

26

GA-C24688

APRIL 2004

**TEST REPORT – DIRECT PART MARK TEST PROGRAM
DIRECT PART MARK READER TEST PROGRAM**

**PREPARED
FOR
OO-ALC/LGHEL**

BY

**AGING LANDING GEAR LIFE
EXTENSION PROGRAM**

**PREPARED UNDER
CONTRACT GS-23F-0150L
FOR OGDEN AIR LOGISTICS CENTER
HILL AFB, UTAH**

PROJECT 39135



SIGNATURE PAGE

TEST REPORT – DIRECT PART MARK TEST PROGRAM
DIRECT PART MARK READER TEST PROGRAM

PREPARED
FOR
OO-ALC/LGHEL

BY

AGING LANDING GEAR LIFE
EXTENSION PROGRAM

Prepared: John Coates
John Coates
Mechanical Engineer
General Atomics

Reviewed: Craig Edwards
Craig Edwards
Project Engineer
General Atomics

Approved: T. Walker
Todd Walker
Project Engineer
General Atomics

TABLE OF CONTENTS

INTRODUCTION 1
OBJECTIVES..... 2
TEST PROCEDURES..... 3
 Coupon Tests 3
 Reading Tests..... 3
RESULTS AND DISCUSSION 4
 Results..... 4
 Reader Comparison: Read Success 4
 Reader Comparison: Select Specifications 4
 Operator Training 4
CONCLUSIONS..... 8
RECOMMENDATIONS 9

- APPENDIX A: COUPON DRAWINGS**
- APPENDIX B: COUPON MARK DECODING SUMMARY DATA**
- APPENDIX C: COUPON MARK DECODING DATA**
- APPENDIX D: READER MANUFACTURER SPECIFICATION SHEETS**

INTRODUCTION

Under the Aging Landing Gear Life Extension (ALGLE) Program, a test program was conducted to evaluate two different readers for machine readable marks applied with direct part marking (DPM) processes to aircraft landing gear parts. OO-ALC/LGHEL is working to qualify DPM processes for marking recoverable landing gear parts. The test program was to determine if there are readers from different manufacturers that are able to read marks for landing gear parts.

For the test program, several guidelines were considered. The guidelines were: the reader(s) must be able to read marks applied to landing gear parts, and the reader(s) must be handheld to be practical as an automatic identification and tracking technology in assisting an operator in collecting data directly from landing gear parts in an overhaul environment.

The test program was a research and development effort that addressed several recommendations from previous test programs on the survivability of machine readable marks under normal aircraft landing gear part overhaul conditions. The final reports for the previous test programs were entitled *Direct Part Mark Survivability Test Program for Normal Aircraft Landing Gear Part Overhaul Conditions GA-C24577* and *Improved Direct Part Mark Survivability Test Program for Normal Aircraft Landing Gear Part Overhaul Conditions GA-C24624*. The reports are herein referred to as the previous test programs. The previous test programs identified: that for lifetime traceability, human readable marks outperform machine readable marks, but no single manual or automatic identification and tracking technology is known to provide complete lifetime traceability; that dot peen, micro mill, and deep laser engrave marks with mark cells that have radii, draft angles, and spacing are robust marks; that a minimum depth for mark survivability with reasonable process controls is 0.003in; and that a sufficient depth range for mark survivability is 0.003in to 0.009in. The previous test programs recommended a mark and materials characterization to qualify a new DPM process. The previous test programs recommended development and implementation of a serial number tracking system with labels as the primary interface and marks applied with DPM processes as the secondary interface. The marks applied with DPM processes would require several process controls and would be used to audit part traceability at *Evaluation and Inspection (E&I)* in a normal landing gear part overhaul process. Finally, the previous test programs recommended development and testing of readers and mark enhancements with performance requirements that encourage reader competition. Performance requirements and reader competition are important since they may enable the Department of Defense or the USAF to successfully require machine readable marks within the constraints of the current logistics and procurement policies. The focus of the current test program is a reader evaluation. The test program was limited, by schedule and economic constraints, to two commercially available readers for marks applied with DPM processes. The two readers were the RVSI MXi handheld reader and the Microscan Quadrus handheld reader.

The test program did not consider the full complexity of a reader evaluation. The test program focused on the ability to decode marks on coupons representative of landing gear parts and materials. The test program only briefly reviewed size, weight, durability, connectivity, portability, and cost issues for the readers. The test program did not consider the full complexity of a reader evaluation, but the test program was a necessary requirement to review the technology and to provide a data package to assist in the decision making processes.

OBJECTIVES

The objective was to evaluate two readers from two different manufacturers that are able to read marks applied with DPM processes for landing gear parts. The objective was to determine if there are readers from two different manufacturers that are able to read marks applied with DPM processes for landing gear parts.

TEST PROCEDURES

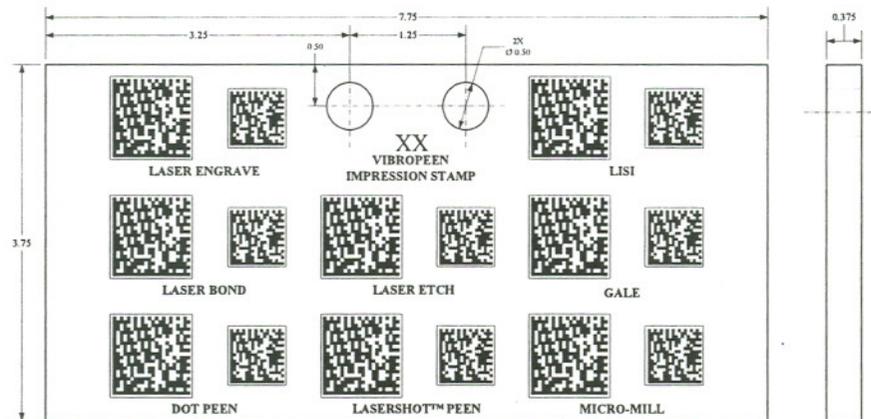
Coupon Tests

1. The test was developed and the testing was conducted by the ALGLE Program. The test was accomplished by reading marks on several coupons that were representative of landing gear parts and materials. The coupons were processed in the previous test programs. The processing focused on normal part mark locations for landing gear parts and normal aircraft landing gear part overhaul conditions. Figure 1 contains a schematic image of the coupons and marks that were tested.

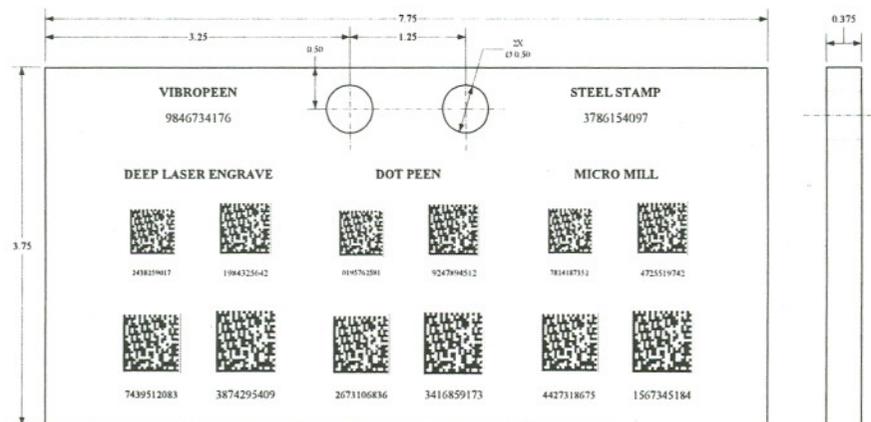
Reading Tests

1. Read marks with the RVSI MXi handheld reader (MXi).
2. Read marks with the Microscan Quadrus handheld reader (MS-Q).
3. Read marks on S1A-05, S1B-05, and A1A-05.
4. Read marks on S1A-17 through S1A-20 and A1A-17 through A1A-20.
5. All the marks were read in a laboratory environment with ambient lighting.
6. All the marks were read by a single, well trained operator.
7. All the marks were read with the readers in the default condition. No lighting optimization for any particular mark was performed.
8. The definition of read success was the ability to successfully decode the mark with the handheld reader within 6 attempts. Note that the read success could change with the operator or the environment.

Figure 1: Coupon Schematics



Coupons X1X-05: Direct Part Marks



Coupons X1X-17 through X1X-20: Improved Direct Part Marks

RESULTS AND DISCUSSION

Results

All the test results are presented in terms of the reader names: MXi for the RVSI MXi handheld reader and MS-Q for the Microscan Quadrus handheld reader. All the test results are presented in terms of the coupon part numbers S1A, S1B, and A1A which contain basic information about the material and when the material was marked. Coupon S1A was 4340 steel (S) that was marked after (A) heat treating to 260 ksi UTS. Coupon S1B was 4340 steel (S) that was marked before (B) heat treating to 260 ksi UTS. Coupon A1A was 7075-T73 aluminum (A) that was marked after (A) heat treating. Appendix A contains the coupon drawings. Appendix B contains mark decoding summary data. Appendix C contains mark decoding data. Appendix D contains the manufacturer specifications for the MXi and the MS-Q.

