Chapter 1-0

METALS AND ALLOYS - INTRODUCTION

CONTENTS

General information

1 Metals and alloys are divided into two categories and classified as ferrous and non-ferrous, each with its own characteristics.

2 Alloys may be defined as the addition of other metals, or substances, to a basic metal, in order to obtain desirable properties, e.g. corrosion resistance, free machining etc.

3 In designing aircraft, aircraft components and ancillary equipment, the reduction of weight, whilst increasing the strength of the unit, is a prime consideration. To this end (together with due consideration of other desirable qualities), various alloys have been developed.

4 Metals and alloys used in the construction and repair of aircraft and other service equipment must conform to M.O.D. approved specifications (para. 7). In the production of metals and alloys, the correct chemical compositions and strict temperature control during the heating processes are crucial.

5 All metals and alloys (except forgings) supplied, are to be identified according to the colour codes tabulated in Chap. 3.

6 Brief descriptions of the ferrous and non-ferrous metals and alloys for various service applications are given in later paragraphs.

Specifications

7 Metals and alloys in service usage are based on:-

7.1 Those issued by the British Standards Institution.

7.2 M.O.D. specifications, e.g. DEF. STAN., D.T.D. etc.

7.3 International specifications e.g. D.I.N., MILS (U.S.)

8 These specifications classify and list the chemical composition, heat treatment and physical tests relevant to a particular metal or alloy.

Additionally, they detail the methods to be adopted in the preparation of test pieces (Chap. 1-1).

8.1 The composition of a given metal or alloy, in terms of acceptable element percentage limits, is fully detailed. Notes regarding any element(s) (impurities) having harmful effects upon the metal or alloy and the maximum percentages of such impurities are also given.

8.2 The effect of each element should be fully understood whether the element is regarded as an important constituent or as an impurity; for example, the percentage of carbon present in steel gives an indication of its suitability for hardening purposes, but consideration should also be given to other elements that will alter the effect of the carbon, as in the cases of manganese, nickel or chromium. Table 1 gives the various values relevant to each.

8.3 Where necessary, the method of heat treatment for a particular metal or alloy, quoting max/min temperatures, quenching mediums, annealing, hardening and ageing, is fully detailed.

8.4 Specified physical tests are those considered necessary for particular metals. (Chap. 1-1).

Characteristics

9 Pure elements have their own characteristics, most of which may be utilised alone, as for example the lightness and ductility of aluminium, the high conductivity of copper or the non-corrosibility of nickel. These characteristics, however, may in many instances be improved and other desirable qualities given to metals, by alloying and heat-treatment.

10 In aircraft construction, light weight metals are extensively used. Various alloys have been developed, whereby, with very slight increases in the specific gravity, a greater strength/weight ratio is obtained.

11 A metal or alloy may have all the desirable qualities required in use but prove difficult to machine or form. In such cases, the addition of some new element(s) may improve the machining quality without affecting the other properties.

12 In certain other instances, a material may be strengthened by:

12.1 Hot or cold working (or forming).

12.2 Heat treatment.

12.3 Metal plating and coating.

Note ...

The specific gravity of a metal gives its density when compared with a comparable volume of water (having a unit weight of 1.00).

Grain structures

13 The grain structures of different metals vary widely in shape, size and density. The shape and size of the grain structure can be varied by:

13.1 Alloying

13.2 Heat treatment

13.3 Hot and cold working and forming.

14 These processes cause chemical, inter-granular and grain-directional changes, all of which impart certain qualities to the relevant metal or alloy.

15 During the production of metals and alloys, strict temperature control is required, usually effected by the use of suitable meters that give temperature readings (Chap. 1-1, para. 28).

Alloying

16 In order to fully understand the effect of alloying metals, and the changes which take place due to different heating and working pressures, a brief reference to the various properties is necessary, and these are:

16.1 Brittleness

16.2 Conductivity of heat (or electricity)

16.3 Corrosion resistance

16.4 Ductility

16.5 Elasticity

16.6 Fusibility

16.7 Hardness

16.8 Malleability

16.9 Softness

16.10 Tenacity

16.11 Toughness

TABLE 1 CHEMICAL ELEMENTS

The atomic weights are based on the 1969 international agreed values of the International Union of Pure and Applied Chemistry, the basis being the carbon - 12 isotope.

