PRELIMINARY EVALUATION OF PROPOSED MIL-P-85891 TYPE VIII ABRASIVE BLAST MEDIA FOR NAVAL AVIATION PAINT REMOVAL

Clint Salter, Naval Aviation Depot Cherry Point NC
Mark Meno, Naval Aviation Depot Cherry Point NC
Dayle Dierks, Naval Air Warfare Center Aircraft Division, Patuxent River MD
Brian Dusch, Naval Air Warfare Center Aircraft Division, Patuxent River MD
Rimi Riveria, Naval Air Warfare Center Aircraft Division, Patuxent River MD

Introduction

Paint removal by plastic media blasting (PMB) with MIL-P-85891 materials has been a viable option for paint removal for over a decade. It is being used to remove organic coating systems from airframe surfaces, aircraft components, select engine components and support equipment surfaces. However, process limitations have existed for certain processes and processed components. For instance, PMB prior to fluorescent penetrant inspecting (FPI) for aluminum alloys is prohibited. PMB of metallic substrates less than 0.016" and composite laminate substrates less than 0.073" is also prohibited. Further limitations on composite substrates prohibit PMB on fiberglass, kevlar and graphite/bismaleimide (BMI) composite substrates entirely. Thus, a need to increase processing capability of PMB is warranted.

Preliminary Evaluation Scope

The evaluation of proposed MIL-P-85891 Type VIII media is pursued to determine process feasibility as an alternative to Type V media in order to increase PMB capability. This preliminary evaluation analyzes proposed Type VIII media in three aspects: the potential to mask cracks in aluminum alloys, the capability of removing paint from laminate and honeycomb lightning strike composites as well as epoxy/graphite and BMI/graphite composite systems and to assess the mechanical properties of graphite/epoxy and graphite/bismaleimide composite systems after multiple blast cycles.

Crack Masking of Aluminum Alloys Analysis

Since the developmental stages of PMB technology, the effect of PMB on crack detection by fluorescent penetrant inspection has been a concern. Industry wide testing has been performed to determine whether or not PMB hides cracks. A wide range of conclusions has been drawn. In such the Naval Air Systems Command (NAVAIR) developed the position that PMB has the potential to hide cracks from detection by fluorescent penetrant inspection and subsequently prohibits the PMB process from use in these cases. However, a change in media type is considered significant in the PMB process and warrants reexamining the effects of PMB on crack detection by fluorescent penetrant inspection.

Test Plan

The objective for the crack masking evaluation of Type VIII media is to determine the detriments of PMB prior to FPI aluminum alloys. In order to standardize the testing, Type V crack closure evaluation protocol was incorporated which used laboratory cracked panels. These panels were nondestructive inspection (NDI) certification standards, resulting in relatively small, but still detectable cracks. The ability for the PMB process to pass this test would ensure that no cracks detectable by FPI would be hidden, thus achieving the first test evaluation goal.

Metcut Research, Inc prepared the aluminum panels. A 2024-T3 and a 7075-T6 aluminum plate 0.5 inch thick was sectioned into six three inch by six inch panels for each alloy. Metcut polished the surface, initiated a centered electrical discharge machining (EDM) notch 0.02 inches long, and applied a three-point bend flexure load, which propagated cracks from each end of the notch. The resultant crack lengths were determined at Metcut using a calibrated travelling microscope and verified at Naval Aviation Depot Cherry Point using a scanning electron microscope (SEM). The crack lengths were from 0.055"-0.020" with the average widths of the cracks being 0.001". Figure 1 illustrates an example of a fatigued panel used in testing.

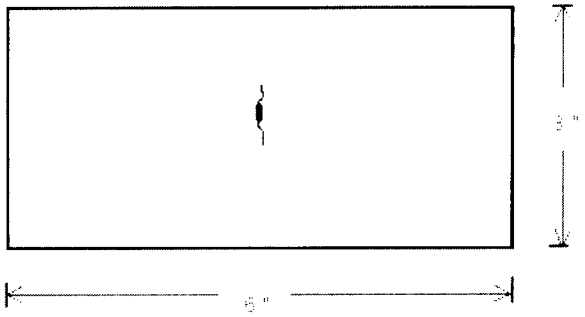

Figure 1. Illustration of a fatigued cracked panel used in testing for crack masking in aluminum alloys.

