ROYAL CANADIAN AIR FORCE

METAL IDENTIFICATION

(This EO replaces Part 3 of EO 05-1-3)

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

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LIST OF RCAF REVISIONS

DATE	PAGE NO	DATE	PAGE NO

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

METAL IDENTIFICATION

METAL RECOGNITION

GENERAL

1 Several simple tests have been designed for the identification of metals. These are the colour code, appearance, chip test, spark test, and gas-welding torch test. Other tests may be made to determine the various properties of the metal such as hardness, brittleness, elasticity, malleability and strength. The tests for these properties include hardness tests, tensile tests, compression tests, shear tests, bend tests and fatigue tests. When using data derived from such tests, it must be remembered that there is considerable variation in the mechanical characteristics of various samples of the same alloys, and that many alloys have similar characteristics. The identification methods following are those for which equipment required is available to the maintenance personnel.

CHARACTERISTIC COLOURS

2 For the characteristic colours of common aircraft materials, see Figure 1.

SURFACE APPEARANCE

3 Examining the outside unfinished surface of a metal is not always sufficient evidence to classify it, but does make it possible to classify the metal into a group, thereby limiting the additional tests needed for classification. The colour of the metal will put it into a class. This classification is further broken down by examining the surface. The outer surface of aluminum may show evidence of having been rolled or moulded. If it shows forging marks or the evidence of a mould, it is probably low-carbon or cast steel. If the outer surface shows rolling or forging marks, the metal may be high-carbon steel. Stainless steel in the unfinished state is only slightly rough. Wrought iron, copper, brass or bronze, monel metal, and nickel all have smooth outer unfinished surfaces. If colour and appearance are insufficient for identification, use further applicable tests.

CHIP TEST

4 Make the chip test by removing a small amount of material from the sample with a sharp cold chisel. The material removed will vary from small broken fragments to a continuous strip. The chip may have smooth sharp edges. It may be coarse-grained or fine-grained. It may have sawlike edges where it has been cut.

5 The size of the chip and the ease of chipping is important in the identification of the sample, but this method is largely a result of practice. If possible, compare results with a known sample. The following information will aid in recognition of the more common materials:-

(a) Aluminum and aluminum alloys: Chips are smooth, have saw edges, and can be continuous if desired.

(b) Monel metal: Chips have smooth edges, and can be continuous if desired. Chips easily.

(c) Nickel: The chips have smooth edges and can be continuous if desired. Chips easily.

(d) High-carbon steel: Chips show fine-grained fracture and can be continuous if desired. Chip edges are lighter in colour than those of low-carbon steel. The metal is hard but can be chipped.

(e) Low-carbon and cast steel: Chips have smooth edges and can be continuous if desired. Metal is easily cut or chipped.

(f) Malleable iron: Chips are 1/4 to 3/8" long. Material is tough and hard to chip.

(g) Wrought iron: Chips have a smooth edge and can be continuous if desired. Metal is soft and easily cut or chipped.

(h) Copper: Chips are smooth, have saw edges where cut, and can be continuous where desired. Metal is easily cut.

(j) Brass and bronze: Chips are smooth and have saw edges. It is difficult to obtain a continuous chip. Brass and bronze are easily cut but more brittle than copper.

SPARK TEST

6 Make the spark test by holding a sample of the material against a power grinder. The sparks given off, or the lack of sparks, assist in identifying the metal. The length of the spark stream, colour and the type of sparks are the identification features.

