.

Product forms:
Plate, sheet and strip, drawn tube, forging stock and tube, bolt and screw stock, rivet stock, wire.

Applications:
Weldable, wrought, heat treatable aluminium alloy for medium strength applications and fabrications, formally known as HE 30 TF.

Chemical composition:

| | |
|----|-----------|
| Si | 0.7-1.3% |
| Fe | 0.5%max |
| Cu | 0.1%max |
| Mn | 0.4-1.0% |
| Mg | 0.6-1.2% |
| Cr | 0.25%max |
| Ni | 0.1%max |
| Zn | 0.2%max |
| Ti | 0.1%max |
| Al | remainder |

Heat treatment:
T6 condition.

1. Solution heat treated at 530±10°C.
2. Water quench.
3. Aged at 175-185°C for 7-12hrs.
4. Air cool.

Welded fabrications should be stress relieved as follows:

1. Heat to 210±10°C .
2. Hold for 2hrs in air circulating furnace.
3. Air cool.

Properties:

| | |
|--|--------------------------------------|
| Tensile strength | 310MPa |
| Tensile modulus | 69GPa |
| 0.2% Proof stress | 270MPa |
| Elongation | 8% |
| Shear strength | 218MPa |
| Fatigue strength (@10 ⁶ cycles) | 124MPa |
| Charpy impact | 12J |
| Hardness | 95-105Hv |
| Density | 2.7gcm ⁻³ |
| Melting range | 570-660°C |
| Linear expansion coef. | 23x10 ⁻⁶ °C ⁻¹ |
| Maximum service temperature | 150°C |

Characteristics and suitability for processing:

| | |
|--|-------------------------------|
| <u>Resistance to atmospheric attack:</u> | good |
| <u>Formability:</u> | good |
| <u>Machinability:</u> | very good |
| <u>Welding:</u> TIG | very good (use 4043 rod/wire) |
| Oxy-gas | fair |
| resistance, spot etc. | very good |
| <u>Adhesive bonding:</u> | good |
| <u>Anodising:</u> protective | good |
| colour | good |
| bright | fair |
| hard | good to very good |
| plating | special treatment required |

Recommended materials

Titanium, commercially pure Grade 2

Drawing reference:

TWR/MS/Ti002 (Ti, CP, Grade 2, stress relieved.)

Purchase condition:

Annealed and de-scaled or bright annealed.

Product forms:

Plate, sheet, welded and seamless tube, forging stock, bar.

Applications:

"Commercially pure" titanium is used because of its resistance to corrosion and in low - medium strength fabrications to exploit its weldability and higher strength than weldable aluminium alloys. Also known as IMI 125.

Chemical composition:

Defined by allowable levels of dissolved gases and other impurities.

| | |
|----|-----------|
| O | 0.15%max |
| N | 0.006%max |
| C | 0.02%max |
| Fe | 0.04%max |

Heat treatment:

Annealed condition:

1. Heat to 650-750°C, hold for 1hr.
2. Air cool.

Stress relieve after welding:

1. Heat to 425°C, hold for 1hr.
2. Air cool.

Properties:

| | |
|--|---------------------------------------|
| Tensile strength | 435MPa |
| Tensile modulus | 105GPa |
| 0.2% Proof stress | 290MPa |
| Elongation | 22% |
| Shear strength | 283MPa |
| Fatigue strength (@10 ⁶ cycles) | 218MPa |
| Charpy impact | 38.6J |
| Hardness | 140-240Hv |
| Density | 4.51gcm ⁻³ |
| Melting point | 1660±10°C |
| Linear expansion coef. | 8.6x10 ⁻⁶ °C ⁻¹ |
| Maximum service temperature | 480°C* |

*(although properties degrade steadily above room temperature such that they are less than 50% @300°C)

Characteristics and suitability for processing:

| | |
|--|-----------|
| <u>Resistance to atmospheric attack:</u> | good |
| <u>Formability:</u> | poor |
| <u>Machinability:</u> | fair |
| <u>Welding:</u> TIG | good |
| Electron beam | very good |
| <u>Adhesive bonding:</u> | very good |
| <u>Anodising:</u> | good. |

Titanium alloy Ti 6Al 4V

Drawing reference:

Ti 6Al 4V, annealed.

Purchase condition:

Annealed

Product forms:

Plate, sheet, forging stock, bar.

Applications:

Machined and fabricated components requiring optimum specific strength. Also known as IMI 318.

Chemical composition:

| | |
|----|------------|
| Al | 6% |
| V | 4% |
| O | 0.2%max |
| Fe | 0.3%max |
| H | 0.0125%max |
| C | 0.010%max |
| N | 0.05%max |
| Ti | remainder |

Heat treatment:

Annealed condition.

