



CONSULTING METALLURGICAL ENGINEERS AND TESTING LABORATORY

October 23, 2019

Harbach Marketing, Inc.
Attn: Mike Henson
218 West Rickey Road
Houston, Texas 77090

By email

Re: 190513 Harbach - Testing of
Lifting Lugs PO HBRM-0364

Dear Mr. Henson:

Pursuant to your purchase order number HBRM-0364, we have completed the testing on the submitted lifting lugs. The results of our analysis follow.

SPECIMENS

Two sizes of lifting lugs were supplied for testing identified as follows:

- A. 4-3/4 Ton Carbon Steel PadEye
- B. 6-1/2 Ton Carbon Steel PadEye



Figure 1

The as-received test samples are shown above. Group A (4-3/4 Ton) is at left, and group B (6-1/2 Ton) at right.

METALLOGRAPHIC EXAMINATION

1. One lug from each group was sectioned through the center to evaluate the forging macro and micro-structures. Examination of the cross sections in the as polished and etched conditions showed no excessive material flow and no edge cracking. The microstructure was composed of fine grained, equiaxed ferrite with some pearlite typical of a low to medium carbon steel.
2. Images of the microstructure are attached in appendix A.

TENSILE TESTING

3. A round, sub-size tensile specimen was removed from each group and tested per ASTM E8. The results are summarized as follows:

Specimen	Tube	0.2% offset Yield Strength [Ksi]	Tensile Strength [Ksi]	Elongation in 1” [%]	Reduction of Area [%]
124-A	A	31.8	60.6	61.6	66.1
124-B	B	39.1	61.9	29.0	64.8

4. The datasheets are attached in Appendix B.

IMPACT TESTING

5. A Set of three Charpy V-notch impact specimens was removed from each group and tested per ASTM E23 at ambient temperature. The results follow:

Group A CVNs Full Size Tested at 70°F			
Specimen	Impact Energy [ft lbs]	Fracture Appearance [% shear]	Lateral Expansion [mils]
1	104	50	87
2	104	60	66
3	106	60	76
Average	105	N/A	76

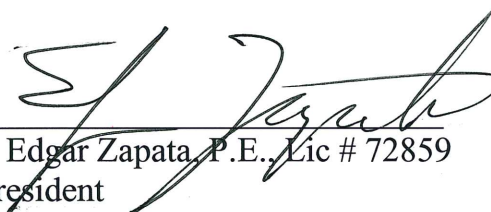
Group B CVNs Full Size Tested at 70°F			
Specimen	Impact Energy [ft lbs]	Fracture Appearance [% shear]	Lateral Expansion [mils]
1	94	60	73
2	87	60	70
3	62	30	57
Average	81	N/A	67

6. If you have any questions, or need any additional information, please let us know. The samples from this investigation will be held through November 30, 2019. If no instructions for sample disposition are received by that date, the samples will be discarded.

Respectfully submitted October 23, 2019.

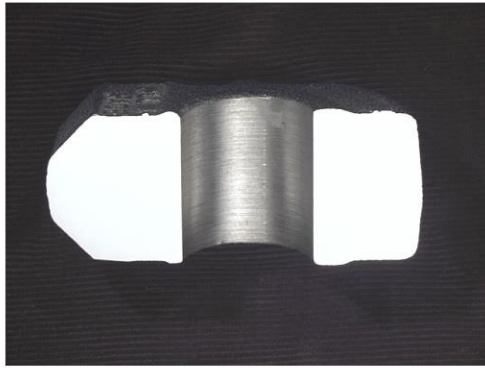
ANDERSON & ASSOCIATES, INC.
Engineering Firm Registration # F-816




