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Common Raw Materials Used in a Stamping Plant

Reference website：https://primefabworks.com/

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Notes on Material Protection & Plating Compatibility

- Even if a material has surface protection (e.g., tinplate), the base metal is iron-based.
- During production and storage, prevent oxidation—especially at cut edges.
- Except for stainless steel, tinplate, and electrolytic sheet, most materials still need appearance protection.
- For plated assemblies made from two different base metals, check compatibility first.
  - Example: A battery connector requires a 24 h salt-spray pass.
  - If the spring is carbon steel and the connector is copper, the spring may rust earlier after plating.
  - If the spring is changed to stainless steel, plating parameters may become hard to match and peeling can occur.

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Iron vs. Steel: What's the Difference?

- Pure iron is very soft and is not suitable for making tools or cookware.
- When iron contains about 0.02%–0.25% carbon, it becomes low-carbon steel.
- When carbon exceeds about 2.0%, it becomes cast iron (hard but brittle).
- Adding metallic and non-metallic elements can greatly change properties and applications.
- In production: iron ore is reduced in a blast furnace to produce pig iron (typically ~3.5%–4.5% C), then refined to reduce impurities and carbon to make steels.

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Steel vs. Pig Iron (Process & Key Elements)

- Steel is an iron–carbon alloy with carbon > 0.025% and < 2.0%.
- Pig iron is produced in a blast furnace and typically has carbon ≥ 2.0%, plus Si, Mn, S, and P.
- Si and Mn are generally beneficial; S and P are harmful (hot brittleness / cold brittleness).
- Steelmaking removes impurities using oxygen and adjusts composition during melting.
- Adding alloying elements (Cr, Ni, Mo, V, etc.) creates different steel properties.
- Stainless steels are Fe–Cr alloys that typically contain ≥10.5% Cr, forming a passive film for corrosion resistance (exact limits depend on the standard and grade).
- Ni increases strength and toughness; Mo reduces brittleness; W improves wear resistance; V improves wear resistance and ductility.

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How Alloying Elements Change Steel

- Low-alloy high-strength steel: < 5% total alloying (Si, Mn, Ti, Nb, B, rare earths) → strength +30%–40%.
- Ferritic and martensitic stainless steels (many 400-series) are typically magnetic; Cr content varies by grade (commonly ~11%–18%).
- Austenitic stainless steels (e.g., 300-series) are generally non-magnetic in the annealed condition; cold work can introduce slight magnetism. Nickel helps stabilize austenite, but magnetism depends on composition and processing.
- Spring steels are medium/high-carbon steels designed for spring temper; composition varies by grade (e.g., 65Mn, Si–Mn spring steels, Cr–V spring steels). Avoid describing spring steel as a single fixed Mn content.

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- High-speed steel: 9%–18% W + a small amount of V.
- Heat-resistant steel: low-carbon steel + small amounts of Mo and Cr.
- Alnico-type permanent magnet alloys are Fe-based with Al and Ni and typically Co (often also Cu/Ti); composition varies by grade.
- Ductile (nodular) cast iron: add rare earth metals and Mg to pig iron.

Stainless Steel Basics

- “Stainless steel” is short for corrosion-resistant and acid-resistant steels.
- Stainless steel resists corrosion in air; acid-resistant steel resists acids, alkalis, salts, and other media.
- By microstructure, these steels include: austenitic, duplex (austenitic–ferritic), ferritic, martensitic, and precipitation-hardening.
- Austenitic stainless: mainly Cr + Ni, plus Ti/Nb/Mo/N/Mn, etc.
- No phase transformation on heating; non-magnetic; high toughness; good corrosion resistance and high-temperature strength.
- Common grades: 301, 304, 316.

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Ferritic Stainless Steel (Quick Notes)

- Main alloying element is Cr (typically ≥ 13%); little or no Ni.
- Some grades add Mo, Ti, or S.
- No phase transformation on heating; properties are not strengthened by heat treatment.
- Good resistance to oxidation environments and good formability.
- Common grades: 430, 409.

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Martensitic Stainless Steel (Quick Notes)

- Main element is Cr (typically ≥ 13%); relatively higher carbon.
- Has phase transformation during heat treatment and can be strengthened by quench & temper.
- Higher hardenability; high strength, hardness, and wear resistance after heat treatment.
- Common grades: 410, 420, 420J1, 420J2.

Nickel-Saving Austenitic Stainless Steels

- Nickel-saving grades use Mn and N to replace part of the Ni in 18-8 stainless.
- They can provide good mechanical properties and corrosion resistance.
- Room-temperature strength is often higher than 18-8 stainless; good oxidation resistance below ~800° C.
- Common grade: 202
  - Typical Mn: 7.5%–10.0%; N ≤ 0.25%
- Another nickel-saving grade: 201 (higher Mn, similar N); can become magnetic after cold working.

