Engineering and Technical Services for Joint Group on Acquisition Pollution Prevention (JG-APP) Pilot Projects

Joint Test Report
TI-R-1-1

June 20, 1996
(Revised October 24, 1997)

Contract No. DAAA21-93-C-0046
Task No. N.072
CDRL No. A006

Prepared by
National Defense Center for Environmental Excellence (**NDCEE*****)***

Operated by Concurrent Technologies Corporation

Engineering and Technical Services for Joint Group on Acquisition Pollution Prevention (JG-APP) Pilot Projects

Joint Test Report
TI-R-1-1

For Alternatives to High Volatile Organic Compound (VOC) Primers and Topcoats Containing Methyl Ethyl Ketone (MEK), Toluene, and Xylene

June 20, 1996
(Revised October 24, 1997)

Contract No. DAAA21-93-C-0046
Task No. N.072
CDRL No. A006

Prepared by:
National Defense for Environmental Excellence (NDCEE)
Operated by: Concurrent Technologies Corporation (*CTC*)
1450 Scalp Avenue
Johnstown, PA 15904

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

PREFACE

This report was prepared by Concurrent Technologies Corporation (*CTC*) through the National Defense Center for Environmental Excellence (NDCEE) under Contract Number DAAA21-93-C-0046. This report was prepared on behalf of, and under guidance provided by the Joint Group on Acquisition Pollution Prevention (JG-APP) through the Joint Pollution Prevention Advisory Board (JPPAB). The structure, format and depth of technical content of the report was determined by the JPPAB, Texas Instruments-Defense Systems & Electronics (TI-DS&E), and government technical representatives in response to the specific needs of this project. THIS VERSION REFLECTS MINOR EDITORIAL CHANGES. TECHNICAL CONTENT HAS NOT BEEN CHANGED.

We wish to acknowledge the invaluable technical, business, and programmatic contributions provided by the following organizations involved in the creation of this document:

Air Force Aeronautical Systems Center
Air Force Corrosion Program Office
Air Force Materiel Command
Air Force Systems Command, Environmental
Army Industrial Ecology Center
Army Materiel Command
Avenger Tactical Missile Program Office
Abrams Tank System Program Office
Close Combat Anti-armor Weapon System Program Office
Defense Contract Management Command, TI-DS&E, Dallas
F3 Production Office
F-16 Program Office
F/A-18 Program Office
HARM Program Office, PMA 242
Harpoon Program Office, PMA 258
Javelin Program Office
Joint Depot Environmental Panel
JSOW Program Office
LAMPS Program Office, PMA-299
LANTIRN Program Office
Naval Depot - Jacksonville
Naval Air Warfare Center - China Lake
Naval Air Warfare Center - Patuxet River
Night Vision and Electro Optics, Horizontal Technology Integration Program Office
Ocean City Research Corporation
P3 ISAR Program Office, PMA-290
PAVEWAY III Program Office
Texas Instruments - Defense Systems & Electronics
Tomahawk Program Office, PMA 280

EXECUTIVE SUMMARY

This report summarizes the evaluation of several alternative coating materials to replace currently used materials containing high amounts of the volatile organic compounds (VOCs) methyl ethyl ketone, toluene, and xylene.

The National Defense Center for Environmental Excellence (NDCEE) is operated by Concurrent Technologies Corporation (*CTC*) for the Department of Defense (DoD). The Joint Group for Acquisition Pollution Prevention (JG-APP) contracted with *CTC* to provide engineering and technical support to its pilot program. This document is a deliverable for the JG-APP Task per Data Item Description (DID) DAAA21-93-C-0046, Contract Data Requirements List (CDRL) A006.

Based on the analysis of available technical and engineering data, commercial and military applications of the proposed substitutions, critical testing requirements documented in the *Joint Test Protocol TI-P-1-1 for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone, Toluene, and Xylene* dated 20 JUN 96 and technical experience and knowledge of DoD and Texas Instruments-Defense Systems and Electronics technical representatives, the following replacements are technically acceptable:

1. MIL-P-85582, a waterborne primer, may be used as a substitute for MIL-P-23377 in current priming applications, though not wet installation of fasteners or faying surfaces.

2. MIL-C-85285, a high-solids topcoat, may be used as a substitute for MIL-C-83286 and MIL-C-22750 in current airborne topcoat applications.

3. MIL-C-46168 Type IV, ground support topcoat and Chemical Agent Resistant Coating (CARC), may be used as a substitute for the Type II topcoat in the current application.