A summary of the test results is contained in Table 1, Figure 2, and Figure 3. Table 1 contains test results from the coupons from the previous test program that identified dot peen, micro mill and laser engrave marks for further development and testing (Coupons X1X-05). Figure 2 and Figure 3 contain test results from the coupons from the previous test program that developed and tested the improved dot peen, micro mill and deep laser engrave marks (Coupons X1X-17 to X1X-20). Dot peen, micro mill, and deep laser engrave marks between 0.003in. and 0.009in. deep are the main focus of the current test results. The remaining test results are included for a more comprehensive comparison between the readers. Also, note that the test results for shot peening, plating, and painting are included to continue to illustrate the points: that *Reader Interface* problems occur with cadmium plating and painting for machine readable marks on steel; that *Reader Interface* problems occur with painting for machine readable marks on aluminum; and that *Mark Damage* problems occur with shot peening for machine readable and human readable marks on aluminum.

Reader Comparison: Read Success

The test results for the coupons demonstrate that there is minimal difference in read success between the MXi and the MS-Q for landing gear applications. Both readers had equal performance for marks between 0.003in. to 0.009in. on coupons X1X-17. Both readers were able to read the majority of the marks on Coupons X1X-17. When all the marks are included, the MXi outperformed the MS-Q for the marks with less depth. However, simple mark enhancements, such as a reliable backfill, could further diminish the differences in read success between the two readers for the marks with less depth. Also note that there were no reader improvements to warrant changing the rankings or definitions of mark survivability in the previous test programs.

The test results for the coupons indicate that deep laser engrave marks were the top performing marks. Both readers had the highest read success with the deep laser engrave marks. This is an indication that the deep laser engrave marks have the most robust cell shape for optical readers.

Reader Comparison: Select Specifications

The manufacturer specification sheets provide data for the readers. Based on the manufacturer specification sheets, the MS-Q outperforms the MXi for size, weight, durability, connectivity, and portability. These are very important performance characteristics for implementation in an overhaul environment. For example: the more compact MS-Q may be better able to interface with a difficult to reach mark on a part or a part in an assembly; the more durable MS-Q (Multiple 6.5 ft Drop to Concrete Compared to Single 4 ft Drop to Concrete) may be better able to survive accidental drops and kicks; the multiple connections of the MS-Q (Cabled: USB or RS232 and Wireless with Batch Compared to RS232) may be easier for network support and system integration. Finally, the retail price of the MS-Q is approximately \$2000, while the retail price of the MXi is approximately \$3000.

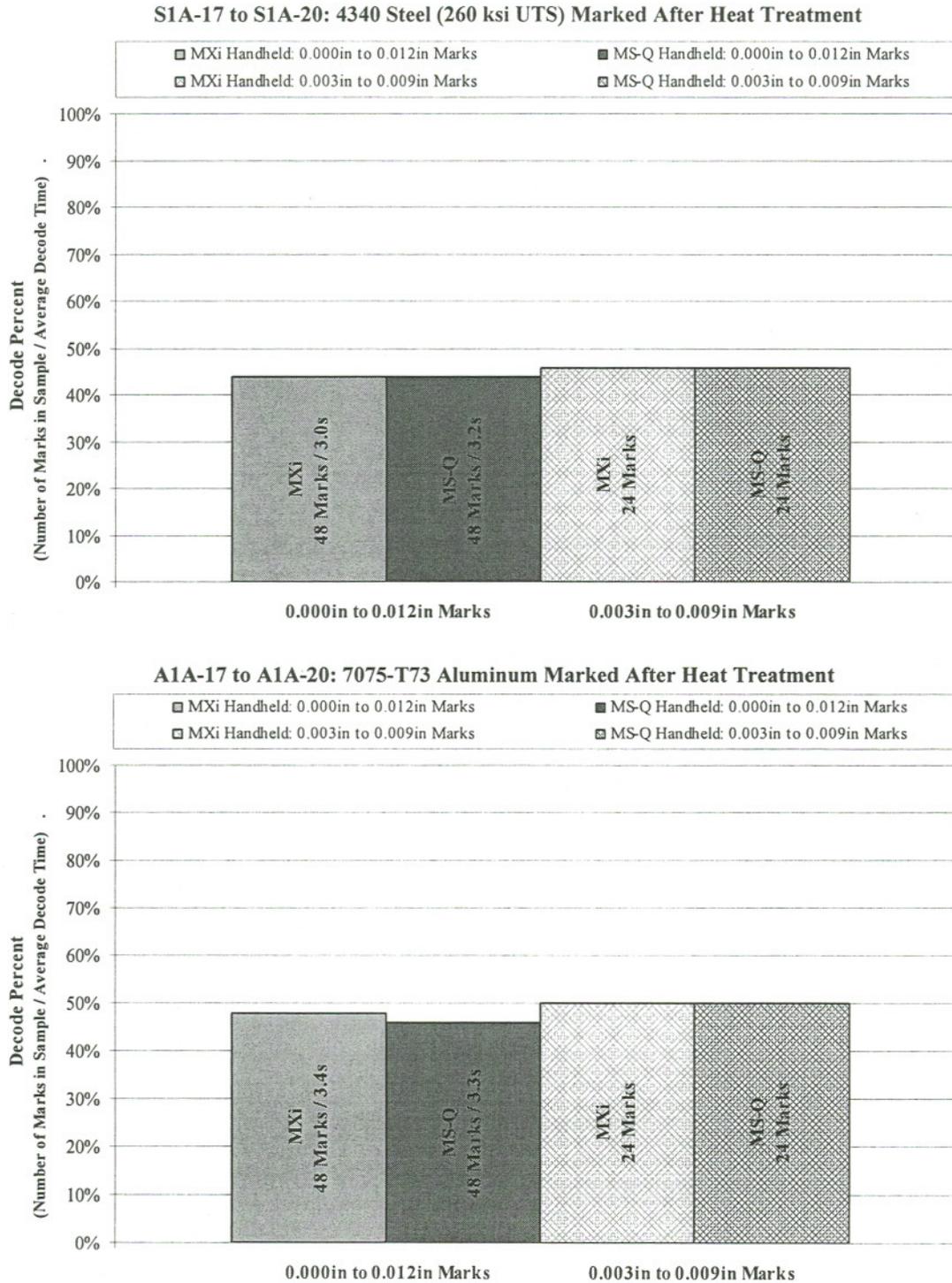
Operator Training

Approximately 15 minutes of operator training were required for both readers. The operator training consisted of gaining familiarity with the hand position, and reading marks to develop an understanding of the offset distance / reader position relative to the mark. Both readers were found to work best when the reader was aimed nearly perpendicular to the mark and slowly but steadily drawn away from the mark until the mark was read. There is concern that the consistency of reading the marks in a laboratory environment may not correlate to an overhaul environment where the same reading procedures may be difficult to maintain with multiple operators and more complicated geometries.

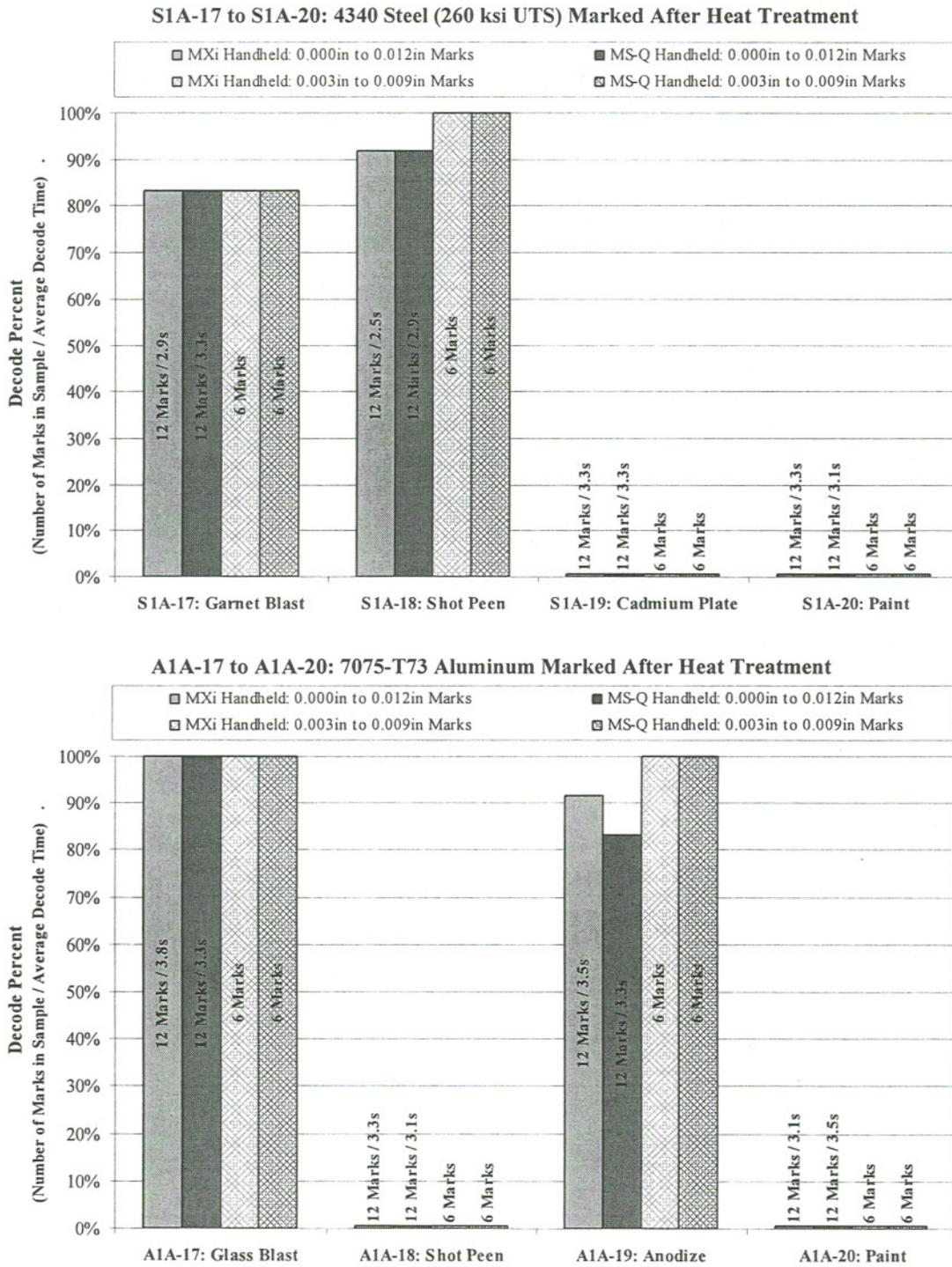
Table 1: Mark Decode for Coupons S1A-05, S1B-05, and A1A-05 After Processing
S1A-05: 4340 Steel (260 ksi UTS) Marked After Heat Treatment
S1B-05: 4340 Steel (260 ksi UTS) Marked Before Heat Treatment
A1A-05: 7075-T73 Aluminum Marked After Heat Treatment