Processing the panels did not warrant painting. Although the presence of a coating system would provide a buffering effect from media impact, the testing approach did not warrant a coating system to be applied. Inspection of the crack before and after blasting was essential. If the panels were painted after crack initiation and inspection, but prior to blasting, the potential existed for paint to fill the crack. This could result in false indications of crack closure during fluorescent penetrant inspection. An additional benefit from the absence of a coating system is that it allows for worst-case scenario test conditions.

The following test parameters were used for testing, since they represent current operating conditions within a glove box operation:

- Media: 30/60 U.S. Sieve size
- Nozzle Pressure: 40 psi (nominal)
- Stand-Off Distance: 8 inches (nominal)
- Simulated Strip Rate: 0.5 and 1.0 ft^2/min
- Angle of Nozzle to Surface: 60° to 75° from parallel

The simulated strip rate was set up as follows:

- Set A: 2024-1,-3,-5; 7075-1,-3,-5 @ 0.5 ft^2/min
- Set B: 2024-2,-4,-6; 7075-2,-4,-6 @ 1.0 ft^2/min

Prior to PMB one side of the cracked panel was masked under magnification using impact resistant tape to preserve crack integrity. This control crack, present on each panel, would be used for comparison to the blasted crack following one abrasive blast cycle.

Following the blast cycle the panels were FPI using ASTM E 1417 type I, sensitivity level III, method D inspection criteria.

Test Results

The media cleanliness samples from both before and after the blasting of the test samples fell within the MIL-P-85891requirements. Therefore, no appreciable heavy particles were present during the blasting that could have potentially skewed the results.

The results of the blasting analysis are outlined in Table 1.

Specimen Number	Side Masked During PMB	Blasted Side Crack Detection	Non-Blasted Side Crack Detection	Strip Rate Simulated During Blast Cycle (ft^2/min)
2024-1	R	Yes	***NO***	0.5
2024-2	R	Yes	Yes	1.0
2024-3	L	Yes	Yes	0.5
2024-4	R	Yes	Yes	1.0
2024-5	L	Yes	Yes	0.5
2024-6	L	Yes	Yes	1.0
7075-1	L	Yes	Yes	0.5
7075-2	L	Yes	Yes	1.0
7075-3	R	Yes	Yes	0.5
7075-4	L	Yes	Yes	1.0
7075-5	R	***NO***	Yes	0.5
7075-6	R	Yes	Yes	1.0
Penetrant: ARDROX 985-P13; Emulsifier: ARDROX 9PR12; Developer: MET-L-CHEK D-70				

Table 1. Testing results for crack masking of aluminum alloys by PMB prior to fluorescent penetrant inspection.

Only one of the twelve cracks exposed to PMB was not visible to fluorescent penetrant inspection. The 7075-5 left side crack had a small crack length and an angular or broken crack appearance when visually examined under magnification. The following SEM photograph, figure 2, of the panel that had a crack hidden from FPI following PMB illustrates that detection by visual examination is also difficult. Figure 3 illustrates a crack that was masked during blasting and undetected with FPI, however, easy to detect visually. These two data points, therefore, may be statically unreliable.

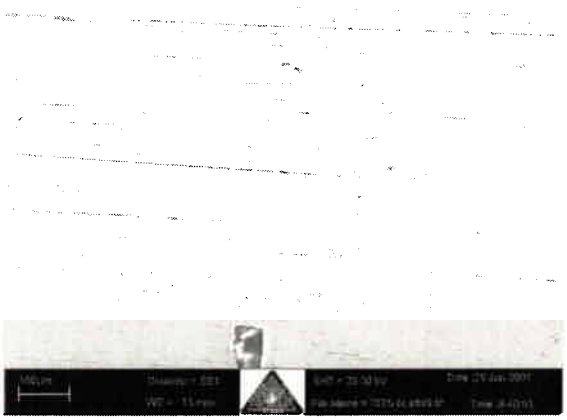

Figure 2. 7075-5 left side that was undetected with FPI after blasting.

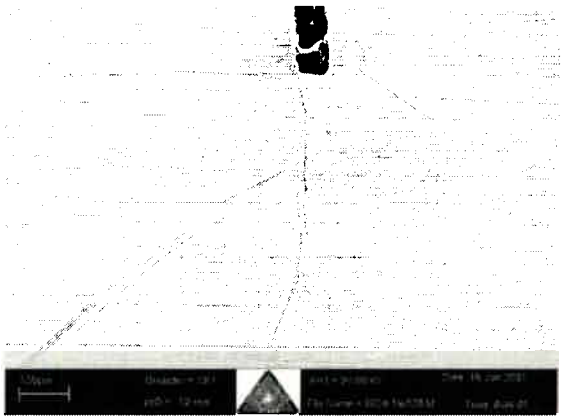

Figure 3. 2024-1 right side that was undetected with FPI, however, masked from blasting.