1. INTRODUCTION

This Joint Test Report (JTR) documents the technical basis for implementing the alternative coating materials identified in Table 1, in place of high volatile organic compound (VOC) materials used as primers and topcoats. In particular, it focuses on the reduction of methyl ethyl ketone (MEK), toluene and xylene. Additionally, it makes available test data and results for future pollution prevention efforts by original equipment manufacturers (OEMs), the Sustainment Community (e.g., depots and bases) and other users to minimize duplication of effort.

During joint technical meetings, technical representatives (TRs) for the 10 major weapons systems manufactured by Texas Instruments-Defense Systems and Electronics (TI-DS&E) reached technical consensus for the four identified alternatives in Table 1. A total of 467 drawings are affected. Since the paint systems under consideration are commercially available, have been accepted and are currently in use at depots and on some military programs, TRs agreed that no further testing is necessary. They reconfirmed that there is sufficient technical and testing data and knowledge about the alternatives, that there is no need for additional technical data, and that the alternatives are technically acceptable replacements.

1.1. JG-APP Background

On 15 September 1994, the Joint Logistics Commanders chartered the Joint Group on Acquisition Pollution Prevention (JG-APP) to coordinate joint service activities affecting pollution prevention issues identified during a weapon system's acquisition process. To avoid duplication of efforts in reducing hazardous material (HazMat) procurement and use, JG-APP will facilitate the Joint Implementation of the Department of Defense Comprehensive Pollution Prevention Strategy dated 11 August 1994. The primary objectives of JG-APP are the following:

- to reduce or eliminate HazMats by fostering joint service cooperation; and
- to avoid duplication of efforts in actions required to reduce or eliminate HazMats and share technology.

TI-DS&E, located in Dallas/Ft. Worth, Texas, is one of the pilot sites. Joint technical meetings led by JG-APP, took place among technical representatives from TI-DS&E, Defense Contract Management Command (DCMC), affected Program Managers, and other technical representatives. These meetings led to the preparation of the *Joint Test Protocol TI-P-1-1 for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone, Toluene and Xylene* (JTP) dated 20 JUN 96 and this JTR documenting the technical consensus of the technical representatives.

JG-APP contracted with Concurrent Technologies Corporation (*CTC*), operator of the National Defense Center for Environmental Excellence (NDCEE), to provide engineering and technical support to the pilot program.

TI-DS&E is continuing the evaluation of additional alternative materials in accordance with the JTP.

1.2. Primers and Topcoats Used at Texas Instruments - Defense Systems and Electronics

TI-DS&E and government Program Managers selected VOCs to be replaced or reduced from high-VOC primer and topcoat operations. Primers and topcoats are currently used in conventional wet-spray coating processes. Table 1 summarizes the alternatives with currently used military specifications for ground support and airborne applications that were selected for consideration by TI-DS&E.

Table 1. Identified Alternatives

Application	Current Specification	Alternative
Primer	MIL-P-23377	MIL-P-85582 (waterborne)
Airborne Topcoats	MIL-C-22750	MIL-C-85285 (high solids)
	MIL-C-83286	MIL-C-85285 (high solids)
Ground Support Topcoats/ Chemical Agent Resistant Coating (CARC) Camouflage	MIL-C-46168 Type II	MIL-C-46168 Type IV

2. TESTING REQUIREMENTS

Critical testing requirements were defined for the alternatives to high-VOC primers and topcoats in the *Joint Test Protocol TI-P-1-1 for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone, Toluene and Xylene* dated 20 JUN 96. The test requirements matrices from the JTP are located in Tables 2, 2A, 3, and 3A of this JTR. The matrices were developed from technical input from TI-DS&E representatives, affected Program Managers, DoD Specification Custodians and other TRs. The identified requirements account for application, performance, and operational impact (supportability) requirements that must be met by a potential alternative for the current application. For each requirement, individual tests and respective procedures and metrics (pass/fail criteria) are identified. Section 2 of the JTP documents the common and extended test requirements for primers, airborne topcoats and ground support topcoats. Common tests are defined as those tests in the JTP that are required by all of the affected parties. Extended tests are required by one or more of the affected parties, but not all.

As mentioned in Section 1, TRs and DoD Specification Custodians concurred that performance testing was not required for the identified alternatives due to the amount of test data already available and the current use of the alternatives identified throughout the DoD industrial painting community. Tables 2 through 3A are provided for reference only.

