Traditional Metal Identification Techniques

Kamran Khodaparasti

August 2023

How do engineers and metalworkers identify different metals?

Here are a few tried and true, traditional methods used today in metal identification.

Appearance Test

The most basic test is done by observing the metal's appearance.

Though not always as accurate as most tests a trained/experienced metal worker can identify metals by the color of their surfaces.

Metals	Color of unfinished, unbroken surface	Color and structure of newly fractured surface	Color of freshly filed surface
White cast iron	dull gray	silvery white; crystalline	silvery white
Gray cast iron	dull gray	dark gray; crystalline	light silvery gray
Malleable iron	dull gray	dark gray; finely crystalline	light silvery gray
Wrought iron	light gray	bright gray	light silvery gray
Low-carbon and cast steel	dark gray	bright gray	bright silvery gray
High-carbon steel	dark gray	light gray	bright silvery gray
Stainless steel	dark gray	medium gray	bright silvery gray
Copper	reddish brown to green	bright red	bright copper color
Brass and bronze	reddish yellow, yellow-green, or brown	red to yellow	reddish yellow to yellowish white
Aluminum	light gray	white; finely crystalline	white
Monel metal	dark gray	light gray	light gray
Nickel	dark gray	off-white	bright silvery white
Lead	white to gray	light gray; crystalline	white

Magnet Test

The use of a magnet is another method used to aid in the general identification of metals.

Generally ferrous metals are magnetic, and nonferrous metals are non-magnetic. This test is not 100 % accurate because some stainless steels are non-magnetic. In this instance, there is no substitute for experience.

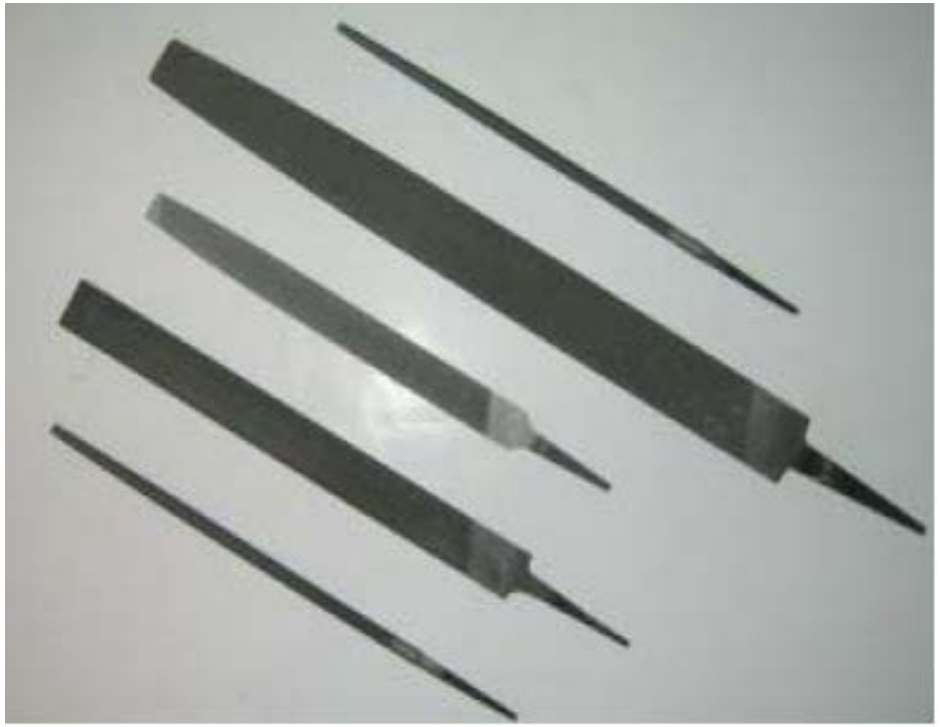
Magnetic: Nickel, Mild Steel, Carbon and Low Alloy Steels, Grey Iron, Malleable Irons, Straight Chromium Steels.
Non-Magnetic: Austenitic Manganese or Austenitic Stainless Steels and all non-ferrous metals.
Slightly Magnetic: Monel 4, Work-Hardened Aust. Mang. Steel and Work-Hardened Stainless Steels.