Metals	Outside Appearance	Newly Fractured Surface	Freshly Filed Surface
Aluminum	Light grey	Fine crystalline	White
Monel metal	Dark grey	Light grey	Light grey
Nickel	Dark grey	Off white	Bright silvery white
High-carbon steel	Dark grey	Light grey	Bright silvery grey
Low-carbon and cast steel	Dark grey	Bright grey	Bright silvery grey
Malleable iron	Dull grey	Fine crystalline	Light silvery grey
Wrought iron	Light grey	Bright grey	Light silvery grey
Stainless steel	Dark grey	Medium grey	Bright silvery grey
Copper	Reddish brown	Bright red	Bright copper grey
Brass and bronze	Reddish yellow, yellow green, brown	Red to yellow	Reddish yellow to yellow white

Figure 1 Colour Code for Identification of Metals

7 There are four fundamental spark forms produced by holding a sample of metal against a power grinder, see Figure 2. Shafts, bud, break and arrow are shown in Detail A. The arrow or spearhead is characteristic of steel alloyed with molybdenum. The swelling or buds in the spark line indicate nickel with molybdenum. Shafts and sprigs or sparklers, which indicate a high carbon content are shown in Detail B. Shafts, forks, and sprigs, which indicate a medium carbon content are shown in Detail C. Shafts and forks, which indicate a low carbon content are shown in Detail D.

8 To make the spark test, hold the piece of metal on the wheel in such a manner as to throw the spark stream about 12" in front of the viewer. Make several tests to obtain proper results. Do not press too hard, as the pressure will increase the temperature of the spark stream and the burst and will also give the appearance of a higher carbon content than that of the metal actually being tested. If possible, compare results with sparks obtained from a known sample.

SPARK TEST FOR STEELS

9 Figure 3 shows sparks obtained from low-carbon and cast steel. Figure 4 shows sparks from high-carbon steel. The spark stream is long (about 70" normally) and the volume is moderately large in low-carbon steel, while in high-carbon steel the stream is shorter (about 55") and large in volume. The few sparklers which may occur at any place in low-carbon steel are forked, while in high-carbon steel the sparklers are small and repeating and some of the shafts may be forked. Both will produce a white spark stream.

10 Stainless steel, see Figure 5, produces a spark stream approximately 50" in length, of moderate volume with few sparklers. The sparklers are forked. The stream next to the wheel is straw-coloured while at the end it is white.