Table 2. Common Primer Test Requirements

JTP Section	Requirement	Test	Pass/Fail Criteria
3.1.1		Salt Spray (Scribed)	No blistering or lifting
3.1.2		Wet Tape Adhesion	No peel away
3.1.3	Full Cure Test	Recoatability Test	No lifting of topcoat
3.1.4		Solvent (MEK) Rub	No substrate show-through
3.1.5	Impact/Flexibility Resistance	GE Impact Test	10% elongation, no cracks

Table 2A. Extended Primer Test Requirements

JTP Section	Requirement	Test	Pass/Fail Criteria
3.1.6		SO2 Salt Spray (scribed)	≥500 hours
3.1.7		Infrared Reflectance	600-2700=10
3.1.8		Filiform Corrosion	All filaments ≤ 1/4” Majority < 1/8” filaments
3.1.9	Fluid Immersion (Film Change)	Hydraulic Fluid	No blistering, whitening, or dulling
		Lubricating Oil	
		DI Water	

Table 3. Common Topcoat Test Requirements

JTP Section	Requirement	Test	Pass/Fail Criteria
3.2.1	Gloss	Gloss (High)	≥90 units
		Gloss (Semi)	15 - 45 units
		Gloss (Low)	≤ 5 units
3.2.2		Wet Tape Adhesion	No peel away
3.2.3		Solvent (MEK) Rub	No substrate show-through
3.2.4		Hiding Power (white only)	≥ 0.95
3.2.5		Humidity	No film defects
3.2.6		Heat Resistance	color change ≤1.0 Delta E
3.2.7		Accelerated Weather	color change ≤2.0 Delta E
3.2.8		Tape Resistance	No marring
3.2.9		Color	Visual match
3.2.10	Fluid Immersion (Film Change)	Hydraulic Fluid	No blisters, dark stains, soften to scratch
		Lubricating Oil	No blisters, dark stains, soften to scratch

Table 3A. Extended Topcoat Test Requirements

JTP Section	Requirement	Test	Pass/Fail Criteria
3.2.7	Extended Environment	Special Accelerated Weathering	color change ≤1.0 Delta E
3.2.11	Low Observability	Infrared Reflectance	600-2700=8
3.2.1		Very Low Gloss	≤ 1.0 units
3.2.12	Chemical Agent Resistance Tests	DS2 Resistance	No blisters, wrinkles, soften to scratch
3.2.13		Standard Chemical Agents:	
		Agent HD	40 microgram max.
		Agent GD	180 microgram max
		Special Chemical Agent VX	Program requirement
3.2.14		Temperature Shock	Visual (no film defects)
3.2.15		Fungus	Visual (no film defects)
3.2.16		High Temp	Visual (no film defects)
3.2.17		Low Temp	Visual (no film defects)
3.2.18		Rain	Visual (no film defects)
3.2.19		Salt Fog (cyclical)	Visual (no film defects)
3.2.20		Humidity (water soak)	Visual (no film defects)

(Table 3A continued next page)

Table 3A. Extended Topcoat Test Requirements (Continued)

JTP Section	Requirement	Test	Pass/Fail Criteria
3.2.21		Specialized Wet Tape Adhesion	5-15% lattice removal
3.2.22		Recoatability Test	No lifting
3.2.23	Specialized Fluid Resistance	Hydrocarbon	No blisters, dark stains, soften to scratch
		Skydrol	No blisters, dark stains, soften to scratch
		JP4	No blisters, dark stains, soften to scratch
		JP6	No blisters, dark stains, soften to scratch
		JP8	No blisters, dark stains, soften to scratch
		JP10	No blisters, dark stains, soften to scratch
		RJ4	No blisters, dark stains, soften to scratch
3.2.24	Increased Flexibility	Impact Flexibility	No adhesion loss
		Low Temp Flexibility	No adhesion loss

3. SELECTED ALTERNATIVES

3.1. Primers

A commercially available primer that meets MIL-P-85582 was selected as an alternative to MIL-P-23377 primers since the waterborne material was designed to be used in place of MIL-P-23377. Furthermore, according to the DoD Specification Custodian for both specifications, the waterborne MIL-P-85582 is designed to provide equal to or better performance than the current MIL-P-23377. The MIL-P-85582 primers are currently being used as an alternative at several commercial facilities and depots as shown in Tables 4 and 4A.