J. Edgar Zapata, P.E., Lic # 72859
President

APPENDIX A
Metallography

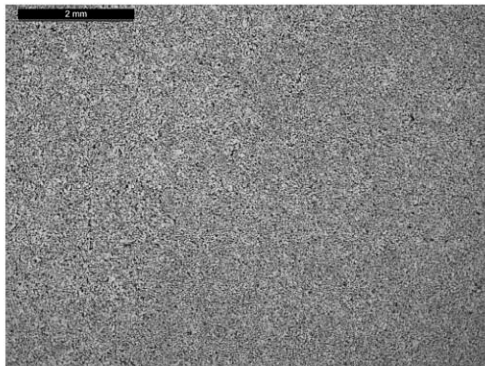
Metallography



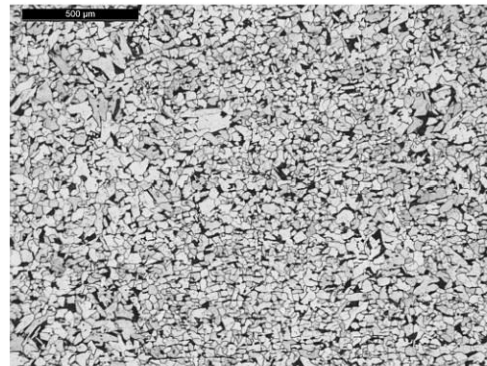
A-1



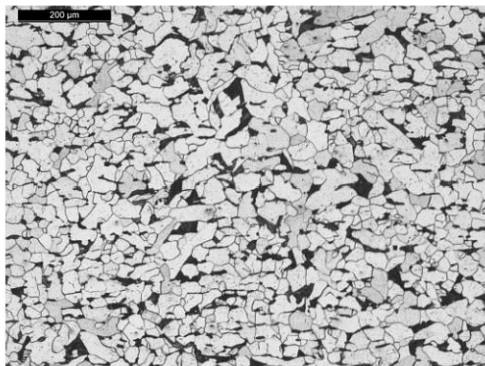
A-1e



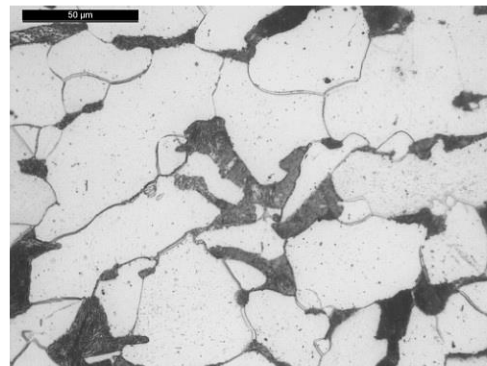
A-2e 12.5x



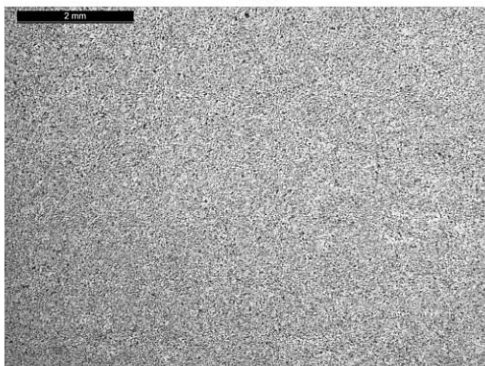
A-3e 50x



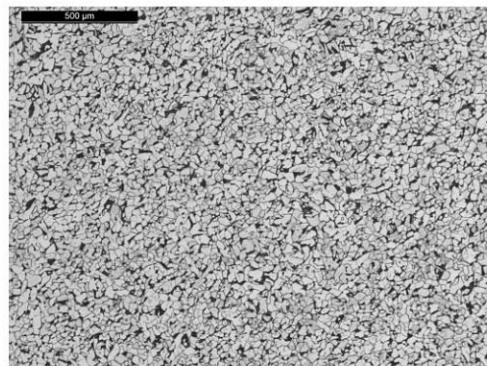
A-4e 100x



A-5e 500x

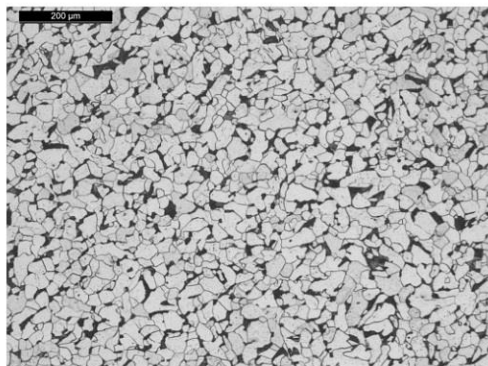


A-6e 12.5x

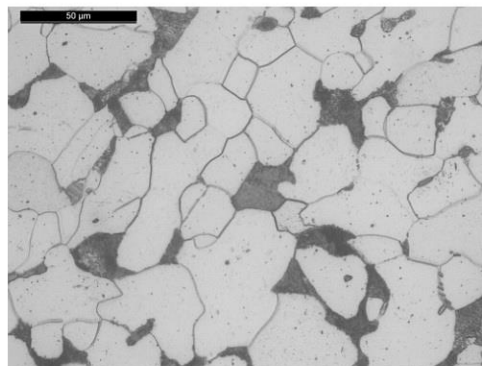