File Test

Observe relative ease of filing

Soft metal files easily, the file bites into the metal.

File slides over the surface of hard metal easily.



Relative Weight

Some metals (lead, tin & zinc) are heavier than others (Aluminum & Magnesium)

RELATIVE WEIGHTS
Approximate kilograms per cubic metre are shown for various metals and alloys:

1.74×10^3	Magnesium
2.70×10^3	Aluminium and its alloys
7.20×10^3	Cast Iron, Tin, Zinc
7.85×10^3	Steel, Stainless Steel
8.85×10^3	Copper, Nickel, Monel, Brass
11.35×10^3	Lead
15.20×10^3	Sintered Tungsten Carbides

Oxy-Acetylene Torch Test

Use a neutral flame …

Test heat conductivity, different metal – different speed of heat travel.

Speed of melting, different metals – different melting temperatures.

Color change, different metals – different color changes

Chip Test

The chip test is made by removing a small amount of material from the test piece with a sharp, cold chisel.

The material removed varies from small, broken fragments to a continuous strip.

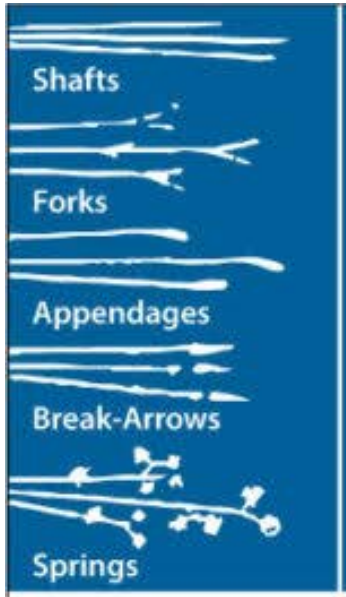
The ease of the chipping process is a factor in identifying the metal.

METALS	CHIP CHARACTERISTICS
WHITE CAST IRON	Chips are small, brittle fragments. Chipped surfaces not smooth.
GRAY CAST IRON	Chips are about 1/8 inch in length. Metal not easily chipped; therefore, chips break off and prevent smooth cut.
MALLEABLE IRON	Chips vary from 1/4 to 3/8 inch in length (larger than chips from cast iron). Metal is tough and hard to chip.
WROUGHT IRON	Chips have smooth edges. Metal is easily cut or chipped, and a chip can be made as a continuous strip.
LOW-CARBON AND CAST STEEL	Chips have smooth edges. Metal is easily cut or chipped, and a chip can be taken off as a continuous strip.
HIGH-CARBON STEEL	Chips show a fine-grain structure. Edges of chips are lighter in color than chips of low-carbon steel. Metal is hard, but can be chipped in a continuous strip.
COPPER	Chips are smooth, with sawtooth edges where cut. Metal is easily cut as a continuous strip.
BRASS AND BRONZE	Chips are smooth, with sawtooth edges. These metals are easily cut, but chips are more brittle than chips of copper. Continuous strip is not easily cut.
ALUMINUM AND ALUMINUM ALLOYS	Chips are smooth, with sawtooth edges. A chip can be cut as continuous strip.
MONEL	Chips have smooth edges. Continuous strip can be cut. Metal chips easily.
NICKEL	Chips have smooth edges. Continuous strip can be cut. Metal chips easily.
LEAD	Chips of any shape may be obtained because the metal is so soft that it can be cut with a knife.

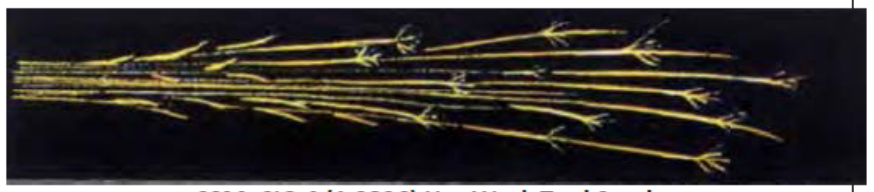
Spark Test

The spark test is made by holding a sample of the material against an abrasive wheel.

