SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP1820B

Issued 1984-10
Reaffirmed 2002-12
Revised 2007-12

Superseding ARP1820A

Chord Method of Evaluating Surface Microstructural Characteristics

RATIONALE

ARP1820B results from a Five-Year Review and update of this document.

INTRODUCTION

The chord method is based on magnifying the near-subsurface zone of a specimen by cutting across the zone at an angle much greater than 90 degrees. It utilizes an easy-to-fabricate specimen, a round disc or a sector thereof, that is mounted with the circumferential surface ready for grinding. It is then ground and polished to provide, for evaluation, a chordal surface that intersects the circumferential surface at approximately 165 degrees, producing approximately 4X magnification. The support provided by the circumferential surface permits 500 g load microhardness testing of hardened steel within 0.0005 in (0.012 mm) of the intersection, and thus allows evaluation of the severity of carburization and decarburization at a depth of 0.00015 in (0.0038 mm) or more. The magnification also facilitates detection and measurement of thin layers of total decarburization and intergranular oxidation.

1. SCOPE

This practice provides a method of evaluating microhardness and microstructure very close to the surface of a disk specimen. It is useful for process control in heat treatment of steel parts to detect nitriding and carburization as well as decarburization and excessive intergranular oxidation. It also may be valuable for other evaluations, e.g., plated coatings and other materials.

2. REFERENCES

There are no referenced publications specified herein.

3. PROCESS CONTROL FOR HEAT TREATMENT OF STEEL PARTS

3.1 Fabricate disc or disc-sector specimens 1/8 to 1/4 in (3 to 6 mm) thick, with a 1/4 to 1/2 in (6 to 12 mm) radius, small central hole permissible, of the same alloy as the parts with texture of circumferential surface approximately 32 µin (0.8 µm) (see 4.4).

3.2 Heat treat specimens with parts but do not temper specimens made from carbon, low-alloy, and martensitic corrosion-resistant steels.

EXCEPTION: Temper specimens made from steels exhibiting secondary hardening characteristics, e.g., H-11.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

3.3 Metallographically mount specimens so that circumferential surface is ready for grinding and polishing.

3.4 Grind and polish specimens to produce a magnification of 3 to 5X near the intersections (I) of the chordal and circumferential surfaces (see Figure 1). The magnification is D/c, where "D" is the disc diameter and "c" is the length of the chordal surface.

3.5 Determine Knoop microhardness, using 500 g load, on a traverse from an intersection (I) at the mid thickness of the disk. Make the first impression 0.0005 in (0.012 mm), and the second 0.0005 in (0.012 mm) further from the intersection. Make subsequent impressions so as to produce a smooth curve when depth versus hardness is plotted.

3.5.1 Continue testing microhardness at increasing depths approximately 0.001 in (0.025 mm) apart until core hardness is determined, i.e., until there is no significant difference in microhardness at adjacent locations. Convert microhardness at 0.0003 in (0.008 mm) depth and at core microhardness from Knoop to HRC (see 3.7.2).

3.5.1.1 Inability to obtain core hardness, i.e., consistent microhardness, may be due to small disc diameter or short chord length. In such a case, grind the specimen further to lengthen the chord.

3.6 Determine depth (d) beneath surface using Equation 1, the approximate formula of Equation 2, or nomographs similar to Figure 2 (for measurements in inches) and Figure 3 (for measurements in millimeters).

$$d = r - \sqrt{r^2 - \Delta\,(c - \Delta)} \text{ or the approximate formula} \qquad \text{(Eq. 1)}$$

$$d = \frac{c\Delta - \Delta^2}{2r} \qquad \text{(Eq. 2)}$$

where:

r = radius of disc

Δ = distance from intersection

c = length of chordal surface

3.7 Plot Hardness Versus Depth Curve

3.7.1 Depth of Partial Decarburization

The depth of partial decarburization is the depth, d, in thousandths of an inch or multiples of 0.025 mm, determined as in 3.5 and 3.6, at the location where the Knoop hardness is within 20 points of the core Knoop hardness.

3.7.2 Severity of Partial Decarburization

The severity of partial decarburization is the difference between the HRC hardness (converted from Knoop) at 0.0003 in (0.008 mm) depth and that of the core.