A-7e 50x

Metallography



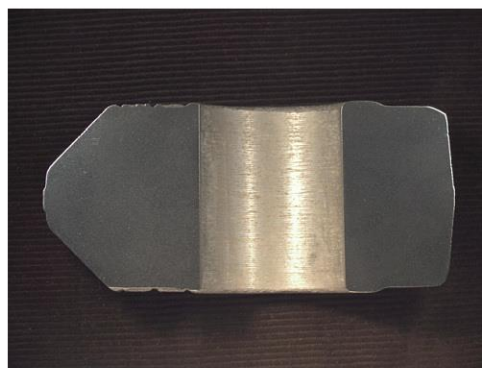
A-8e 100x



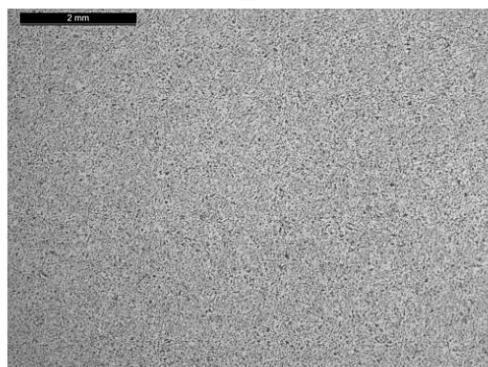
A-9e 500x



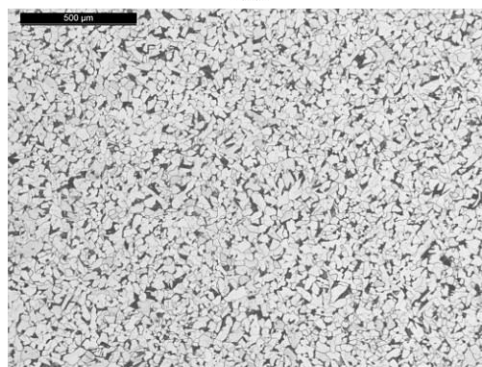
B-1



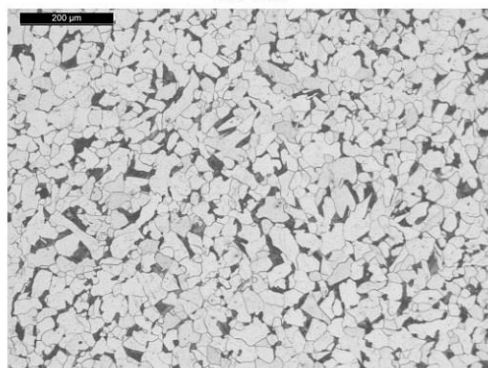
B-1e



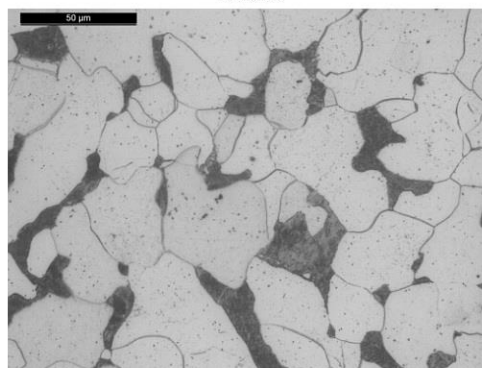
B-2e 12.5x



B-3e 50x

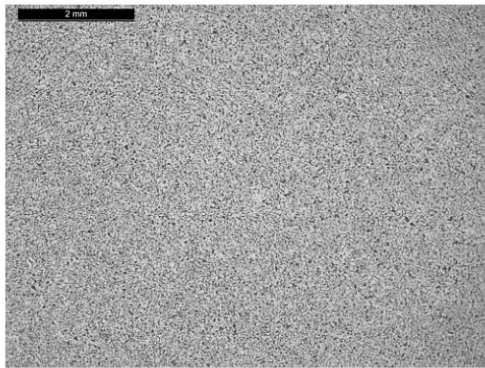


B-4e 100x

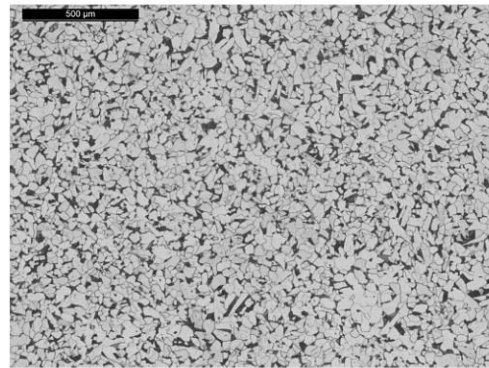


B-5e 500x

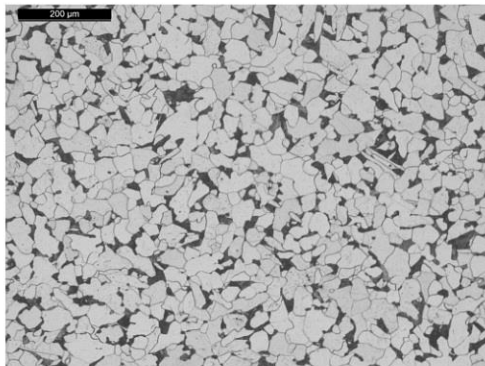
Metallography