Yes: 1/6 to 6/6 No: 0/6	Coupon S1A-05 After 20 Processes		Coupon S1B-05 After 20 Processes		Coupon A1A-05 After 11 Processes	
	MXi Handheld	MS-Q Handheld	MXi Handheld	MS-Q Handheld	MXi Handheld	MS-Q Handheld
DPM Process						
1 - Dot Peen	Yes	Yes	Yes	Yes	Yes	Yes
2 - LaserShot™ Peen	No	No	No	No	Yes	No
3 - Micro Mill	No	No	Yes	Yes	Yes	Yes
4 - Laser Bond	No	No	No	No	Yes	No
5 - Laser Etch	No	No	No	No	Yes	Yes
6 - GALE	No	No	No	No	Yes	Yes
7 - Laser Engrave	No	No	No	No	Yes	Yes
8 - LISI	No	No	No	No	Yes	Yes

Figure 2: Mark Decode Percent for Coupons XIX-17 to XIX-20 After Processing Marks Applied with Deep Laser Engrave, Dot Peen, and Micro Mill DPM Processes



**Figure 3: Mark Decode Percent for Coupons X1X-17 to X1X-20 After Processing
 Marks Applied with Deep Laser Engrave, Dot Peen, and Micro Mill DPM Processes**



CONCLUSIONS

The test program was conducted to evaluate two different readers for machine readable marks applied with direct part marking (DPM) processes to aircraft landing gear parts. The test program was to determine if there are readers from different manufacturers that are able to read marks for landing gear parts. The test program was conducted with an RVSI MXi handheld reader and a Microscan Quadrus handheld reader. The test was accomplished by reading marks on several coupons that were representative of landing gear parts and materials.

The test results for the coupons demonstrate that there is minimal difference in read success between the MXi and the MS-Q for landing gear applications. Both readers had equal performance in read success for dot peen, micro mill, and deep laser engrave marks between 0.003in. and 0.009in. deep. These marks are the main focus of the current and future efforts for DPM processes for landing gear parts.

Based on the manufacturer specification sheets, the MS-Q outperforms the MXi for size, weight, durability, connectivity, and portability.

The test results are significant since there are two commercially available readers for marks applied with DPM processes from two independent manufactures. Marking performance specifications and reading performance specifications could be developed to encourage competition and enable the Department of Defense or the USAF to successfully require machine readable marks within the constraints of the current logistics and procurement policies. The information technology industry continues to develop, and reader manufacturers continue to develop better optical imagers and better software algorithms for reading.

RECOMMENDATIONS

It is recommended to pursue the development and implementation of a mark performance specification and a reader performance specification. A performance specification for marks applied with DPM processes could define the mark cell shape and the mark cell layout with appropriate tolerances. It could also define the material condition after marking. It could also define a minimum fatigue strength for a specific coupon after marking. A performance specification could define standard procedures and coupons for dimensional characterization, microstructure characterization, and fatigue testing. A marking manufacturer would submit a qualification package that included dimensional characterization, microstructure characterization, and fatigue strength data to qualify specific mark and DPM process. A performance specification for a reader could include defining the ability to read a qualified mark on a specific coupon. A performance specification could define standard procedures and coupons. A reader manufacturer would submit a qualification package that includes the standard reader specification along with a reading report for the specification.

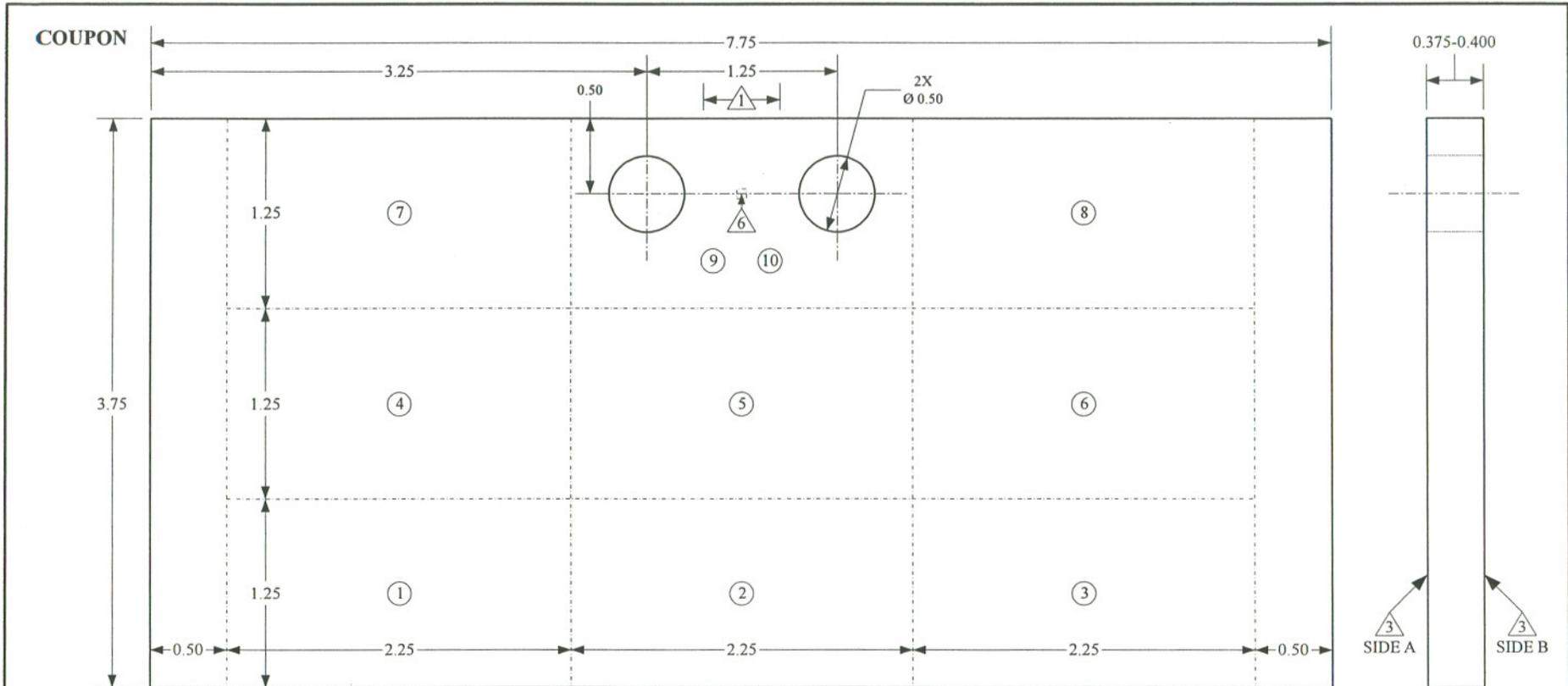
It is recommended to pursue further reader development and testing in an overhaul environment with condemned landing gear parts. The development and testing should focus on how well reading the marks in a laboratory environment on coupons that are representative of landing gear parts and materials correlates to reading marks in an overhaul environment on landing gear parts. It should also include multiple operators, more complicated geometries, and mark enhancements such as backfilling. To support further reader development and testing, a general request for information should be posted to allow all reader manufacturers to participate. At a minimum, further reader development and testing should include the MXi and the MS-Q.

