MiSUMi®
Configured to Save Time™

NAAMS LOCATING PINS

HARDNESS TESTING

Developed by: The MISUMI Automotive Business Development Team
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CONTENTS

Introduction

Material surfaces can wear over time due to the application environment. To combat this, heat treatment is often specified to increase resistance to wear and increase life. For locating pins, many applications will require surface to surface contact of steel and aluminum workpieces therefore it is important for the pin to have a high surface hardness. This surface hardness is key to resist wear and premature failure.

A major North American automotive manufacturer approached MISUMI with their situation. They found that the NAAMS locating pins on their tooling were failing prematurely despite having been purchased to the proper hardness specification. It seemed as though the hardness of the pins were not up to the NAAMS specification.

To validate this claim, testing was performed on 3 different samples taken from the production tooling along with a MISUMI standard configurable as a baseline comparison. These tests included

- Surface hardness
- Case depth by optical method
- Effective case depth by microhardness
- Grain size measurement
- Cross section micrograph
- Chemical analysis

All tests were carried out by an independent, A2LA accredited laboratory.

Sample Identification

From left to right: 1-A, 2-B, 3-C, and 4-D

Sample ID	Part Number	Description	Manufacturer
1-A	ARP132M	NAAMS std.	Company T*
2-B	ARP134M	NAAMS std.	Company T*
3-C	1234567	Custom detail	Unknown
4-D	APFSPBB-D15.8-A25.4-KE	Configurable std.	MISUMI

*Company T is a NAAMS Standard Manufacturer

Specifications

It is important to note the NAAMS and MISUMI hardness, material, and dimensional specifications for comparison and reference before the tests are run.

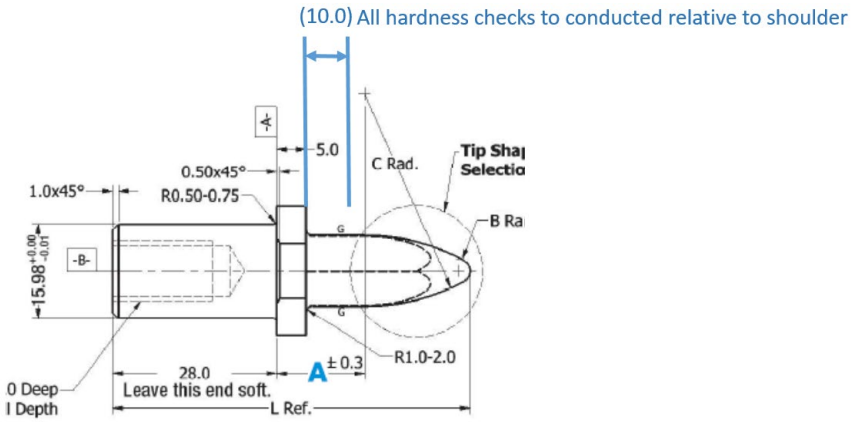
Hardness & Material

Sample	Material	Hardness
1-A	S.A.E 8620 Steel	58 - 62 Rc to a depth of 0.5-0.7mm after grinding
2-B	S.A.E 8620 Steel	58 - 62 Rc to a depth of 0.5-0.7mm after grinding
3-C	8620 Steel	58 - 62 Rc to a depth of 0.5-0.7mm after grinding
4-D	8620 Alloy Steel	Carburized 58~ 62 HRC (Depth 0.5-0.7 after grinding)

Results

Surface Hardness

Surface Hardness testing was performed 10mm from the shoulder of the pin. The method used was Rockwell 15N then converted to HRC.



Sample ID	Results HR15N			Average
1	90.5	91.5	91.5	91.2
2-Raw	83.0	83.0	83.5	93.2
2-Corrected*	83.3	83.3	83.8	83.4
3**	71.5	70.0	70.0	70.5
4	91.0	91.0	91.0	91.0

*Corrected for Convex Cylindrical Surfaces as noted in ASM E18-2016, Table A6.3. Results are approximate only. Samples 1, 3, and 4 do not require corrections due to either Results or Size.

Note: All impression s were taken within 10 mm of shoulder as noted on customers supplied drawing
**Sample 3 did not have a shoulder. Impressions take within 10mm of edge of body.

