A-2 air hardening
Atlantica 33
A-36 - general purpose steel
Above 35 to harden

SHADE TREE METALLURGY

INTRO

AGENDA
- GENERALITIES
- TYPES OF STEEL
- OBTAINING & IDENTIFYING
- HARDENING PROCESSES
- QUESTIONS ANYTIME

GENERALITIES
- STEEL AMAZING PRODUCT
- BUY WORK HORSE CHISELS — MODERN TECHNOLOGY
- HARDENING DOESN'T HAVE TO BE PERFECT TO DO A GREAT JOB
- MAKE TOOLS TO TEST BEFORE BUYING
- ONLY NEED SPECIAL STEEL IF NEED EDGE
- TRY STUFF

TYPES
- SAMPLES CAN'T TELL DIFFERENCE
- ANSI, ASME, ASTM, SAE, MANUFACTURERS NAMES
- HOT ROLLED & COLD ROLLED - MANUFACTURING PROCESS NOT A TYPE
- **IRON** — WROUGHT; CAST
- **CARBON** — **LOW OR MILD** 1006-1035; **MEDIUM** 1035-1055; **HIGH** 1055-1095
- **ALLOY** — (TITANIUM, VANADIUM, MOLYBDENUM, TUNGSTEN, CHROMIUM, MANGANESE, COBALT)
- **LOW ALLOY BELOW 4%**
- **TOOL ABOVE 4%**

S	SHOCK
H	HOT
O, W, A, D	COLD
M, T	HIGH SPEED
P	MOLD
L, F	SPECIAL

1095 = file
W - water quench
O - Oil quench
A - Air

- BLACKSMITH — HIGH CARB, H-13, S-7, LOW ALLOY
- WOODWORKING — W1, A2, M2 T HIGH SPEED, HI CARBON

OBTAINING & IDENTIFYING
- BUY
- FIND
  - WHAT IS IT
  - SPARK TEST — lots of branches, short plume = high carbon

HARDENING PROCESS
- TERMS — HARDENING, QUENCHING, ANNEALING, NORMALIZING, TEMPERING
- ANNEAL IN HARD AND IF NEED TO MODIFY A LOT — heat until non-magnetic, air or ashes cool → normalize
- NORMALIZE IF WELDING ON TANG
- HEAT TO CRITICAL TEMP RISING
- QUENCH IN PROPER MEDIA — WATER, AIR, OIL — carbon atoms trapped in during quenching makes it harder
- MOVE IN FIGURE 8 TO PREVENT STEAM BUILD UP — while quenching
  - MOVE UP AND DOWN TO PREVENT BRITTLE LINE
- TEMPER IMMEDIATELY AFTER QUENCHING
- TEMPER BASED ON STEEL
- WAYS
  - IN HOME OVEN
  - RIGHT AFTER QUENCHING WITH RESIDUAL HEAT
  - TORCH
  - ON A TEMPERING BLOCK
- POLISH STEEL ON SIDE
- WATCH FOR PROPER TEMPERING COLOR (NOT FORGING COLOR)
  - WOODWORKING USUALLY STRAW
  - COLOR IS JUST RUST THAT FORMS AT DIFFERENT TEMPS
    - BLACKSMITH BECAUSE BLACK RUST AT HI TEMP
    - BROWN AT AMBIENT
  - QUENCH AGAIN TO STOP
  - CAN BE REPEATED FOR CONSISTENCY
- SHARPEN WITH OUT HEATING TO TEMPER COLOR
  - IF YOU DO START OVER

Thanks to Jan Kochansky for this set of data.

Heat-Treating Data for Selected Tool Steels

(All temperatures are in °F)

Steel	Forging Temperature (start/stop)	Anneal From	Harden From[1]	Quench In	Temper Temperature[2]	Notes
W-1, W-2	1900–1825/1500–1450	1425–1400	1450–1410	water/brine	300–600	3
O-1	1900/1500	1450	1475	oil	300–600	5,8
O-6	1950/1500	1500	1450–1480	oil	300–1000	4,8
L-6	1900/1650	1375	1500–1550	oil	200–700	
A-2	2050/1700	1650	1775	air	300–1300	4,5,8
A-6	2025/	1375	1525–1600	air	200–1000	5,8
D-2	2050/1700	1650	1850	air	900–1200 (900–960 Rc 59)	4,5,6,7,8
D-3	1900/1700	1600	1740	warm oil	400–1300	5,8
D-5	2000/1750	1650	1850–1875	air	300–1000	4,5,7,8
S-1	2100/1660	1475	1750	oil	300–1200	4,9
S-3	1900/1700	1375–1525	1600 (1450)	oil (water)	300–400	10
S-5	1950/1650	1450	1600	oil	300–1300	9
S-7	2050/1700	1550	1725	air <2½inch	300–1300	4,5,6
H-13	2150/1650	1600	1850	air	1050–1150	4,5
6150	2250/1950	1550	1550–1600	oil	400–900	

