Aobo Steel
Tool steel supplier, Huangshi, China
sales@aobosteel.com

Sorting Steel Bars Without Cutting Them

A mixed lot of bar, or one bar that will not reach the ordered hardness, is expensive to discover after the die is cut. The tables below give the electromagnetic approach, the conductivity of common metals, the coil set that reports three things in one pass and the gate positions that separate hardness, grade and structure.

Reference only. This is a reference summary of published practice and it is not a specification of ours. The values are reproduced from the source tables, and tool material, machine rigidity, cutting fluid and workpiece condition will all move them. Final conditions are set on the job.

Two families of electromagnetic test

How far eddy current reaches into the bar

Metal or alloy	Resistivity, microhm mm	Conductivity, % IACS
Silver	16.3	105
Copper, annealed	17.2	100
Gold	24.4	70
Aluminum	28.2	61
Aluminum alloy 6061-T6	41	42
Aluminum alloy 7075-T6	53	32
Aluminum alloy 2024-T4	52	30
Magnesium	46	37
70-30 brass	62	28
Phosphor bronzes	160	11
Monel	482	3.6
Zirconium	500	3.4
Titanium	548	3.1
Zircaloy-2	720	2.4
Type 304 stainless steel	700	2.5
Inconel 600	980	1.7
Hastelloy X	1150	1.5
Waspaloy	1230	1.4

Electrical resistivity and conductivity of common metals and alloys, reproduced from Table 1 of Eddy Current Inspection in ASM Handbook, Volume 17. The table is set on nonferrous metals because those are the ones sorted by conductivity, and it shows that conductivity also shifts with temperature, composition, heat treatment and residual stress, which is what allows a conductivity sort to track heat treatment and hardness in an alloy where those changes move the reading enough.

The coil set that reports three things in one pass

Coil set in the test head	What it reports
Primary coil	Excites the bar at line frequency, adjustable from 1000 to 30,000 ampere turns and usually set between 10,000 and 15,000
Two null coils	A matched pair spaced 75 to 102 mm apart and connected in opposition, so the meter reads a flaw in the section between them
Standard coil A	Compares every bar against the setup bar and reports a different grade or a full-length seam or crack
Standard coil B	Compares every bar against the setup bar and reports a change of hardness or structure

The coil set used for the simultaneous detection of flaws and of variation in composition, structure and hardness in steel bars, reproduced from Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. The whole assembly is set on the bar in a single pass.

Reading a mixed lot

Where the gates sit on the wave

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Gate position on the wave	What that gate is set to report
Near the low end of the half cycle, about 10 to 30 degrees	Hardness
Across the top of the half cycle, near 90 degrees	Grade
On the falling side of the top of the half cycle, about 90 to 120 degrees	Structure

The three electronic gate positions used to inspect one lot of bar for hardness, grade and structure, reproduced from the sorting example and Fig. 21 of Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. The angles are read from an oscilloscope trace of one half of an electrical cycle, and every bar in the lot is compared against the setup bar.

What the method will not do

Stock condition	Flaw detection efficiency by the permeability system
Heat treated, quenched, drawn and machine straightened	Highest
Cold drawn and machine straightened	High
Cold drawn, annealed and machine straightened	Medium
Hot rolled and machine straightened, centerless ground	Low
Hot rolled and machine straightened	Lowest

Efficiency of flaw detection by a magnetic permeability system against the condition of the bar, reproduced from Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. After straightening, the bars should be aged for 24 to 48 hours near room temperature, or stress relieved at up to 260 C, for best sensitivity.

Grades and stock

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Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, DC53, A2, O1, H13, H11, H10, H21, S7, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.

Source, ASM Handbook, Volume 17, Nondestructive Evaluation and Quality Control, ASM International, 1989.

CONTACT

EMAIL
sales@aobosteel.com
WHATSAPP
+86 180 6294 5370
WEB
aobosteel.com

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