

NAVISTAR, INC.		
Material, Parts, and Process Specifications (MPAPS)		NUMBER: MPAPS- A-41
		Former Designation: CEMS A-41
TITLE: Flame and Induction Hardened Steel and Iron Parts		CURRENT REV No.: 1512
		DATE: Dec. 2015
WRITTEN/EDITED BY: W. Cook	APPROVED BY: R. Goluch	SUPERSEDES: October 2001
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<i>This specification may involve hazardous materials, equipment, and procedures. This specification does not purport to address all of the safety issues associated with its use. The user is responsible to consult appropriate safety and health practices and to determine the applicability of regulatory limits prior to use.</i>		
Change Notice: <i>Reissued as MPAPS; Incorporation of Appendix; Editorial changes</i>		

1.0 APPLICATION

This specification applies to gears, shafts and forgings valve stems and other parts made of medium carbon or alloy steels that require hardened cases. Flame and induction hardening are less expensive means for achieving hardened case microstructures on suitable parts to achieve improved wear resistance, torsional and bending strength and fatigue life.

2.0 SCOPE

This specification covers the Company's requirements for the properties of hardened cases produced by flame or induction hardening. All properties shown refer to finished parts.

2.1 Restricted Chemical Substances

Effective January 1, 2007, all product supplied to the requirements of this specification must comply with the requirements of the MPAPS B-50 specification.

3.0 REFERENCE DOCUMENTS

Unless otherwise specified, the latest issue of all referenced standards shall apply. The following Specifications, Standards, and Regulations are referenced in this specification.

Quality System Standard ISO 9001 or TS-16949	ASTM E 112
CFR Title 29, Part 1910	ASTM E 140
NAVISTAR Manufacturing Std. MS-D-13	
NAVISTAR Engineering Design Std A-16	
NAVISTAR MPAPS B-50	

4.0 REQUIREMENTS

Flame and induction hardened grades or parts are classified by the depth of the hardened surface zone and the surface hardness.

4.1 Hardened Depth

Eleven classes which define the hardened depths are shown in Table I.

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TABLE I
CLASSIFICATION OF FLAME AND INDUCTION HARDENED DEPTHS

Navistar Class	Hardened Depth, Minimum ⁽²⁾	
Induction Hardened ⁽¹⁾	in	mm
SH ⁽³⁾	Depth sufficient only to obtain specified surface hardness using specified hardness scale.	
30	0.030	0.75
45	0.045	1.15
60	0.060	1.50
90	0.090	2.30
120	0.120	3.05
150	0.150	3.80
180	0.180	4.55
240	0.240	6.10
300	0.300	7.60
IND	Depth as indicated on drawing.	

- (1) An F prefix indicates that flame hardening is permitted.
- (2) The maximum hardened depth as defined herein must not exceed 50% of the radius of cylindrical solid parts, or for hollow shafts, the maximum case depth will not exceed 50% of the wall thickness unless otherwise specified. For other shapes the hardened depth should not exceed 50% of the cross section unless otherwise indicated. If hardened from both sides the maximum hardened depth from one side should not exceed 25% of the cross section. This is difficult or impossible on parts with small section sizes such as some gear teeth or shifter pads. If such a condition exists this must be negotiated with the supplier.
- (3) Obsolete Class 10

4.1.1 Flame or induction hardened depth is defined, unless otherwise specified, as the perpendicular distance from the specified surface to a point having a hardness equivalent to Rockwell C 40.

4.1.2 When it is deemed necessary to specify a hardened depth other than as defined by Rockwell C 40, that hardness will be shown in parentheses following the class designation as follows:

4.1.3 Navistar Class 60 (RC 35) means the perpendicular distance from the surface to a point having a hardness equivalent to Rockwell C 35 will be 1.50 mm (0.060 in.) minimum.

4.1.4 See “Methods of Test,” for methods for determining hardened depths.

4.1.5 Hardness at other points below the surface may be specified in special cases. See Appendix, “Selection of Hardness Gradients” for further information.

4.1.6 Since this specification refers only to case depth of finished parts, it may be necessary to produce cases deeper than those specified herein to compensate for stock removed during grinding or other manufacturing processes.

4.2 Surface Hardness

4.2.1 Location of the required surface hardness and induction or flame hardened depth class must be clearly shown on drawings. Surface hardness will include OD, profile and roots of gear teeth and

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splines unless otherwise specified. See “Designation on Drawings,” and “Appendix – General Design Information” for guidance.

4.2.2 Where the hardening pattern ends, a transition zone of lower hardness may occur, especially in cold worked or prehardened material. If hardness limits in the transition zone are critical, these limits must be negotiated between the supplier and product engineering and shown on the drawing.

4.3 Gear Teeth – Contour Hardened

Contour hardening of gear teeth is recommended for optimum strength. However, it *not* required unless shown on the drawing. Contour hardening may require preheat, particular induction frequencies, special quenches or steel hardenabilities which may be expensive or not readily available. See “Appendix – General Information” for further discussion. When it is required the drawing will read “contour hardening required.” This notation requires that a hardness traverse from the OD through the center of the tooth taken on a cross section midway between faces will not exceed Rockwell C 50 at the percent of the whole depth of tooth as shown in Table II on page 4. If the percent of the whole tooth depth is exceeded for 4.5 to 6.0 diametral pitch gears, the gears must be shot peened to an intensity of 0.010-0.014 A, 100% coverage, S-230 shot with a hardness of Rockwell C 58-62. In no case will the hardened depth exceed 110% of the tooth height.

