Non-Chromated Bond Primer Technical Interchange – Phase II Update [External]

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Version **01**

This document is released for purpose of providing a high-level summary of the IAEG WG2 project focused on non-chromated Bond Primers

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Version History

Date	v#	Modified By	Section, Page(s) and Text Revised
6th Mar 2025	*1*	P. Guthrie	Initial Revision: External Report

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Executive Summary

Members of the International Aerospace Environmental Group (IAEG), Working Group 2 (Replacement Technologies), which included Airbus, Bell Textron Inc/Textron Aviation, The Boeing Company, Rolls-Royce plc, SAAB AB, Spirit Aerosystems, and United Technologies (now Raytheon Technologies), participated in a Technical Exchange Project on non-chromate bond primers, Phase I. The members collaborated to exchange information on key requirements for implementation of chromate-free bond primer and adhesive systems for aerospace applications, which are summarized in the Phase I project summary report titled: Non-Chromated Bond Primer Technical Interchange. Available results from prior and ongoing development activities on non-chromate bond primers within the participating companies, data published in reports and data provided by formulators were also collected and compiled as part of this technical exchange project and are included in the original report. Members plan to use the outcome of this project as a basis for a follow-on collaboration project, Phase II, between the participating end-user companies and bond primer formulators to develop non-chromate bond primers to meet aerospace application requirements.

Prior to the start of Phase II, IAEG member companies were invited to join the bond primer project. As a requirement of participation in Phase II, new member companies were required to exchange information on key requirements for implementation of chromate-free bond primer and adhesive systems for aerospace applications. The received data was then combined with the data collected in Phase I and the Project Summary Report revised. Data from member companies that are not continuing into Phase II was removed from this updated report.

The companies that joined at Phase II were Bombardier, De Havilland Canada, Gulfstream Aerospace, Israel Aerospace Industries, Leonardo and Lockheed Martin.

All results generated by the project are for voluntary and unilateral consideration and use of the companies.

1 Background

This report is a summary of results from a technical exchange collaborative project on non-chromate bond primers used by the aerospace industry under the Charter of the International Aerospace Environmental Group (IAEG), Working Group 2 (Replacement Technologies).

Phase I was conducted under the terms and conditions set forth in the Collaboration Agreement and Addendum entered into by and among the International Aerospace Environmental Group, Inc. (IAEG), Airbus, Bell and Textron Aviation, The Boeing Company, GE Aviation, GKN Aerospace Services Ltd., Rolls-Royce plc, SAAB AB, Spirit Aerosystems, and UTC (now Raytheon Technologies) dated 22 May 2017, Addendum dated 18 April 2018, and the Statement of Work (SoW) dated 18 April 2018.

Prior to commencing the project's second phase a new collaboration agreement, addendum and statement of work were signed by all continuing parties, as well as new companies to the project team. The terms and conditions governing this report are those set forth in the Collaboration Agreement and Addendum entered into by and among the International Aerospace Environmental Group, Inc. (IAEG), Airbus, Bell and Textron Aviation, The Boeing Company, Bombardier, De Havilland Aircraft Canada, Israel Aerospace Industries, Leonardo, Lockheed Martin, Raytheon Technologies, SAAB AB, Spirit Aerosystems, and Viking Air dated 12 January 2021, Addendum dated 19 May 2021, the Statement of Work (SoW) dated 11 January 2021 and the Statement of Work Amendment Letter dated 12 February 2021.

Gulfstream Aerospace joined the consortium in 2024 having signed the Addendum dated 19 May 2021.

2 Problem Statement

Bond primers, widely used within the aerospace industry, utilize hexavalent chromium compounds as corrosion inhibitors. Under applicable government regulatory programs, hexavalent chromium has been determined to have an adverse effect on human health and the environment. The European Chemicals Agency (ECHA) has placed strontium chromate on the Annex XIV Authorization List. Import and use of strontium chromate (CAS 7789-06-2) after January 2019 is subject to authorization, and as such, adhesive bond primers containing strontium chromate, may only be used for applications covered by Applications for Authorization ID 0046-01, 0046-02 and 0117-01.

Bond primer for metallic substrates can provide the following attributes:

- Environmental and corrosion resistance
- Stabilize the oxide layer on the substrate for storage and handling
- Enhanced wetting capability for film adhesive contact
- Compatible interface between substrate and the adhesive to maintain structural properties of the adhesive

While there are several alternatives under development, no direct replacements are yet available for implementation into production. All available potential replacements for the chromated bond primer will require detailed application analysis and validation.