1. Heat to 700°C and hold for 1hr.
2. Air cool.

Properties:

| | |
|--|---------------------------------------|
| Tensile strength | 900MPa (800 at 200°C) |
| Tensile modulus | 108GPa |
| 0.2% Proof stress | 830MPa |
| Elongation | 8% |
| Shear strength | 649MPa |
| Fatigue strength (@10 ⁶ cycles) | 560MPa |
| Charpy impact | 40.6J |
| Hardness | 350Hv |
| Density | 4.42gcm ⁻³ |
| Melting point | 1665±15°C |
| Linear expansion coef. | 9.0x10 ⁻⁶ °C ⁻¹ |
| Maximum service temperature | 300°C* |

*(above this temperature the alloy must be used in a controlled atmosphere)

Characteristics and suitability for processing:

| | |
|--|---|
| <u>Resistance to atmospheric attack:</u> | good |
| <u>Formability:</u> | poor, although may be readily formed by warm working. |
| <u>Machinability:</u> | fair. |
| <u>Welding:</u> TIG | fair, but must be carried out in an argon "tent" and post weld stress relieved. |

Electron beam excellent, but must be stress relieved:

1. Heat to 540°C and hold for 2hrs.
2. Air cool.

Adhesive bonding: excellent.

Note:

This alloy may be heat treated to improve strength up to ≈ 1200MPa, but at the expense of ductility.

Magnesium alloy ZE41 A T5

Drawing reference:
TWR/MS/Mg002 (Mg, ZE41 A T5)

Purchase condition:
Castings, solution treated and age hardened to T5 condition.

Product forms:
Castings

Applications:
Large lightweight castings, in particular gear box casings.
Formally known as RZ 5 or mag 5.

Chemical composition:

| | |
|-------------|-----------|
| Zn | 4.0% |
| Rare earths | 1.2% |
| Zr | 0.7% |
| Mn | 0.15%max |
| Cu | 0.10%max |
| Ni | 0.01%max |
| Mg | remainder |

Heat treatment:
T5 condition.

1. Solution treatment at 320-340°C for 2-4hrs in an inert atmosphere.
2. Air cool.
3. Age at 170-200°C for 10-20hrs.
4. Air cool.

Properties:

| | |
|--|--|
| Tensile strength | 205MPa |
| Tensile modulus | 45GPa |
| Yield strength | 140MPa |
| Compressive strength | 345MPa |
| Shear strength | 160MPa |
| Shear modulus | 17GPa |
| Elongation | 3.5% |
| Fatigue strength (@10 ⁶ cycles) | 75MPa |
| Charpy impact | 6.7J |
| Hardness | 80Hv |
| Density | 1.84gcm ⁻³ |
| Melting range | 510-640°C |
| Linear expansion coef. | 27.1x10 ⁻⁶ °C ⁻¹ |
| Maximum service temperature | 150°C |

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor
Machinability: very good

Welding: may be TIG welded using welding rod of base metal composition, post weld stress relief is required:
1. Heat to 260°C for 1hr.
2. Air cool.

Adhesive bonding: fair

Note:

A modicum of protection against atmospheric corrosion may be achieved by the application of a black chromate coating.

Phosphor Bronze BS 1400 PB1

Drawing reference:
Phosphor Bronze, PB1

Purchase condition:
Stress relieved

Product forms:
Castings, cast billet, bar.

Applications:
Bearings and bushes to exploit its wear resistance. Also known as Copper Alloy C 90700, SAE J461, J462.

Chemical composition:

| | |
|----|-----------|
| Al | 0.005%max |
| At | 0.20%max |
| Cu | 88-90% |
| Fe | 0.15%max |
| Pb | 0.50%max |
| Ni | 0.50%max |
| P | 0.30%max |
| Si | 0.005%max |
| S | 0.05%max |
| Sn | 10-12% |
| Zn | 0.50%max |

Heat treatment:
Stress relieve:

1. Heat to 260°C hold for 1hr.
2. Air cool.

Properties:

| | |
|--|--|
| Tensile strength | 300MPa |
| Tensile modulus | 105.4GPa |
| 0.5% proof stress | 211MPa |
| Elongation | 16% |
| Fatigue strength (@10 ⁶ cycles) | 176MPa |
| Hardness | 108Hv |
| Density | 8.78gcm ⁻³ |
| Melting range | 832-1000°C |
| Linear expansion coef | 18.1x10 ⁻⁶ °C ⁻¹ |

Characteristics and suitability for processing:

Resistance to atmospheric attack: poor
Machinability: fair

Formability: cannot be cold worked but may be warm worked.
Welding: not recommended, although may be readily brazed and soldered.