Sample ID	Results Converted to HRC			Average	Pass/Fail
1	60.9	63.3	63.3	62.5	✓
2-Raw	44.9	44.9	45.9	45.3	✗
2-Corrected*	45.4	45.4	46.4	45.8	✗
3**	23.8	21.1	21.1	22.0	✗
4	62.1	62.1	62.1	62.1	✓
All conversions done in accordance with ASTM E140-12b					

KEY FINDING: SAMPLE 1 (NAAMS Standard) and SAMPLE 4 (MISUMI) AVERAGED THE SAME HRC COMPARED TO THE OTHER SAMPLES.

Results

Case Depth Testing

The thickness of the hardened layer on the component is called the case depth. Testing the case depth verifies that the component underwent the carburizing heat treatment in the manufacturing process.

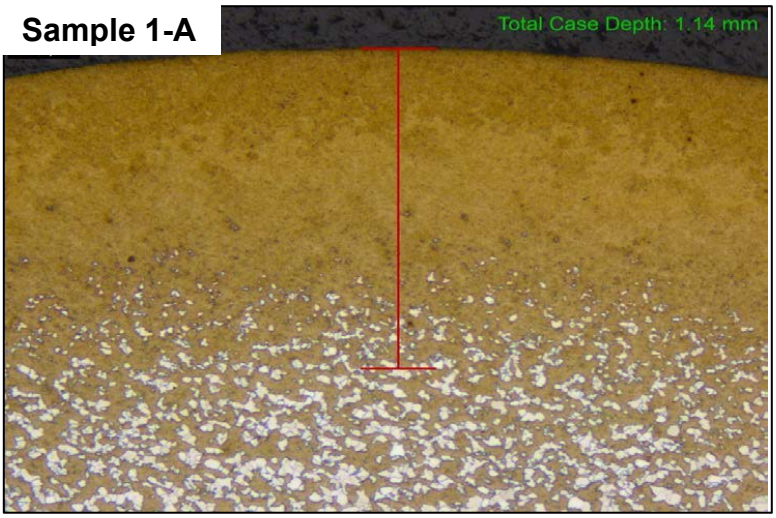
In the NAAMS standard, case depth is specified between 0.5mm and 0.7mm. Two types of case depth testing were performed: Optical and Vickers Microhardness.

Part 1: Optical

Optical case depth testing measures the depth from a visual standpoint using a microscope. It measures the total case depth.

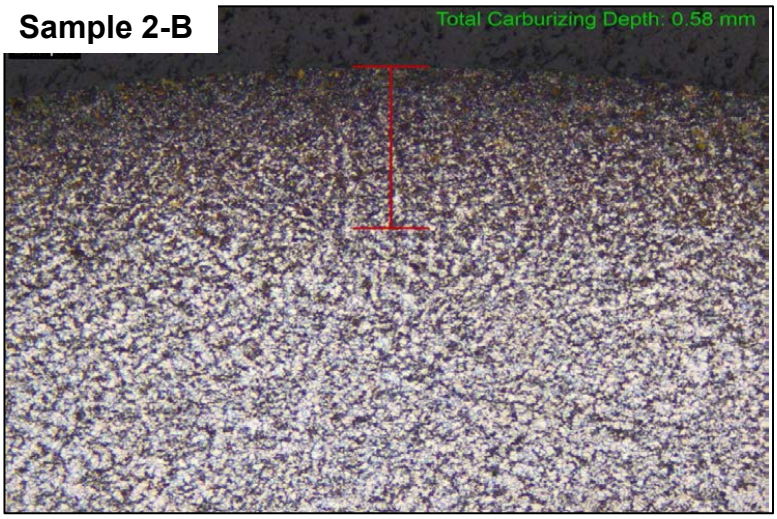
The measurement standard is the distance measured perpendicularly from the surface of the hardened or unhardened case to a point where the differences in chemical or physical properties of the case and core no longer can be distinguished.