3.7.3 Carburization and Nitriding

The presence is indicated by Knoop hardness at 0.0005 in (0.0127 mm) depth, or any other location, in excess of Knoop hardness of core.

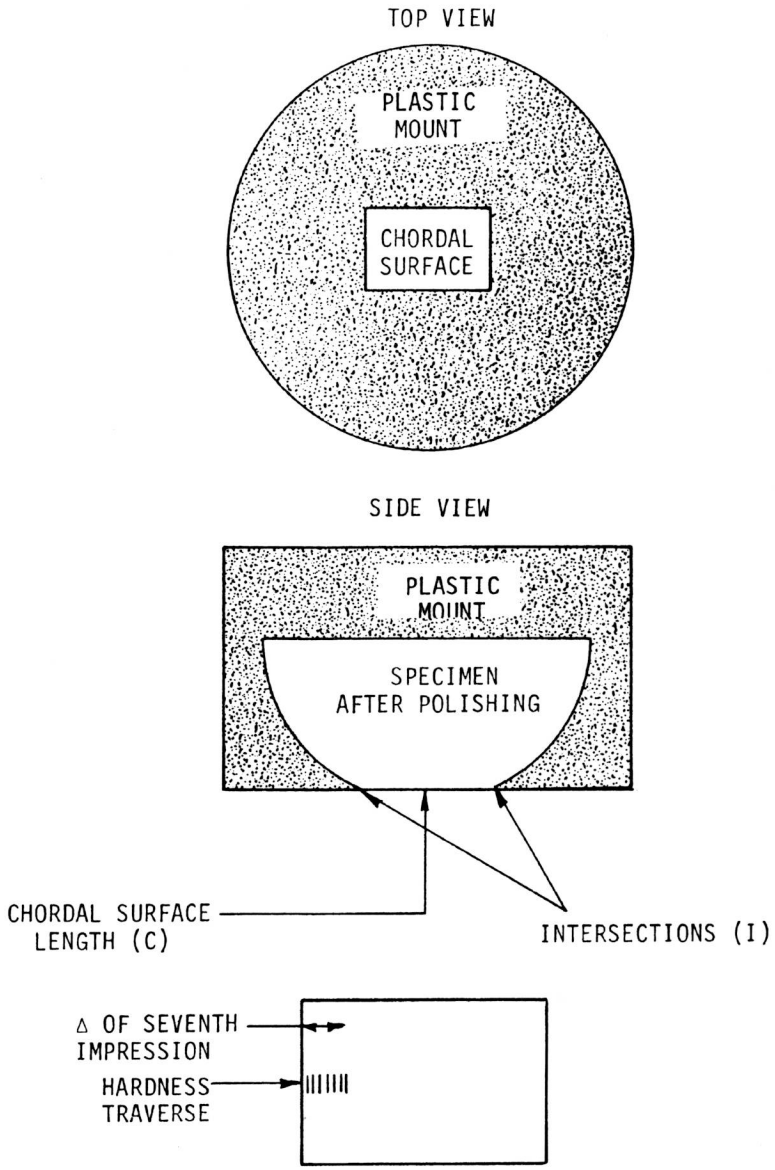

FIGURE 1 - MOUNTED AND POLISHED SPECIMEN

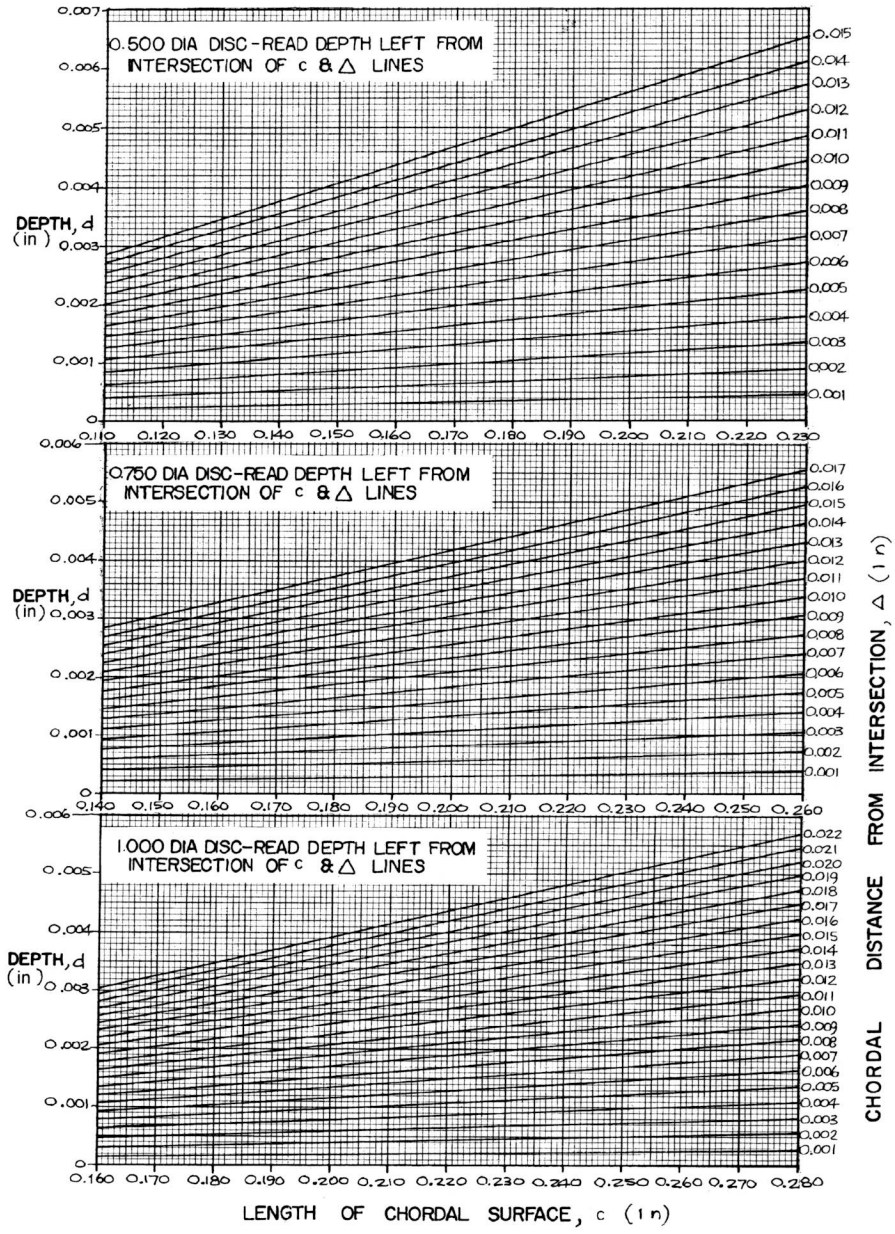

FIGURE 2 - CHORDAL LENGTH AND DISTANCE VERSUS DEPTH FOR 1/2, 3/4, AND 1 in DIAMETER DISCS

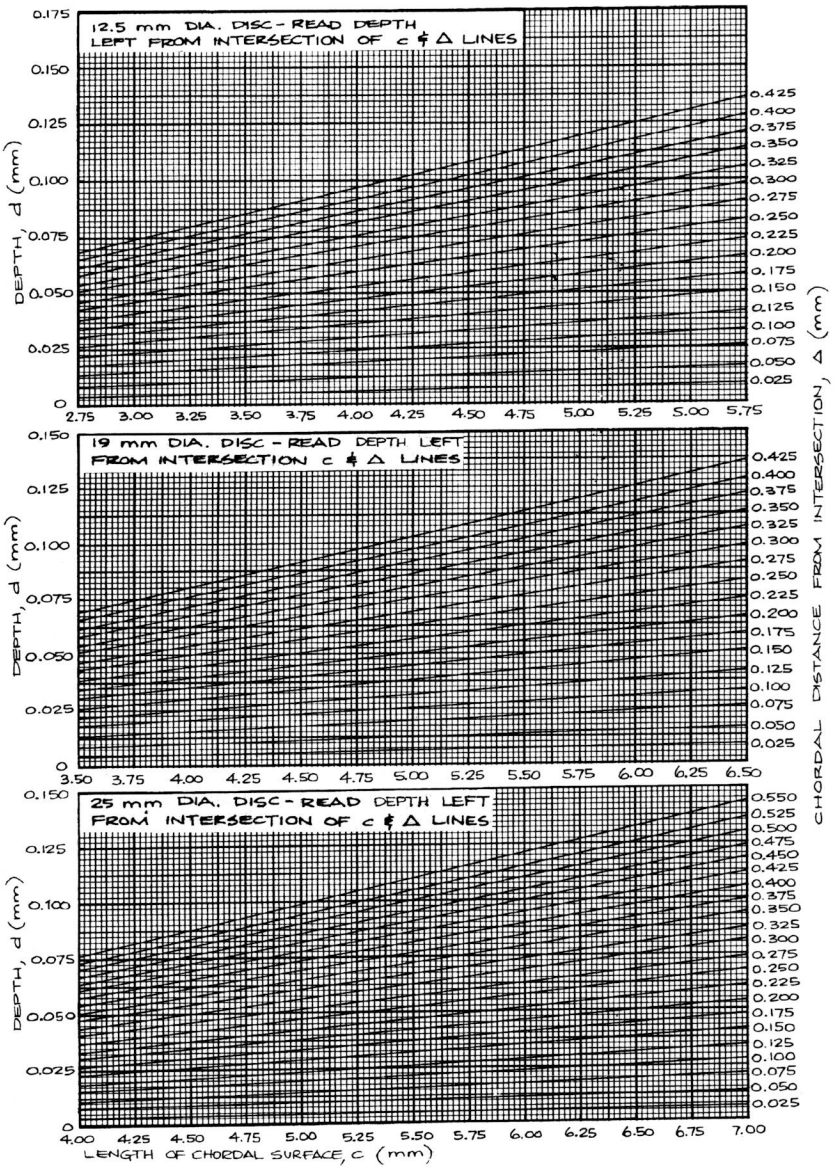

FIGURE 3 - CHORDAL LENGTH AND DISTANCE VERSUS DEPTH FOR 12.5, 19 AND 25 mm DIAMETER DISCS

3.8 Metallographically determine the presence of any complete (total) decarburization and the depth of any intergranular oxidation present on the circumferential surface. Use approximately 250X and appropriate etchant as necessary.

3.9 Recommended Rejection Criteria

Unless otherwise specified, if any specimen fails to conform to the limits in Table 1, all parts in the furnace load with which it was heat treated are subject to rejection. Also, any parts subsequently