Table 4. Companies Using MIL-P-85582 Waterborne Primer in Lieu of MIL-P-23377 Primers

Company Name	Programs/Products	Approved By
Boeing Defense & Space Group Puget Sound Operations	All programs except IUS and 13-2	Engineering M&P
Boeing Helicopters	All programs except IUS and 13-2	Engineering M&P
Lockheed Martin Tactical Aircraft Systems, Ft. Worth, TX	F-16 Program	LMTAS Testing
The Boeing Company	H-46, CH-47, V-22, and RAH-66 Helicopters F-22 Jet Fighter	Internal Boeing Helicopter requirements
Northrop Grumman B-2 Division, CA	B-2/All interior surfaces	B-2 M&P
Sikorsky Aircraft, CT	All aircraft models	NAVAIR/ATCOM

Table 4A. DoD Depots Using MIL-P-85582 Waterborne Primer in Lieu of MIL-P-23377 Primers

Depot	Programs/Products	Approved By
SM-ALC/TIELA McClellan Air Force Base, CA	Limited A-10, F-15 application	WL/MLSA
Naval Aviation Depot, Alameda, CA	P-3, A-6, S-3, F-15, F-16 aircraft components and ground support equipment	NAVAIR SYSCOM
Naval Aviation Depot, Cherry Point, NC	H-46, H-53, AV-86, E-4, A-4, C-130	NAVAIR 01-1A-509- Manuals, to 1-1-8
Naval Aviation Depot, Jacksonville, FL	Naval weapon systems	NAVAIR 01-1A-509
WR-ALC/TIEDM Warner Robins Air Force Base, GA	Support and electronics equipment	WA-ALC/TIEDM (Mat. Eng.)

3.2. Airborne Topcoats

A commercially available topcoat that meets the requirements of MIL-C-85285 was selected as an alternative to MIL-C-83286 topcoats, which has been canceled by the DoD for new designs and superseded by MIL-C-85285.

The MIL-C-85285 topcoat has also been selected as an alternative to MIL-C-22750 topcoats. The current version of MIL-C-22750 F is low-VOC, but has problems associated with application. The MIL-C-85285 topcoat is capable of meeting the airborne requirements of MIL-C-22750 and is currently being used as an alternative at several commercial and depot facilities as shown in Tables 5 and 5A.

Table 5. Companies Using MIL-C-85285 Airborne Topcoat in Lieu of MIL-C-83286 or MIL-C-22750 Airborne Topcoats

Company Name	Programs/Products	Approved By
Sikorsky Aircraft, CT	Navy A/C (SH60) (CA53) (Coast Guard)	NAVAIR/ATCOM
The Boeing Company	V-22 Helicopter	Boeing Helicopters and its customers' approval
Lockheed Martin Tactical Aircraft Systems, Ft. Worth, TX	F-16 Program	LMTAS Testing
Northrop Grumman B-2 Division, CA	B-2/Specific interior surfaces for decorative/ functional reasons	B-2 M&P

Table 5A. DoD Depots Using MIL-C-85285 Airborne Topcoat in Lieu of MIL-C-83286 or MIL-C-22750 Airborne Topcoats

Depot	Programs/Products	Approved By
OC-ALC/ITE Tinker Air Force Base, OK	B-1, B-52, C-135, E-3	Operating under waiver of Oklahoma State law regarding air emissions
OO-ALC/TIELM Hill Air Force Base, UT	Landing gear F-16, F-15, C-130	Weapons system Technical Orders (TO's)
SA-ALC/TIESM Kelly Air Force Base, TX	C-5 Aircraft, T-37/T-38 Aircraft, Ground support equipment, C-17 Aircraft	T.O. 1-1-8; AF Corrosion Office
AGMC/MA, Newark Air Force Base, OH	B-1B displacement gyroscope	Being replaced by GSA
Naval Aviation Depot, Alameda, CA	P-3, A-6, S-3, F-15, F-16 aircraft components and ground support equipment	NAVAIR SYSCOM
Naval Aviation Depot, Cherry Point, NC	H-46, H-53, AV-86, E-4, A-4, C-130	NAVAIR 01-1A-509 - Manuals, to 1-1-8

(Table 5A continued next page)

Table 5A. DoD Depots Using MIL-C-85285 Airborne Topcoat in Lieu of MIL-C-83286 or MIL-C-22750 Airborne Topcoats (Continued)

Depot	Programs/Products	Approved By
Naval Aviation Depot, Jacksonville, FL	Naval weapon systems	NAVAIR 01-14-509
Naval Weapons Station Code 30 Yorktown, VA	Maverick, Sidearm, Skipper, TOW, HARM, Harpoon, Phoenix, Shrike, Sidewinder, Sparrow, Hellfire, Walleye, AMRAAM, SLAM, bomb racks, cluster bomb units, 2.75" rockets, 2.75" rocket launchers, pyrotechnics, all containers, missile launchers, test sets	NAVAIR 01-1A-75
SM-ALC/TIELA McClellan Air Force Base, CA	A10, F-15, various shelters, and communication-electronic equipment	Technical Orders*
WR-ALC/TICOM Warner Robins Air Force Base, GA	C-130 & C-141 electrical, AGE	Not available*
Naval Air Warfare Center, IN	Navy Avionic Equipment	Drawings*
WR-ALC/TIEDM Warner Robins Air Force Base, GA	F-15, C-130, and C-141 aircraft and support equipment and electronics equipment	WA-ALC/TIEDM (Mat. Eng.); C-130, C-141, and C-15 SPD's

***** Specific approval information was not available from the depot. Approval at the depot was made with information available locally.