The stream of sparks is then observed and evaluated by the color, shape and number of the sparks, and length of the spark stream. With this information, the metal type can easily be determined using one's knowledge or a chart (see next slides).



CHARACTERISTICS OF SPARK TEST	LOW C. STEEL (0.1%C)	MILD STEEL (0.25%C)	MED C. STEEL (0.4%C)	HIGH C. STEEL (0.7%C)	GREY CAST IRON	MALLEABLE CAST IRON	AUSTENITIC MANG. STEEL	HIGH ALLOY STEELS 18/18 STAIN	HIGH ALLOY STEELS DIE STEEL
Volume of Stream	Large	Large	Large	Med. Large	Small	Moderate	Mod. Large	Moderate	Small
Relative Length	1.6m	1.8m	1.6m	1.4m	0.6m	0.75m	1.1m	1.3m	0.9m
Color at Wheel	Straw	White	White	White	Red	Straw	White	Straw	Red
Color at end	Straw-white	White	White	White	Straw	Straw	White	White	
DESCRIPTION OF SPARK STREAM (COMPARE WITH KNOWN SAMPLES)	As carbon increases in iron, spark changes form long straw shafts with appendages to forked shafts and some springs, number of springs increasing with carbon content.			Mass of small fine repeating springs.	Many small repeating springs.	Long shaft than grey iron, small repeating springs.	Many fine repeating springs.	Alloys reduce spark length of comparable carbon steel.	

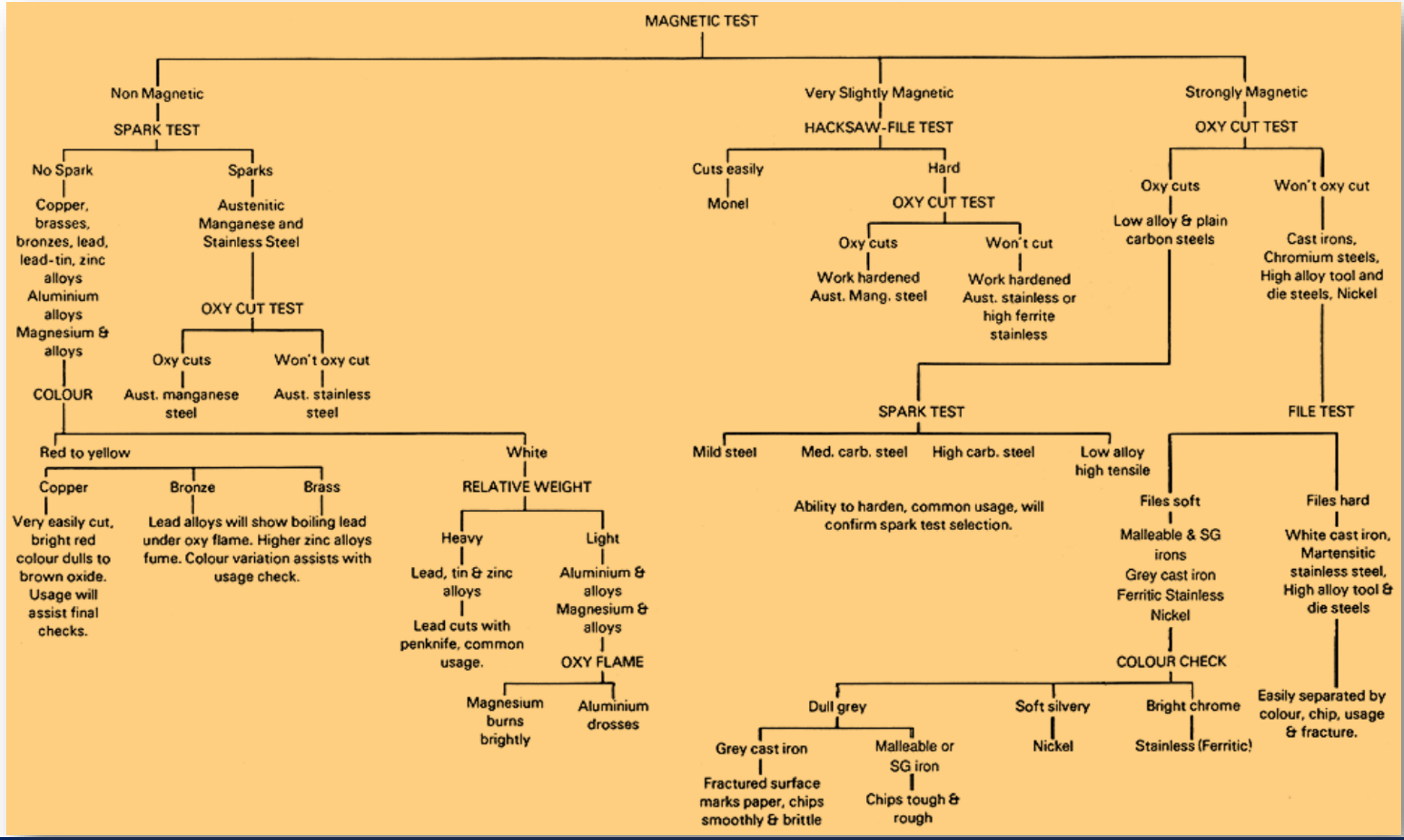
Steel Composition (%)	Spark Shape
0.15 C 0.25 Si 0.37 Mn	 C15 (1.0401) Case Hardening Steel
0.45 C 0.25 Si 0.65 Mn	 Ck 45 (1.1191) Heat Treatable Steel
1.0 C < 0.25 Si < 0.25 Mn	 Ck 101 (1.1274) Spring Steel
0.6 C 1.0 Si 1.0 Mn	 60MnSiCr4 (1.2826) Hot Work Tool Steel
0.45 C 0.25 Si 0.7 Mn 1.4 Cr 0.7 Mo 0.3 V	 45CrMoV 6-7 (1.7737) High Temperature Spring Steel