**APPENDIX A
COUPON DRAWINGS**

COUPON S1A

COUPON S1A REVISION D: HISTORY

- New: Unmarked Coupon
- A: Unmarked Coupon: Drawing Configuration Change
- B: Unmarked Coupon: Material Change
- C: Marked Coupon: S1A-01 to S1A-16
- D: Marked Coupon: S1A-17 to S1A-20



NOTES

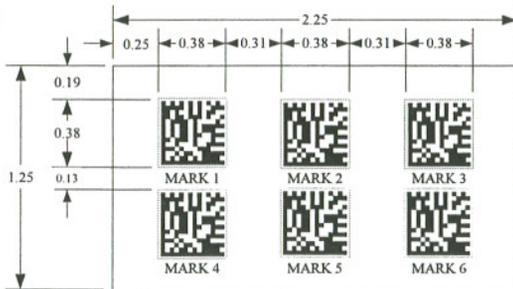
- ① SERIALIZE THE COUPONS S1A-01 TO S1A-22 ON TOP EDGE AT NOTED LOCATION USING 0.25 IMPRESSION STAMP, 0.004-0.008 DEEP
- 2 HEAT TREAT AND PROCESS TO 260-280 KSI ULTIMATE TENSILE STRENGTH PER AMS-H-6875, MAXIMUM ALLOWABLE DECARBURIZATION 0.003
- ③ $\frac{125}{0.025} \sqrt{\frac{64}{M}}$ BEFORE 2, $\frac{125}{\sqrt{\frac{64}{M}}}$ AFTER 2
- 4 BREAK ALL SHARP EDGES 0.005-0.015
- 5 FLUORESCENT MAGNETIC PARTICLE INSPECT PER ASTM E1444
- ⑥ FOR COUPONS WITH EVEN SERIAL NUMBERS: PERFORM ROCKWELL HARDNESS C TEST PER ASTM A370 AT NOTED LOCATION
- 7 FOR COUPONS WITH EVEN SERIAL NUMBERS: PERFORM SURFACE ROUGHNESS MEASUREMENT PER ASME B46.1
- i) FOR COUPONS S1A-01 TO S1A-04: MARK SIDE A WITH DATA MATRIX™ SYMBOLS PER TABLE I REQUIREMENTS
- ii) FOR COUPONS S1A-05 TO S1A-16: MARK SIDE A WITH DATA MATRIX™ SYMBOLS PER TABLE II REQUIREMENTS
- iii) FOR COUPONS S1A-17 TO S1A-20: MARK SIDE A WITH DATA MATRIX™ SYMBOLS PER TABLE III REQUIREMENTS

ALGLE PROGRAM 	TITLE	DRAWING NUMBER	REVISION	DIMENSIONS	TOLERANCES	DRAWN
	COUPON	S1A	D	ALL DIMENSIONS IN INCHES	UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	JOHN COATES
DPM EVALUATION	MATERIAL 4340	DATE	SHEET	SCALE		CHECKED
	PER AMS 6415	2/28/03	1 OF 4	NOT TO SCALE		FRANK ZUECH

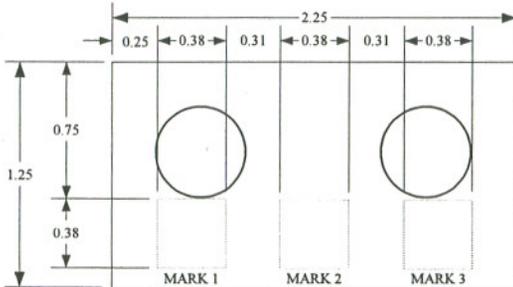
TABLE I: DATA MATRIX™ OPTIMIZATION

- ① - ⑩ i) AT LEAST ONE COUPON MUST CONTAIN THE MINIMUM NUMBER OF MARKS
- ii) FOR THE MINIMUM NUMBER OF MARKS, USE DIFFERENT DPM PROCESS CONTROLS
- ① DOT PEEN A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ② LASERSHOT™ PEEN A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ③ MICRO-MILL A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ④ LASER BOND A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑤ LASER ETCH A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑥ GAS ASSIST LASER ETCH (GALE) A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑦ LASER ENGRAVE A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑧ LASER INDUCE SURFACE IMPROVEMENT (LISI) A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑨ VIBRA-ETCH A MINIMUM OF 3 MARKS IN DETAIL I.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)
- ⑩ IMPRESSION STAMP A MINIMUM OF 3 MARKS IN DETAIL I.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)

DETAIL I.A*



DETAIL I.B*



MARK DATA

①	XXXXXXXXXX
②	XXXXXXXXXX
③	XXXXXXXXXX
④	XXXXXXXXXX
⑤	XXXXXXXXXX
⑥	XXXXXXXXXX
⑦	XXXXXXXXXX
⑧	XXXXXXXXXX
⑨	ALPHANUMERIC CHARACTER
⑩	ALPHANUMERIC CHARACTER

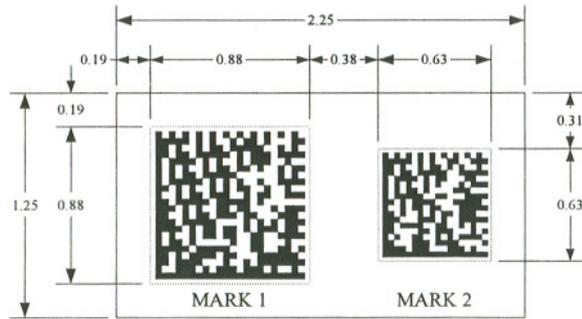
*DIMENSIONS INDICATE THE MAXIMUM ALLOWABLE AREA FOR MARKING

ALGLE PROGRAM 	TITLE COUPON	DRAWING NUMBER S1A	REVISION D	DIMENSIONS ALL DIMENSIONS IN INCHES	TOLERANCES UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	DRAWN JOHN COATES
	DPM EVALUATION	MATERIAL 4340 PER AMS 6415	DATE 2/28/03	SHEET 2 OF 4	SCALE NOT TO SCALE	CHECKED FRANK ZUECH

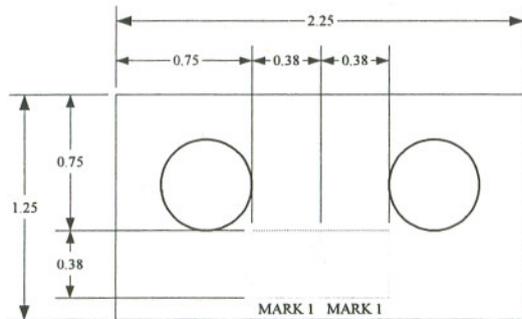
TABLE II: DATA MATRIX™ REQUIREMENTS

- ① DOT PEEN MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.008-0.016 DEEP
- ② LASERSHOT™ PEEN MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.008-0.016 DEEP
- ③ MICRO-MILL MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.024-0.032 DEEP
- ④ LASER BOND MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑤ LASER ETCH MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑥ GAS ASSIST LASER ETCH (GALE) MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑦ LASER ENGRAVE MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.008-0.016 DEEP
- ⑧ LASER INDUCE SURFACE IMPROVEMENT (LISI) MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑨ VIBRA-ETCH MARK IN DETAIL II.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)
- ⑩ IMPRESSION STAMP MARK IN DETAIL II.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)

DETAIL II.A*



DETAIL II.B*



MARK DATA		
	MARK 1 DATA	MARK 2 DATA
①	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX1	XXXXXXXXXXXXXXXXXXXXXXXXX1
②	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2	XXXXXXXXXXXXXXXXXXXXXXXXX2
③	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3	XXXXXXXXXXXXXXXXXXXXXXXXX3
④	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX4	XXXXXXXXXXXXXXXXXXXXXXXXX4
⑤	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX5	XXXXXXXXXXXXXXXXXXXXXXXXX5
⑥	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX6	XXXXXXXXXXXXXXXXXXXXXXXXX6
⑦	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX7	XXXXXXXXXXXXXXXXXXXXXXXXX7
⑧	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX8	XXXXXXXXXXXXXXXXXXXXXXXXX8
⑨	ALPHANUMERIC CHARACTER	NONE
⑩	ALPHANUMERIC CHARACTER	NONE

*DIMENSIONS INDICATE THE MAXIMUM ALLOWABLE AREA FOR MARKING

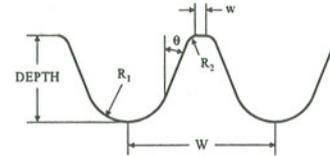
		TITLE	DRAWING NUMBER	REVISION	DIMENSIONS	TOLERANCES	DRAWN
	COUPON MATERIAL 4340 PER AMS 6415	S1A	D	ALL DIMENSIONS IN INCHES	UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	JOHN COATES	
DPM EVALUATION		DATE	SHEET	SCALE		CHECKED	
		2/28/03	3 OF 4	NOT TO SCALE		FRANK ZUECH	