3.3. Ground Support Topcoats

A commercially available topcoat that meets the requirements of MIL-C-46168 Type IV has been selected as a candidate for replacement of MIL-C-46168 Type II topcoat for ground support topcoat and CARC applications. According to the DoD Specification Custodian for MIL-C-46168, both Types II and IV chemical agent resistant coatings must meet the same performance requirements and are technically interchangeable. Both are lead- and chromate-free, but they differ in chemistries required to meet environmental regulations for VOCs. Per MIL-C-46168, type II permits a higher VOC limit of 20% by volume and Type IV is limited to 3.5 pounds per gallon (of paint). Tables 6 and 6A document several commercial facilities and depots currently using MIL-C-46168 Type IV topcoats.

Table 6. Companies Using MIL-C-46168 Type IV Ground Support Topcoat in Lieu of Type II

Company Name	Programs/Products	Approved By
Sikorsky Aircraft, CT	Army H-60 A/C (UH60)	NAVAIR/ ATCOM
Boeing Helicopters	CH-47 and RAH-66	Engineering M&P and customer's approval

Table 6A. DoD Depots Using MIL-C-46168 Type IV Ground Support Topcoat in Lieu of Type II

Company Name	Programs/Products	Approved By
Anniston Army Depot, Anniston, AL	M1, Abrams Tank Systems	Depot Maintenance Work Requirements
Naval Aviation Depot, Jacksonville, FL	When needed to meet weapon system requirements	NAVAIR 01-14-509
SM-ALC/TIELA McClellan Air Force Base, CA	Various shelters, trailers, and communication-electronic equipment	Systems managers via PO's

4. RESULTS

The following sections document the technical, scientific, and engineering rationale that supports the selection of the alternatives identified in Table 1.

As shown in this section, the selected alternatives are currently being used at DoD depots performing rework in accordance with:

- NAVAIR 01-1A-509, TO 1-1-691, "Aircraft Weapons Systems Cleaning and Corrosion Control" Manual
- TO 1-1-8, "Application and Removal of Organic Coatings"
- TM-43-0139, "Painting Instructions for Army Materiel"

4.1. Primers

The MIL-P-85582 primer is an acceptable replacement for MIL-P-23377 as per the DoD Specification Custodian. A comparison of the current and proposed alternatives is listed in Table 7.

Table 7. Comparison of Performance Requirements for MIL-P-23377F, MIL-P-23377G, and MIL-P-85582B Primers

	MIL-P-23377F, Type I, Class 1	**Interim Systems MIL-P-23377G, Type I, Class C**	**MIL-P-85582B, Type I, Class C2**
VOC Content, MIL SPEC Limit (lb/gal)	Solvent quantities suitable for air or airless spray application	2.8	3.5
VOC Content (lb/gal of solids applied)*	15.5	4.78	4.88
Compatibility with MIL-T-81772 Type II Thinner	Compatible	Compatible	Not compatible; Use water in place of thinner
Storage Stability of Unopened Package	1 year between 35° F and 115° F	1 year between 35° F and 115° F	1 year between 35° F and 115° F
Drying Time	0.5-1 hour 1 hour "tack free" 6 hours dry hard	5 hour set-to-touch 8 hours dry hard	0.5-1 hour 1 hour "tack free" 6 hours dry hard
Pot Life	8 hours	4 hours	4 hours
Strippability	90% stripped in 1 hour	90% stripped in 1 hour	90% stripped in 15 minutes
Wet Tape Adhesion	Pass after 24 hours	Pass after 24 hours	Pass after 24 hours
Impact Flexibility (elongation)	10% minimum	10% minimum	10% minimum

(Table 7 continued next page)

Table 7. Comparison of Performance Requirements for MIL-P-23377F, MIL-P-23377G, and MIL-P-85582B Primers (Continued)