Notes:

1. Variations in temperature may depend on size, and higher temperatures may give greater hardness at the expense of increased grain size.
2. Higher temperatures give higher toughness and lower hardness. Generally the lowest temperature gives about Rc 60 and the highest about Rc 30.
3. W-1 and W-2 come in different carbon contents. The higher the carbon, the lower the forging, annealing, and hardening temperatures. This also applies to the SAE 10xx carbon steels.
4. Steel needs an intermediate temperature (about 1200°) soak before heating to final hardening temperature.
5. Controlled atmosphere furnace preferred, but packing in a neutral medium like cast iron chips is also possible to prevent decarburization. Air hardening steels may be wrapped in stainless steel foil during heating to prevent decarburization and scaling.
6. Large sizes (generally >2½6 inches) are quenched in oil
7. Draw temper twice, with the second draw about 50° lower than the first.
8. Furnace cooling required for annealing (20 °F/hour maximum). It is not realistically possible to anneal these steels properly in a blacksmith shop.
9. May be quenched in water for simple sections.
10. There are different heat-treating procedures (oil/water/case harden/temperature) available for different purposes.

Carbon Content of Steel for Different Uses

Points Carbon	Properties	Uses
5-10	Very soft, plastic	Stampings, rivets, nails, wire, general forging
10-20	Tough	Structural steel, general use, good for case hardening, general forging
20-30	Quite tough	Better grade for structural and machine parts, screws, general forging
30-40	Very tough	Crane hooks, machine parts, connecting rods
40-50	Great toughness with little hardness	Heat-treated machine parts, gears, axles, shafts
50-60	Great toughness with some hardness	Crowbars, garden tools, gears, shafts, machine parts
60-70	Great toughness with fair hardness	Flatters, fullers, hot swages, tools to be used on hot work, drop-forging dies
70-80	Great toughness with medium hardness	All general blacksmith's tools, hammers, rivet sets, hot sets, wood augers, gun barrels, wood chisels, screwdrivers
80-90	Very tough, better than medium hardness with slight cutting edge	Cold chisels, hammers, sledges, hammer dies, shear blades, large springs, scissors
90-100	Fair toughness, hard with medium cutting edge	Pneumatic chisels, knives, punches, mills, reamers, taps, anvil faces, wrenches, railroad springs
100-110	Little toughness, hardness with good cutting edge	Drifts, swages, springs, stone drills, pliers
110-120	Great hardness with keen cutting edge	Planing tools, axes, saws, woodworking tools, threading discs, coil springs
120-130	Very keen cutting edge; somewhat brittle	Drills, taps, lathe tools, shear knives, basic steel used for cutting-tool purposes, files
130-140	Very hard keen cutting edge; brittle	Cold-trimming discs, razors, glass cutters, ball bearings, steel engraving
140-150	Extremely hard and very brittle	Brass cutting tools with fine edge, turning hard metals, tools used to cut other partially hardened metals