Sample 1-A



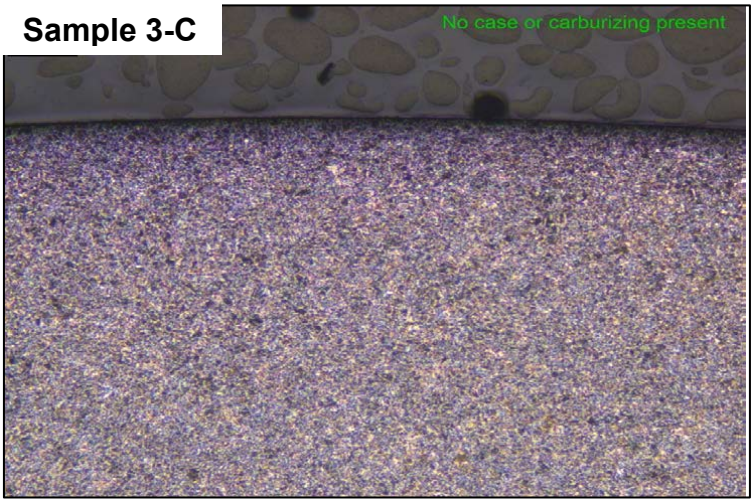
There is a clear boundary between core and case.
(Ref: avg. surface hardness 62.5HRC)

Sample 2-B



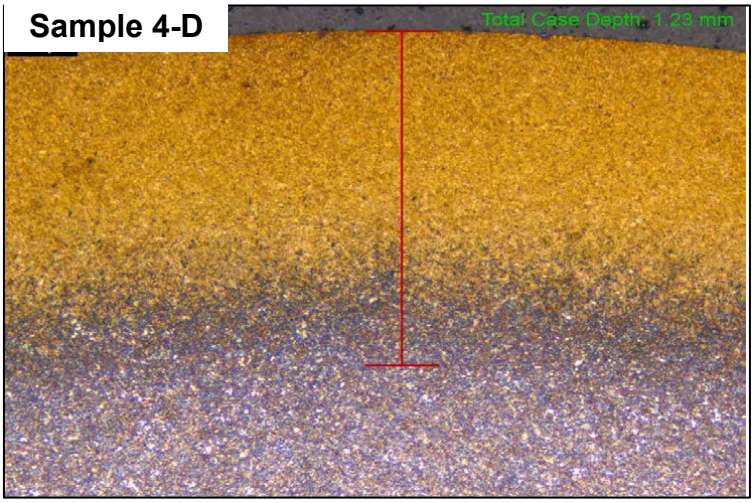
No developed case. Darker areas are carbon. White areas are ferrite. Part appears to have been carburized but not quenched as evidenced by darker shades near the surface and the amount of ferrite present.
(Ref: avg. surface hardness 45.8HRC)

Sample 3-C



No case or carburizing present.
(Ref: avg. surface hardness 22HRC)

Sample 4-D



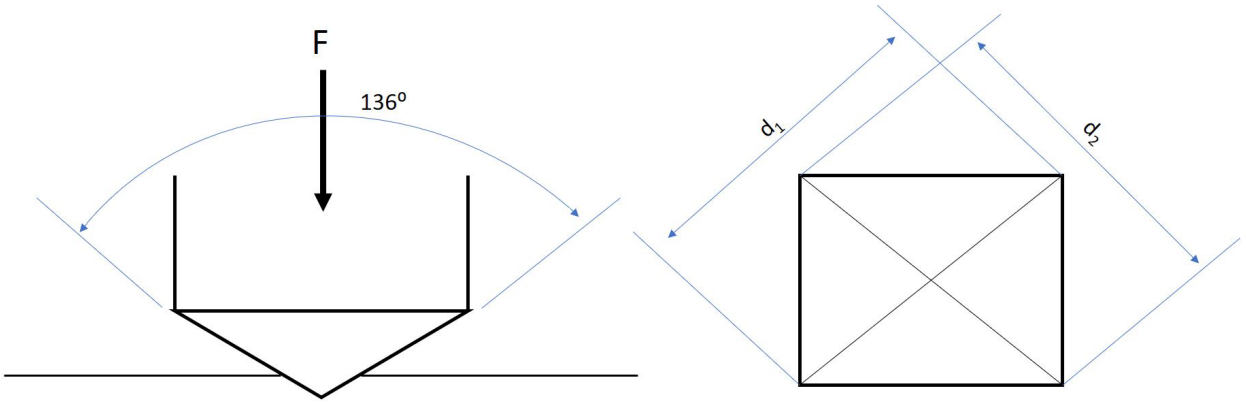
Clearly developed and distinguishable core/case boundary.
(Ref: avg. surface hardness 62.1HRC)

Part 2: Vickers Microhardness Test

Vickers Microhardness: The method of hardness testing to determine a material's resistance to penetration. It can provide details about the material's surface.

