

How Steel Bar and Billet Are Inspected for Flaws

A tool steel bar arrives with a mill certificate and, on larger sizes, a flaw detection report. The tables below give the four methods used on bar, the published specifications of the ultrasonic and eddy current lines, the seam depth a permeability system reaches and the blind length at each end of a bar.

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.

Four methods cover a bar

Method	What it finds on a bar	Practical limit
Visual inspection	Surface condition, scale, seams visible to the eye, handling damage	Depends on the eye of the inspector and the judgement of severity
Magnetic particle	Surface and near-surface seams, cracks, laps and slivers	Cannot reach flaws more than about 2.5 mm (0.1 in.) below the surface
Liquid penetrant	Flaws that are open to the surface, including tight grinding and fatigue cracks	Surface breaking flaws only, and too slow for bar inspected in quantity
Ultrasonic	Internal flaws, voids, inclusions and cracks in the body of the bar	Needs a liquid couplant and runs more slowly than an electromagnetic line
Electromagnetic	Seams and cracks, and at the same time composition, hardness and structure	The method most widely used on bars, and the one that suits mass production

The four methods used on steel bar, with what each one finds and the limit stated for it in the source article, reproduced from Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. The industry also notes a further reason for inspecting bar at the bar stage, which is to remove unacceptable material before time and energy are spent machining a part that would fail later.

Magnetic particle on bar

Ultrasonic inspection of drawn bar and wire

Parameter	Rotating probe, round bar	Twelve probes, hexagonal bar	Rotating probe, cold-drawn wire
Material dimension, mm (in.)	15-32 (0.59-1.26)	12-32 (0.472-1.260)	15-30 (0.590-1.181)
Testing method and frequency	Normal beam and angle beam, 10 and 5 MHz	Normal beam, 6 channels, and angle beam, 6 channels, at 5 MHz	Normal beam 10 MHz, angle beam 5 MHz, surface wave 5 MHz
Probe rotation, rev/min	1000	Fixed in circumferential direction	1000
Signal transmission	Noncontact rotation transmit	Not stated	Noncontact rotation transmit
Marker	One each for near-surface and inside flaws	Two, near-surface and inside	One each for near-surface and inside flaws
Smallest flaw reported	0.2 to 0.3 mm (0.008 to 0.012 in.) at the near surface	0.3 mm (0.012 in.) near surface and 0.2 mm (0.008 in.) inside	0.1 mm (0.004 in.) surface depth and 0.2 mm (0.008 in.) inside

Specifications of three published rotating-type ultrasonic flaw detection systems for cold-drawn round bar, cold-drawn hexagonal bar and cold-drawn wire, reproduced from Tables 1, 2 and 3 of Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. Not stated marks a parameter the source does not give for that system. On the hexagonal line the six normal-beam and six angle-beam probes sit around the circumference so that the whole section is covered, and the coupling medium is a special oil chosen to avoid rusting the bar.

Eddy current and the rotating probe

Parameter	Rotating probe, Type I	Rotating probe, Type II	Sheared bolt head
Material dimension	5-32 mm (0.197-1.260 in.)	5-25 mm (0.197-0.984 in.)	M20
Number of probes	2	4	Rotating head, self induction and self comparison
Probe area, mm ² (in. ²)	10 (0.016)	5 (0.0078)	Not stated
Probe rotation, rev/min	3000	6000	300
Testing frequency	64 kHz	512 kHz	125 kHz
Testing speed	Not stated	Not stated	60 pieces per minute
Smallest flaw reported	0.1 mm (0.004 in.)	0.1 mm (0.004 in.)	0.3 mm (0.012 in.)

Specifications of two published rotating probe eddy current systems for cold-drawn bar, in Table 4, and of one system for a cold-forged high-tension sheared bolt head, in Table 5, reproduced from Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. On the drawn-bar systems the minimum detectable flaw depth is 0.1 mm, and at a feed of 60 m/min the full surface is covered with a minimum detectable flaw length equal to the length of the probe coil. The bolt head carries a rougher surface, so its minimum detectable depth is 0.3 mm.

How small a seam a permeability system will find

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Bar form and condition	Smallest seam depth detected by the permeability system
Round bar, cold drawn and machine straightened	About 0.025 mm (0.001 in.) for each 1.6 mm (1/16 in.) of bar diameter
Worked case, 25 mm (1 in.) round bar	A 0.41 mm (0.016 in.) seam is readily detected
Same stock in hexagonal or square bar	0.30 to 0.33 mm (0.012 to 0.013 in.) is detected in the same processing

Minimum seam depth detected by a magnetic permeability system on cold-drawn, machine straightened bar, reproduced from Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. Under the surface the reach depends on carbon content, and the source gives approximately 6.4 mm for low-carbon steel, 7.9 mm for medium-carbon steel and up to 13 mm for many alloy steels.

Bar diameter, mm	Bar diameter, in.	Noninspected length at each end, mm	in.
6.4-13	1/4-1/2	102-152	4-6
13-25	1/2-1	152-203	6-8
25-50	1-2	203-305	8-12
50-75	2-3	305-406	12-16

Noninspected length at each end of a bar in a permeability system, reproduced from Nondestructive Inspection of Steel Bar, Wire and Billets in ASM Handbook, Volume 17. This end effect is why a flaw detection report on bar is normally quoted for the body of the bar rather than for the full length.

Why billet is harder to inspect than bar

Grades and stock

Aobo Steel, tool steel supplier

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.

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