TABLE III: MARK REQUIREMENTS

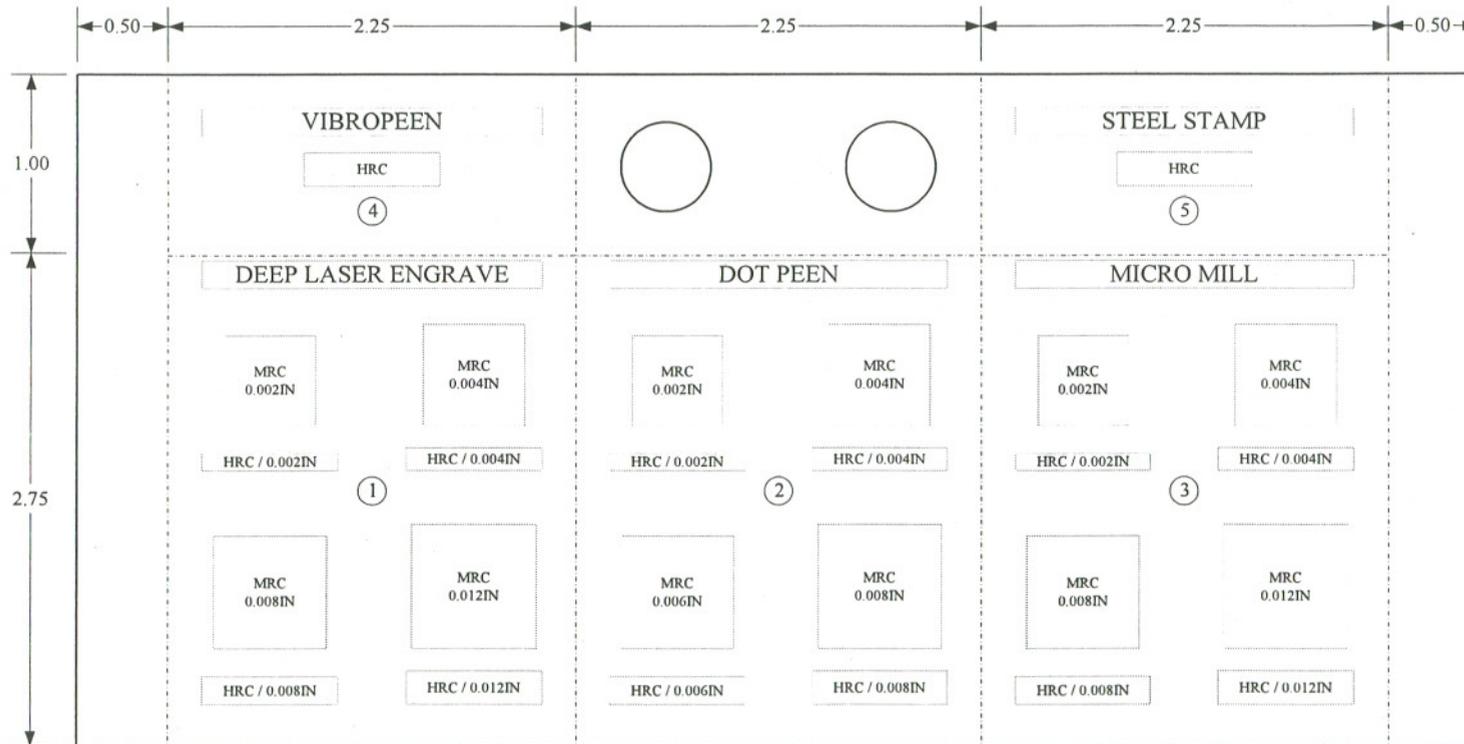
- ① DEEP LASER ENGRAVE MARKS IN DETAIL III PER NASA-HDBK-6003 (P027)
- ② DOT PEEN MARKS IN DETAIL III PER NASA-HDBK-6003 (P027)
- ③ MICRO MILL MARKS IN DETAIL III PER NASA-HDBK-6003 (P027)
- ④ VIBROPEEN MARKS IN DETAIL III PER OO-ALC/MANPP PROCEDURE
- ⑤ IMPRESSION STAMP MARKS IN DETAIL III PER OO-ALC/MANPP PROCEDURE
- ⑥-⑩ NOT APPLICABLE

DETAIL III: NOTES AND CELL DETAIL

- III.1 LINES AND BOXES INDICATE LOCATIONS FOR MARKS
- III.2 MRC / MACHINE READABLE CODE: 22 X 22 DATA MATRIX / DEPTH INDICATED IN BOXES
- III.3 HRC / HUMAN READABLE CODE: 10 NUMBERS / DEPTH INDICATED IN BOXES EACH HRC SHALL BE A DIFFERENT RANDOM NUMBER
- III.4 MRC AND HRC CELLS SHALL INCLUDE RADII AND TAPERS AS SHOWN



DETAIL III: FIGURE



ALGLE PROGRAM 	TITLE COUPON	DRAWING NUMBER S1A	REVISION D	DIMENSIONS ALL DIMENSIONS IN INCHES	TOLERANCES UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	DRAWN JOHN COATES
	MATERIAL 4340 PER AMS 6415	DATE 2/28/03	SHEET 4 OF 4	SCALE NOT TO SCALE		CHECKED FRANK ZUECH

COUPON A1A

COUPON A1A REVISION D: HISTORY

New: Unmarked Coupon

A: Unmarked Coupon: Drawing Configuration Change

B: Unmarked Coupon: Material Change

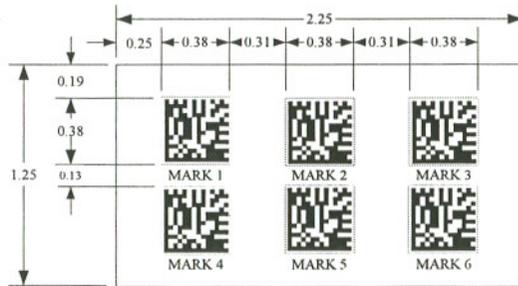
C: Marked Coupon: A1A-01 to A1A-16

D: Marked Coupon: A1A-17 to A1A-20

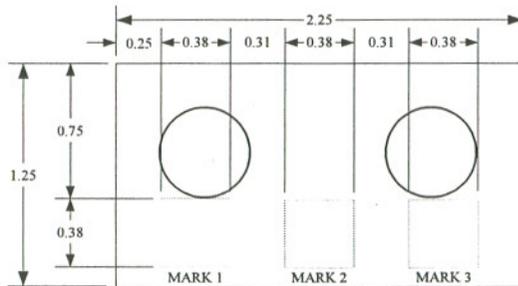
TABLE I: DATA MATRIX™ OPTIMIZATION

- ① – ⑩ i) AT LEAST ONE COUPON MUST CONTAIN THE MINIMUM NUMBER OF MARKS
- ii) FOR THE MINIMUM NUMBER OF MARKS, USE DIFFERENT DPM PROCESS CONTROLS
- ① DOT PEEN A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ② LASERSHOT™ PEEN A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ③ MICRO-MILL A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ④ LASER BOND A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑤ LASER ETCH A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑥ GAS ASSIST LASER ETCH (GALE) A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑦ LASER ENGRAVE A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑧ LASER INDUCE SURFACE IMPROVEMENT (LISI) A MINIMUM OF 6 MARKS IN DETAIL I.A PER NASA-HDBK-6003 (P027)
- ⑨ VIBRA-ETCH A MINIMUM OF 3 MARKS IN DETAIL I.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)
- ⑩ IMPRESSION STAMP A MINIMUM OF 3 MARKS IN DETAIL I.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)

DETAIL I.A*



DETAIL I.B*



	MARK DATA
①	XXXXXXXXXX
②	XXXXXXXXXX
③	XXXXXXXXXX
④	XXXXXXXXXX
⑤	XXXXXXXXXX
⑥	XXXXXXXXXX
⑦	XXXXXXXXXX
⑧	XXXXXXXXXX
⑨	ALPHANUMERIC CHARACTER
⑩	ALPHANUMERIC CHARACTER

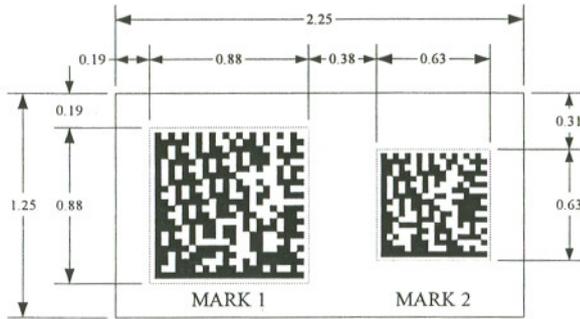
*DIMENSIONS INDICATE THE MAXIMUM ALLOWABLE AREA FOR MARKING

	TITLE COUPON	DRAWING NUMBER A1A	REVISION D	DIMENSIONS ALL DIMENSIONS IN INCHES	TOLERANCES UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	DRAWN JOHN COATES
	DPM EVALUATION	MATERIAL 7075-T7351 PER AMS 4078 (0.5 INCH PLATE)	DATE 2/28/03	SHEET 2 OF 4	SCALE NOT TO SCALE	CHECKED FRANK ZUECH

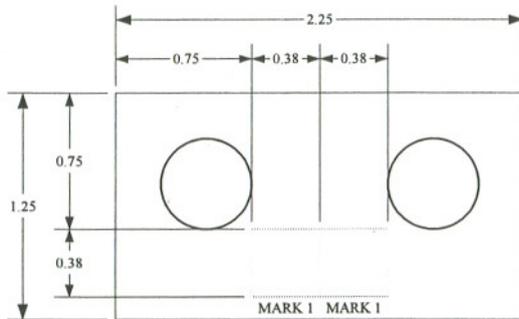
TABLE II: DATA MATRIX™ REQUIREMENTS

- ① DOT PEEN MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.008-0.016 DEEP
- ② LASERSHOT™ PEEN MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.008-0.016 DEEP
- ③ MICRO-MILL MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.024-0.032 DEEP
- ④ LASER BOND MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑤ LASER ETCH MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑥ GAS ASSIST LASER ETCH (GALE) MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑦ LASER ENGRAVE MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027), 0.008-0.016 DEEP
- ⑧ LASER INDUCE SURFACE IMPROVEMENT (LISI) MARKS IN DETAIL II.A PER NASA-HDBK-6003 (P027)
- ⑨ VIBRA-ETCH MARK IN DETAIL II.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)
- ⑩ IMPRESSION STAMP MARK IN DETAIL II.B PER OO-ALC/LITP PROCEDURE (NOT A MACHINE READABLE MARK)