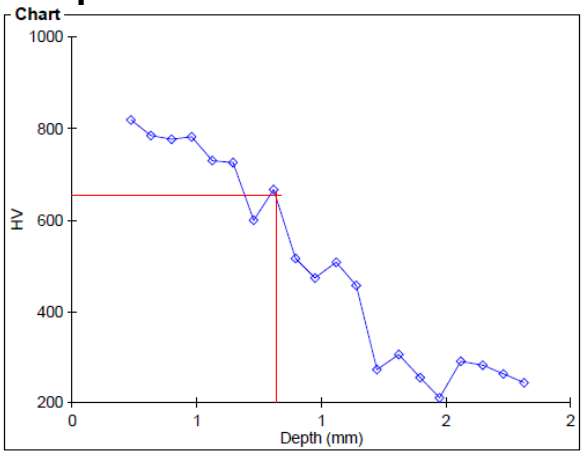
Vickers Microhardness tests for effective case depth (Eff.) which is the point at which the hardness measurement drops below a stated specification. In other words, it tests for whether it meets the hardness specifications in which it was manufactured in.

It utilizes an indenter probe to penetrate the surface of the material with a light load (under 10 N). A microscope is used to measure the indentation and the hardness is measured as the average stress applied. For the Vickers test, the shape of the indenter is diamond and the formula as below.



$$HV = \frac{2F \sin\frac{136°}{2}}{d^2} = 1.854\frac{F}{d^2}$$

Sample 1-A



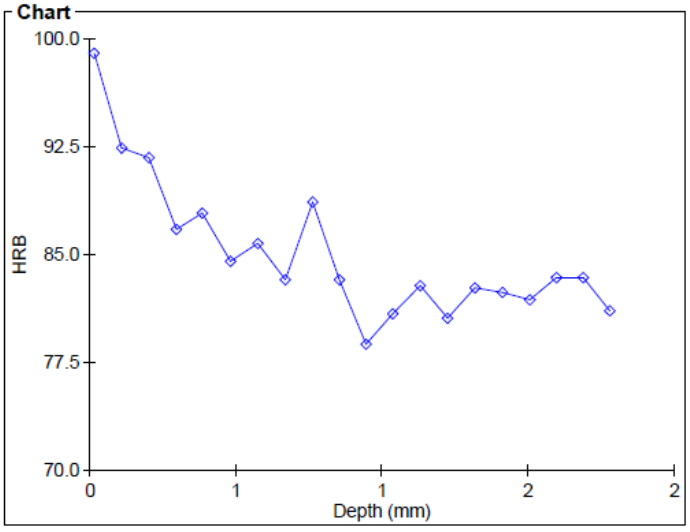
Sample Statistics

Minimum:	212 HV	
Maximum:	820 HV	
Count:	20 of 20	
	Hardness	Depth
Eff.	58.0 HRC (653 HV)	1.0 mm

Field #	Hardness HRC (HV)	Depth mm
1	64.6 (820)	0.284
2	63.5 (785)	0.382
3	63.2 (777)	0.481
4	63.4 (782)	0.578
5	61.4 (731)	0.676
6	61.2 (726)	0.775
7	55.3 (600)	0.876
8	58.7 (667)	0.974
9	50.2 (516)	1.078
10	47.2 (473)	1.171
11	49.7 (508)	1.273
12	45.9 (457)	1.369
13	26.1 (273)	1.471
14	30.5 (306)	1.577
15	23.3 (256)	1.677
16	(212)	1.772
17	28.6 (291)	1.875
18	27.5 (283)	1.979
19	24.7 (264)	2.079
20	21.2 (244)	2.178

The spikes indicate a non-homogenous structure.
The results highlighted in red show that this sample has a deeper hardness depth than the specifications listed previously.

Sample 2-B



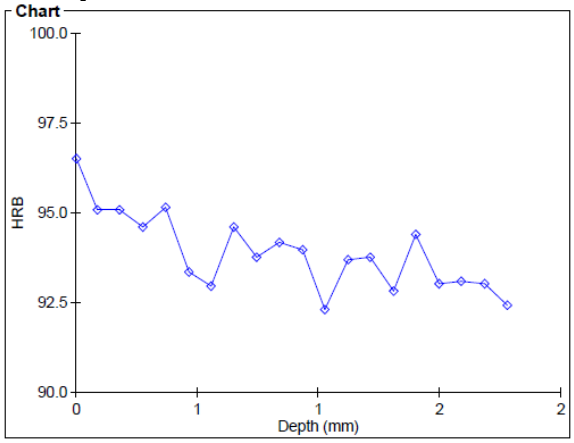
Sample Statistics

Minimum:	78.8 HRB	(146 HV)
Maximum:	99.0 HRB	(234 HV)
Count:	20 of 20	
	Hardness	Depth
Eff.	* (653 HV)	[out of range]

