

NOTICE OF
ADOPTIONADOPTION NOTICE 1
17 March 1989 for
ARP 1820
1 October 1984

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Title of Document: CHORD METHOD OF EVALUATING SURFACE MICROSTRUCTURAL CHARACTERISTICS

Date of Specific Issued Adopted: 1 October 1984

Releasing Non-Government Standards Body: SAE

Custodians:

Air Force - 11
Army - MR
Navy - AS

Military Coordinating Activity
Air Force - 11

(Project No: 95GP - 0323)

FSC 95GP

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**AEROSPACE
RECOMMENDED
PRACTICE**

ARP 1820

Issued 10-1-84
Revised

CHORD METHOD OF EVALUATING SURFACE MICROSTRUCTURAL CHARACTERISTICS

1. **SCOPE:** This practice provides a method of evaluating microhardness and microstructure very close to the surface. 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. **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, which is mounted with the circumferential surface ready for grinding. It is then ground and polished to provide, for evaluation, a chordal surface which intersects the circumferential surface at approximately 165 deg, 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.
3. **PROCESS CONTROL FOR HEAT TREATMENT OF STEEL PARTS:**
 - 3.1 Fabricate disc or disc-sector specimens, 1/8 - 1/4 in. (3 - 6 mm) thick, 1/4 - 1/2 in. (6 - 12 mm) radius, small central hole permissible, of the same alloy as the parts with texture of circumferential surface approximately 32 microin. (0.8 μm) (See 4.3).
 - 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.

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- 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 - 5X near the intersections (I) of the chordal and circumferential surfaces. (See Fig. 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 microhardnesses, using 500 g load, on a traverse from an intersection (I) at the mid-thickness of the disc. Make the first impression 0.0005 in. (0.012 mm) from the intersection and the second impression 0.0005 in. (0.012 mm) deeper than the first. Make subsequent impressions so as to produce a smooth curve when plotted.
- 3.6 Determine depth (d) beneath surface using the formula
- $$d = r - \sqrt{r^2 - \Delta(c - \Delta)}$$
- or the approximate formula
- $$d = \frac{c\Delta - \Delta^2}{2r}$$
- where r = radius of disc, Δ = distance from intersection, and c = length of chordal surface. Nomographs, similar to those in Figs. 2 and 3, may be used in lieu of calculation.
- 3.7 Plot hardness vs. depth curve.
- 3.7.1 Depth of Partial Decarburization: Is the depth, d , in thousandths of an inch or multiples of 0.025 millimetre, 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: 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: Presence is indicated by Knoop hardness at 0.0005 in. (0.012 mm) depth, or any other location, in excess of Knoop hardness of core.
- 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.

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3.9 Recommended Rejection Criteria: Unless otherwise specified, if any specimen fails to conform to the limits in the table below, 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.

MINIMUM TENSILE STRENGTH		220,000 psi (1520 Mpa), and over	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) decar- burization (surface ferrite)		None	None
Partial decarburization	Depth	0.006 in. (0.15 mm) and under	0.008 in. (0.20 mm) and under
	Severity	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 Use of Figure 2: Select the nomograph which 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. (12.5 mm), Δ is 0.015 in. (0.375 mm), and c is 0.180 in. (4.5 mm), then d is 0.005 in. (0.097 mm).
- 4.2 Basis for Limits in 3.9: The limits for high strength steels are based on achieving optimum fatigue performance of surfaces which are shot peened. The limits for low strength steels are based upon what is commonly achievable in modern protective atmosphere furnaces.

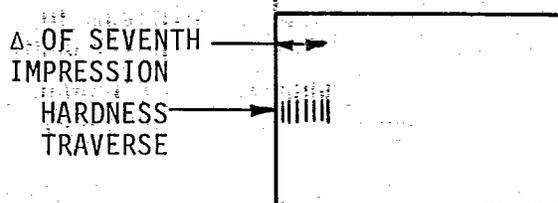
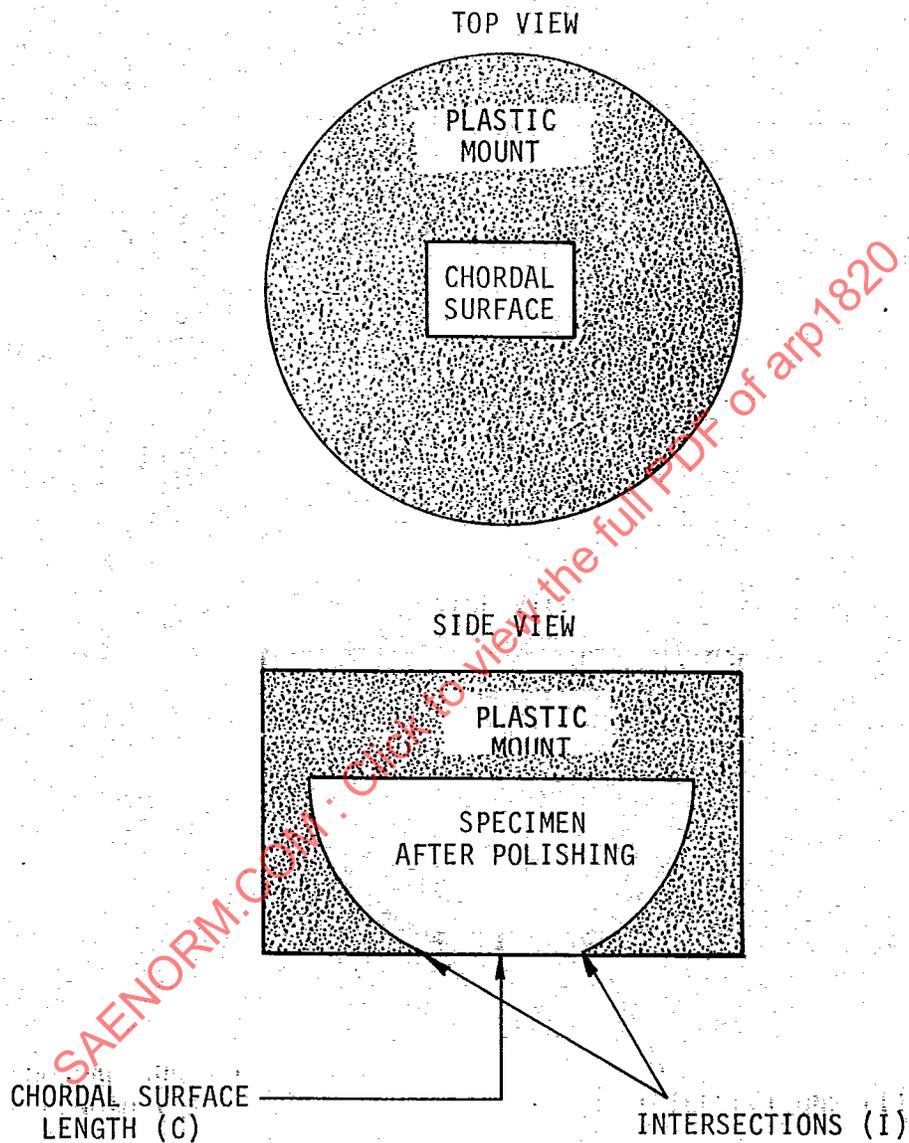
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- 4.3 CAUTION: It is imperative that the circumferential surface of specimens be free from carburization, nitriding, decarburization, and intergranular oxidation. This is not necessarily ensured when circumferential surface is that of steel bar procured as "centerless ground."

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FIGURE 1
MOUNTED AND POLISHED SPECIMEN



MAGNIFIED TOP VIEW OF CHORDAL SURFACE