Metal Descriptions

from: http://www.metalexpress.net/cgi-bin/index.pl

Alloy Steel

Steel is iron that is combined with other elements such as carbon, manganese and silicon.
It falls into a number of families: *Alloy, Carbon, Stainless, Tool,* as well as plain *Cast Iron.*

Alloy steels contain added elements that cause the steel to exhibit enhanced properties when heat treated.

Cold Rolled

- 4140 Annealed
  - Responds well to heat treatment;
  - Chromium content provides good hardness penetration;
  - Molybdenum imparts uniformity of hardness and high strength;
  - Properties:
    - Good wear resistance
    - Excellent toughness
    - Good ductility in the quenched and tempered condition.

- 41l40 Annealed
  - Like 4140;
  - Lead content increases machinability;
  - Excellent finish and good tool life.

- 4140/4142 Heat Treated
  - General purpose alloy, normally (.95%)chromium, (.20%)molybdenum;
  - Properties:
    - good hardness penetration, strength, toughness, and ductility
    - Rockwell 28/32C type. Heat Treat Condition 28/32c.

- 8620
  - 8620 is the most widely used carborizing alloy
  - Its nickel content imparts good toughness and ductility
  - The chromium and molybdenum increase hardness penetration and wear-ability
  - Permits hardening to produce a strong tough core and high case hardness
  - Good welding qualities.

Hot Rolled

- 4130 annealed or heat treated
- 4140 annealed or heat treated
- 4150 heat treated
- 4340 heat treated

Carbon Steel

Carbon steels are basic steels which harden only with surface (case) treatments.

Cold Rolled

- C1018
  - Low carbon steel with good case hardening properties;
  - Excellent for bending and cold forming;
  - Good brazing and welding properties;
  - Smooth - clean - cold drawn (rolled) surface;
  - Yield strengths are approx. 50000 PSI.

- C1045
  - Medium carbon steel;
  - Fair for heat treating (quenching and tempering);
  - Used extensively in induction hardening applications;
  - Poor/Fair machinability;
  - Fair for brazing and welding;
  - Good forging properties;
  - Common shafting steel in the medium carbon range.

- C1117
  - Resulpherized steel with good machinability and surface finish;
  - Suitable for cutting threading and automatic screw machine operations at moderate speeds and feeds;
  - It may be bent or formed where such cold working operations are not too severe;
  - Smooth - clean - cold drawn (rolled) surface;
  - Not good for welding due to sulphur content;
  - Yield strengths are approximately 55000 PSI.

- C11L17
  - Like C1117;
  - 15/35 lead content increases machinability;
  - Good finish and good tool life.

- C1141
  - Medium-carbon steel with high mechanical properties;
  - Fee machining properties;
  - Close finish tolerances and bright finish.

- C12L14
  - Lead-bearing cold drawn steel;
  - Inherent ductility combined with finer surface quality;
  - Can be bent, crimped, and riveted;
  - Extraordinary machinability, rated at 195% and 325 surface feet per minute;
  - Smooth cold finish (rolled) surface;
  - Yield strengths are approx. 60K psi.

- C1026 -- ASTM A-366 -- DOM Tubing
  - Drawn Over Mandrel, or D.O.M., is electric resistance welded tubing that has been finished by

cold drawing through a die and over a mandrel to make Mechanical Seamless Tubing;
- Close tolerances, cold drawn surface finish, and excellent wall uniformity;
- Used in the manufacturing of hydraulic cylinders where concentricity, close tolerances and good or honed surfaces are of importance.

Hot Rolled

- A36/1020 and Structural Tubing
  - Low carbon, hot rolled "mild steel" is suitable for general purpose applications;
  - Excellent welding and forming characteristics;

- 1018
  - Low carbon steel with a higher maganese content than Mild Steel.
  - Good for carburized parts, produces a harder and more uniform case;
  - Higher mechanical properties and better machinability than Mild Steel;
  - Suitable for applications involving forging, heat treating, cold drawing, machining, etc.

- 1045
  - Medium carbon steel;
  - Good for applications involving forging, heat treating, cold drawing and machining.
  - Greater strength than low carbon steels;
  - Used for axles, machine parts, pinions, forming dies, ordinary shafts, gears, tool shanks;
  - Not readily welded due to higher carbon content.

- 1117
  - Low carbon, high manganese and sulphur steel;
  - Excellent machinability;
  - Close tolerances with a smooth finish.
  - Good mechanical and carbarizing properties;
  - Because of high sulphur content this grade is not readily welded.

- 1141
  - Medium carbon, with manganese and sulphur;
  - Machinability is excellent, because of added sulphur.
  - Not readily welded due to high carbon, manganese, and sulphur content.