	MIL-P-23377F, Type I, Class 1	Interim Systems MIL-P-23377G, Type I, Class C	MIL-P-85582B, Type I, Class C2
Filiform Corrosion Resistance	Pass	Pass	Pass
Salt Spray Resistance (scribed)	1,000 hours	2,000 hours	2,000 hours
Fluid Immersion Resistance: Lubricating Oil	24 hours at 250° F	24 hours at 250° F	24 hours at 250° F
Fluid Immersion Resistance: Hydraulic Fluid	24 hours at 150° F	24 hours at 150° F	24 hours at 150° F
Fluid Immersion Resistance: Distilled Water	4 days at 120° F	4 days at 120° F	4 days at 120° F
Lifting	None visible	None visible	None visible
Solvent Retention	Less than 1% after 7 days	Not required	Not required
Comments	Solvent borne MIL-P-23377F, Class 1 "Standard Solvents", canceled for new designs	Solvent borne, High-solids High Rework Rate Orange Peel Problem - Thin Coat Poor Topcoat Adhesion - Thick Coat Too Glossy 23377G does not work as well as 23377F	Water-reducible Not currently used for bare steel or wet installation of fasteners

*Data provided by TI-DS&E on 30 AUG 95. Calculation of VOCs in pounds per gallon of solids is required by the Texas Natural Resource Conservation Commission.

In October 1995, JG-APP chartered *CTC* to study companies and DoD depots that have made the transition from MIL-P-23377 to MIL-P-85582. Also, the Joint Maintenance Analysis Group's Joint Depot Environmental Panel (JDEP) conducted a similar survey of DoD depots. A summary of the results is in Tables 4 and 4A.

Based on the technical data and current usage of MIL-P-85582 primers and current performance requirements, MIL-P-85582 primers are recommended as an acceptable replacement for MIL-P-23377 primers that will meet the identified current performance requirements for the particular application.

4.2. Airborne Topcoats

The DoD Specification Custodian for MIL-C-83286 identified MIL-C-85285 topcoats as technically acceptable alternatives to MIL-C-83286 topcoats since it was canceled for new designs as of 1995. A comparison of the performance requirements for MIL-C-22750, MIL-C-83286, and MIL-C-85285 is in Table 8.

Table 8. Comparison of Performance Requirements for MIL-C-22750, MIL-C-83286, and MIL-C-85285 Airborne Topcoats

	MIL-C-22750F	MIL-C-83286B	MIL-C-85285B
VOC Content, MIL SPEC Limit (lb/gal)	2.8	Not Specified	3.5 (Type I) 2.8 (Type II)
VOC Content (lb/gal of solids applied)*	4.2	15.5	6.8
Compatibility with Type I Thinner	Not required	Compatible	Compatible
Compatibility with Type II Thinner	Compatible	Not required	Compatible
Drying Time	0.5 hour maximum set-to-touch 3 hours dry hard 4 hours dry through	1 hour dry-to-recoat max. 2 hours set-to-touch 6 hours dry hard	4 hours set-to-touch 8 hours dry hard
Pot Life	8 hours	6 hours	8 hours
Settling (no curdling, precipitation, or separation)	Not required	6 hours	8 hours
Storage Stability of Unopened Package	1 year between 35° F and 115° F	1 year between 0° F and 115° F	1 year between 35° F and 115° F
Colors	All colors allowed	Available	Available
60 Degree Specular Gloss; Gloss Colors	90 minimum	90 minimum	90 minimum
60 Degree Specular Gloss; Semi-gloss Colors	15 minimum; 30 maximum	Not required	15 minimum
60 Degree Specular Gloss; Camouflage Colors	5 maximum	7 maximum	5 maximum
Wet Tape Adhesion	Pass	Pass	Pass
Impact Flexibility (elongation)	Not required	60% min. (gloss); 20% min. (flat)	40% min. (Type I); 5% min. (Type II)
Flexibility	Pass over 1 inch mandrel	Not required	Pass over 1 or 2 inch mandrel
Hiding Power (contrast ratio)	0.9 minimum	0.85 minimum	0.9 minimum (white)
Salt Spray Resistance	336 hours (with primer)	500 hours	2,000 hours (with primer)
Humidity Resistance	Not required	30 days at 95% RH and 120° F	30 days at 100% RH and 120° F
Heat Resistance	1 hour at 250° F	4 hours at 300° F	1 hour at 250° F

(Table 8 continued next page)

Table 8. Comparison of Performance Requirements for MIL-C-22750, MIL-C-83286, and MIL-C-85285 Airborne Topcoats (Continued)

