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Chromate-free Exterior Painting for Boeing Commercial Aircraft

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Exterior Coatings for Commercial Aircraft

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- Critically important to image and branding of airlines
- Provides a protective function
- Condition influences perception of safety & quality
- Decorative Coating Cornerstones
 - Attractive
 - Durable
 - Economical to Apply
 - Removable

Major Applications of Boegel EPII as Pretreatment

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April 2008



Describe implementation of Boegel technology for BCA exterior painting

- **Brief history of Rivet Rash**
- **The rivet solution**
- **The need for additional improvements**
- **Solgel as a conversion coating**
- **Paint Stripping Considerations**
- **Summary**

Exterior Finishing Process

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Remove
Temporary
Coating/
Reactivate
Aged Coatings

Clean
with
Solvents
or
Alkaline
Cleaner

Deoxidize
Aluminum
(mechanical or
chemical)



Topcoat

Prime

Apply Conversion
Coating/
Adhesion Promoter

- Each process and material in the exterior coating system is critical to ensure overall durability
- Changes require careful consideration....and lots of testing and verification

Aerospace's Oldest Exterior Coating Issue

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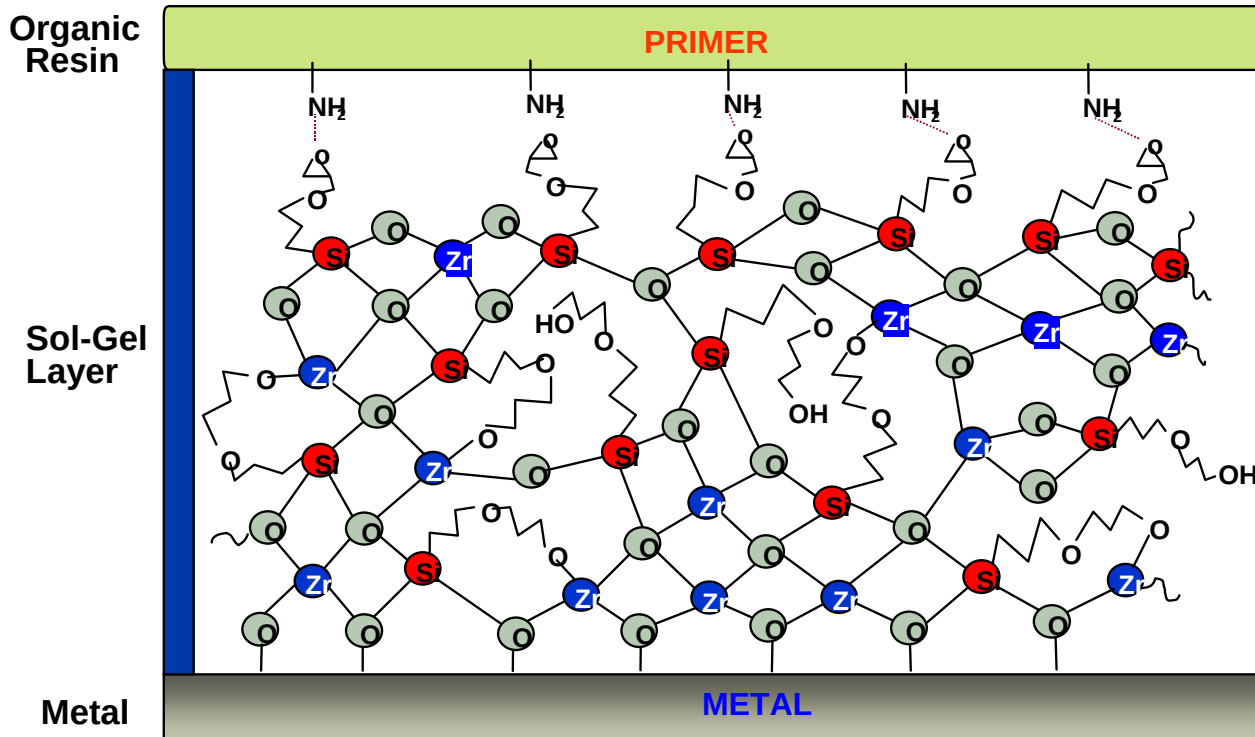
Paint Loss from Rivet Head (Rivet Rash)



Boegel EPII on Exterior Decorative Surfaces

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- Boeing developed sol-gel based coating system
 - Licensed to AC Tech, PPG, Socomor
- Non-chromated adhesion promoter for painting and bonding
- Superior adhesion on aluminum, titanium, CRES, nickel etc.