DETAIL II.A*



DETAIL II.B*



MARK DATA		
	MARK 1 DATA	MARK 2 DATA
①	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX1	XXXXXXXXXXXXXXXXXXXXXXXXXXXX1
②	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX2	XXXXXXXXXXXXXXXXXXXXXXXXXXXX2
③	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX3	XXXXXXXXXXXXXXXXXXXXXXXXXXXX3
④	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX4	XXXXXXXXXXXXXXXXXXXXXXXXXXXX4
⑤	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX5	XXXXXXXXXXXXXXXXXXXXXXXXXXXX5
⑥	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX6	XXXXXXXXXXXXXXXXXXXXXXXXXXXX6
⑦	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX7	XXXXXXXXXXXXXXXXXXXXXXXXXXXX7
⑧	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX8	XXXXXXXXXXXXXXXXXXXXXXXXXXXX8
⑨	ALPHANUMERIC CHARACTER	NONE
⑩	ALPHANUMERIC CHARACTER	NONE

*DIMENSIONS INDICATE THE MAXIMUM ALLOWABLE AREA FOR MARKING

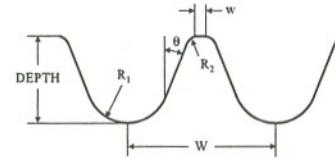
ALGLE PROGRAM 	TITLE COUPON	DRAWING NUMBER A1A	REVISION D	DIMENSIONS ALL DIMENSIONS IN INCHES	TOLERANCES UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	DRAWN JOHN COATES
	DPM EVALUATION	MATERIAL 7075-T7351 PER AMS 4078 (0.5 INCH PLATE)	DATE 2/28/03	SHEET 3 OF 4		SCALE NOT TO SCALE

TABLE III: MARK REQUIREMENTS

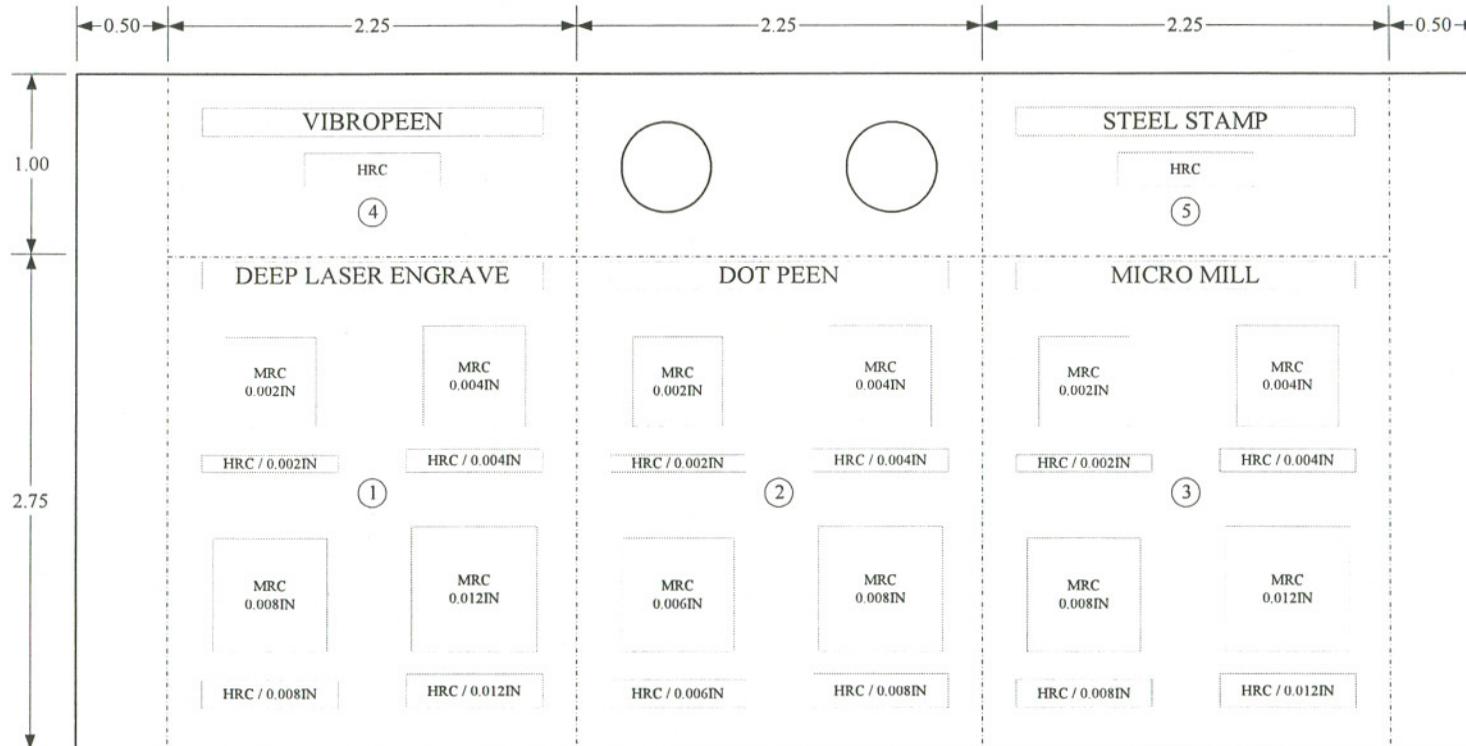
- ① DEEP LASER ENGRAVE MARKS IN DETAIL III PER NASA-HDBK-6003 (P027)
- ② DOT PEEN MARKS IN DETAIL III PER NASA-HDBK-6003 (P027)
- ③ MICRO MILL MARKS IN DETAIL III PER NASA-HDBK-6003 (P027)
- ④ VIBROPEEN MARKS IN DETAIL III PER OO-ALC/MANPP PROCEDURE
- ⑤ IMPRESSION STAMP MARKS IN DETAIL III PER OO-ALC/MANPP PROCEDURE
- ⑥-⑩ NOT APPLICABLE

DETAIL III: NOTES AND CELL DETAIL

- III.1 LINES AND BOXES INDICATE LOCATIONS FOR MARKS
- III.2 MRC / MACHINE READABLE CODE: 22 X 22 DATA MATRIX / DEPTH INDICATED IN BOXES
- III.3 HRC / HUMAN READABLE CODE: 10 NUMBERS / DEPTH INDICATED IN BOXES EACH HRC SHALL BE A DIFFERENT RANDOM NUMBER
- III.4 MRC AND HRC CELLS SHALL INCLUDE RADII AND TAPERS AS SHOWN



DETAIL III: FIGURE



ALGLE PROGRAM 	TITLE COUPON	DRAWING NUMBER A1A	REVISION D	DIMENSIONS ALL DIMENSIONS IN INCHES	TOLERANCES UNLESS OTHERWISE NOTED X.X = ± 0.1 X.XX = ± 0.05 ANGLES = ± 0.5°	DRAWN JOHN COATES
	MATERIAL 7075-T7351 PER AMS 4078 (0.5 INCH PLATE)	DATE 2/28/03	SHEET 4 OF 4	SCALE NOT TO SCALE		CHECKED FRANK ZUECH

APPENDIX B
COUPON MARK DECODING SUMMARY DATA

COUPON S1A-05, S1B-05, A1A-05 SUMMARY DATA SHEETS

Coupon S1A-05: After Processing

Process Data: Coupon S1A-05 / 4340 Steel (260ksi UTS) Marked After Heat Treatment

- 0 Mark Per Drawing S1A
- 1 Fluorescent Magnetic Particle Inspect per ASTM E1444
- 2 Paint Per MIL-STD-7179: One Coat Primer Per MIL-P-85582, Type 1, Class 2 / Two Top Coats Per MIL-C-85285, Type 1
- 3 Paint Strip per MIL-STD-871
- 4 Abrasive Blast per MIL-STD-1504: Abrasive Media (Plastic Media) per MIL-P-85891
- 5 Abrasive Blast per MIL-STD-1504: Abrasive Media (Glass Media) per MIL-G-9954
- 6 Temper Etch per MIL-STD-867
- 7 Shot Peen per AMS-S-13165 with Marks Masked: Intensity 0.006A to 0.010A, Shot S-110
- 8 Chrome Plate per MIL-STD-1501 with Marks Masked: Type II, Class 2, 0.001in to 0.003in
- 9 Chrome Plate Strip per MIL-STD-871
- 10 Nickel Plate per MIL-STD-868 with Marks Masked: Type II, 0.001in to 0.003in
- 11 Nickel Plate Strip per MIL-STD-871
- 12 Cadmium Plate per MIL-STD-870: Type II, Class 1
- 13 Cadmium Plate Strip per MIL-STD-871
- 14 IVD Aluminum Plate per MIL-DTL-83488: Type II, Class 1
- 15 IVD Aluminum Plate Strip per MIL-STD-871
- 16 Electroless Nickel Plate per MIL-C-26074: Class 1, Grade A
- 17 Electroless Nickel Plate Strip per MIL-STD-871
- 18 Abrasive Blast per MIL-STD-1504 with Marks Masked: Abrasive Media (Grit Media) per MIL-G-5634
- 19 Abrasive Blast per MIL-STD-1504: Abrasive Media (Aluminum Oxide Media) per MIL-S-17726
- 20 Abrasive Blast per MIL-STD-1504: Abrasive Media (Glass Media) per MIL-G-9954