Symbol	Name	Atomic		Specific gravity	Melting or Fusing Pt. °C
		No.	Wt.		
Ag	Silver (argentum)	47	107.868	10.5	860
Al	Aluminium	13	26.9815	2.58	658
Ar	Argon	18	39.948	Gas	-188
As	Arsenic	33	74.9216	5.73	Volatile, 450
Au	Gold (aurum)	79	196.9665	19.3	1062

TABLE 1 CHEMICAL ELEMENTS (continued)

Symbol	Name	Atomic		Specific gravity	Melting or Fusing Pt. °C
		No.	Wt.		
B	Boron	5	10.81	2.5	2300
Ba	Barium	56	137.34	3.75	850
Be	Beryllium (glucinum)	4	9.0122	1.93	1281
Bi	Bismuth	83	208.9806	9.80	268
Br	Bromine	35	79.904	3.19	-7.3
C	Carbon	6	12.011	3.52	Infusible
Ca	Calcium	20	40.08	1.58	851
Cd	Cadmium	48	112.40	8.64	320
Ce	Cerium	58	140.12	6.68	623
Cl	Chlorine	17	35.453	Gas	-102
Co	Cobalt	27	58.9332	8.6	1490
Cr	Chromium	24	51.9996	6.5	1510
Cs	Caesium	55	132.9055	1.88	26
Cu	Copper (cuprum)	29	63.546	8.9	1083
F	Fluorine	9	18.9984	Gas	-223
Fe	Iron (ferrum)	26	55.847	7.86	1525
Ga	Gallium	31	69.72	5.95	30
Ge	Germanium	32	72.59	5.47	958
H	Hydrogen	1	1.0080	Gas	-258
He	Helium	2	4.0026	Gas	-272
Hf	Hafnium	72	178.49	12.1	2500
Hg	Mercury (hydrargyrum)	80	200.59	13.596	38.9
I	Iodine	53	126.9045	4.95	-114
In	Indium	49	114.82	7.4	155
Ir	Iridium	77	192.22	22.4	2375
K	Potassium (kalium)	19	39.102	0.87	63
Kr	Krypton	36	83.80	Gas	-169
La	Lanthanum	57	138.9055	6.1	810
Li	Lithium	3	6.941	0.585	186
Mg	Magnesium	12	24.305	1.74	651
Mn	Manganese	25	54.9380	7.39	1220
Mo	Molybdenum	42	95.94	10.2	2500
N	Nitrogen	7	14.0067	Gas	-211
Na	Sodium (natrium)	11	22.9898	0.978	97
Nb	Niobium (columbium)	41	92.9064	8.4	1950
Nd	Neodymium	60	144.24	6.96	840
Ne	Neon	10	20.179	Gas	248.6
Ni	Nickel	28	58.71	8.9	1452
O	Oxygen	8	15.9994	Gas	-227
Os	Osmium	76	190.2	22.48	2700
P	Phosphorous	15	30.9738	1.8-2.3	44
Pb	Lead (plumbum)	82	207.2	11.37	327
Pd	Palladium	46	106.4	11.4	1549

TABLE 1 CHEMICAL ELEMENTS (continued)

Symbol	Name	Atomic		Specific gravity	Melting or Fusing Pt. °C
		No.	Wt.		
Pr	Praseodymium	59	140.9077	6.48	940
Pt	Platinum	78	195.09	21.5	1755
Ra	Radium	88	226.0254	6.0	700
Rb	Rubidium	37	85.4678	1.52	39
Re	Rhenium	75	186.2	21	3000
Rh	Rhodium	45	102.9055	12.1	1950
Ru	Ruthenium	44	101.07	12.26	2400
S	Sulphur	16	32.06	2.07	115-119
Sb	Antimony (stibium)	51	121.75	6.62	629
Se	Selenium	34	78.96	4.5	170-220
Si	Silicon	14	28.086	2.0-2.4	1370
Sm	Samarium	62	150.4	7.7	1350
Sn	Tin (stannum)	50	118.69	7.3	232
Sr	Strontium	38	87.62	2.54	800
Ta	Tantalum	73	180.9479	16.6	2900
Te	Tellurium	52	127.60	6.0	446
Th	Thorium	90	232.0381	11.00	1750
Ti	Titanium	22	47.90	4.54	1850
Tl	Thallium	81	204.37	11.85	302
U	Uranium	92	238.029	18.7	<1850
V	Vanadium	23	50.9414	5.5	1710
W	Tungsten (wolfram)	74	183.85	19.1	2900-3000
Yb	Ytterbium	70	173.04		1800
Zn	Zinc	30	65.37	7.12	418
Zr	Zirconium	40	91.22	4.15	2130

Note ...

The elements listed are those mainly used in metallurgy.