Stainless Steels

Austenitic

When nickel is added to stainless steel in sufficient amounts the crystal structure changes to "austenite". The basic composition of austenitic stainless steels is 18% chromium and 8% nickel (and are refered to as 18/8 stainless). This enhances their corrosion resistance and modifies the structure from ferritic to austenitic. Austenitic grades are the most commonly used stainless steels accounting for more than 70% of production (type 304 is the most common).

- Highly corrosion resistant
- Have very good high and low temperature response
- Non-magnetic
- Not hardenable by heat treatment

- Easily work hardened
- Ductile and free machining
- Easily welded

- 303
  - Highly corrosion resistant to atmospheric exposures, sterilizing solutions, most organic and many inorganic chemicals, most dyes, nitric acid and foods;
  - Free machining with non-galling and non-seizing qualities;
  - Less easily welded, use ER312 rod;
  - Non-magnetic, can become slightly magnetic when cold worked.

- 304 or 18/8
  - Low (.3-.8%)carbon, (18-20%)chromium - (8-12%)nickel alloy;
  - Highly corrosion resistant;
  - Harder to machine than 303;
  - Easier to weld than type 303, use ER312 rod, minimizes carbide precipitation during welding;
  - Non-magnetic.

- 316
  - Low (.03-.08%)carbon, (16-18%)chromium - (10-14%)nickel - (2.3%)molybdenum alloy;
  - Best corrosion resistance of the standard stainless steels;
  - Resists pitting and most chemicals used in paper, textile and photographic industries;
  - Machine with low speeds and feeds to minimize work hardening;
  - Good weldability, use ER316 rod;
  - High temperature strength;
  - Non-magnetic.

- 630 (17-4Ph)
  - Superior corrosion resistance;
  - Good machinability in the annealed condition;
  - Good weldability using ER630 rod;
  - Can be heat treated to high strength levels with minimum distortion by aging at selected temperatures;
  - Non-magnetic.

Ferritic

Ferritic stainless steels are plain chromium steels containing between 10.5 and 18% chromium and have a low carbon content. They are magnetic and not hardenable by heat treatment. Ferritic alloys have good ductility and formability but a relatively poor high temperature strength compared to that of austenitic grades.

- Medium corrosion resistance
- Have good high and and poor low temperature response
- Magnetic
- Not hardenable by heat treatment
- Medium work hardening
- Have medium ductility and machinability
- Not easily welded

- 430F
  - Plain (10-18%)chromium alloy;
  - Free machining due to sulphur content;

- Poor weldability due to sulphur content;
- Minimal cold working;
- Magnetic.

- 444
  - Plain (10-18%)chromium alloy;
  - Good weldability;
  - Magnetic.

Martensitic

Martensitic stainless steels were the first stainless steels that were commercially developed and have a relatively high carbon content (0.1 - 1.2%) compared to other stainless steels. They are plain chromium steels containing between 12 and 18% chromium. They are magnetic and hardenable by quenching and tempering like plain carbon steels and find their main application in cutlery, aerospace and general engineering.

- Medium corrosion resistance
- Have poor high and and low temperature response
- Magnetic
- Hardenable by heat treatment, like carbon steels
- Medium work hardening
- Have low ductility and machinability
- Not easily welded

- 416
  - High carbon, (12%)chromium alloy;
  - Useful corrosion resistance to natural food acids, basic salts, water and most atmospheres;
  - Free machining due to sulphur content;
  - Not good for welding or cold working;
  - Heat treatable;
  - Magnetic.

- 440(A,B,C)
  -
  - High carbon, (12%)chromium alloy;
  - Moderate corrosion resistance to natural food acids, basic salts, water and most atmospheres;
  - Poor machining and welding;
  - Best hardening by heat treatment;
  - Magnetic.

Tool Steels and Drill Rod

High carbon and chromium steels for hardened tooling.

- A-2 Decarb Free
  - Air-hardening, fine grain, 5% chrome tool steel;
  - Excellent wear and abrasion resistant properties;
  - Good machinability when annealed;
  - Heat treating

        - Preheat at 1450 F
        - Increase to 1760 F and hold for 30 to 40 minutes
        - Air cool.
    - Tempering
        - Heat to 350 F for Rockwell C 62, to 1000 F for Rockwell C 56.
    - Annealing
        - Anneal at 1575 F and slow furnace cool at 40 F per hour, or less.

- D-2 Decarb Free
    - Fine quality, air hardening, electric furnace melt tool steel
    - Superior abrasion resistance and toughness;
    - Poor machinablilty;
    - Specified for the most demanding applications.
    - Heat treating
        - Preheat slowly to 1500 F
        - Increase to 1850 F and hold for 20 to 45 minutes
        - Air cool.
    - Tempering
        - Heat to 400 F for Rockwell C 61, to 1000 F for Rockwell C 54.
    - Annealing
        - Anneal at 1625 F and slow furnace cool at 40 F per hour, or less.