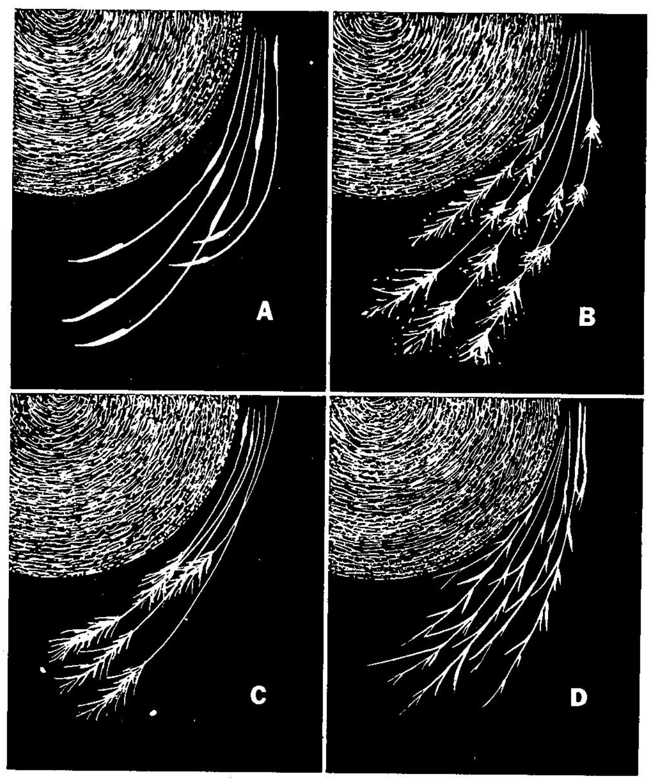

Figure 2 Fundamental Spark Forms

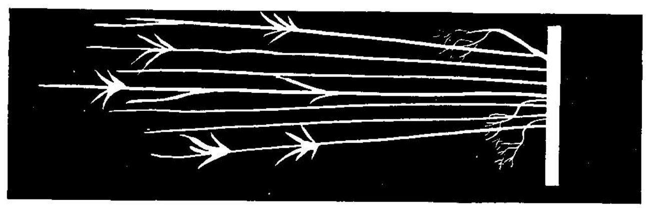

Figure 3 Sparks from Low-Carbon and Cast Steel

Figure 4 Sparks from High-Carbon Steel

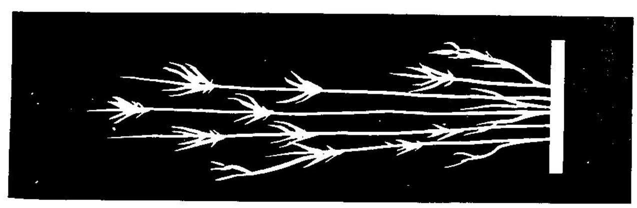

Figure 5 Sparks from Stainless Steel

SPARK TEST FOR IRON

11 Sparks produced from malleable iron are about 30 inches long, see Figure 6, of moderate volume, with many small repeating sparklers toward the end of the stream. The entire stream is straw-coloured.

12 The wrought iron spark, see Figure 7, produces a stream about 65 inches in length. The stream is of large volume with few sparklers, which show up toward the end of the stream and are forked. The stream next to the grinding wheel is straw-coloured, while the outer end of the stream is a bright red.

SPARK TEST FOR NON-FERROUS METALS

13 Nickel, see Figure 8, produces a spark stream only about 10 inches in length. It is small in volume and orange in colour. The sparks form wavy streaks with no sparklers.

14 Monel metal forms a spark stream almost identical to that of nickel and must be identified by other means.

15 Aluminum and its alloys, copper, brass, bronze, and lead form no sparks on the grinding wheel but are identifiable by other means such as colour, surface appearance and chip tests.

WELDING TORCH TEST

16 The acetylene welding torch is used as an aid toward identification of metals by the rate of melting, the appearance of the molten metal and slag, as well as any colour changes which occur during heating. Experience with the torch is required for consistent results. Watch for the following indications:-

(a) Aluminum and its alloys melt faster than steel, with no apparent change in colour. The stiff black scum which forms is usually quiet. The molten puddle is the same colour as the unheated metal and is fluid. The black scum forming on the surface tends to mix with the metal and is difficult to remove.

(b) Monel melts more slowly than steel and becomes red before melting. It flows clearly without any sparklers. The slag forms a grey scum in considerable amounts, is quiet and is hard to break up. The molten puddle is fluid under the slag and is quiet. A heavy black scale is formed on cooling.

(c) Nickel melts more slowly than steel and becomes red before melting. The slag, in the form of grey scum, is quiet and is hard to break up. The molten puddle is fluid under the slag.

(d) Stainless steel: The action under the flame varies with the alloy.

Figure 6 Sparks From Malleable Iron

Figure 7 Sparks From Wrought Iron

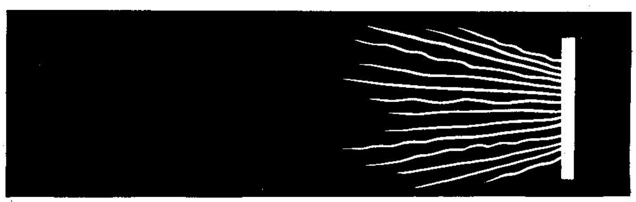

Figure 8 Sparks From Nickel

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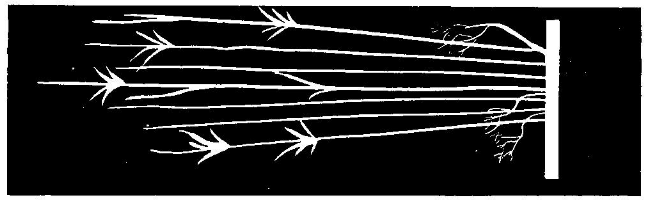