	MIL-C-22750F	MIL-C-83286	MIL-C-85285B
Cold Resistance	Not required	4 hours at -65° F	4 hours at 60° F
Fluid Immersion Resistance: Lubricating Oil	24 hours at 250° F	24 hours at 250° F	24 hours at 250° F
Fluid Immersion Resistance: Hydrocarbon	7 days, standard conditions	7 days, standard conditions	Not required
Fluid Immersion Resistance: Hydraulic Fluid	24 hours at 150° F	7 days, standard conditions	24 hours at 150° F
Fluid Immersion Resistance: Skydrol 500B	Not required	7 days, standard conditions	Not required
Fluid Immersion Resistance: Distilled Water	4 days at 120° F	4 days at 100° F	4 days at 120° F
Accelerated Weathering	500 hours	500 hours	500 hours
Outdoor Weathering	Not required	1 year in Florida	1 year in Florida
Tape Resistance without Marring	8 hours	16 hours (except black)	8 hours
DS2 Decontamination Solution Resistance	Pass	Not required	Not required
Chemical Warfare Agent GD	Not required	Not required	Not required
Chemical Warfare Agent HD	Not required	Not required	Not required
MEK Resistance	Pass	Not required	Pass
Strippability	90% minimum in 1 hour	Not required	90% minimum in 1 hour
COMMENTS	High solids Revision E and F version - poor quality Chronic problems: Orange peel, gloss, viscosity, cure, adhesion, source of supply High rework (strip) rate - excess emissions Revision D provides good quality @ 11.8 lb/gal VOC	Solvent borne MIL-C-83286 canceled MIL-C-85285 - Future acquisition	Solvent borne, high solids Used on LAMPS III FLIR, Tomahawk, and JSOW

*Data provided by TI-DS&E on 30 AUG 95. Calculation of VOCs in pounds per gallon of solids is required by the Texas Natural Resource Conservation Commission.

In October 1995, JG-APP chartered *CTC* to study companies and DoD depots that have made the transition from MIL-C-83286 or MIL-C-22750 topcoats to

MIL-P-85285. JDEP conducted a similar survey of DoD depots. A summary of the results is in Tables 5 and 5A.

Based on the technical data and the current usage of MIL-C-85285 airborne topcoats and current performance requirements, MIL-C-85285 topcoats are recommended as an acceptable replacement for MIL-C-83286 and MIL-C-22750 topcoats.

4.3. Ground Support Topcoats

Per the DoD Specification Custodian, the MIL-C-46168 Type II and Type IV topcoats are technically equivalent with respect to performance characteristics and are technically interchangeable. The two types of coatings have identical requirements, performance and paint shop application techniques and both are technically acceptable. Performance requirements for MIL-C-46168 Type II and Type IV coatings are compared in Table 9.

Table 9. Comparison of Performance Requirements for MIL-C-46168 Types II and IV Ground Support Topcoats

	MIL-C-46168 Type II	MIL-C-46168 Type IV
VOC Content, MIL SPEC Limit	20% by volume (per SCAQMD* Rule 102)	3.5 lb/gal
VOC Content (lb/gallon of solids applied)**	10.42	7.26
Compatibility Type I Thinner	Compatible	Compatible
Storage Stability of Unopened Package	1 year between 0° F and 115° F	1 year between 0° F and 115° F
Drying Time	0.5 hour maximum set-to-touch 3 hours dry hard 4 hours dry through	0.5 hour maximum set-to-touch 3 hours dry hard 4 hours dry through
Colors	Selected colors allowed with variation	Selected colors allowed with variation
60 Degree Spectacular Gloss	1 maximum	1 maximum
Infrared Spectral Reflectance	Low	Low
Wet Tape Adhesion	Pass	Pass
Flexibility (phosphatized thin steel only)	Pass over 1/4 inch mandrel	Pass over 1/4 inch mandrel
Hiding Power (contrast ratio)	0.92 minimum	0.92 minimum
Polish Resistance	Max 85° Gloss = 12	Max 85° Gloss = 12
Recoatability	Recoatable	Recoatable
DS2 Decontamination Solution Resistance	Pass	Pass

(Table 9 continued next page)

Table 9. Comparison of Performance Requirements for MIL-C-46168 Types II and IV Ground Support Topcoats (Continued)

	MIL-C-46168 Type II	MIL-C-46168 Type IV
Chemical Warfare Agent GD	Pass	Pass
Chemical Warfare Agent HD	Pass	Pass
Fluid Immersion Resistance: Hydrocarbon	7 days, standard conditions	7 days, standard conditions
Acetic Acid Resistance	1 hour	1 hour
Fluid Immersion Resistance: Distilled Water	7 days, standard conditions	7 days, standard conditions
Accelerated Weathering	300 hours	300 hours
Outdoor Weathering	2 years exposure; vicinity of Washington, DC	2 years exposure; vicinity of Washington, DC
COMMENTS	Solvent borne Rule 102 - SCAQMD Used on: M1A2 Abrams MBT CITV, Avenger Sight	Solvent borne, high solids Used on: HMMWV, Bradley, DNTSS, CITV, IBAS, Air Force, Navy

* South Coast Air Quality Management District

**Data provided by TI-DS&E on 30 AUG 95. Calculation of VOCs in pounds per gallon of solids is required by the Texas Natural Resource Conservation Commission.

