



METALLURGICAL TEST REPORT

Ref. D143056

Date: August 21, 2009

Page 1 of 7

Zack Bishop
Test Engineering, Inc.
12718 Cimarron Path
San Antonio, TX 78249-3423

Purchase Order #: 14062

Test Procedure

Hardness	<input checked="" type="checkbox"/>	Material: Cast Iron
Case Depth	<input type="checkbox"/>	
Microstructure	<input checked="" type="checkbox"/>	Specifications: None provided
Coating Thickness	<input type="checkbox"/>	
Grain Size	<input type="checkbox"/>	
Other	<input type="checkbox"/>	

Test Results

Part Identification	Quantity	Results	Remarks
Cylinder Sleeves		<u>Average Hardness</u>	
Sample A	1	48 HRC	Hardness tested per ASTM E 18-08.
Sample B	1	45 HRC	Samples prepared per ASTM E 3-01(07).
<p>The microstructures are shown in Figures 1 through 6. Sample A consisted of Type VII A and E graphite in a martensitic matrix with steadite and carbides. Sample B consisted of Type VII A, D, and E graphite in a martensitic matrix with steadite.</p>			



Prepared by: _____ Erin Gilligan, E.I.T.
Metallurgist

Approved by: _____ Joseph Maciejewski, P.E.
Group Manager

This report may not be reproduced except in full. This report represents interpretation of the results obtained from the test specimen and is not to be construed as a guaranty or warranty of the condition of the entire material lot.