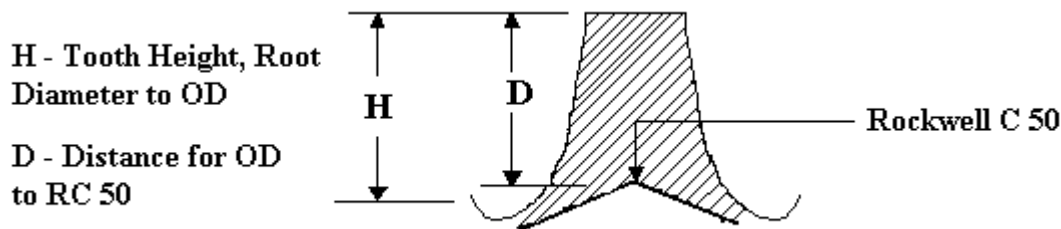


TABLE II
GEAR TEETH CONTOUR HARDENING LIMITS

Diametral Pitch	Pressure Angle, Degrees	Max % of Whole Tooth Height $\frac{D}{H} \times 100$
2.5	25	66
4.5	25	76
5.0	25	85
5.5	25	93
6.0	20	98

4.3.1 Other contour patterns may be shown on the drawing as required. See “Appendix – General Information” for discussion.

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4.4 Supplemental Heat Treatments

It may be desirable to quench and temper prior to flame or induction hardening. This must be specified on the drawing if required.

4.4.1 Tempering after induction or flame hardening will be shown on the drawing if required. Furnace tempering will be used unless otherwise specified.

4.4.2 Some applications may require induction or flame hardening of a previously carburized surface.

4.5 Microstructure

Microstructure of hardened areas will be grain size number 5 or finer per ASTM E112 and will be essentially martensite or tempered martensite at the surface with no ferrite. Grain size requirements do not apply in low stress areas such as most external corners. There will be no signs of grain boundary melting.

4.6 Prototype Parts

Hardened test parts must be produced by methods which will produce the same strength and residual stress gradients as those which will be used in production. Thus engineering should consult with manufacturing and be aware of the processes available. Blast cleaning may be substantially increase fatigue strength. Therefore blast cleaning should not be used for test parts unless it will also be required for production parts.

5.0 QUALITY

All product supplied shall be clean and free from scale, dirt, oils, sharp edges, or defects harmful to product performance. The supplier should be capable of providing statistical evidence that the product supplied has been produced using manufacturing processes which are in statistical control and are competent to meet the requirements of this specification

6.0 QUALIFICATION

Engineering qualification of sources is required in advance of production shipments. Samples shall be accompanied by test data certifying that all requirements of the specification have been met.

6.1 Quality Control Plan

A Quality Control Plan for products supplied to the requirements of this specification will be established by mutual agreement between NAVISTAR and the supplier. Characteristics for inclusion in the control plan may be specified on the engineering drawing and/or purchase order. Features for management by statistical process control are subject to NAVISTAR Engineering Design Standard A-16.

6.2 Methods of Test

6.2.1 Location Of Measurement

Measurement of surface hardness will be made on one or more significant surfaces of the finished part, or as shown on the drawing.

6.2.2 Case Depths

Make a series of microhardness impressions across the case on a polished and unetched section perpendicular to the hardened surface, using a properly calibrated microhardness tester. Space the microhardness impressions so that they are not distorted by adjacent impressions or by the surface. Using loads of 4.9 or 9.8N (0.5 or 1.0 kgf), spacings of 0.13 mm (0.005 inch) have been found

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satisfactory. Closer spacing may be obtained, if necessary, by two or more traverses of impressions at staggered distances from the surface.

6.2.2.1 When the desired traverse has been completed, convert to the nearest whole number of the Rockwell C scale per ASTM E140 Table 1. Plot the hardness values against their depth from the surface, draw a curve and determine the depth at which the curve crosses the Rockwell C 40 or other specified hardness level. This is the case depth.

6.2.2.2 Knoop or Vickers microhardness indenters are to be used for these evaluations. The usage of other indenters must be approved by the controlling International facility. It is the producer's responsibility to establish correlation between the method used and the specified method.

6.2.3 Other Methods Of Case Depth Measurement

The method described above will be used for determining if the case depth of a finished part conforms to the specification on the drawing.

6.2.3.1 For production control it may be desirable to use other methods for measuring case depth, at the discretion of the producer. However, it is the producer's responsibility to establish correlation between the method employed and the method specified above.

7.0 SOURCE APPROVAL AND QUALITY CONTROL

7.1 Supplier Requirements

All suppliers to NAVISTAR are required to be registered to ISO 9001 Quality System Requirements. NAVISTAR will also accept TS-16949 registration as long as the supplier can also fulfill all AIAG PPAP (Production Part Approval Process) documentation and approval requirements. Suppliers must maintain their certification with an accredited registrar and must furnish copies of registration certificates to their Corporate Buyer upon request.

7.2 Approval

Parts supplied against contracts or purchase orders citing this specification shall be equivalent in all respects to those samples which were approved by the purchaser. No changes in formulation or processing practices are permitted without approval. In the event that changes in material, properties, processing practices, construction, color, or labeling of the product are required, the supplier shall notify NAVISTAR Materials Engineering and Purchasing and Supplier Development of the proposed change(s). Test data indicating conformance to all requirements of this specification, test samples, and new or amended or updated Material Safety Data Sheet(s) (MSDS), in accordance with CFR Title 29, Part 1910 shall be submitted with the request for change.

7.3 Process Control

The supplier shall either perform and report results of tests on specific lots of parts produced using ISO 9001 or TS-16949 guidelines, or provide statistical evidence of the lot having been produced in a state of statistical control and with a process capable of providing all required properties. The part supplier and the quality control manager of the using NAVISTAR plant may determine testing and reporting requirements on specific products.

8.0 SHIPPING AND HANDLING

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