As part of the October 1995 JG-APP chartered study, *CTC* also investigated the transition from MIL-C-46168 Type II ground support topcoats to Type IV coatings. A summary of the results is in Table 6 and 6A.

Based on technical data and the current usage, Type IV ground support topcoats are being used in lieu of Type II for similar applications. Furthermore, both types have similar performance requirements. Therefore, a change from Type II ground support topcoats to Type IV is technically acceptable and recommended.

5. CONCLUSION

The following replacements are technically acceptable and will yield satisfactory results equal to or better than the current requirements with no adverse impact on product performance.

1. MIL-P-85582, a waterborne primer, may be used as a substitute for MIL-P-23377 in current priming applications, though not wet installation of fasteners or faying surfaces.

2. MIL-C-85285, a high-solids topcoat, may be used as a substitute for MIL-C-83286 and MIL-C-22750 in current airborne topcoat applications.

3. MIL-C-46168 Type IV, ground support topcoat and a Chemical Agent Resistant Coating (CARC), may be used as a substitute for the Type II topcoat in the current application.

This conclusion is based on the analysis of technical and engineering data available to date, commercial and military applications of the proposed substitutions, critical testing requirements documented in *Joint Test Protocol TI-P-1-1 for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone, Toluene, and Xylene* dated 20 JUN 96 and technical experience and knowledge of DoD and TI-DS&E technical representatives.

6. REFERENCE DOCUMENTS

DOCUMENT	NAME	SECTION	DATE
MIL-C-22750	Coating, Epoxy, High-Solids	All	1994
MIL-C-46168	Coating, Aliphatic Polyurethane, Chemical Agent Resistant	All	1993
MIL-C-83286	Coating, Polyurethane	All	1995
MIL-P-85582	Primer Coating: Epoxy, Waterborne	All	1994
MIL-C-85285	Coating, Polyurethane, High-Solids	All	1990
MIL-L-23699	Lubricating Oil, Aircraft	All	1994
MIL-H-83282	Hydraulic Fluid, Fire-Resistant, Aircraft	All	1986
MIL-P-23377	Primer Coating: Epoxy, High-Solids	All	1994
MIL-T-81772	Thinner, Aircraft Coatings	Types I and II	1991
MIL-C-53072	Chemical Agent Resistant Coating (CARC), Systems Application Procedures		1992
MIL-R-81294	Remover, Paint, Epoxy, Polysulfide, Polyurethane Systems	Type 1, Class 1	1990
ASTM D-2794	Rapid Deformation (Impact)	All	1992
ASTM B-117	Salt Spray (Fog) Testing	All	1990
ASTM D-522	Low Temperature Flexibility	All	1992
ASTM D-523	Gloss Test	All	1989
ASTM D-2803	Filiform Corrosion Test	All	1993
ASTM D-1308	Fluid Immersion Test	All	1993
ASTM D-2247	Humidity Test	All	1994
ASTM D-3359	Tape Adhesion	All	1992
ASTM D-2805	Hiding Power Test	All	1988
ASTM G-26	Accelerated Weathering Test	All	1990
ASTM G-85.A4	SO2 Salt Spray	All	1990
FED-STD-141	Wet Tape Test	Method 6301.2	1986
FED-STD-141	Humidity Test	Method 6201	1986
FED-STD-141	Heat Resistance Test	Method 6051	1986
FED-STD-141	Color Test	Method 4250.1	1986
FED-STD-141	Gloss Test	Method 6101.1	1986
FED-STD-141	Infrared Reflectance from Spectrophotometric Data	Method 6241.1	1986
FED-STD-141	Infrared Reflectance from Reflectometer	Method 6242.1	1986
FED-STD-141	Knife Test	Method 6304.1	1986
FED-STD-595B	Color Standards	All	1989
MIL-STD-810	High Temperature Test	M501	1989
MIL-STD-810	Low Temperature Test	M502	1989
MIL-STD-810	Temperature Shock	M503	1989
MIL-STD-810	Rain Test	M506	1989
MIL-STD-810	Humidity Test	M507	1989
MIL-STD-810	Fungus Test	M508	1989
MIL-STD-810	Salt Fog Test	M509	1989
JTP TI-P-1-1	Joint Test Protocol TI-P-1-1 for Alternatives to High Volatile Organic Compounds (VOCs) Primers and Topcoats Containing: Methyl Ethyl Ketone, Toluene, and Xylene	All	20 Jun 96