Field #	Hardness HRB (HV)	Depth mm
1	99.0 (234)	0.279
2	92.4 (197)	0.379
3	91.7 (194)	0.479
4	86.8 (171)	0.578
5	87.9 (176)	0.675
6	84.5 (164)	0.776
7	85.8 (168)	0.876
8	83.2 (160)	0.977
9	88.7 (179)	1.077
10	83.2 (160)	1.175
11	78.8 (146)	1.273
12	80.9 (153)	1.372
13	82.8 (159)	1.471
14	80.6 (152)	1.571
15	82.7 (158)	1.671
16	82.4 (157)	1.772
17	81.8 (156)	1.872
18	83.4 (160)	1.970
19	83.4 (160)	2.069
20	81.1 (153)	2.167

The results in this sample show that hardness specifications do not match and confirm the results from the Optical method This is likely due to increased carbon levels at the surface. No hardened case is evident.

Sample 3-C



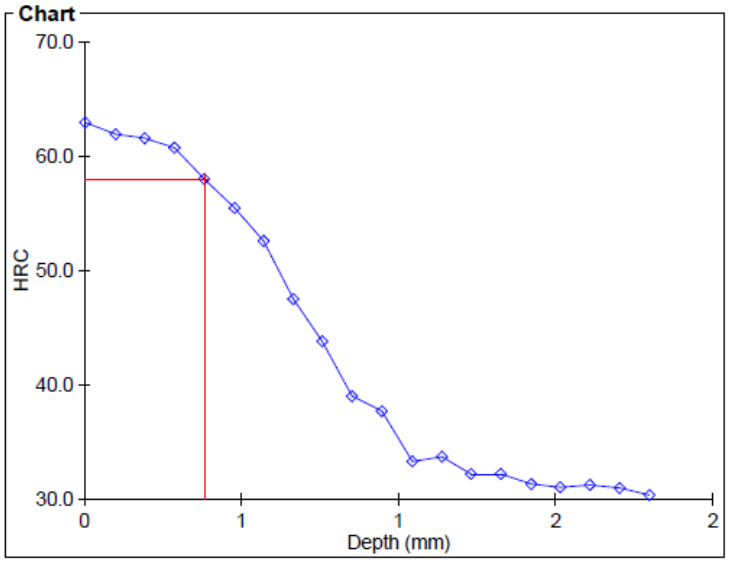
Sample Statistics

Minimum:	92.3 HRB	(196 HV)
Maximum:	96.5 HRB	(219 HV)
Count:	20 of 20	
	Hardness	Depth
Eff.	* (653 HV)	[out of range]

Field #	Hardness HRB (HV)	Depth mm
1	96.5 (219)	0.285
2	95.1 (211)	0.376
3	95.1 (211)	0.473
4	94.6 (208)	0.573
5	95.1 (211)	0.673
6	93.4 (202)	0.775
7	93.0 (200)	0.872
8	94.6 (208)	0.971
9	93.8 (204)	1.070
10	94.2 (206)	1.172
11	94.0 (205)	1.272
12	92.3 (196)	1.370
13	93.7 (204)	1.471
14	93.8 (204)	1.569
15	92.8 (199)	1.671
16	94.4 (207)	1.769
17	93.0 (200)	1.871
18	93.1 (200)	1.967
19	93.0 (200)	2.067
20	92.4 (197)	2.168

The results in this sample show that hardness specifications do not match and confirm the results from the Optical method This is likely due to increased carbon levels at the surface. No hardened case is evident.