3 Purpose and Objectives

As part of this non-chromate bond primer technical exchange project, participating members of the International Aerospace Environmental Group (IAEG), Working Group 2 (Replacement Technologies) on this project, collaborated to:

- Exchange data and their experiences that are (a) available in the public domain and (b) obtained from members´ replacement activities.
- Exchange data for alternatives to chromated bond primer that can be used to support substitution within OEM designs and standard parts.
- Identify environmentally compliant alternatives to current bond primer systems.
- Demonstrate the availability of substitutes to those that utilize conventional bond primer if the target engineering permits.

The objectives of the technical interchange project were established in the Phase I SoW. Minor modifications were made during the project to the work breakdown structure of the deliverables, whilst keeping within the original scope of the project objectives. The objectives and corresponding deliverables were as follows:

1. Map identified applications and its key requirements (Deliverable D1)
2. Description of replacements that could potentially be used in place of chromated bond primers, or are already applied, including:
    a. summary of non-chromated primers evaluated by the participating companies and those available in the public domain (Deliverable D2A), and
    b. summary of bond primers in development provided by suppliers of bond primers (Deliverable D2B)
3. Consolidate and aggregate the results into a detailed IAEG report for participating companies only, including recommendations for future collaboration activities in a potential follow-on collaboration project among the project partners, and in accordance with the collaboration agreement governing the Bond Primer project and compliant to the IAEG anti-trust policy. (Deliverable D3)
4. Prepare an Executive Summary report summarizing the general outcome of the project for circulation to all the WG2 member companies (Deliverable D4)

At the start of Phase II of the project the four deliverables from Phase I were updated with data from new member companies.

All results generated by the project are for voluntary and unilateral consideration and use of the companies.

4 Timeline (Milestones & Deliverables)

The Phase I technical interchange project was originally projected to last 4 months after launch of project. However, delays in getting agreements signed, internal approvals within the member companies to release information, addition and admission of new member companies after the start of Phase II, the inability to participate and decision to withdraw by two Phase I companies after the project had started, coordinating supplier presentations, and availability of team to support this

project given other priorities extended this project to 24 months, as shown in Figure 1. Since many of the member companies had active projects covering the scope of this project, the extension benefited the project as new results became available. These were shared during this project by the team members and are included in the report.

Task/Deliverable/Milestone			Start	End	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21
D 1	Mapping of identified applications	WP1	M0	M8																					
D 2A	Results of replacements candidates – Participant input	WP1	M2	M9																					
D 2B	Results of replacements candidates – Supplier input	WP1	M12	M14																					
D 3	Detailed Report "Project summary"	WP2	M13	M 20																					
D 4	IAEG report on bond primer replacement (Executive Summary)	WP2	M18	M 20																					

Figure 1 - Timeline for Bond Primer Technical Interchange (Phase I) Project

After launch of Phase II, the collection of new and updated member data, work package 1, was originally projected to last 3 months. However, delays in getting agreements signed, internal approvals within the member companies to release information, addition and admission of six companies after the start of the project, extended this work package to 6 months, as shown in Figure 2.

WP #	Task/Deliverable/Milestone	Start	End	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12	M 13	M 14	M 15	M 16	M 17	M 18	M 19	M 20	M 21	M 22	M 23	M 24
1	SOW signed	M1	M6																								
	Collaboration signed	M1	M6																								
	D1/D2 shared by new members	M2	M6																								
2	Updated Phase 1 report – new member data	M3	M7																								
	Test Matrix approved	M3	M7																								
3	Supplier Presentations	M4	M8																								
	Candidate Down-Selection	M7	M9																								
4	Test specimen Fabrication	M8	M15																								
	Testing	M9	M16																								
	Test report Complete	M18	M24																								

Figure 2 - Timeline for Bond Primer Technical Interchange (Phase II) Project

5 Data Collection & Analysis

5.1 Information Collection Approach

In Phase I of the project, the collaboration team developed questionnaire templates using Microsoft Excel for completing Deliverables D1 Application Requirements and D2A Company Test Results, which were then used by the participating companies to provide their inputs. Project leads from the participating member companies populated the templates with available information. All data was uploaded on the IAEG WG2 Bond Primer SharePoint site. Information received from the participating companies for each of the deliverables, D1 and D2A, were consolidated into a single file and anonymized.

In Phase II, new member companies populated the D1 and D2A spreadsheets. Several Phase I member companies provided updated information in Phase II. Data from Phase I members that had left the project was removed. All Phase II information received was consolidated, anonymized and added to the Phase I data.

5.2 Data Analysis

A summary of member company bond primer applications and the key test requirements (extracted from consolidated D1 data file) were presented in Table 1. The team reviewed and discussed the output from Table 1 and decided that focus of the test screening matrix required to be on three key applications: paint adhesion, bond adhesion and corrosion protection. The member companies down selected seven tests for the test screening matrix, Table 2. The key test screening requirements were supplied to bond primer formulators as the proposed minimum test requirements for Phase II of the bond primer project.