- O-1 Decarb Free
    - Oil-hardening tool steel with a full-spheroidized structure;
    - Non-shrinking general purpose tool steel;
    - Excellent abrasion resistance and toughness;
    - Excellent machinability when annealed;
    - Heat treating
        - Preheat slowly to 1200 F
        - Increase to 1475 F and hold for 10 to 30 minutes
        - Quench in oil.
    - Tempering
        - Heat to 350 F for Rockwell C 62, to 500 F for Rockwell C 57.
    - Annealing
        - Anneal at 1450 F and slow furnace cool at 40 F per hour, or less.

- S-7 Decarb Free
    - Excellent shock steel often used in hot work applications at 1000°F;
    - High strength and good ductility for cold and medium hot work applications.

- W-1 Decarb Free
    - High carbon, water hardening, less expensive;
    - May be used without heat treatment for many maintenance applications;
    - Often used for hand tools;
    - Good machinability;
    - Fully-spheroidized 100% decarb free condition.
    - Heat treating
        - Preheat slowly to 1100 F
        - Increase to 1500 F and hold for 10 to 30 minutes
        - Quench in water or brine.
    - Tempering
        - Heat to 350 F for Rockwell C 64, to 650 F for Rockwell C 50.
    - Annealing

        - Anneal at 1400 F and slow furnace cool at 40 F per hour, or less.

High Speed Steels, high carbon and molybdenum steels for tooling.

- M2 (HSS)
    - Medium machinability when annealed;
    - Relatively poor grinding;
    - Heat treating
        - Preheat at 1450 F
        - Heat rapidly from 1450 F to 2200 F and hold for 3 to 5 minutes
        - Quench in oil, air or salt bath.
    - Tempering
        - Heat to 1050 F for a hardness of Rockwell C 60 to 65.
    - Annealing
        - Anneal at 1625 F and slow furnace cool at 40 F per hour, or less.

- M33, M34, M42, M43 (Cobalt HSS)
    - Increasing amounts of cobalt in alloy;
    - Very high hardness when treated;
    - Medium machinability when annealed;
    - Relatively poor grinding;
    - Heat treating
        - Preheat at 1600 F
        - Heat rapidly from 2200 F
        - Quench in salt bath.
    - Tempering
        - Heat to 1000 F and air cool, three times
    - Annealing
        - Anneal at 1600 F and slow furnace cool at 40 F per hour, or less.

Carbide tooling (not iron based), for those hard to get places.

- C2 (C1-C4)
    - (94%)tungsten carbide, (6%)cobalt alloy
    - Rockwell 92;
    - High abrasion resistance and toughness;
    - Medium red hardness;
    - For cutting non-ferrous, cast iron, and milder steels;
    - Very hard on grinding wheels;

- C5 (C5-C8)
    - (73%)tungsten carbide, (8%)titanium carbide, (2%)tantalum carbide, (13%)cobalt alloy
    - Rockwell 90;
    - Medium abrasion resistance and toughness, vs C2;
    - High red hardness;
    - For cutting more difficult alloy and tool steels;
    - Very hard on grinding wheels;

Cast Iron

Also known as gray iron, this material features a close grain structure and moderately high strength. It has good machinability and responds well to fast heat treating. Excellent for valve bodies, bearing rings and seals, gears, spacers and bushings.

- Class 40
  - Continuously cast, fine grain, uniform density and hardness, with a microstructure of finely distributed graphite flakes in an iron matrix;
  - Easy to machine, hone, and polish;
  - Will lap to within two light bands of uniform optical flatness and five RMS for smoothness;
  - Can be flame or induction hardened to Rockwell C-50, as well as deep hardened;
  - Tensile strength 40K psi, Compressive 150K psi, deflection 0.25-0.34".
  - Brinell hardness range 183/285;

Aluminum

Aluminum alloys are strong, naturally soft, lightweight, ductile and malleable. Easy to machine, fabricate, join and work. Aluminum is non-toxic and electrically and thermally conductive.

- 2011
  - Most free-machining of the common alloys;
  - Excellent mechanical properties;
  - It may be resistance welded;
  - Good corrosion resistance;
  - Hardness and strength are excellent.

- 2024
  - Best known of high strength aluminum alloys;
  - High strength and excellent fatigue resistance;
  - Low corrosion resistance;
  - Easily machined to a high finish;
  - Good welding, but should be heat treated afterwards;
  - Easily formed when annealed
  - Heat treating
    - Heat to 920 F
    - For T6 temper, lower temp to 375 F for 10 hours then air cool
    - For T4 temper, quench in water after heating
    - Allow to age at room temperature
  - Annealing
    - Heat to 775 F for 2 hours and slow furnace cool.

