

# Cleanliness Rating of Steels By the Magnetic Particle Method—SAE J421b

SAE Recommended Practice  
Last revised November 1977

SAENORM.COM : Click to view the full PDF of J421b-197711

THIS IS A PREPRINT WHICH IS  
SUBJECT TO REVISIONS AND  
CORRECTIONS. THE FINAL  
VERSION WILL APPEAR IN THE  
1979 EDITION OF THE SAE  
HANDBOOK.

Society of Automotive Engineers, Inc.  
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096



**PREPRINT**

S. A. E.  
LIBRARY

SAENORM.COM : Click to view the full PDF of j421b\_197711

# CLEANLINESS RATING OF STEELS BY THE MAGNETIC PARTICLE METHOD—SAE J421b

## SAE Recommended Practice

Report of Iron and Steel Division approved January 1941 and last revised by Iron and Steel Technical Committee November 1977.

**1. Scope**—This SAE Recommended Practice provides a rating procedure for the cleanliness rating of steels by the magnetic particle method. The procedure is based on counting the number of indications (frequency) and employs a weighted value to obtain a severity factor. The method outlined is similar to that described in SAE Aerospace Material Specification AMS 2301.

**2. Sampling**—Experience has shown that sampling of steel is primarily a matter of agreement between producer and consumer. For heat qualification, unless otherwise agreed, a sample shall be taken from product representing the top and bottom of the first ingot and last usable ingot from heats having not over 10 ingots or not over 30 tons (2700 kg) or from portions of heats within these limits; and from the top and bottom of the first ingot, middle ingot, and last usable ingot of heats having more than 10 ingots or over 30 tons (2700 kg). Where ingot identity has not been maintained, specimens are taken from not less than 10% of the steel to be evaluated.

### 3. Test Specimens

**3.1** The specimens shall be prepared in accordance with the details given in paragraph 3.2. The recommended procedure for developing the specimens from blooms, billets, and bars, in round or square sections is as follows:

**3.1.1** Cross Section over 36 in<sup>2</sup> (230 cm<sup>2</sup>)—Cut a quarter section as shown in Figs. 1 or 2 and develop the specimen by machining, or forging and machining, to a straight cylinder of a diameter between 2½ and 6 in. An alternative method is to forge or roll the full section to 6 in square or round and machine the quarter section in accordance with Item 3.1.2.

**3.1.2** Cross Section 16–36 in<sup>2</sup> (100–230 cm<sup>2</sup>) Inclusive—Cut a quarter section as shown in Figs. 1 or 2 and develop the specimen by machining, or forging and machining, to a straight cylinder of the largest possible diameter.

**3.1.3** Cross Section less than 16 in<sup>2</sup> (100 cm<sup>2</sup>)—Machine the specimen to a straight cylinder. An alternative method is to use a three-step step-down specimen, each step having 3 inches in length. The diameter, D, of the first step is the stock size less minimum stock removal shown in paragraph 3.2.2; the diameter of the second step is ¾ D; and the diameter of the third step is ½ D.

**3.2** The specimens shall conform to the following requirements unless specified otherwise in paragraph 3.1.

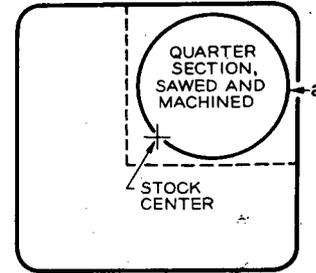
**3.2.1** The length of the rated surface is nominally 5 in (13 cm). A 1 in extension for holding is usually employed.

**3.2.2** The minimum amount of stock removed from the surface shall be as follows:

Nominal Size of Specimen, Round or Square		Minimum Stock Removal from Surface	
in	mm	in	mm
To 1/2	13	0.030	0.76
Over 1/2 to 3/4	13–19	0.045	1.1
Over 3/4 to 1	19–25	0.060	1.5
Over 1 to 1-1/2	25–38	0.075	1.9
Over 1-1/2 to 2	38–51	0.090	2.3
Over 2 to 2-1/2	51–64	0.125	3.2
Over 2-1/2 to 3-1/2	64–89	0.156	4.0
Over 3-1/2 to 4-1/2	89–114	0.187	4.7
Over 4-1/2 to 6	114–152	0.250	6.4

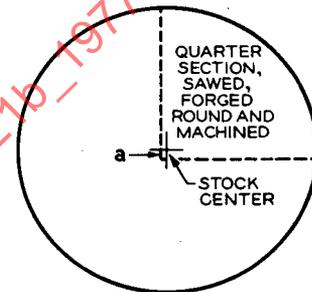
**3.2.3** All quarter sections shall be cut oversize as shown in Figs. 1 and 2 so that the center of the original stock will be approximately on the surface of the test specimen. The location of the center of the original stock shall be identified on the test specimen.

The  $\phi$  symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.



a, DENOTES DISTANCE EQUAL TO SURFACE REMOVAL  
NOTE: METHOD ALSO APPLICABLE TO SQUARE SECTIONS

FIG. 1—QUARTER SECTION SPECIMEN FROM SQUARE SECTION FOR MAGNETIC PARTICLE TEST, MACHINE ONLY



a, DENOTES SURFACE REMOVAL  
NOTE: THIS METHOD IS ALSO APPLICABLE TO ROUND SECTIONS

FIG. 2—QUARTER SECTION SPECIMEN FROM ROUND SECTION FOR MAGNETIC PARTICLE TEST, FORGING AND MACHINING

### 4. Preparation of Specimen

**4.1** After the specimen is rough turned, it shall be heat treated to a hardness of 250 Bhn minimum for carbon 0.25% or over, 200 Bhn minimum for carbons less than 0.25% by oil or water quenching from well above the critical temperature and tempering within the range of 400–1200 F (200–650 C), depending upon the composition of the steel. Care shall be taken to avoid quenching cracks. The heat treatment tends to develop a more uniform structure hard enough to retain some residual magnetism, thus helping to hold the magnetic powder in place after test.

**4.2** After heat treatment, the specimen shall be ground, and the ends of the specimen shall also be ground or otherwise cleaned to insure good contact for magnetizing. Care shall be taken to avoid grinding checks during the grinding. The grinding shall be transverse to the length of the specimen. Longitudinal grinding scratches may be deep enough to retain the magnetic powder and confuse the inclusion determination.

**4.3** Before magnetizing, the specimen shall be thoroughly washed with some quick-drying solvent in order to remove all grease and finger marks.

### 5. Procedure

**5.1** Magnetization shall be accomplished by passing direct current through the specimen in the longitudinal direction for 1/5–1/2 s. The magnitude of the current shall be 800–1200 amp per in (300–500 amp per cm) of diameter of specimen.

**5.2** In general the wet continuous method that has the specimen covered with magnetic particle suspension during magnetization shall be used. Hardened steel specimens (Rockwell C 50 or higher) may be tested using the wet residual method, applying the suspension after magnetization. Care shall be taken not to disturb indications before inspection is completed.

**5.3** The finely divided magnetic particles are usually suspended in kerosene or other light oil of about 40 s Saybolt Universal viscosity. About