CHAPTER 4. METAL STRUCTURE, WELDING, AND BRAZING

SECTION 1. IDENTIFICATION OF METALS

4-1. GENERAL. Proper identification of the aircraft structural material is the first step in ensuring that the continuing airworthiness of the aircraft will not be degraded by making an improper repair using the wrong materials.

a. Ferrous (iron) alloy materials are generally classified according to carbon content. (See table 4-1.)

TABLE 4-1. Ferrous (iron) alloy materials.

MATERIALS	CARBON CONTENT
Wrought iron	Trace to 0.08%
Low carbon steel	0.08% to 0.30%
Medium carbon steel	0.30% to 0.60%
High carbon steel	0.60% to 2.2%
Cast iron	2.3% to 4.5%

b. The strength and ductility, or toughness of steel, is controlled by the kind and quantity of alloys used and also by cold-working or heat-treating processes used in manufacturing. In general, any process that increases the strength of a material will also decrease its ductility.

c. Normalizing is heating steel to approximately 150 °F to 225 °F above the steel's critical temperature range, followed by cooling to below that range in still air at ordinary temperature. Normalizing may be classified as a form of annealing. This process also removes stresses due to machining, forging, bending, and welding. After the metal has been held at this temperature for a sufficient time to be heated uniformly throughout, remove the metal from the furnace and cool in still air. Avoid prolonging the soaking of the metal at high temperatures, as this practice will cause the grain structure to enlarge. The length of time required for the soaking temperature depends on the mass of the metal being treated. The soaking time is roughly ¼ hour per inch of the diameter of thickness (Ref: Military Tech Order (T.O.) 1-1A-9).

4-2. IDENTIFICATION OF STEEL STOCK. The Society of Automotive Engineers (SAE) and the American Iron and Steel Institute (AISI) use a numerical index system to identify the composition of various steels. The numbers assigned in the combined listing of standard steels issued by these groups represent the type of steel and make it possible to readily identify the principal elements in the material.

a. The basic numbers for the four digit series of the carbon and alloy steel may be found in table 4-2. The first digit of the four number designation indicates the type to which the steel belongs. Thus, "1" indicates a carbon steel, "2" a nickel steel, "3" a nickel chromium steel, etc. In the case of simple alloy steels, the second digit indicates the approximate percentage of the predominant alloying element. The last two digits usually indicate the mean of the range of carbon content. Thus, the designation "1020" indicates a plain carbon steel lacking a principal alloying element and containing an average of 0.20 percent (0.18 to 0.23) carbon. The designation "2330" indicates a nickel steel of approximately 3 percent (3.25 to 3.75) nickel and an average of 0.30 percent, (0.28 to 0.33) carbon content. The designation "4130" indicates a chromium-molybdenum steel of approximately 1 percent (0.80 to 1.10) chromium, 0.20 percent (0.15 to 0.25) molybdenum, and 0.30 percent (0.28 to 0.33) carbon.

b. There are numerous steels with higher percentages of alloying elements that do not fit into this numbering system. These include a large group of stainless and heat resisting alloys in which chromium is an essential alloying element. Some of these alloys are identified by three digit AISI numbers and many others by designations assigned by the steel company that produces them. The few examples in table 4-3 will serve to illustrate the kinds of designations used and the general alloy content of these steels.

c. "1025" welded tubing as per Specification MIL-T-5066 and "1025" seamless tubing conforming to Specification MIL-T-5066A are interchangeable.

4-3. INTERCHANGEABILITY OF STEEL TUBING.

a. "4130" welded tubing conforming to Specification MIL-T-6731, and "4130" seam-less tubing conforming to Specification MIL-T-6736 are interchangeable.

b. NE-8630 welded tubing conforming to Specification MIL-T-6734, and NE-8630 seamless tubing conforming to Specification MIL-T-6732 are interchangeable.

4-4. IDENTIFICATION OF ALUMINUM. To provide a visual means for identifying the various grades of aluminum and aluminum alloys, such metals are usually marked with symbols such as a Government Specification Number, the temper or condition furnished, or the commercial code marking. Plate and sheet are usually marked with specification numbers or code markings in rows approximately 5 inches apart. Tubes, bars, rods, and extruded shapes are marked with specification numbers or code markings at intervals of 3 to 5 feet along the length of each piece.

The commercial code marking consists of a number which identifies the particular composition of the alloy. In addition, letter suffixes (see table 4-4) designate the basic temper designations and subdivisions of aluminum alloys.

TABLE 4-2. Numerical system for steel identification.