METALLURGICAL TEST REPORT

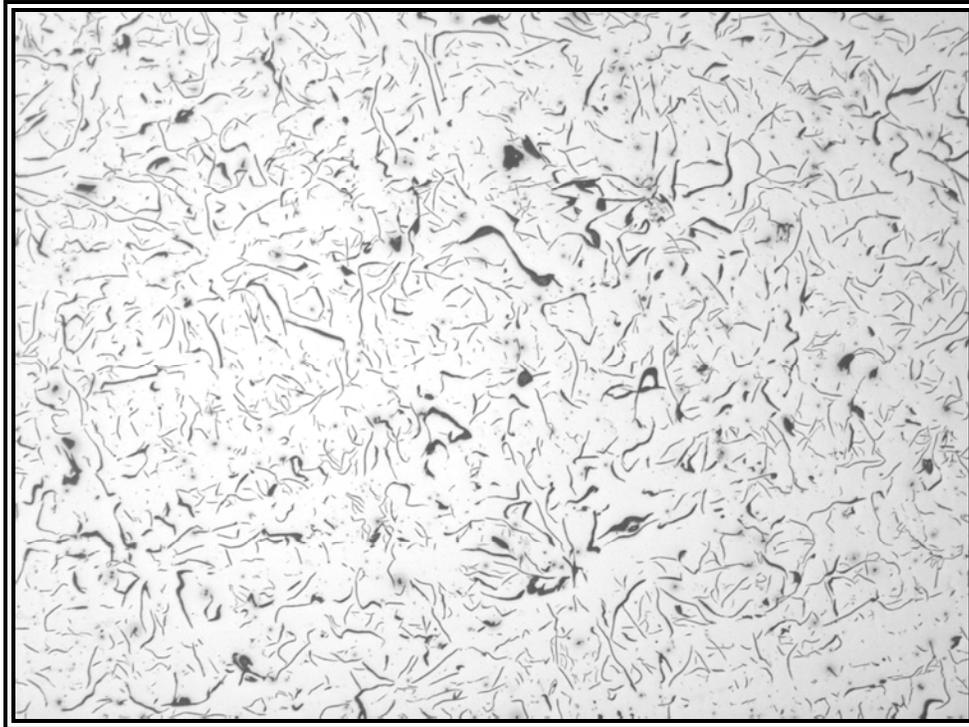
Ref. D143056

Date: August 21, 2009

Page 2

of

7



As-polished

Magnification: 50X

Figure 1: Micrograph showing Type VII A and E graphite of Sample A



METALLURGICAL TEST REPORT

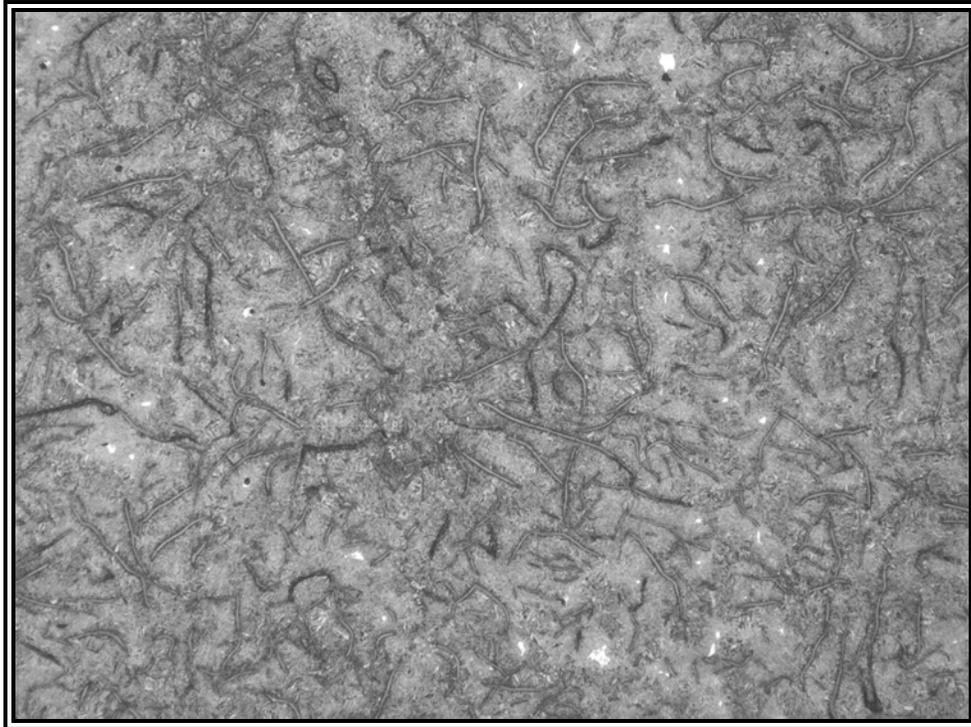
Ref. D143056

Date: August 21, 2009

Page 3

of

7



Etchant: Nital

Magnification: 100X

Figure 2: Micrograph Sample A after etching with Nital

METALLURGICAL TEST REPORT**Ref.** D143056**Date:** August 21, 2009**Page** 4**of**

7



Etchant: Nital

Magnification: 1,000X

Figure 3: Microstructure of Sample A consisted of a martensitic matrix with islands of steadite (arrows) and carbides (encircled)