Further Evaluation Proposals

Recommend the following variables continue to be further investigated:

- Increase data pool to known cracked in-service components
- Compare chemical paint removers and Type VIII PMB prior to FPI
- Investigate post blast surface profiles comparing Type V and Type VIII media.

Composite Systems Paint Removal Analysis

The process limitations for PMB on select composite systems limit the efficiency of composite paint removal. Although PMB is authorized for graphite/epoxy laminate systems with a thickness of 0.073" and greater, PMB is not authorized for fiberglass, graphite/BMI, or laminate/honeycomb lightning strike composite systems. The second goal of this evaluation in to investigate the characteristics of removing paint systems from lightning strike composite systems and graphite/epoxy and graphite/BMI test panels with MIL-P-85891 Type VIII media.

Test Plan

The objective of the composite systems paint removal analysis is to determine the detriments of removing paint systems from composite lightning strike panels and graphite/epoxy and graphite/BMI test panels with MIL-P-85891 Type VIII media. This evaluation used scrapped laminate and honeycomb lightning strike cutout panels from various areas of a weapon system to evaluate the detriments of PMB lightning strike components. This evaluation also used graphite/epoxy and graphite/BMI laminate test panels to evaluate the mechanical properties of a baseline, 1-cycle strip and 5-cycle strip operation. The test panels, a total of ten, were constructed in a 14 ply $(0,0,90,0,0,90,0)_s$ composite matrix. The panels were autoclave cured and NDI with ultrasonic c-scan after cure to inspect for defects. The panels were assigned numbers for classification purposes.

The panels were identified as follows:

- scrap laminate V1-V10
- scrap honeycomb V11-V17
- graphite/epoxy test panels 1-cycle V19/V20, 5-cycle V21/V22
- graphite/bismaleimide test panels 1-cycle V18/V25, 5-cycle V23/V24.

Illustrated below are examples of the scrap laminate and honeycomb lightning strike panels used in the stripping evaluation.

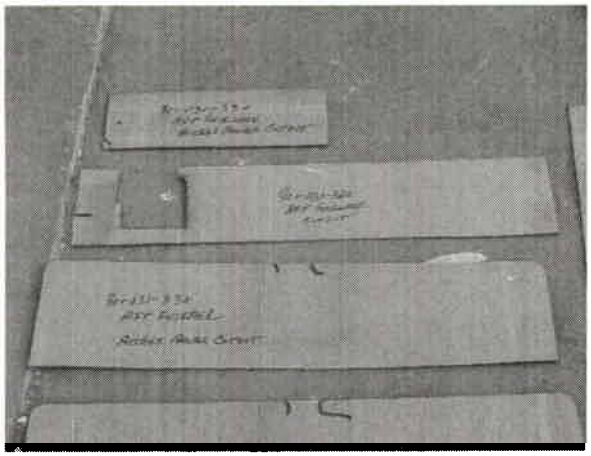

Figure 4. Scrap laminate panels used in stripping evaluation.

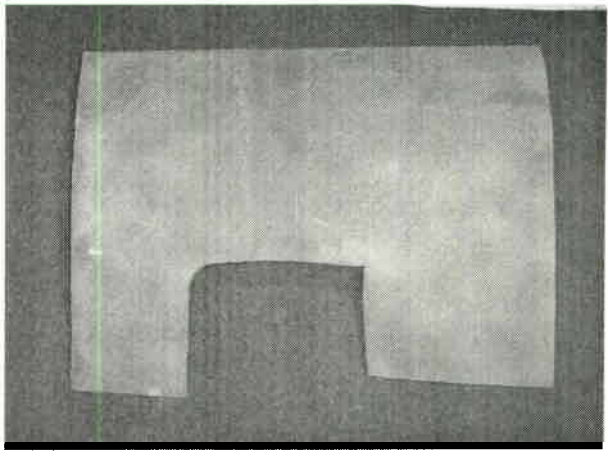

Figure 5. Scrap honeycomb panels used in stripping evaluation.

Once the panels were classified, a MIL-PRF-85582 waterborne epoxy primer and a flat gray MIL-PRF-85285 Type I high solids polyurethane topcoat paint system was applied to all of the panels. The first cycle panels were then cured under accelerated conditions to simulate paint aging.