heat treated in the furnace are subject to rejection until successful retests prove that the cause of the discrepancy has been determined and corrected.

TABLE 1 - RECOMMENDED REJECTION CRITERIA

Surface Condition	Minimum Tensile Strength 220,000 psi (1520 MPa), and over	Minimum Tensile Strength Up to 220,000 psi (1520 MPa), excl
Carburization and nitriding (excess of surface hardness over core hardness)	Less than 20 Knoop	Less than 20 Knoop
Complete (total) decarburization (surface ferrite)	None	None
Partial decarburization Depth (see 3.7.1)	0.006 in (0.15 mm) and under	0.008 in (0.20 mm) and under
Partial decarburization Severity (see 3.7.2)	5 HRC and less (converted from Knoop)	8 HRC and less (converted from Knoop)
Depth of intergranular oxidation	0.0005 in (0.012 mm) and under	0.0007 in (0.018 mm) and under

4. NOTES

4.1 The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document.

4.2 Use of Figure 2

Select the nomograph that corresponds to disc diameter. Find intersection of appropriate Δ (diagonal) line and c (vertical) line. Move horizontally left to find depth (d).

EXAMPLE: If disc diameter is 0.500 in, Δ is 0.015 in, and c is 0.180 in , then d is 0.005 in.

4.3 Basis for Limits in 3.9

The limits for high strength steels are based on achieving optimum fatigue performance of surfaces that are shot peened. The limits for low strength steels are based upon what is commonly achievable in modern protective atmosphere furnaces.

4.4 Caution

Before use, it is imperative that the circumferential surface of specimens be free from carburization, nitriding, decarburization, and intergranular oxidation. This is not necessarily ensured when circumferential surface is that of steel bar procured as "centerless ground."

4.5 The results produced by this method are equivalent to those obtained using methods that employ microhardness tests on a surface perpendicular to the surface exposed to the heat treating medium.

PREPARED BY AMS COMMITTEE "E"