Figure 3 Sparks from Low-Carbon and Cast Steel

Figure 4 Sparks from High-Carbon Steel

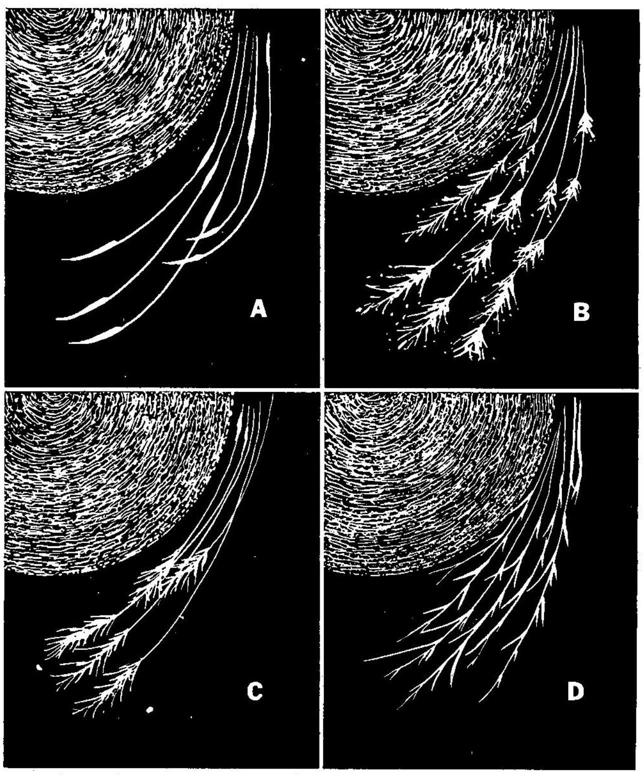

Figure 2 Fundamental Spark Forms

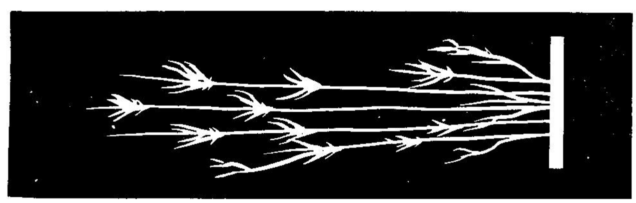

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Figure 6 Sparks From Malleable Iron

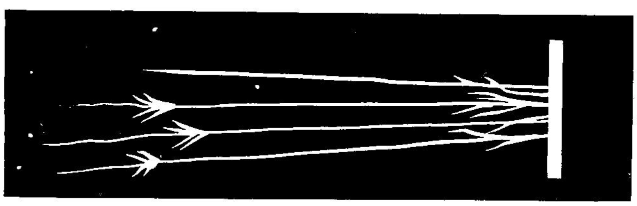

Figure 7 Sparks From Wrought Iron

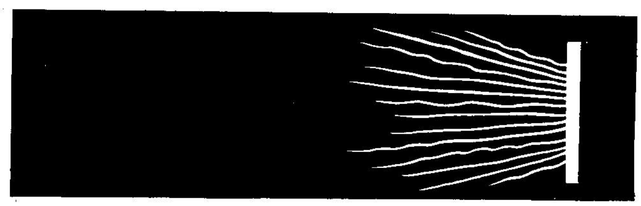

Figure 8 Sparks From Nickel

(e) High-carbon steel: The molten metal is brighter than in the case of low-carbon steel and the melting surface has a cellular appearance. It sparks more freely than mild steel and the sparks are whiter. It melts quickly under the torch and becomes bright red before melting. The slag is similar to the molten metal.

(f) Low-carbon and cast steel give off sparks when melted and solidify quickly (almost instantly). They melt quickly under the torch and become bright red before melting. The slag is similar to the molten metal. The molten puddle is liquid, straw-coloured, and gives off sparks.