Sample 4-D



Sample Statistics

Minimum:	30.4 HRC	(305 HV)
Maximum:	63.0 HRC	(772 HV)
Count:	20 of 20	
	Hardness	Depth
Eff.	58.0 HRC (653 HV)	0.7 mm

Field #	Hardness HRC (HV)	Depth mm
1	63.0 (772)	0.285
2	62.0 (745)	0.387
3	61.6 (735)	0.485
4	60.8 (715)	0.586
5	58.0 (653)	0.686
6	55.5 (603)	0.788
7	52.6 (554)	0.887
8	47.6 (478)	0.985
9	43.9 (432)	1.084
10	39.0 (382)	1.185
11	37.7 (369)	1.286
12	33.3 (330)	1.387
13	33.7 (334)	1.488
14	32.3 (320)	1.587
15	32.3 (320)	1.687
16	31.4 (313)	1.788
17	31.0 (310)	1.887
18	31.3 (312)	1.987
19	31.0 (310)	2.087
20	30.4 (305)	2.188

KEY FINDING: These are perfect results! The smooth curve of the graph indicates a homogenous microstructure. The hardness and depth resuts conform to the hardness specifications listed above. The effective case depth results from the Optical resultsare proven correct.

Grain Size

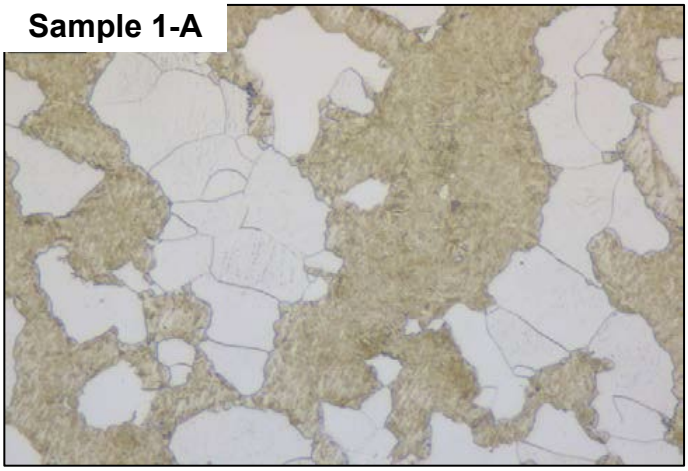
For further evidence of resistance to wear, grain size measurements should be examined. Generally, the smaller the grain size the greater resistance to cracking and may lead to better wear characteristics. In the chart below, the smaller number represents a larger grain size.

Sample 1		Sample 2		Sample 3		Sample 4	
100x	Grain Size	200x	Grain Size	500x	Grain Size	500x	Grain Size
1	7.5	1	10.0	1	11.6	1	10.6

Cross-Sectional Micro Examination

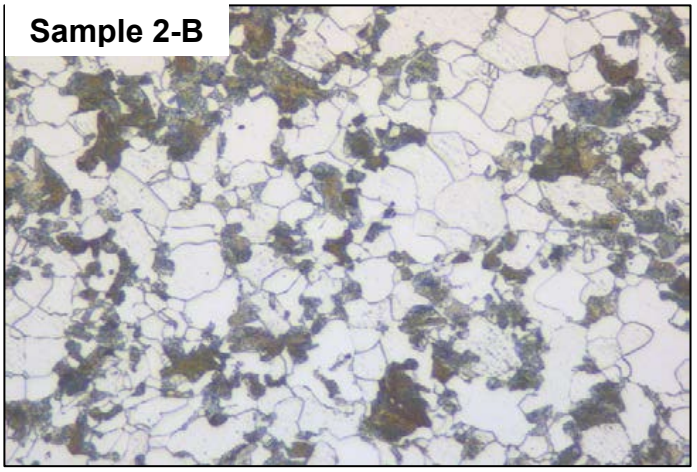
This examination views the structure and color of each sample. It also reveals the quality of the material under a microscope.

Sample 1-A



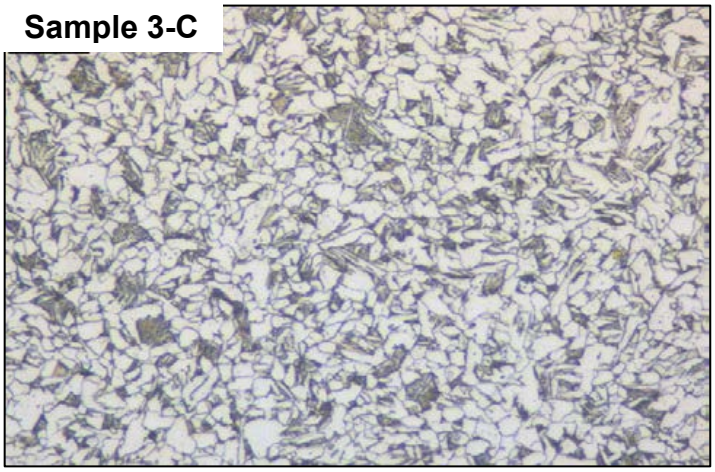
Microstructure consists of a ferrite matrix (white)with bulky fine martensite grains (brown) Large grains size-may be prone to micro cracking. Martensite will lead to better wear resistance.