Steel Composition (%)	Spark Shape
2.1 C 0.3 Si 0.3 Mn 12 Cr 0.7 W	 X210CrW12 (1.2436) Tool Steel
0.75 C 1.1 V 4.2 Cr 18 W	 S 18-0-1 (1.3355) High Speed Steel
1.05 C 0.25 Si 1.0 Mn 1.0 Cr 1.2 W	 105WCr6 (1.2419) Cold Work Tool Steel
0.45 C 1.0 Si 0.3 Mn 1.1 Cr 2.0 W 0.2 V	 45WCrV7 (1.2542) Hot Work Tool Steel

Tips for Stainless Steels

AISI Type	Grade	Group	Magnet Test	Spark Test	Hardness Test	Sulfuric Acid Test	Hydrochloric Acid Test
302	Chromium-Nickel	Austenitic	Non-Magnetic	Few forks - short, reddish	>165 Brinell after heated to 1800°F and water quench	Strong attack - green crystals and dark surface	Rapid reaction - pale blue-green solution
303							Spoiled egg odor - heavy black smudge
303Se							Garlic odor
304						Strong attack - green crystals and dark surface	Fast attack - gas formation
308				Full red without many forks			
309							
310							
316				Few forks - short, reddish		Slow attack - tan surface turns brown	Very slow attack
317							
321							Fast attack - gas formation
347							
410	Chromium	Martensitic	Magnetic	Long white with few forks	> 280 Brinell after heated to 1800°F and water quench		Rapid reaction - dark green solution
414							
416							Spoiled egg odor - heavy black smudge
416Se							Garlic odor
420				Long white-red with burst			
431				Long white with few forks			
440 A, B, C				Long white-red with burst			
430		Ferritic		Long white with few forks	180 - 250 Brinell after heated to 1800°F and water quench		
430F							Spoiled egg odor - heavy black smudge
430FSe							Garlic odor
446				Full red without many forks			

Find out a Strategy



This presentation was developed by Kamran Khodaparasti.

Publication date: August 2023

References:

Internet Documents
Key to Steel, C. Wegst and M. Wegst

kkhodaparasti@yahoo.com

www.linkedin.com/in/khodaparasti

kamrankhodaparasti.ir