(g) Malleable iron melts at a moderate rate under the torch and becomes red before melting. A medium film of slag develops which is tough but can be broken up. The molten puddle is fluid, watery and straw-coloured. It boils and leaves blowholes. The outside bright steel-like band gives off sparks, but not the centre.

(h) Wrought iron melts rapidly under the torch without sparking and becomes a bright red before melting. It has a peculiar slag coating, oily or greasy in appearance, with white lines. The molten puddle is liquid but not viscous, is straw-coloured and is usually quiet, although it may have a tendency to spark.

(j) Copper melts slowly under the flame and may turn black then red. The copper colour may become intense before melting. There is little slag. The molten puddle has a mirror-like surface directly under the flame and a tendency to bubble. On account of good heat-conducting properties, a larger flame is required to produce fusion of copper than would be needed for steel of the same size. Copper containing small amounts of other metal melts more easily and solidifies more slowly than pure copper.

(k) Brass and bronze melt quite rapidly under the flame and become noticeably red before melting. True brasses contain zinc, which gives off white fumes when the brass is melted. Bronze contains tin. Even a slight amount of tin makes the alloy flow freely like water. Because of a small amount of zinc which is usually present, bronze may fume slightly, but not as much as brass.

RESIDUAL MAGNETISM TEST

17 Residual magnetism may be used as a guide to the type of material in question. When in the heat treated condition, low-carbon steels and alloys containing nickel or cobalt, will hold magnetism. High-carbon steel will not hold magnetism easily. Compare the strength of the magnetic pull, using a small compass or field indicator, with a known material. This method is also helpful in distinguishing between austenite stainless steel (300 series, non-magnetic) and martensite stainless steel, (400 series, magnetic).

FILE HARDNESS TEST

18 The file test is a simple test for hardness of metals and is carried out as follows:-

(a) Use a 10 inch bastard file. Hold the piece to be tested in a vise and file the surface of the piece to be tested slowly but firmly. As soon as the file cuts into the metal, remove it.

(b) If the material is cut by the file with extreme ease and tends to clog the surface of the file, it is very soft.

(c) If the material offers some resistance to the file and tends to clog the teeth, it is soft.

(d) If the material offers considerable resistance to the file, but can be filed with repeated effort, it is hard. This material may or may not have been heat treated.

(e) If the material can be removed by extreme effort, in small quantities, by the file, it is very hard and probably has been heat treated.

(f) If the file slides over the material and the file teeth are dulled, it is extremely hard and has been heat treated.

OTHER HARDNESS TESTS

19 For information regarding other methods of hardness testing, refer to EO 05-1-3/4.

TENSILE TEST

20 Tensile tests are performed in the laboratory, using special equipment, to determine the strength of the metal in resisting forces which tend to pull it apart.

BEND TEST

21 A simple bend test may be performed, using a known sample as a guide to determine elasticity. If the metal is bent back and forth until it breaks, the breaking is the result of fatigue or overload and may be used as an indication of identity.

SHEAR TEST

22 Shear strength may be compared to that of a known sample by the ease with which the material may be cut with a pair of shears.

DISTINGUISHING BETWEEN 75S AND 26S (14S) OR 24S

23 To differentiate between 75S and 26S (14S) or 24S aluminum alloy sheet, coil and extrusion, use the following procedure:-

(a) Clean a small area, approximately 1 inch square, of the aluminum alloy to be tested.

(b) Abrade the cleaned area with new fine sandpaper or emery cloth.

(c) Place one drop of the cadmium sulphate test solution, refer to para. 24, following. on the abraded area and allow to stand for two minutes.

(d) A dark deposit indicates that the test material is 75S aluminum alloy. If the test solution remains colourless, the test material is not 75S aluminum alloy.

(e) Wipe off the test solution and any deposit thoroughly with a clean, dry cloth.