- 6061
  - Extremely versatile;
  - Heat-treatable alloy,
  - Good weldability using 4043 filler;
  - High machinability in T4 and T6 tempers, low when annealed;
  - Easily cold worked when annealed;
  - High corrosion resistance;
  - Medium strength;
  - Tempered yield strength is up to 40K psi.
  - Hardness is 95 Brinell.

- Melting range is 1080° to 1205° F.

- 6063
  - Commonly referred to as the architectural alloy for windows, doors, trim;
  - An extrusion alloy with relatively high tensile properties and excellent finishing characteristics;
  - Good weldability using 4043 filler;
  - Average machinability;
  - High degree of resistance to corrosion;
  - Best alloy for anodizing applications;
  - Tempered yield strength is 17K psi. Hardness is XX Brinell.
  - Melting range is x° F.

Sheet Aluminium

- 5251 H22
  - Medium strength alloy, work hardens rapidly. Resistant to marine atmosphere.
- 1050A
  - Malleable. Good corrosion resistance.
- 5083"O"
  - Readily welded, suitable for use in cryogenic applications e.g. storage & transportation of liquid gases & in shipbuilding. Used in general engineering for tooling, jigs & fixtures.
- 6082-T6
  - The recommended alloy for structural purposes with good strength & general Corrosion resistance.
    Used for vehicles, bridges & cranes, general engineering & tooling plates.
  - Not recommended for folding/forming.

Copper and Alloys

Copper is corrosion resistant and highly ductile. Great for electrical applications.

- Copper C110
  - Electrolytic Tough Pitch Copper has the highest degree of electrical conductivity of any metal except silver;
  - High ductility makes it a good choice for drawing, forming and spinning operations;
  - Can be cold-worked or hot-formed and has highly suitable characteristics for welding and soldering;
  - Excellent corrosion resistance;

Brass

An alloy of copper with high percentage of zinc makes it stronger and more durable than copper or bronze. Brass resists atmospheric corrosion, water, and many salt water solutions. It is easy to manufacture and maintains higher electrical characteristics.

- C260
  - Cartridge brass, softer;
  - Normal composition: Copper 70% Zinc 30%;
  - Excellent cold working behavior;
  - Finishes well and is easily plated, soldered, and brazed.

- C360
  - Free Cutting brass, machinable;
  - Added lead gives it high machinability;
  - The standard of 100% machineability against which all nonferrous alloys are rated;
  - Corrosion resistant and rustproof;
  - Finishes well and is easily plated, soldered, and brazed.

- C464
  - Naval brass, stronger;
  - Added tin gives greater strength and rigidity;
  - High degree of corrosion resistance to sea water at even at high temperatures;
  - Excellent for hot-working;
  - Fair for cold-working;
  - Medium machinability;
  - Easily soldered, brazed, and welded;

Bronze

An alloy of copper and tin which is generally ductile and malleable. Its high copper content makes it more corrosion resistant than brass. It is also harder and stronger than copper. Various alloys are used for bearings and marine parts.

- Aluminum Bronze -- C954 (C642, C624...)
  - (81%)Copper, (10%)Aluminium, (3%)Iron;
  - High strength and good ductility;
  - Good bushing qualities;
  - Resistance to wear, abrasion and fatigue, deformation, and corrosion;
  - Tensile 100K psi, Yield 40K psi, Elongation 12%;
  - Brinell hardness 170/180, Rockwell 80B.

- Bearing Bronze -- C932 (SAE660)
  - (81-85%)Copper, (6-7%)Tin, (6-8%)Lead, (2-4%)Zinc;
  - Used for general bearings;
  - Good wear resistance and lubrication;
  - Operating temperature 450 F;
  - Tensile 35K psi, Yield 20K psi, Elongation 10%;
  - Brinell Hardness 65.

- Phosphor Bronze -- C544
  - Free cutting, machineability rating of 85%;
  - Added lead and phosphorus;
  - High strength with excellent corrosion resistance and good fatigue properties;
  - Good soldering and brazing, poor weldability;
  - Uses include gears, valve parts, bushing, shafts and bearings. Also electrical instrument and meter parts.
  - Rockwell Hardness 80B;
  - Tensile 68K psi, Yield 57K psi, Elongation 20.

- Silicon Bronze -- C655
  - Moderate strength with good corrosion resistance;
  - High percentage of silicon;

- Typically used for marine hardware;
- Fair machinability rating of 30%;.
- Excellent capacity for being cold worked and hot formed;
- Good soldering, brazing, and weldability;
- Rockwell Hardness 85B;
- Tensile 78K psi, Yield 45K psi, Shear 52K psi, Elongation 35%.

Nickel Silver

- 792
  - Free cutting leaded nickel silver has a machinability rating of 60%;
  - High strength and corrosion resistance;
  - Used for optical goods, cameras, jewelry, dental parts, instruments and hardware.