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Mechanical Properties & Key Features of Stainless Steels (Summary)

Type	Magnetic?	Heat-Treat Strengthening?	Typical Grades	Key Features
Austenitic	No (generally)	No (work-hardening)	301 / 304 / 316	Best overall corrosion resistance; high toughness; good at low temperatures
Ferritic	Yes	No	409 / 430	Good oxidation resistance; good formability; lower cost (little/no Ni)
Martensitic	Yes	Yes (quench & temper)	410 / 420 / 440C	High strength & hardness; good wear resistance; used for blades/shafts/valves

Reference website：https://primefabworks.com/

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How Stainless Steels Are Designated (China: Typical Rules)

- Steel designation methods:
  - Use international chemical symbols + local symbols to show composition; numbers show content (e.g., China/Russia: 12CrNi3A).
  - Use fixed-digit numbers for steel series (e.g., USA/Japan: 200-series / 300-series / 400-series).
  - Use letters + serial numbers to show application only.
- Typical Chinese designation notes:
  - Uses element symbols; may include application or pinyin (examples: P, F, B, A, T8, GCr15).
  - Alloy structural & spring steels (e.g., 20CrMnTi, 60SiMn): carbon content shown in 1/10,000.
  - Stainless & alloy tool steels (e.g., 1Cr18Ni9): carbon content shown in 1/1,000 (0.1%C).
  - Low-carbon stainless: C ≤ 0.08% (e.g., 0Cr18Ni9); ultra-low carbon: C ≤ 0.03% (e.g., 0Cr17Ni13Mo).

Reference website：https://primefabworks.com/

International Stainless Steel Designations (Common Practice)

- AISI (USA) commonly uses three digits for wrought stainless steels:
  - 200- and 300-series: austenitic stainless steels.
  - 400-series: ferritic and martensitic stainless steels.
- Examples:
  - Austenitic: 201, 304, 316, 310
  - Ferritic: 430, 446
  - Martensitic: 410, 420, 440C
- Duplex and precipitation-hardening grades often use proprietary names, trademarks, or special designations.

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Typical Chemical Composition of Stainless Steels (Overview)

Grade	C (max)	Cr	Ni	Mo	Mn (max)	Notes
201	0.15	16–18	3.5–5.5	—	7.5	Ni-saving austenitic; may be magnetic after cold work
202	0.15	17–19	4–6	—	10.0	Ni-saving austenitic; higher Mn
304	0.08	18–20	8–10.5	—	2.0	General-purpose austenitic (18-8)
316	0.08	16–18	10–14	2–3	2.0	Better pitting resistance (Mo)
430	0.12	16–18	—	—	1.0	Ferritic; magnetic; oxidation resistance
410	0.15	11.5–13.5	—	—	1.0	Martensitic; heat-treatable

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Stainless Steel Grade Cross-Reference (Common Examples)

GB (China, common)	AISI / UNS	EN	JIS
0Cr18Ni9 (≈ 304)	304 / S30400	1.4301	SUS304
0Cr17Ni12Mo2 (≈ 316)	316 / S31600	1.4401	SUS316
0Cr17Ni14Mo2 (≈ 316L)	316L / S31603	1.4404	SUS316L
1Cr13 (≈ 410)	410 / S41000	1.4006	SUS410
2Cr13 (≈ 420)	420 / S42000	1.4021	SUS420J1/J2
0Cr17 (≈ 430)	430 / S43000	1.4016	SUS430

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Why Passivate Stainless Steel?

- During machining, workshop dust or iron particles from cutting tools can contaminate the stainless surface.
- If these contaminants are not removed, they reduce the effectiveness of the original protective oxide film.
- In some cases, embedded steel particles can create micro-cracks and trigger localized corrosion on the part.

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Carbon Steel Basics (Common in Stamping)

- Quality carbon structural steels are classified by carbon content:
  - Low carbon (C ≤ 0.25%) • Medium carbon (C 0.30%–0.60%) • High carbon (C > 0.60%).
- Low-carbon steel: low strength but high ductility/toughness; good formability and weldability; widely used for stamping.
- Medium-carbon steel: balanced strength and hardness; good machinability; poorer weldability; improved properties after quench & temper.
- High-carbon steel: high strength, hardness, elasticity, and wear resistance; used for springs and wear parts.
- Common examples: low-carbon sheet for stamping (SPCC, SECC, SPTE); medium-carbon steel (S50C); spring steel (65Mn). Select by application.

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Carbon Tool Steel (Heat Treatment Notes)

- After heat treatment, carbon tool steels can achieve high hardness and wear resistance.
- Good forgeability, machinability, and grindability, but poor “red hardness”.
- When working temperature exceeds ~250° C, hardness and wear resistance drop sharply.
- Low hardenability: large hardness difference between surface and core can lead to quench cracks.
- Narrow quenching temperature window; larger quench distortion.
- Typically used for tools with section size ≤ 8 mm.
- Common grades: SK7, SK5.