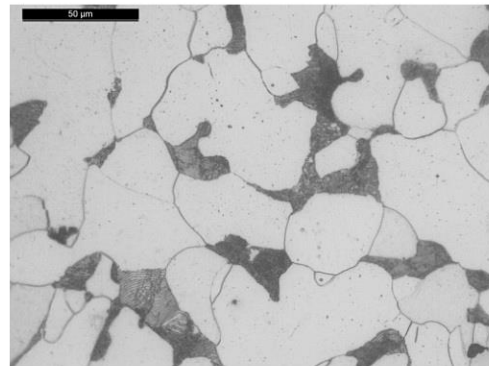
B-6e 12.5x



B-7e 50x



B-8e 100x



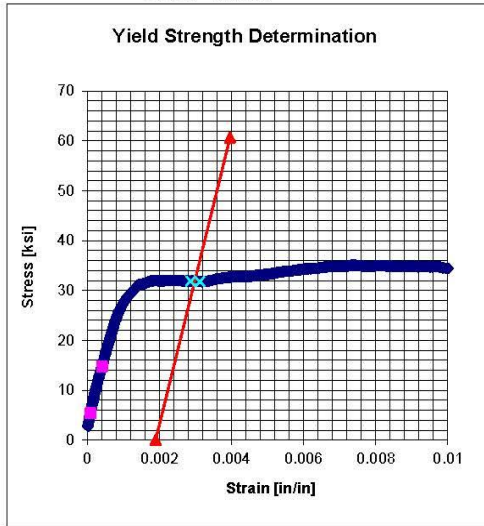
B-9e 500x

APPENDIX B
Tensile Test Data

ANDERSON & ASSOCIATES
 CONSULTING METALLURGICAL ENGINEERS AND TESTING LABORATORY

Specimen: 513-A
 Job #: 190513

Other ID: R/T
 Other ID:
 Other ID:



Tensile Strength Determination per ASTM E8

0.2% Offset Yield Strength [Ksi]	Ultimate Tensile Strength [Ksi]	Elongation [%]	Reduction of Area [%]
31.825	60.648	31.6	66.1