After the first cycle cure was complete, a baseline NDI using thermal/infrared image analysis was preformed. This baseline set the standard for the following stripping cycle with NDI being performed after the first, third and fourth cycles.

Once fully cured the panels were PMB using the following open booth operating parameters:

- Media size: 30/60 U.S. Sieve size
- Nozzle size: ½" ID double Venturi
- Nozzle Pressure: 25-30 psi (nominal)
- Media feed rate: 650 lbs/min
- Stand-Off Distance: 24 inches nominal, 12 inches minimum
- Strip Rate: $\geq$ 1.0 ft^2/min
- Angle of Nozzle to Surface: 60° from parallel (nominally, varying for surface profile)

Test Results

From a processing evaluation, Type VIII media was compatible with existing PMB equipment. No special equipment was needed to process the media in regards to media delivery or personal protective equipment (PPE). The higher media feed rate and lower nozzle pressure were in accordance with manufactures instructions in order to achieve the desired stripping conditions. During the five PMB cycles the breakdown rate was comparable to Type V, however, a calculated value was not determined.

Preliminary visual examinations illustrated no concerning evidence of surface delaminations or disbonds from PMB. All copper mesh was left intact and undisturbed from the process for three consecutive cycles. Further thermal/infrared image analysis did not detect surface of subsurface degradation as illustrated below in the baseline and fourth cycle figures of V21 (graphite/epoxy) and V18 (graphite/bismaleimide).

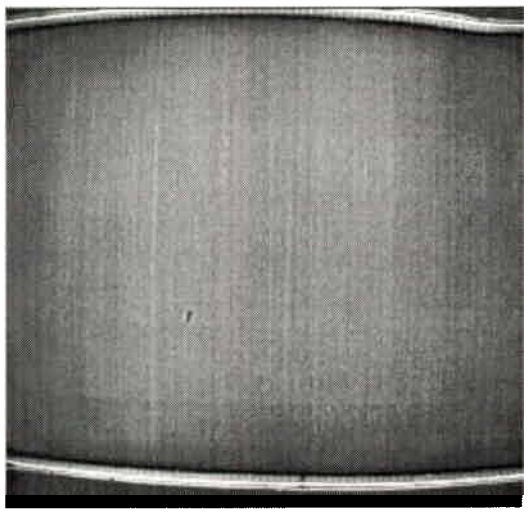

Figure 6. Baseline thermal/infrared image of V21.

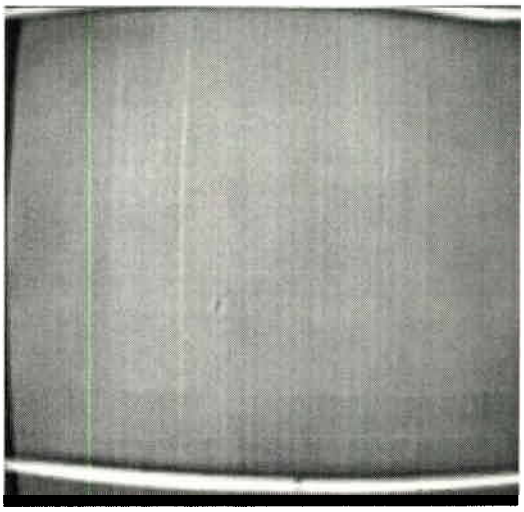

Figure 7. Fourth cycle thermal/infrared image of V21.

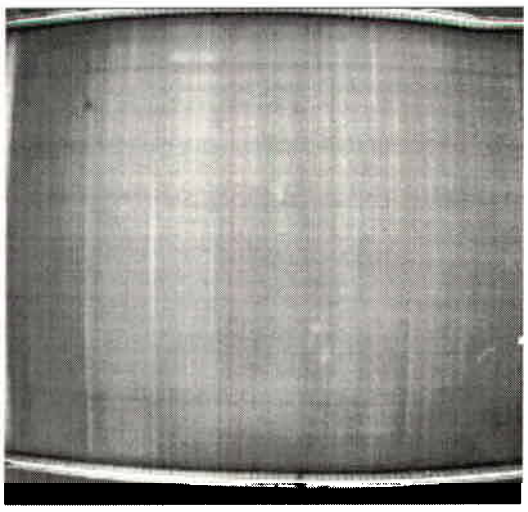

Figure 8. Baseline thermal/infrared image of V18.