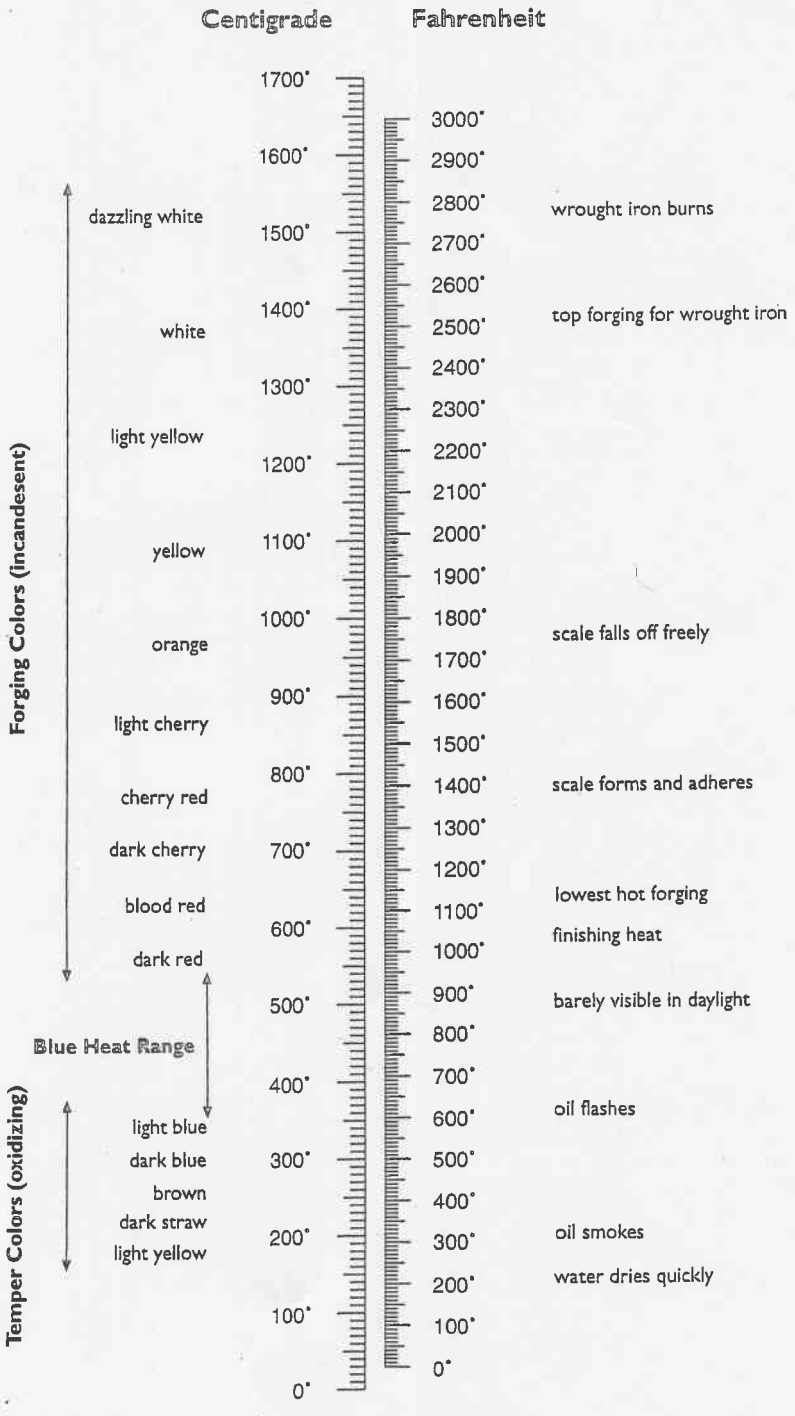

Chart 8. Temperature scales and ranges of incandescent and tempering colors.

JUNKYARD STEELS

The following list describes some potential types of steel used for common junkyard items. This information was compiled from several sources, Machinery's Handbook, Country Blacksmith, Blacksmith's Journal and Carpenter Technology Corp. Machinery's Handbook is an excellent source for heat treatment of these steels.

This page was created by David W. Wilson
North Texas Blacksmiths Association

APPLICATION	Number	Letter
Agricultural steel	1080	
Axels	1040	
Ball Bearing Balls	52100	
Ball Bearing Races	52100	
Band Saw Blades		L-6
Bits, Router		M2
Bolts, anchor	1040	
Bolts, heat treated	2330	
Bolts, heavy duty	4815	
Brake Lever	1030	
Cams		A6,S7
Chisels		O2,O6,L6
Clutch disk	1070	
Clutch Springs	1060	
Coil Springs, auto	4063	
Coil Springs, truck	5160	
Cold-rolled steel	1070	
Connecting Rods	1040	
Crankshafts	1045	
Cutters, Bolt		S2,S7
Drifts		L6,S2,S7
Drills		M2
End Mills		M2
Fan Blades	1020	
Files		W2
Gear Shift levers	1030	
Gears, transmission	3115	
Hammers		L6
Harrow Disk	1080	

APPLICATION	Number	Letter
Hay Rake Teeth	1095	
Jackhammer Bits	1040	S5
Knives, machine		M2
Knives, woodworking		O2
Leaf Springs	1084, 5160	
Lock Washer	1060	
Mauls		L6, S2
Mower knives	1085	
Music Wire	1085	
Nail Sets		L6
Plow Beams	1070	
Plow Disk	1080	
Plow Shares	1080	
Pneumatic Tools		L6, A6, S7
Punches-Cold		A2, O2
Reamers		M2, O2, A2
Roller Bearings	4815	
Screw Drivers		L6, S2
Snap Ring	1060	
Spring Clips	1060	
Spring Steel, clock	1095	
Steering Arm Bolts	3130	
Steering Arms	4042	
Taps		M2, O2
Transmission Shafts	4140	
Tubing	1040	
Universal Joints	1145	
Valve Springs	1060	
Wrenches		L6, S2