Strain Hardening Exponent per ASTM E646

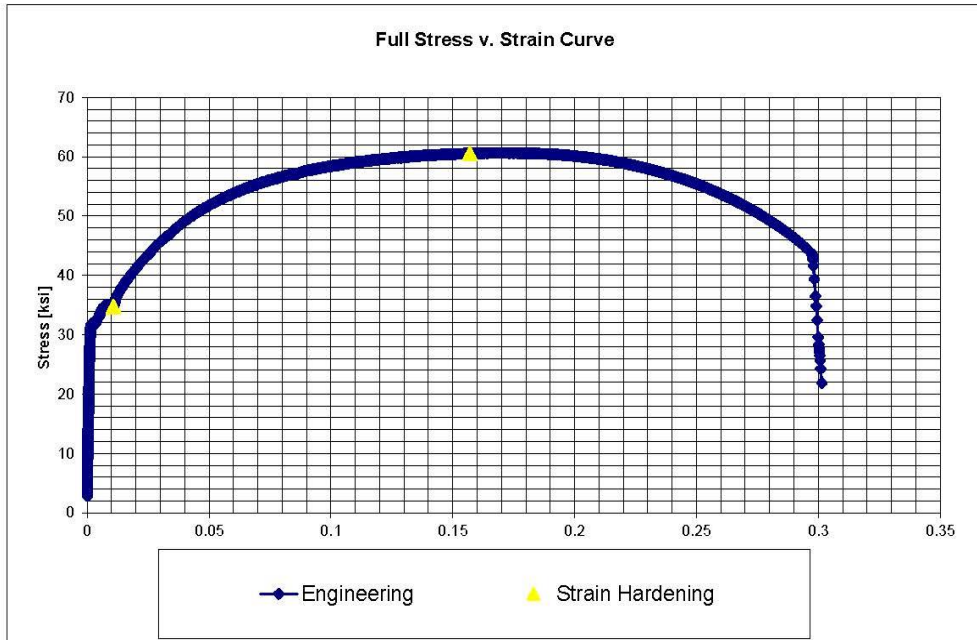
Strain Hardening Exponent n	Strength Coefficient K	Standard Deviation of the n value
0.2597888	117.868803	0.000296616

Ramberg-Osgood Constants

K: 2.75336E+46
 n: 16.57109593
 α: 1.846562292

Estimated Modulus of Elasticity

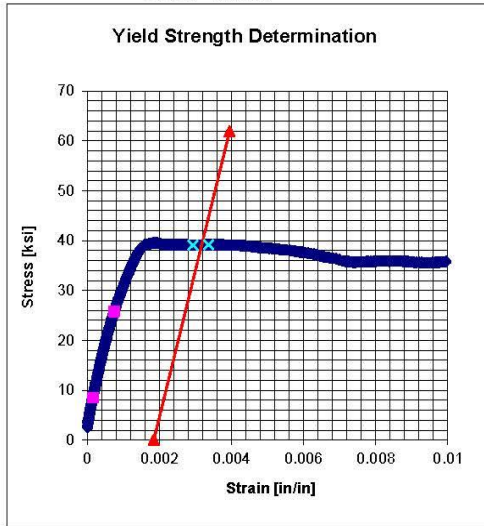
E [Mpsi] 29.383



ANDERSON & ASSOCIATES
 CONSULTING METALLURGICAL ENGINEERS AND TESTING LABORATORY

Specimen: 513-B
 Job #: 190513

Other ID: R/T
 Other ID:
 Other ID:



Tensile Strength Determination per ASTM E8

0.2% Offset Yield Strength [Ksi]	Ultimate Tensile Strength [Ksi]	Elongation [%]	Reduction of Area [%]
39.133	61.861	29.0	64.8

Strain Hardening Exponent per ASTM E646

Strain Hardening Exponent n	Strength Coefficient K	Standard Deviation of the n value
0.2684033	123.295294	0.000344583

Ramberg-Osgood Constants

K: 1.1892E+66
 n: 23.91084671
 α: 1.50420604

Estimated Modulus of Elasticity

E [Mpsi] 29.432