Sample 2-B



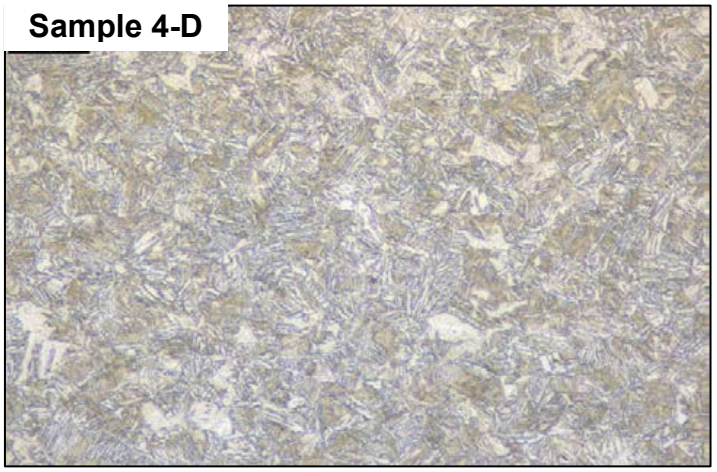
Microstructure consists of a ferrite matrix (white) and medium to fine lamellar pearlite (dark areas). No martensite present, indicating that this sample is in an annealed condition.

Sample 3-C



Microstructure consists of a ferrite matrix (white) with decomposed pearlite (dark areas) and some spheroidized iron carbide particles (small black dots). No martensite present. Likely annealed to some degree.

Sample 4-D



Microstructure consist of lath martensite. Martensite is uniform and homogeneous for increased wear resistance. Small grain size leads to increased toughness, less prone to micro cracking

Chemical Analysis

While this analysis does not identify the alloy specification, it does measure the conformance to the SAE specification to 8620 alloy.

Sample 3-C the alloy is unknown, but does not meet requirements for 8620. This sample contained low levels of critical elements affecting hardenability.

Element	AMS6274 (SAE 8620)		Sample Result			
	Low	High	1-A	2-B	3-C	4-D
Carbon	0.17	0.23	0.212	0.211	0.200	0.219
Manganese	0.60	0.95	0.761	0.744	0.659	0.749
Silicon	0.15	0.35	0.207	0.237	0.175	0.255
Phosphorous	-	0.025	0.010	0.015	0.009	0.017
Sulfur	-	0.025	0.005	0.021	0.026*	0.014
Chromium	0.35	0.65	0.630	0.546	0.100	0.486
Nickel	0.35	0.75	0.515	0.477	0.053	0.476
Molybdenum	0.15	0.25	0.187	0.190	0.014	0.149*
Copper	-	0.35	0.072	0.071	0.219	0.113
Compliance Result			Meets	Meets	Does Not Meet	Meets

Critical hardening elements

*Within variation limits

CONCLUSION

Sample 1-A meets hardness and alloy requirements but has issues relating to microstructure. Samples 2-B & 3-C do not meet NAAMS standard specifications for hardness and have issues relating to microstructure. Sample 3-C does not meet chemistry requirements for 8620. Lastly, Sample 4-D meets all standards for hardness and chemistry as well as exhibits a preferred microstructure. The below chart shows an overview of the results of each test. In conclusion, it appears that MISUMI's manufacturing of NAAMS locating pins adheres to the NAAMS standard. Additionally, it is expected that the MISUMI locating pin will exhibit improved wear resistance due to its developed microstructure. The results are evidence that not all NAAMS components are manufactured equally.

Test	1-A Company T	2-B Company T	3-C Unknown	4-D MISUMI
Surface Hardness	62.5	45.8	22	62.1
Case Depth: Optical	✓	✗	✗	✓
Case Depth: Vickers Microhardness	—	✗	✗	✓
Grain size	—	✓	✓	✓
Micrograph	—	✗	✗	✓
Chemistry	✓	✓	✗	✓

THANK YOU!
For more information, contact:
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