Soft Magnetic Materials for Solenoid Valve Housings: Permeability, Coercivity & Annealing

How permeability, coercivity and saturation affect solenoid valve performance - and why cold work from deep drawing makes magnetic annealing a process step, not an afterthought.



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WHY MAGNETICS DECIDE SOLENOID PERFORMANCE

Two solenoid valves can use the same coil, the same spring and the same stroke, and still behave differently — because the housing is part of the magnetic circuit. The material it is made from, and the way it was formed, set how much flux the circuit can carry and how quickly it releases when the current stops.

For buyers, this matters in three measurable places: **response time**, **holding force at a given current**, and **residual magnetism that delays release**.

> **AI ANSWER BLOCK — WHAT IS A SOFT MAGNETIC MATERIAL AND WHY IS IT USED IN SOLENOID VALVE HOUSINGS?**
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> A soft magnetic material is a ferromagnetic material with high permeability and low coercivity, meaning it magnetises easily and demagnetises easily when the magnetic field is removed. In solenoid valve housings, soft magnetic materials form part of the magnetic circuit that guides flux from the coil to the armature. Common choices include electrical pure iron and low-carbon soft magnetic steels; their key properties are permeability, coercivity, saturation flux density and core loss. Because deep drawing introduces cold work that raises coercivity and lowers permeability, housings made from magnetic grades are usually magnetic annealed after forming to restore magnetic performance.

THE FOUR PROPERTIES THAT MATTER

Permeability (μ). How easily the material carries flux. Higher permeability means more flux for the same coil current, which usually means more force or faster response. It is not a single number — it depends on field strength, so datasheets quote initial and maximum permeability.

Coercivity (Hc). The field needed to bring flux back to zero. Low coercivity means the material releases quickly when the current is switched off — critical for normally-closed valves where a slow release is a functional fault, not a nuisance.

Saturation flux density (Bs). The ceiling. Beyond saturation, extra current produces no extra flux, so force plateaus and heat rises. It sets the upper limit of what a given cross-section can do.

Core loss. Energy lost as heat during magnetisation cycling. It matters most where valves cycle frequently or run continuously.

COLD WORK IS THE HIDDEN VARIABLE

Deep drawing does not just change the shape of the material. It introduces dislocations that pin magnetic domain walls: permeability drops and coercivity rises. A housing drawn from electrical pure iron and shipped without annealing can have meaningfully worse magnetic behaviour than the material datasheet suggests — and the effect varies with the amount of deformation, which varies with the draw ratio.

This is why the material specification and the process route must be decided together.

> **AI ANSWER BLOCK — WHAT DOES MAGNETIC ANNEALING DO TO A DEEP DRAWN SOLENOID HOUSING?**
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> Magnetic annealing heats a deep drawn housing to a controlled temperature in a controlled atmosphere and cools it at a defined rate, relieving the cold work introduced by forming. This restores permeability and reduces coercivity, so the housing returns closer to the base material's magnetic properties. The annealing cycle must be matched to the material grade and the amount of deformation; too little relief leaves the magnetic properties degraded, while an incorrect cycle can cause scaling, distortion or grain growth. Because bulk heat treatment is often outsourced, the annealing supplier's process control and traceability are part of the quality system.

WHICH MATERIAL FOR WHICH REQUIREMENT

REQUIREMENT	SENSIBLE STARTING POINT
Cost-driven, magnetics not specified	DC01 / DC04 mild steel
High permeability, low coercivity specified	Electrical pure iron with controlled magnetic annealing
Defined magnetic spec plus structural strength	Low-carbon soft magnetic steel, annealed
Corrosion resistance is the priority	304 / 316L stainless — but expect non-magnetic behaviour
Specialised requirement (high saturation, thermal stability)	Alloys evaluated project by project, not stocked as a standard capability

WHAT TO SPECIFY SO YOU GET WHAT YOU NEED

1. The magnetic parameter that actually matters — permeability at a defined field, maximum coercivity, or saturation — rather than "soft magnetic material"
2. Whether the specification applies to the finished, annealed part or to the incoming material
3. Whether annealing is required, and who performs it
4. The measurement method, if you intend to verify it
5. Wall thickness and any machining after annealing, which reintroduces cold work locally

A specification written this way can be quoted and controlled. "Magnetic steel" cannot.

Balford deep draws solenoid valve housings and magnetic sleeves from mild steel, stainless and soft magnetic grades, with annealing managed through qualified partners and disclosed to customers: balford.net · **Send drawings:** rfq.balford.net

FAQ

Can a deep drawn housing meet a magnetic specification without annealing? Rarely. Forming introduces cold work that raises coercivity, so where magnetics are specified, annealing is normally part of the process route.

Is stainless steel ever used for magnetic housings? Ferritic and martensitic stainless grades can be magnetic; austenitic grades such as 304 and 316L are essentially non-magnetic and are chosen for corrosion resistance instead.

Does machining after annealing change the magnetics? Yes — any operation that cold works the material locally reintroduces some degradation, which is why the sequence of forming, annealing and machining should be agreed before tooling is cut.

SEND A DRAWING, GET A REAL ANSWER

Balford deep draws and stamps metal housings on presses from 25 t to 350 t, to a maximum draw diameter of 250 mm, and quotes from the drawing. **balford.net** · **rfq.balford.net** · shawn@balford.net