METALLURGICAL TEST REPORT

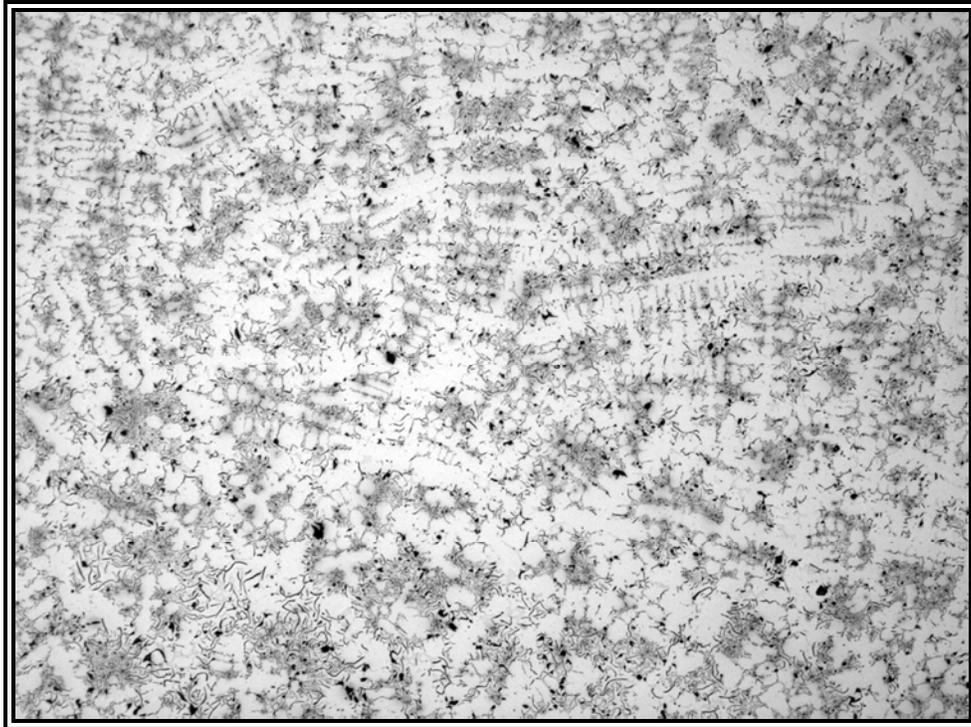
Ref. D143056

Date: August 21, 2009

Page 5

of

7



As-polished

Magnification: 50X

Figure 4: Micrograph showing Type VII A, D, and E graphite of Sample B



METALLURGICAL TEST REPORT

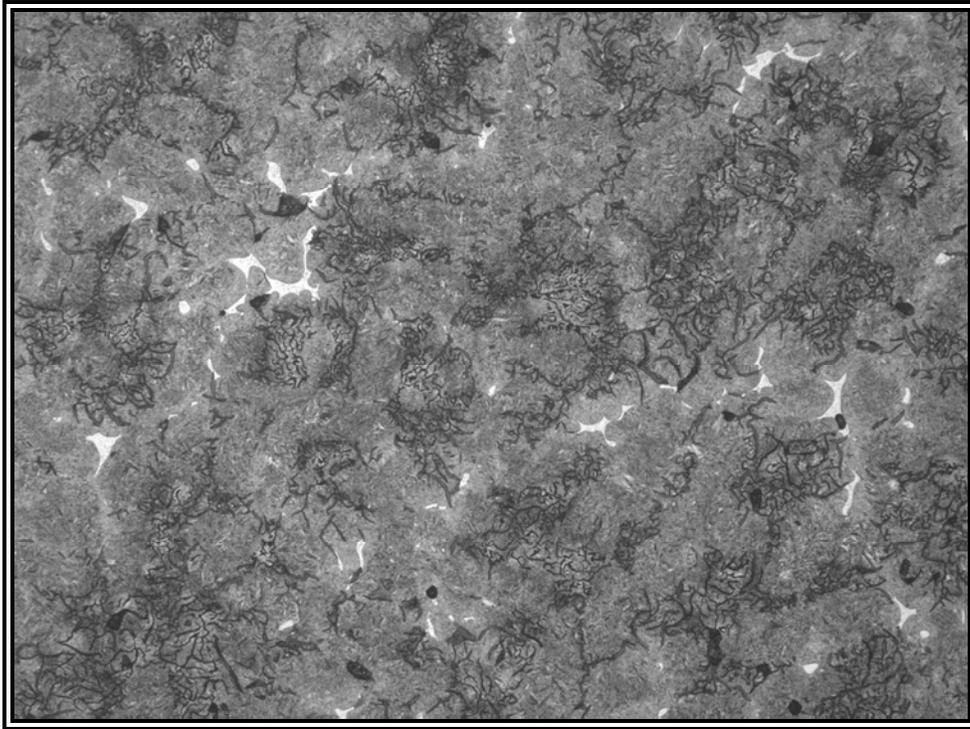
Ref. D143056

Date: August 21, 2009

Page 6

of

7



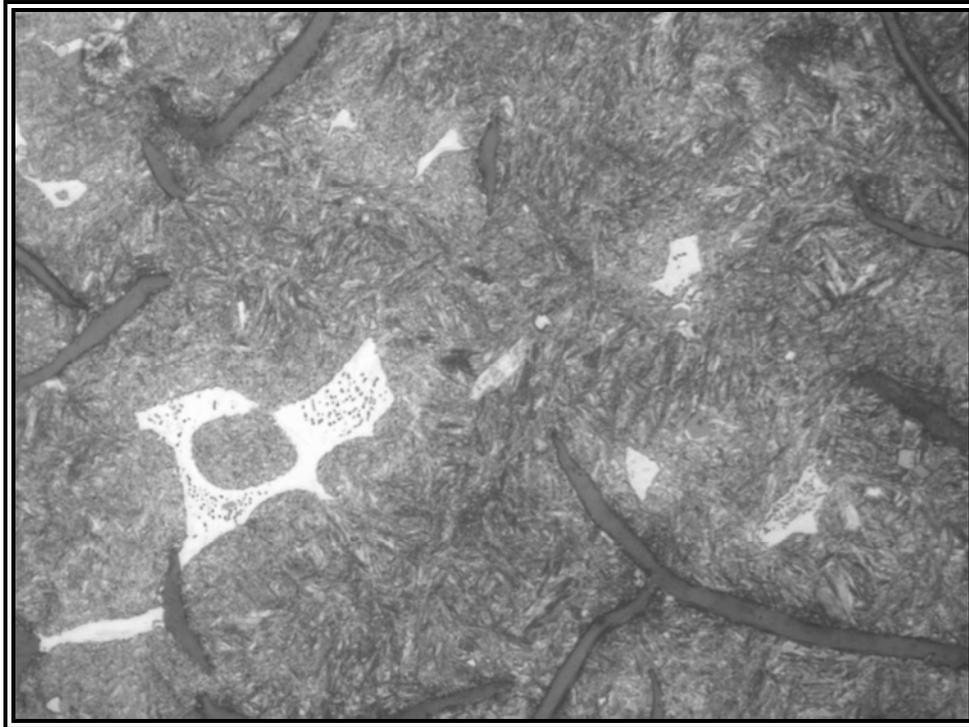
Etchant: Nital

Magnification: 100X

Figure 5: Micrograph Sample B after etching with Nital

METALLURGICAL TEST REPORT**Ref.** D143056**Date:** August 21, 2009**Page** 7**of**

7



Etchant: Nital

Magnification: 1,000X

Figure 6: Microstructure of Sample B consisted of a martensitic matrix with island of steadite (white)