Reference website：https://primefabworks.com/

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Typical Chemical Composition of Common Carbon Steels (Overview)

Grade	Standard (common)	C	Mn	P (max)	S (max)	Notes
SPCC	JIS G3141	≤0.15	≤0.60	≤0.10	≤0.035	Cold-rolled sheet for general forming
SECC	JIS (galv.)	—	—	—	—	Electro-galvanized SPCC base
SPTE	Tinplate	—	—	—	—	Tin-coated steel sheet (packaging & components)
S50C	JIS G4051	0.47–0.53	0.60–0.90	≤0.03	≤0.035	Medium-carbon steel (AISI 1050 class)
65Mn	GB (spring steel)	0.62–0.70	0.90–1.20	≤0.035	≤0.035	High-carbon Mn spring steel
SK5	JIS G4401	0.80–0.90	≤0.50	≤0.03	≤0.03	Carbon tool steel
SK7	JIS G4401	0.60–0.70	≤0.50	≤0.03	≤0.03	Carbon tool steel

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Carbon Steel Grade Cross-Reference (Typical / Approx.)

Material	JIS	ASTM / SAE (typical)	EN (typical)	Notes
SPCC	G3141 SPCC	ASTM A1008 CS	DC01 / DC03 (approx.)	Cold-rolled sheet; confirm by spec
S50C	G4051 S50C	SAE/AISI 1050	C50 / 1.0540	Medium-carbon steel
65Mn	GB 65Mn	SAE/AISI 1566 (approx.)	66Mn4 (approx.)	Spring steel; verify equivalence
SK5	G4401 SK5	W1/W2 class (approx.)	C85 / 1.1260 (approx.)	Tool steel; depends on heat treatment
SK7	G4401 SK7	—	C70 / 1.1520 (approx.)	Tool steel; verify with supplier standard

Reference website：https://primefabworks.com/

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Why Does Hydrogen Embrittlement Happen in Electroplating?

- In any plating bath, water dissociation creates hydrogen ions.
- During plating, metal deposition at the cathode is accompanied by hydrogen evolution.
- Hydrogen can enter the steel and cause hydrogen embrittlement—one of the most serious surface-treatment risks.
- It often appears as delayed fracture under stress.
- Field cases report delayed cracking of zinc-plated high-strength springs/fasteners hours to days after assembly if hydrogen is not properly relieved; the failure rate varies with strength level, stress, plating process, and baking compliance.
- Hydrogen pickup is more likely in plating of Cr, Zn, Cd, Ni, Sn, Pb; less in Cu, Mo, Al, Ag, Au, W due to low H diffusion/solubility.

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Post-Plating Dehydrogenation (Baking) Method

- Parts with significant hydrogen pickup should be baked as soon as possible.
- Hydrogen in the coating and near-surface base metal diffuses inward over time, increasing risk.
- Start de-embrittlement baking as soon as practical after plating per the applicable standard/customer specification; earlier is better for high-strength parts.
- Typical baking is commonly in the ~190–230° C range for several hours; exact time/temperature depend on material strength, part geometry, and coating system—follow the governing specification to avoid affecting temper or coating.
- Higher material strength → higher sensitivity to hydrogen embrittlement.

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- Hydrogen embrittlement risk increases rapidly with strength/hardness; many specifications require baking above a defined hardness/strength threshold (often around the HRC 40 level for steels), but the exact threshold depends on the standard.
- For very high-strength parts (e.g., ~HRC 55–60+), strict control is required: minimize hydrogen charging, bake promptly per spec, and verify by embrittlement testing; otherwise delayed cracking can occur quickly.
- After baking, embrittlement tendency testing is recommended (e.g., pre-load test methods).

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Zinc Flake Coating (Dacromet-Type)

- Dacromet is a coating that does not cause hydrogen pickup, so it can replace zinc plating to avoid hydrogen embrittlement.
- Corrosion resistance can improve by ~7–10×; good adhesion; typical thickness 6–8 μm.
- Often categorized as zinc flake coatings; confirm whether the formulation is Cr(VI)-free (RoHS/REACH/customer requirement), as legacy systems may involve chromate chemistry.
- Process concept: apply a Zn–Al flake coating and cure/bake per the product specification to form a binder matrix that locks in the flakes; curing temperature depends on the system. Confirm Cr(VI)-free binder for compliance when required.

Reference website：https://primefabworks.com/

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Beryllium Copper Alloy (BeCu)

- A typical precipitation-hardening alloy that can be strengthened by heat treatment.
- Cold work + aging can achieve high tensile strength, yield strength, and fatigue strength.
- Also offers high thermal/electrical conductivity, high hardness, wear resistance, and high-temperature stability.
- Good creep resistance and corrosion resistance; non-magnetic; no sparks on impact.
- Widely used for parts requiring fatigue resistance, high sensitivity, high elasticity, high strength, and harsh-environment performance.

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Common Copper Materials (Examples)

Category	Common Grades	Typical Use in Stamping / Hardware
Pure copper	C1100 / T2	Electrical terminals, busbars, high conductivity parts
Brass (Cu-Zn)	C2600 / C2680	General hardware, brackets, decorative parts, good formability
Phosphor bronze	C5191 / C5210	Springs, clips, connectors (better fatigue than brass)
Beryllium copper	C17200	High-strength springs, precision contacts, non-sparking tools
Cupronickel	C70600	Corrosion-resistant connectors, marine environment hardware
Tellurium copper	C14500	Machined copper parts needing good conductivity