(f) Apply a few drops of 10% chromic acid solution to the tested area, and allow to react for a few minutes. Wipe off thoroughly with a clean, damp cloth.

(g) Test known samples of 26S (14S) and 24S and 75S aluminum alloy and compare with the results produced.

NOTE

The cadmium sulphate test solution is extremely corrosive and any of the solution spilled on aircraft materials must be wiped off immediately.

24 Cadmium sulphate test solution is made up, when required, as follows:-

(a) Cadmium sulphate - 5 gm.

(b) Concentrated hydrochloric acid - 5 ml.

(c) Sodium chloride - 3 gm.

(d) Distilled water to make - 100 ml.

TEST FOR HEAT-TREATABLE AND NON HEAT-TREATABLE ALUMINUM ALLOYS

25 All aluminum-base sheets are marked with the specification number or code marking on approximately every square foot of material. If, for any reason, this identification is not on the material, it is possible to separate the heat-treatable alloys from the non heat-treatable alloys by immersing a sample of the material in a 10% solution of caustic soda (sodium hydroxide). The heat-treatable alloys will turn black due to the copper content, whereas the others will remain bright. This test applies to the alloys containing copper. In the case of Alclad, the surface will remain bright but there will be a dark area in the middle when viewed from the edge.

STRENGTH CHARACTERISTICS

26 For strength characteristics of various alloys, refer to EO 05-1-3/5.

MAGNESIUM RECOGNITION TESTS

27 To differentiate between aluminum and magnesium alloys, use the following tests:-

(a) Chip test: Magnesium may be chipped easily but the chips are crystalline in shape, not a continuous chip. Aluminum chips are usually continuous.

(b) Flash test: Magnesium filings will burn with an explosive flame at low temperature. Aluminum filings will not ignite.

(c) Appearance: Magnesium alloys are porous. Remove primer and paint coats, if necessary, to compare with a known material.

TITANIUM RECOGNITION TESTS

28 Titanium has a dull silver grey colour similar to that of stainless steel. Some titanium parts now in use are identified by an etched part number and the word TITANIUM on the part. The following tests may be made to determine if a material is made of titanium:-

(a) Spark test: Titanium gives off white traces ending in brilliant white bursts.

(b) Water test: Titanium leaves grey-white marks when moistened with water and rubbed on glass.

COLOUR MARKINGS

29 Colour markings on raw material provide an accurate means of identification. Background colour and colour of stripes used to denote the various steel alloys are shown in Figures 9 and 10. Width of stripe used is determined by the area available for colour marking. For sizes under 3/4 inch a small tag bearing the colour code for the material is attached. The colour code

in the tables is the system adopted by the National Committee on Iron and Steel for the National Association of Purchasing Agents. This sytem has not been adopted by all suppliers and is given here for interest only.

DESIGNATION

GENERAL

30 Various societies and metal producers have devised codes for the determination of the material using numbers and letters. The most widely used are the SAE system for steels, and the Aluminum Company of America (ALCOA) for aluminum alloys.

Steels	SAE No.	Background
Carbon	1000 series	Colours vary depending on carbon content.
	1300 series	Colours vary depending on carbon content.
Chrome nickel	3100 series	White.
	3200 series	Orange.
	3300 series	Black.
	3400 series	Brown.
Chromium	5100 series	Yellow.
	5200 series	Yellow.
Chromium vanadium	6100 series	Dark blue.
Molybdenum	4100 series	Green.
	4600 series	Green.
Nickel	2300 series	Natural and red.
	2500 series	Lead.
Screw stock	1100 series	Colours vary depending on carbon content.
Silico-manganese	9200 series	Light blue.
Staybolt		Brown.
Tungsten	7100 series	Tan.
	7200 series	Tan.