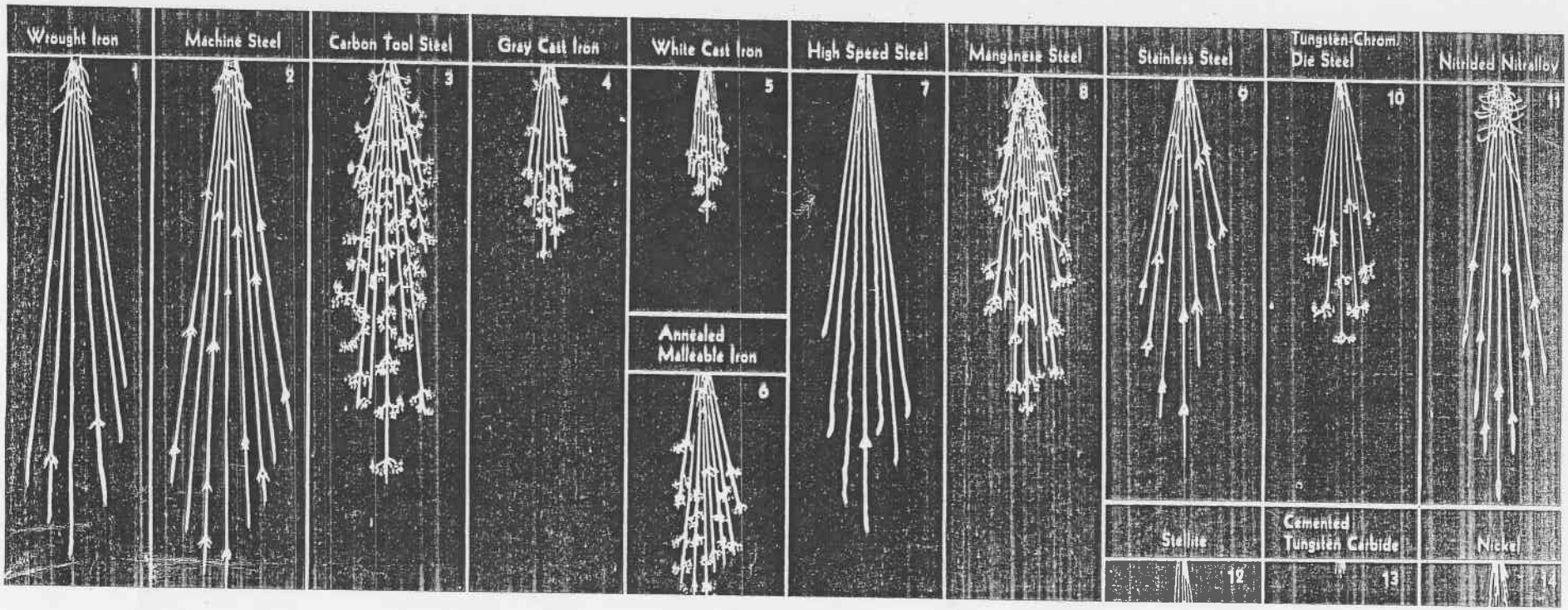

Table 130-5
Characteristics of Sparks Generated by the Grinding Metals

Metal	Volume of Stream	Relative Length of Stream, mm (in.)†	Color of Stream Close to Wheel	Color of Streaks Near End of Stream	Quantity of Spurts	Nature of Spurts
1. Wrought iron	Large	1651 (65)	Straw	White	Very few	Forked
2. Machine steel (AISI 1020)	Large	1778 (70)	White	White	Few	Forked
3. Carbon tool steel	Moderately large	1397 (55)	White	White	Very many	Fine, repeating
4. Gray cast iron	Small	635 (25)	Red	Straw	Many	Fine, repeating
5. White cast iron	Very small	508 (20)	Red	Straw	Few	Fine, repeating
6. Annealed malleable iron	Moderate	762 (30)	Red	Straw	Many	Fine, repeating
7. High-speed steel (18-4-1)	Small	1524 (60)	Red	Straw	Extremely few	Forked
8. Austenitic manganese steel	Moderately large	1143 (45)	White	White	Many	Fine, repeating
9. Stainless steel (Type 410)	Moderate	1270 (50)	Straw	White	Moderate	Forked
10. Tungsten-chromium die steel	Small	889 (35)	Red	Straw*	Many	Fine repeating*
11. Nitrided Nitralloy	Large (curved)	1397 (55)	White	White	Moderate	Forked
12. Stellite	Very small	254 (10)	Orange	Orange	None	
13. Cemented tungsten-carbide	Extremely small	51 (2)	Light Orange	Light Orange	None	
14. Nickel	Very small**	254 (10)	Orange	Orange	None	
15. Copper, brass, aluminum	None				None	

†Figures obtained with 305 mm (12") wheel on bench stand are relative only. Actual length in each instance will vary with grinding wheel, pressure, etc. *Blue-white spurts **Some wavy streaks

(Norton)