A summary of the available tests results for the non-chromated bond primers was extracted from consolidated D2A data file and included information available in the public domain. The summary is shown in Table 2. The data verified that there were currently no non-chromated bond primers that met the necessary performance criteria of the project member companies.

For the D2B deliverable in Phase I, the team invited four formulators of bond primers to provide an overview of their development activities. Three of the formulators accepted our invitation. At the time of publication of this report, two of the formulators, Henkel and Syensqo (formally Solvay) presented their development activities and progress update on non-chromate bond primers and adhesive systems to the team.

During Phase II of the report, Henkel and Syensqo were invited to present their updated data on non-chromated bond primers. Other formulators have been invited to provide information including 3M, Hexcel, Indestructible Paints and Socomore. The information shared will be included in a later revision of this report.

6 Conclusions

At the conclusion of the Phase I and Phase II technical interchanges, there was consensus among the participating companies of this project that there was a common need for chromate-free bond primers that offer corrosion protection for adhesively bonded metal structures for various aerospace components. The team has compiled a set of key requirements including applicable material systems and pertinent screening tests for identifying, evaluating and qualifying chromate-free bond primer and adhesive systems. There are at least three formulators that are developing chromate-free bond primer and adhesive systems. Further development and testing are needed before these systems can be considered for implementation in aerospace applications. The participating team members plan to continue to collaborate together and with formulators in order to accelerate the development and implementation of chromate-free systems for their applications.

7 Lessons Learned and Recommendations

Based on the results in Phase I Technical Interchange, all participating companies have commonality in needs and requirements for chromate-free bond primers and adhesive systems and see value in working together and with formulators to evaluate non-chromate bond primers for aerospace applications.

At the conclusion of Phase I, all participating team members proposed to continue working together on this collaborative project. The team was also open to other Working Group 2 member companies with an interest in non-chromate primers joining the team for a follow-on Phase II.

Participating team members drafted a statement of work with the proposed scope for Phase II to continue this collaborative project, which was signed in 2021. As part of Phase II, the companies will continue to evaluate non-chromate bond primers by engaging with different formulators, share technical requirements and performance data, and potentially explore the development of common industry specifications.

8 References

1. Phase I project summary report: Non-Chromated Bond Primer Technical Interchange

9 Tables

Table 1 - Summary of Applications and Key Test Requirements

Application	Test	Related Standard	Company													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Paint Adhesion	Pull-Off	ISO 4624															
	Cross Cut	ISO 2409															
	Adhesion tape test	-															
	Pencil Hardness	-															
	Mandrel Bend Test	ASMT D 522															
	Impact Resistance	-															
Bond Adhesion	Single Lap Shear (SLS)	ASTM D1002															
	Wide Area Lap Shear (WALS)	ASTM D3165															
	Floating Roller Peel (FRP)	ASTM D3167															
	Climing Drum Peel (CDP)	ASTM D1781															
	T-Peel	ASTM D1876															
	Wedge Crack (WC)	ASTM D3762															
	Flat Wise Tension (FWT)	ASTM C297															
Corrosion Protection	Filiform Corrosion	EN 3665															
	Salt Spray	EN 9227															
	Neutral Salt Fog	ASTM B117															
	Acidified salt Spray	ASTM G85 Annex 2															
Long-term Corrosion	Bondline corrosion	AITM 5-0009															
	Long-term Exposure	ISO 21207 method B															
	Outdoor Exposure	-															
Environmental Durability	Water Immersion	-															
	Solvent resistance	-															
	Fuel resistance	-															
	Skydrol Resistance + SLS	-															
	Hydraulic fluid resistance	-															
	Humidity + WC	ASTM D3762															
	Humidity + SLS	-															
	Humidity + Adh Durability	ASTM D2919															
	Humidity + CDP	-															
	Hot air + SLS	-															
	Neutral salt fog + SLS	-															
	Neutral salt fog + WC	ASTM D3762															
	Neutral salt fog + CDP	-															
	Neutral salt fog + FWT	-															
Thermal Ageing	Humidity Resistance	-															
	Heat Resistance	-															
Thermal Cycling	Low Temp Shock	-															
Compatibility	epoxy	-															
	sealants	-															
	Ti & Al	-															
Additional Test	Impact Test Fan Blades	-															

Table 2 – Down selection of Key Test Requirements for Screening Bond Primer Systems

Application	Test	Standard
Paint Adhesion	Cross-Cut	ISO 2409
Adhesion	Single Lap Shear	ASTM D1002
	Climbing Drum Peel (metal to metal)	ASTM D1781
	Climbing Drum Peel (metal to honeycomb)	ASTM D1781
	Floating Roller Peel	ASTM D3167
	Wedge Crack	ASTM D3762
Corrosion	Salt Spray	ASTM B117