Figure 9 Table of Raw Material Background Colours

Carbon content	Colour
0.10-0.20	Red
0.15-0.25	Blue
0.20-0.30	Green
0.25-0.35	Lead
0.30-0.40	Orange
0.35-0.45	White
0.40-0.50	Brown
0.45-0.55	Black
0.45 and over	Yellow
Note: No stripes are used in 1000 and 1100 series.	

Figure 10 Table of Raw Material Stripe Colours

Type of Steel	Classification
Carbon	1000 series
Nickel	2000 series
Nickel - chromium	3000 series
Molybdenum	4000 series
Chromium	5000 series
Chromium vanadium	6000 series
Tungsten	7000 series
Silicon - manganese	9000 series

Figure 11 SAE Code for Steels

STEEL

GENERAL

31 A numerical index system devised by the Society of Automotive Engineers (SAE) identifies the composition of SAE steels. Each SAE number consists of a group of digits. The first digit represents the type of steel. The second digit represents the percentage of the principal alloying element. The last two or three digits indicate the percentage in hundredths of one percent of carbon in the alloy.

SAE CODE FOR STEELS

32 The common SAE symbols used in the identification of steels are shown in Figure 11.

33 Examples of the application of SAE numbers are as follows:-

(a) The SAE number 4150 indicates a molybdenum steel containing 1% molybdenum and 0.50% carbon.

(b) The SAE number 1010 denotes a carbon steel containing 0.10% carbon. The first 0 indicates the lack of a principal alloying element, and hence a plain carbon steel.

(c) The percentages indicated in the SAE number are average. For example, the carbon content of SAE 1050 steel may vary from 0.45% to 0.55% and is indicated as 0.50%.

ALUMINUM ALLOYS

GENERAL

34 The aluminum alloys fall into several groups, each group being distinguished by one main alloying constituent. The wrought alloys are designated by numbers followed by the letter S (e.g. 17S) while the cast alloys are designated only by a number. Sometimes, when an alloy has been developed by modifying the composition of an existing alloy, it may be designated by the same number preceded by a letter, such as A17S or B195. Symbols are used following the alloy designation to describe the various tempers resulting from cold working, heat-treating or a combination or both.

WROUGHT ALLOYS

35 The symbols used for the various groups of wrought alloys are shown in Figure 12.

HEAT-TREATABLE ALLOYS

36 The heat-treatable alloys are those in which the mechanical properties may be improved by heat treatment. In contrast to the non heat-treatable alloys, the increased strength is obtained with little sacrifice of ductility. Heat-treatable alloys have the further advantage that they can be heat treated again after annealing to restore their original properties.

Alloy	Aluminum Co. of Canada	Aluminum Co. of America
99.5% - 99.69% Pure Aluminum Group	1S	1075
99.0% - 99.49% Commercial Pure Aluminum Group	2S	1100
Manganese Group	3S-9S	3000
Copper Group	10S-29S	2000
Silicon Group	30S-49S	4000
Magnesium and Magnesium Silicide Group	50S-69S	5000 &6000
Zinc Group	70S-79S	7000

Figure 12 Aluminum Company Code For Alloy Groups

NON HEAT-TREATABLE ALLOYS

37 The non heat-treatable alloys contain elements that remain substantially in solid solution or form constituents that are insoluble. This group includes the high-purity alloys and the alloys 2S, 3S, 52S and 56S.

38 The five tempers, with symbols to describe them, used by Canadian mills are shown in Figure 13.

Symbols	Description
O	Fully annealed
1/2H	One-half hard
3/4H	Three-quarters hard
H	Fully hard
F	As fabricated

Figure 13 Alcan Hardness Code

Symbols	Description
O	Fully annealed
W	Solution heat-treated
T	Solution heat-treated and aged
RW	Solution heat-treated and cold-worked
RT	Solution heat-treated, aged and cold-worked
F	As fabricated
Q	Quenched
A33	Quenched and aged

Figure 14 Canadian Temper Designations

CANADIAN TEMPER DESIGNATIONS

39 There are eight tempers in which the heat-treatable alloys are supplied by the Canadian mills, but each alloy or product is not always supplied in all tempers. The symbols following the alloy numbers that are used to describe these tempers are shown in Figure 14.