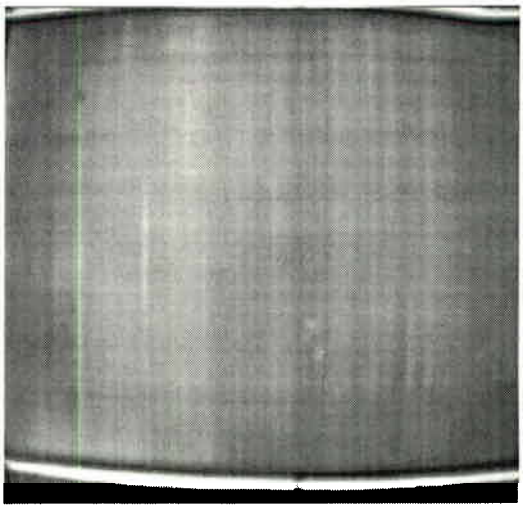

Figure 9. Fourth cycle thermal/infrared image of V18.

The only noted visual detriment the PMB process had on the lightning strike composite systems was observed after the third cycle. An attack on the copper mesh was observed in the resin-starved areas between the surface of the panel and copper mesh interface. The attack on the copper mesh is illustrated in figure 10 and 11, which is the thermal/infrared image of V17, a patch repair.

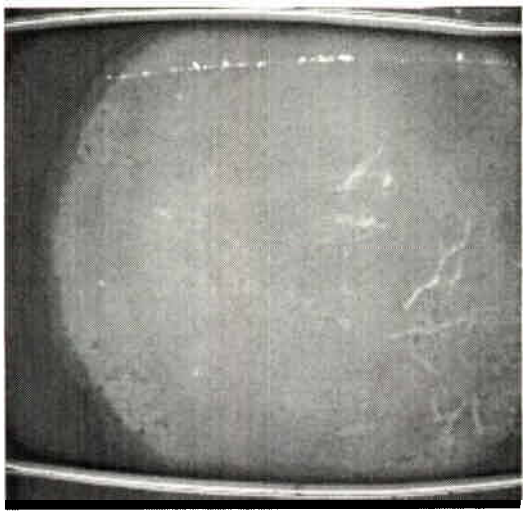

Figure 10. Baseline thermal/infrared image of V17.

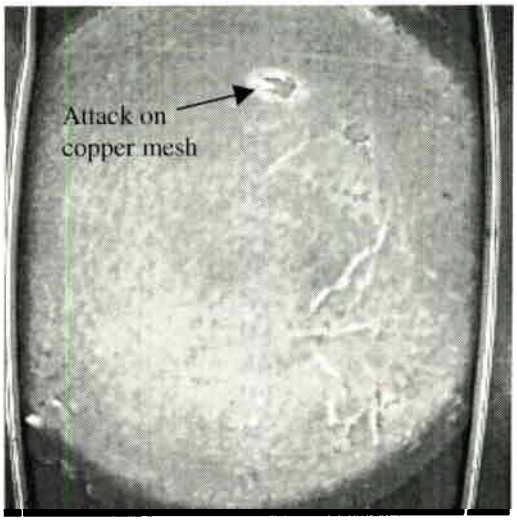

Figure 11. Third cycle thermal/infrared image of V17, which illustrates an attack on the copper mesh.

Conclusions

The Type VIII media illustrated a marginally quicker strip rate and could be processed with the same equipment used for Type V media. No visual surface delaminations or disbonds were observed on any of the panels after 5-cycles of striping. The only observed attack was on the copper mesh matrix after 3-cycles in resin-starved regions. This indicates that paint removal with Type VIII media appears to be suitable for copper mesh composite systems for the foreseeable future. Large patch repairs and other known resin starved areas should be handled on a case by case basis.

Mechanical Properties Analysis

The last part of the preliminary evaluation of MIL-P-85891 Type VIII media is an analysis of the mechanical properties of the graphite/epoxy and graphite/bismaleimide laminate test panels used in the paint removal evaluation. The three mechanical properties analyzed were flexural, tensile and compression. These tests were performed in accordance with the appropriate ASTM testing procedures.

Test Plan and Results

The panels were machined into specimens from each test panel in the zero and ninety-degree orientation for this evaluation. For each material, one panel was used as baseline, two were subjected to 1-cycle strip and two were exposed to 5-cycle strip.