Decoding Data: Mark 1: 40 Character Mark

<p>1 - Dot Peen</p> 	<p>2 - LaserShot™ Peen</p> 	<p>3 - Micro Mill</p> 	<p>4 - Laser Bond</p> 																																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>Yes</td> <td>6/6</td> </tr> <tr> <td>MS-Q</td> <td>Yes</td> <td>3/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	Yes	6/6	MS-Q	Yes	3/6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6
Mark 1	Decode	Attempts																																					
MXi	Yes	6/6																																					
MS-Q	Yes	3/6																																					
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					
<p>5 - Laser Etch</p> 	<p>6 - GALE</p> 	<p>7 - Laser Engrave</p> 	<p>8 - LISI</p> 																																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Mark 1</th> <th>Decode</th> <th>Attempts</th> </tr> </thead> <tbody> <tr> <td>MXi</td> <td>No</td> <td>0/6</td> </tr> <tr> <td>MS-Q</td> <td>No</td> <td>0/6</td> </tr> </tbody> </table>	Mark 1	Decode	Attempts	MXi	No	0/6	MS-Q	No	0/6
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					
Mark 1	Decode	Attempts																																					
MXi	No	0/6																																					
MS-Q	No	0/6																																					

Decode: *MXi*: One Operator with RVSI MXi Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

MS-Q: One Operator with Microscan Quadrus Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

Attempts: Number of successful decodes in 6 attempts.

Coupon S1B-05: After Processing

Process Data: Coupon S1B-05 / 4340 Steel (260ksi UTS) Marked Before Heat Treatment

- 0 Mark Per Drawing S1B
- 1 Fluorescent Magnetic Particle Inspect per ASTM E1444
- 2 Paint Per MIL-STD-7179: One Coat Primer Per MIL-P-85582, Type 1, Class 2 / Two Top Coats Per MIL-C-85285, Type 1
- 3 Paint Strip per MIL-STD-871
- 4 Abrasive Blast per MIL-STD-1504: Abrasive Media (Plastic Media) per MIL-P-85891
- 5 Abrasive Blast per MIL-STD-1504: Abrasive Media (Glass Media) per MIL-G-9954
- 6 Temper Etch per MIL-STD-867
- 7 Shot Peen per AMS-S-13165 with Marks Masked: Intensity 0.006A to 0.010A, Shot S-110
- 8 Chrome Plate per MIL-STD-1501 with Marks Masked: Type II, Class 2, 0.001in to 0.003in
- 9 Chrome Plate Strip per MIL-STD-871
- 10 Nickel Plate per MIL-STD-868 with Marks Masked: Type II, 0.001in to 0.003in
- 11 Nickel Plate Strip per MIL-STD-871
- 12 Cadmium Plate per MIL-STD-870: Type II, Class 1
- 13 Cadmium Plate Strip per MIL-STD-871
- 14 IVD Aluminum Plate per MIL-DTL-83488: Type II, Class 1
- 15 IVD Aluminum Plate Strip per MIL-STD-871
- 16 Electroless Nickel Plate per MIL-C-26074: Class 1, Grade A
- 17 Electroless Nickel Plate Strip per MIL-STD-871
- 18 Abrasive Blast per MIL-STD-1504 with Marks Masked: Abrasive Media (Grit Media) per MIL-G-5634
- 19 Abrasive Blast per MIL-STD-1504: Abrasive Media (Aluminum Oxide Media) per MIL-S-17726
- 20 Abrasive Blast per MIL-STD-1504: Abrasive Media (Glass Media) per MIL-G-9954

Decoding Data: Mark 1: 40 Character Mark

1 - Dot Peen



Mark 1	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	6/6

2 - LaserShot™ Peen



Mark 1	Decode	Attempts
MXi	No	0/6
MS-Q	No	0/6

3 - Micro Mill



Mark 1	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	6/6

4 - Laser Bond



Mark 1	Decode	Attempts
MXi	No	0/6
MS-Q	No	0/6

5 - Laser Etch



Mark 1	Decode	Attempts
MXi	No	0/6
MS-Q	No	0/6

6 - GALE



Mark 1	Decode	Attempts
MXi	No	0/6
MS-Q	No	0/6

7 - Laser Engrave



Mark 1	Decode	Attempts
MXi	No	0/6
MS-Q	No	0/6

8 - LISI



Mark 1	Decode	Attempts
MXi	No	0/6
MS-Q	No	0/6

Decode: *MXi*: One Operator with RVSI MXi Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.
MS-Q: One Operator with Microscan Quadrus Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

Attempts: Number of successful decodes in 6 attempts.

Coupon A1A-05: After Processing

Process Data: Coupon A1A-05 / 7075-T73 Aluminum Marked After Heat Treatment

- 0 Mark Per Drawing A1A
- 1 Fluorescent Penetrant Inspect per ASTM E1417
- 2 Paint Per MIL-STD-7179: One Coat Primer Per MIL-P-85582, Type 1, Class 2 / Two Top Coats Per MIL-C-85285, Type 1
- 3 Paint Strip per MIL-STD-871
- 4 Abrasive Blast per MIL-STD-1504: Abrasive Media (Plastic Media) per MIL-P-85891
- 5 Shot Peen per AMS-S-13165 with Marks Masked: Intensity 0.006A to 0.010A, Shot S-110
- 6 Abrasive Blast per MIL-STD-1504 with Marks Masked: Abrasive Media (Grit Media) per MIL-G-5634
- 7 Flame Spray per MIL-STD-869 with Marks Masked: Type I, 0.025in to 0.050in
- 8 Anodize per MIL-STD-8625: Type II, Class 1
- 9 Anodize Strip per MIL-STD-871
- 10 Abrasive Blast per MIL-STD-1504: Abrasive Media (Plastic Media) per MIL-P-85891
- 11 Abrasive Blast per MIL-STD-1504: Abrasive Media (Glass Media) per MIL-G-9954

Decoding Data: Mark 1: 40 Character Mark

1 - Dot Peen



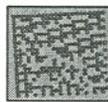
Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	6/6

2 - LaserShot™ Peen



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	No	0/6

3 - Micro Mill



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	6/6

4 - Laser Bond



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	No	0/6

5 - Laser Etch



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	3/6

6 - GALE



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	3/6

7 - Laser Engrave



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	6/6

8 - LISI



Mark I	Decode	Attempts
MXi	Yes	6/6
MS-Q	Yes	6/6

Decode: *MXi*: One Operator with RVSI MXi Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.
MS-Q: One Operator with Microscan Quadrus Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

Attempts: Number of successful decodes in 6 attempts.

COUPON S1A-17 TO S1A-20 SUMMARY DATA SHEETS

Coupon S1A-17: After Processing

Process Data: Coupon S1A-17 / 4340 Steel (260ksi UTS) Marked After Heat Treatment

- 0 Mark Per Drawing S1A
- 1 Plastic Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
- 2 Glass Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 30psi, 6in to 12in Distance
- 3 Garnet Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
- 4 Shot Peen Per AMS-S-13165, 5X / 500% Surface Coverage with Marks Masked, 12 Almen Intensity
- 5 Steam Clean / Scotch Pad Clean

Deep Laser Engrave: Decoding Data

Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth
MXi	Yes	6/6	2.9	0.002	MXi	Yes	6/6	2.9	0.004
MS-Q	Yes	6/6	3.3	0.002	MS-Q	Yes	6/6	3.3	0.004
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth
MXi	Yes	6/6	2.9	0.008	MXi	Yes	6/6	2.9	0.012
MS-Q	Yes	6/6	3.3	0.008	MS-Q	Yes	6/6	3.3	0.012

Deep Laser Engrave: Image



Dot Peen: Decoding Data

Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth
MXi	Yes	6/6	2.9	0.000	MXi	Yes	6/6	2.9	0.002
MS-Q	Yes	1/6	3.3	0.000	MS-Q	Yes	3/6	3.3	0.002
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth
MXi	No	0/6	2.9	0.004	MXi	Yes	6/6	2.9	0.006
MS-Q	No	0/6	3.3	0.004	MS-Q	Yes	6/6	3.3	0.006

Dot Peen: Image



Micro Mill: Decoding Data

Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth
MXi	No	0/6	2.9	0.001	MXi	Yes	6/6	2.9	0.002
MS-Q	No	0/6	3.3	0.001	MS-Q	Yes	6/6	3.3	0.002
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth
MXi	Yes	6/6	2.9	0.006	MXi	Yes	6/6	2.9	0.010
MS-Q	Yes	6/6	3.3	0.006	MS-Q	Yes	6/6	3.3	0.010

Micro Mill: Image

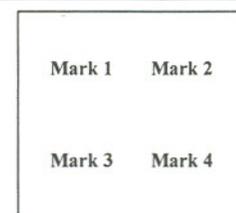


Decode: *MXi*: One Operator with RVSI MXi Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.
MS-Q: One Operator with Microscan Quadrus Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

Attempts: Number of successful decodes in 6 attempts.