NOTE

This table is frequently replaced by the American temper designations even when used for Canadian alloys.

AMERICAN TEMPER DESIGNATIONS

40 For heat-treated materials supplied by American mills, the temper designations consist of the letter T followed by a number of from one to three digits. The basic designations are shown in Figure 15.

Designations	Description
T2	Annealed-castings only
T3	Solution heat-treated and then cold-worked
T4	Solution heat-treated
T5	Artificially aged only
T6	Solution heat-treated and then artificially aged
T7	Solution heat-treated and then stabilized
T8	Solution heat-treated, cold-worked and then artificially aged
T9	Solution heat-treated, artificially aged and then cold-worked
T10	Artificially aged and then cold-worked

Figure 15 American Temper Designations

41 The first numeral following the letter T shows the type of treatment. The actual conditions will usually be different for different alloys and may be varied for a single alloy to produce certain desired results. In this case the tempers, other than the one usually considered standard or the first one used, are designated by a second numeral following the one which shows the type of heat-treatment. Here also there is no attempt to have this numeral indicate any specific set of conditions. Just as the actual temperatures and times required to produce 61S-T6 are different from those required for 18S-T6 or 19S-T6, so are those used for 61S-T61 different from those required for 18S-T61. The numeral 1 following the 6 merely designates properties different from those developed by the standard T-6 treatment for the respective alloys because there has been some modifications of the conditions but not of the type of treatment. The comparative designations for American and Canadian products, are shown in Figure 16.

Alcan Alloy	Type	Alcoa Alloy	
		Obsolete	Current
1S	Sheet, Tubing, Wire, Bar and Rod		
2S	Sheet, Wire, Bar and Rod	2S	1100
3S	Sheet	3S	3003
16S	Wire, Bar and Rod	A17S	2117
17S	Wire, Bar and Rod	17S	2017
18S	Wire, Bar and Rod	18S	2017
24S	Sheet, Extrusion, Tubing, Wire, Bar and Rod	24S	2024
24S Alclad	Sheet	24S Alclad	2024
26S	Extrusion, Wire, Rod, Bar and Forging	14S	2014
28S	Wire, Rod and Bar	11S	2011
50S	Extrusion, Tubing, Wire, Bar and Rod	63S	6063
55S	Wire, Rod and Bar	53S	6053
56S	Wire, Rod and Bar	56S	5056
57S	Sheet, Tubing, Wire, Bar and Rod	52S	5052
61S	Forgings	A51S	6151
65S	Sheet, Extrusion, Tubing, Wire, Bar and Rod	61S	6061
75S	Sheet, Extrusion, Wire, Bar, Rod and Forging	75S	7075
75S Alclad	Sheet	75S Alclad	7075
78S	Forging	78S	7178
79S	Sheet	79S	7079

Figure 16 (Sheet 1 of 2) Aluminum Company Codes for Alloys

Alcan Alloy	Type	Alcoa Alloy	
		Obsolete	Current
A111	Casting Sand		
117	Casting Sand		
123	Casting Sand	43	
125	Casting Sand	355	
135	Casting Sand	356	
225	Casting Sand	195	
236	Casting Sand		
250	Casting Sand	122	
A320	Casting Sand		
350	Casting Sand	220	
117	Casting Permanent Mould		
123	Casting Permanent Mould		
125	Casting Permanent Mould	355	
135	Casting Permanent Mould	356	
162	Casting Permanent Mould	A132	
236	Casting Permanent Mould		
250	Casting Permanent Mould	122	
160X	Casting Die		
340	Casting Die		

The specifications listed above have similar chemical compositions; the mechanical property requirements may differ.

Figure 16 (Sheet 2 of 2) Aluminum Company Codes for Alloys