The flexural testing in the zero degree orientation showed no discernable trend for either the 1 or 5 strip cycles, or material type. The ninety-degree testing displayed a slightly increasing trend for the 3501-6 epoxy material for 1-cycle strip process when compared to the baseline data. The data showed a 4.5 and 7.7 percent increase respectively in flexural strength over the baseline data. However, this trend was not seen for the tensile or compression data utilizing the same test panels exposed to the 1-cycle strip process. Additionally, the remainder of the ninety-degree flexural data did not display any specific trend. Based on the data there is no concern with the 1-cycle strip process for the 3501-6 epoxy material. Additional test panels would be recommended to enlarge the data pool, as there were only two panels for each of the 1 and 5 strip cycle processes for comparison with the baseline data.

The tensile testing in the zero and ninety-degree orientations showed no discernible trend. There was one value showing a six percent decrease in strength for the 3501-6 material 1-cycle strip process panel in the zero degree orientation, however, no specific trend was noted in comparison with the second testing panel, or additional compression or tensile testing results. The composite panel modulus was tested using a clip-on extensometer during tensile testing. All modulus data compared well, with one noted exception. There was a large standard deviation for the second 3501-6 material testing panel in the ninety-degree direction, as the result of only two specimens available from the machining process. Additional testing would need to be performed to validate this data point. However, with the limited data available, the tensile and modulus data compare well with baseline and first panel test data.

The compression testing in the zero and ninety-degree orientations showed no discernible trend, and all testing data was within five percent when compared to the baseline for the respective panels and polymer type.

Appendix A provides the data for the mechanical properties evaluation.

Conclusion

Based on the data, the stripping process had no affect on the tensile, flexure or compression mechanical properties of IM6/3501-6 or IM7/5250-4 materials. Additional testing is recommended to evaluate the effect of the stripping process on environmentally exposed composite panels.

Preliminary Evaluation Summary

The results from the preliminary evaluation of proposed MIL-P-85891 Type VIII media were encouraging. The evaluation of PMB prior to FPI of aluminum alloys produced favorable results. The evidence presented in this analysis illustrated that PMB with Type VIII prior to FPI

had no discernable effect on crack detection. However, additional experimental results would be needed to confirm with this analysis using in-service or known cracked components.

Type VIII media could be processed with the existing equipment used for Type V media and exhibited a marginally quicker strip rate. In addition, PMB with Type VIII media could also be expanded to include certain composite systems. From this analysis, no visual surface delaminations or disbonds were observed on the panels after five consecutive stripping cycles. The only observed detriment was noted after the third strip cycle on the copper mesh matrix in areas that were resin-starved.

In addition to the visual and nondestructive examinations, the stripping process had no discernable effect on the tensile, flexure or compression strength of IM6/3501-6 or IM7/5250-4 materials used in the analysis.

It is hypothesized that with the small amount of follow-on work as recommended coupled with an extended production prototype, the PMB process using Type VIII material will be approved and consequently greatly expand NAVAIR's stripping capabilities.

CONTRACT DATA REQUIREMENTS LIST

(1 Data Item)

Form Approved
OMB No. 0704-0188

A. CONTRACT LINE ITEM NO.	B. EXHIBIT	C. CATEGORY: TDP ____ TM ____ OTHER ____
D. SYSTEM/ITEM	E. CONTRACT/PR NO.	F. CONTRACTOR

1. DATA ITEM NO.	2. TITLE OF DATA ITEM	3. SUBTITLE
A001	**Finished Lot Sample Test Data**	

4. AUTHORITY (Data Acquisition Document No.)	5. CONTRACT REFERENCE	6. REQUIRING OFFICE
N/A	**SOW PARA 5.2.2**	**Materials Division**

7. DD 250 REQ.	9. DIST STATEMENT REQUIRED	10. FREQUENCY	12. DATE OF FIRST SUBMISSION	14. DISTRIBUTION
NO	**NO**	**See BLK 16**	**SEE BLK 16**	

8. APP CODE	11. AS OF DATE	13. DATE OF SUBSEQUENT SUBMISSION
	See BLK 16	**See BLK 16**

a. ADDRESSEE	b. COPIES		
	Draft	Final	
		Reg	Repro
NADEP 4.3.4.3	**0**	**1**	**0**

16. REMARKS

EACH FINISHED LOT SAMPLE TEST DATA SHALL BE PROVIDED WITH THE SHIPMENT. CONTRACTOR FORMAT ACCEPTABLE. LETTER OF TRANSMITTAL ACCEPTABLE.

15. TOTAL		1	

G. PREPARED BY	H. DATE	I. APPROVED BY	J. DATE
Eric Gallo	9-3-02	C. Brand	9/3/02

DD Form 1423-1, JUN 90 Previous editions are obsolete. Page 1 of 1 Pages

Enclosure (6)