Time: Average time to decode the mark.

Depth: Average cell depth based on 3 dial gage measurements.

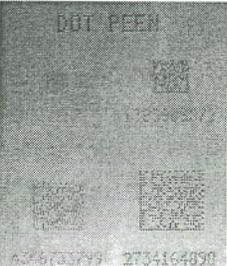


Coupon S1A-18: After Processing

Process Data: Coupon S1A-18 / 4340 Steel (260ksi UTS) Marked After Heat Treatment

0	Mark Per Drawing S1A
1	Plastic Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
2	Glass Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 30psi, 6in to 12in Distance
3	Garnet Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
4	Shot Peen Per AMS-S-13165, 5X / 500% Surface Coverage with Marks Unmasked, 12 Almen Intensity
5	Steam Clean / Scotch Pad Clean

Deep Laser Engrave: Decoding Data										Deep Laser Engrave: Image
Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth	
MXi	Yes	6/6	2.5	0.002	MXi	Yes	6/6	2.5	0.004	
MS-Q	Yes	1/6	2.9	0.002	MS-Q	Yes	6/6	2.9	0.004	
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth	
MXi	Yes	6/6	2.5	0.008	MXi	Yes	6/6	2.5	0.012	
MS-Q	Yes	6/6	2.9	0.008	MS-Q	Yes	6/6	2.9	0.012	

Dot Peen: Decoding Data										Dot Peen: Image
Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth	
MXi	Yes	6/6	2.5	0.000	MXi	Yes	6/6	2.5	0.002	
MS-Q	Yes	1/6	2.9	0.000	MS-Q	Yes	6/6	2.9	0.002	
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth	
MXi	Yes	6/6	2.5	0.003	MXi	Yes	6/6	2.5	0.006	
MS-Q	Yes	6/6	2.9	0.003	MS-Q	Yes	6/6	2.9	0.006	

Micro Mill: Decoding Data										Micro Mill: Image
Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth	
MXi	No	0/6	2.5	0.000	MXi	Yes	6/6	2.5	0.003	
MS-Q	No	0/6	2.9	0.000	MS-Q	Yes	6/6	2.9	0.003	
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth	
MXi	Yes	6/6	2.5	0.007	MXi	Yes	6/6	2.5	0.012	
MS-Q	Yes	6/6	2.9	0.007	MS-Q	Yes	6/6	2.9	0.012	

Decode: *MXi*: One Operator with RVSI MXi Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.
MS-Q: One Operator with Microscan Quadrus Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

Attempts: Number of successful decodes in 6 attempts.

Time: Average time to decode the mark.

Depth: Average cell depth based on 3 dial gage measurements.

Mark 1 Mark 2

Mark 3 Mark 4

Coupon S1A-19: After Processing

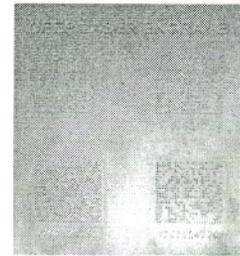
Process Data: Coupon S1A-19 / 4340 Steel (260ksi UTS) Marked After Heat Treatment

- 0 Mark Per Drawing S1A
- 1 Plastic Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
- 2 Glass Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 30psi, 6in to 12in Distance
- 3 Garnet Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
- 4 Cadmium Plate Per MIL-STD-870, Type II, Class I / 24 Hour Bake at 375°F
- 5 Dry Cloth Clean

Deep Laser Engrave: Decoding Data

Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth
MXi	No	0/6	3.3	0.002	MXi	No	0/6	3.3	0.003
MS-Q	No	0/6	3.3	0.002	MS-Q	No	0/6	3.3	0.003
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth
MXi	No	0/6	3.3	0.009	MXi	No	0/6	3.3	0.013
MS-Q	No	0/6	3.3	0.009	MS-Q	No	0/6	3.3	0.013

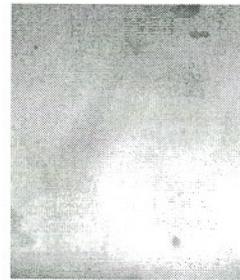
Deep Laser Engrave: Image



Dot Peen: Decoding Data

Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth
MXi	No	0/6	3.3	0.000	MXi	No	0/6	3.3	0.001
MS-Q	No	0/6	3.3	0.000	MS-Q	No	0/6	3.3	0.001
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth
MXi	No	0/6	3.3	0.004	MXi	No	0/6	3.3	0.006
MS-Q	No	0/6	3.3	0.004	MS-Q	No	0/6	3.3	0.006

Dot Peen: Image



Micro Mill: Decoding Data

Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth
MXi	No	0/6	3.3	0.000	MXi	No	0/6	3.3	0.002
MS-Q	No	0/6	3.3	0.000	MS-Q	No	0/6	3.3	0.002
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth
MXi	No	0/6	3.3	0.007	MXi	No	0/6	3.3	0.010
MS-Q	No	0/6	3.3	0.007	MS-Q	No	0/6	3.3	0.010

Micro Mill: Image

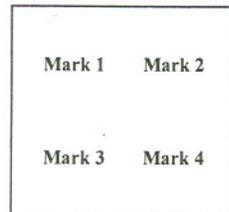


Decode: *MXi:* One Operator with RVSI MXi Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.
MS-Q: One Operator with Microscan Quadrus Handheld Reader Database Entry
 Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts.
 Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.

Attempts: Number of successful decodes in 6 attempts.

Time: Average time to decode the mark.

Depth: Average cell depth based on 3 dial gage measurements.



Coupon S1A-20: After Processing

Process Data: Coupon S1A-20 / 4340 Steel (260ksi UTS) Marked After Heat Treatment

- 0 Mark Per Drawing S1A
- 1 Plastic Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
- 2 Glass Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 30psi, 6in to 12in Distance
- 3 Garnet Media Blast Per MIL-STD-1504, 5X / 500% Surface Coverage, 60psi, 6in to 12in Distance
- 4 Cadmium Plate Per MIL-STD-870, Type II, Class 1 / 24 Hour Bake at 375°F
- 5 Paint Per MIL-STD-7179: One Coat Primer Per MIL-P-85582, Type 1, Class 2 / Two Top Coats Per MIL-C-85285, Type 1
- 6 Dry Cloth Clean

Deep Laser Engrave: Decoding Data										Deep Laser Engrave: Image
Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth	
MXi	No	0/6	3.3	0.001	MXi	No	0/6	3.3	0.002	
MS-Q	No	0/6	3.1	0.001	MS-Q	No	0/6	3.1	0.002	
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth	
MXi	No	0/6	3.3	0.006	MXi	No	0/6	3.3	0.010	
MS-Q	No	0/6	3.1	0.006	MS-Q	No	0/6	3.1	0.010	

Dot Peen: Decoding Data										Dot Peen: Image
Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth	
MXi	No	0/6	3.3	0.000	MXi	No	0/6	3.3	0.000	
MS-Q	No	0/6	3.1	0.000	MS-Q	No	0/6	3.1	0.000	
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth	
MXi	No	0/6	3.3	0.001	MXi	No	0/6	3.3	0.001	
MS-Q	No	0/6	3.1	0.001	MS-Q	No	0/6	3.1	0.001	

Micro Mill: Decoding Data										Micro Mill: Image
Mark 1	Decode	Attempts	Time	Depth	Mark 2	Decode	Attempts	Time	Depth	
MXi	No	0/6	3.3	0.000	MXi	No	0/6	3.3	0.002	
MS-Q	No	0/6	3.1	0.000	MS-Q	No	0/6	3.1	0.002	
Mark 3	Decode	Attempts	Time	Depth	Mark 4	Decode	Attempts	Time	Depth	
MXi	No	0/6	3.3	0.004	MXi	No	0/6	3.3	0.007	
MS-Q	No	0/6	3.1	0.004	MS-Q	No	0/6	3.1	0.007	

<p>Decode: <i>MXi:</i> One Operator with RVSI MXi Handheld Reader Database Entry Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts. Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.</p> <p><i>MS-Q:</i> One Operator with Microscan Quadrus Handheld Reader Database Entry Successful Decode - Yes: Mark decodes with 1/6 to 6/6 attempts. Unsuccessful Decode - No: Mark does not decode with 0/6 attempts.</p> <p>Attempts: Number of successful decodes in 6 attempts.</p> <p>Time: Average time to decode the mark.</p> <p>Depth: Average cell depth based on 3 dial gage measurements.</p>	<table border="1" style="width: 100%; height: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; text-align: center;">Mark 1</td> <td style="width: 50%; text-align: center;">Mark 2</td> </tr> <tr> <td style="width: 50%; text-align: center;">Mark 3</td> <td style="width: 50%; text-align: center;">Mark 4</td> </tr> </table>	Mark 1	Mark 2	Mark 3	Mark 4
Mark 1	Mark 2				
Mark 3	Mark 4				