TYPES OF STEELS	NUMERALS AND DIGITS
Plain carbon steel	10XX
Carbon steel with additional sulfur for easy machining.	11XX
Carbon steel with about 1.75% manganese	13XX
.25% molybdenum.	40XX
1% chromium, .25% molybdenum	41XX
2% nickel, 1% chromium, .25% molybdenum	43XX
1.7% nickel, .2% molybdenum	46XX
3.5% nickel, .25% molybdenum	48XX
1% chromium steels	51XX
1% chromium, 1.00% carbon	51XXX
1.5% chromium steels	52XX
1.5% chromium, 1.00% carbon	52XXX
1% chromium steel with .15% vanadium	61XX
.5% chromium, .5% nickel, .20% molybdenum	86XX
.5% chromium, .5% nickel, .25% molybdenum	87XX
2% silicon steels, .85% manganese	92XX
3.25% nickel, 1.20% chromium, .12% molybdenum	93XX

TABLE 4-3. Examples of stainless and heat-resistant steels nominal composition (percent)

ALLOY DESIGNATION	CARBON	CHROMIUM	NICKEL	OTHER	GENERAL CLASS OF STEEL
302	0.15	18	9		Austenitic
310	0.25	25	20		Austenitic
321	0.08	18	11	Titanium	Austenitic
347	0.08	18	11	Columbium or Tantalum	Austenitic
410	0.15	12.5			Martensitic, Magnetic
430	0.12	17			Ferritic, Magnetic
446	0.20	25		Nitrogen	Ferritic, Magnetic
PH15-7 Mo	0.09	15	7	Molybdenum, Aluminum	Precipitation Hardening
17-4 PH	0.07	16.5	4	Copper, Columbium or Tantalum	Precipitation Hardening

TABLE 4-4. Basic temper designations and subdivisions from aluminum alloys.

NON HEAT-TREATABLE ALLOYS		HEAT-TREATABLE ALLOYS	
Temper Designation	**Definition**	**Temper Designation**	**Definition**
-0	Annealed recrystallized (wrought products only) applies to softest temper of wrought products.	-0	Annealed recrystallized (wrought products only) applies to softest temper of wrought products.
-H1	Strain-hardened only. Applies to products which are strain-hardened to obtain the desired strength without supplementary thermal treatment.	-T1	Cooled from an elevated temperature shaping process (such as extrusion or casting) and naturally aged to a substantially stable condition.
-H12	Strain-hardened one-quarter-hard temper.	-T2	Annealed (castings only).
-H14	Strain-hardened half-hard temper.	-T3	Solution heat-treated and cold-worked by the flattening or straightening operation.
-H16	Strain-hardened three-quarters-hard temper.	-T36	Solution heat-treated and cold-worked by reduction of 6 percent
-H18	Strain-hardened full-hard temper.	-T4	Solution heat-treated.
-H2	Strain-hardened and then partially annealed. Applies to products which are strain-hardened more than the desired final amount and then reduced in strength to the desired level by partial annealing.	-T42	Solution heat-treated by the user regardless of prior temper (applicable only to 2014 and 2024 alloys).
-H22	Strain-hardened and partially annealed to one-quarter-hard temper.	-T5	Artificially aged only (castings only).
-H24	Strain-hardened and partially annealed to half-hard temper.	-T6	Solution heat-treated and artificially aged.
-H26	Strain-hardened and partially annealed to three-quarters-hard temper.	-T62	Solution heat-treated and aged by user regardless of prior temper (applicable only to 2014 and 2024 alloys).
-H28	Strain-hardened and partially annealed to full-hard temper.	-T351, -T451, -T3510, -T3511, -T4510, -T4511.	Solution heat-treated and stress relieved by stretching to produce a permanent set of 1 to 3 percent, depending on the product.
-H3	Strain-hardened and then stabilized. Applies to products which are strain-hardened and then stabilized by a low temperature heating to slightly lower their strength and increase ductility.	-T651, -T851, -T6510, -T8510, -T6511, -T8511.	Solution heat-treated, stress relieved by stretching to produce a permanent set of 1 to 3 percent, and artificially aged.
-H32	Strain-hardened and then stabilized. Final temper is one-quarter hard.	-T652	Solution heat-treated, compressed to produce a permanent set and then artificially aged.
-H34	Strain-hardened and then stabilized. Final temper is one-half hard.	-T8	Solution heat-treated, cold-worked and then artificially aged.
-H36	Strain-hardened and then stabilized. Final temper is three-quarters hard.	-T/4	Solution heat-treated, cold-worked by the flattening or straightening operation, and then artificially aged.
-H38	Strain-hardened and then stabilized. Final temper is full-hard.	-T86	Solution heat-treated, cold-worked by reduction of 6 percent, and then artificially aged.
-H112	As fabricated; with specified mechanical property limits.	-T9	Solution heat-treated, artificially aged and then cold-worked.
-F	For wrought alloys; as fabricated. No mechanical properties limits. For cast alloys; as cast.	-T10	Cooled from an elevated temperature shaping process artificially aged and then cold-worked.
		-F	For wrought alloys; as fabricated. No mechanical properties limits. For cast alloys; as cast.

4-5. - 4-15. [RESERVED.]