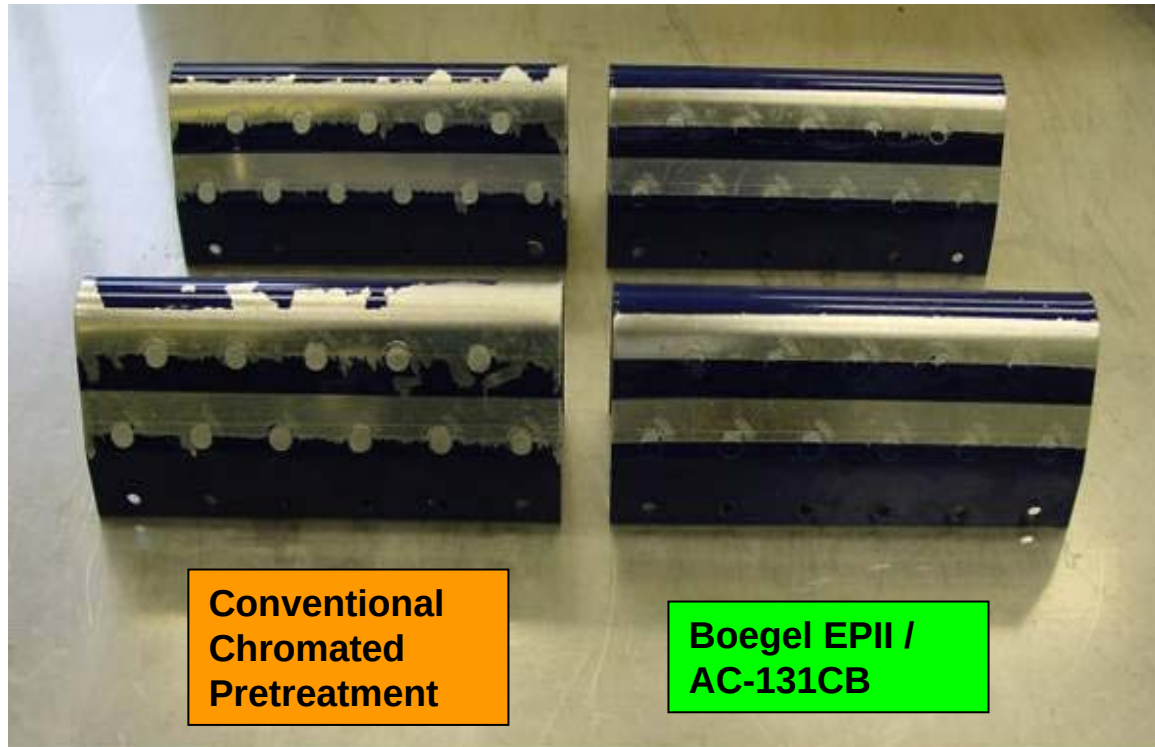


AC-131CC PROPERTIES

50:1 Mix Ratio
5 minute mix time
30 min Induction
24 hour pot life
3% solids in H₂O
1.0 specific gravity
vinegar odor
pH 4 after mixed
Apply with no rinse

Adhesion Tests

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Rain erosion testing showed improved adhesion to rivets when AC-131/Boegel is used as metal pretreatment coating



AC-131/Boegel Rivet In-service Performance

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Pre AC-131 at 18 Months

**100's of rivets missing coating
in high erosion area**



Post AC-131 at 14 Months

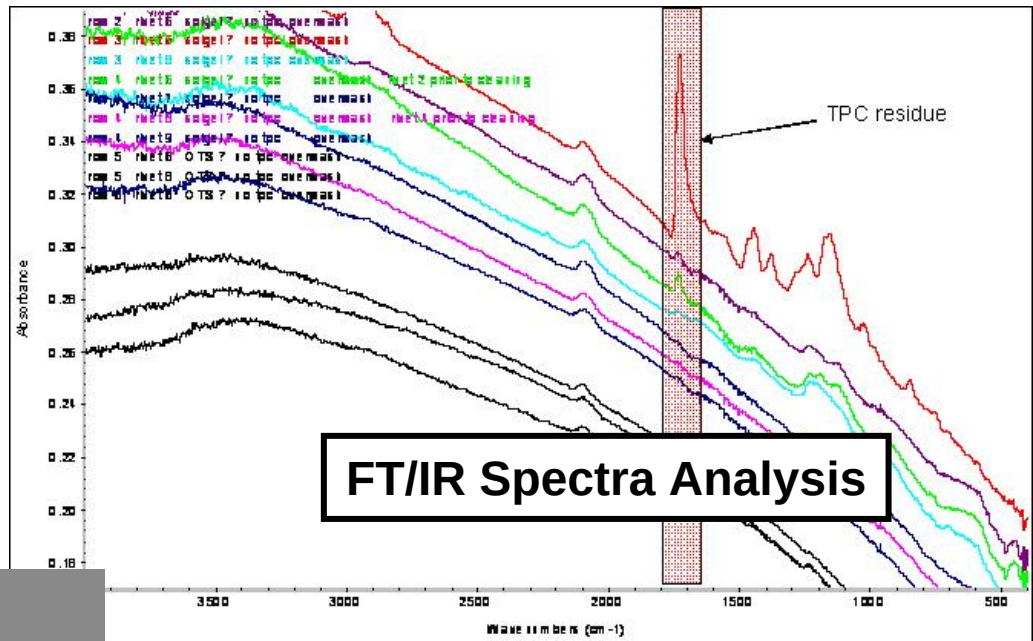
**~20 rivets missing coating in
high erosion area (many partials)**

Root Cause Analysis - Why Any Loss?

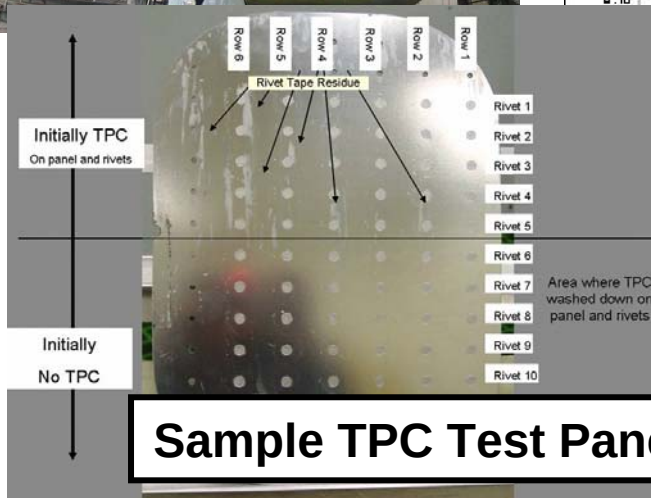
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TPC before removal



FT/IR Spectra Analysis



Sample TPC Test Panel

Testing proved the improved sol-gel adhesion was capturing dissolved Temporary Protective Coating (TPC).

Cleaning methods were improved.

Additional improvements were investigated.

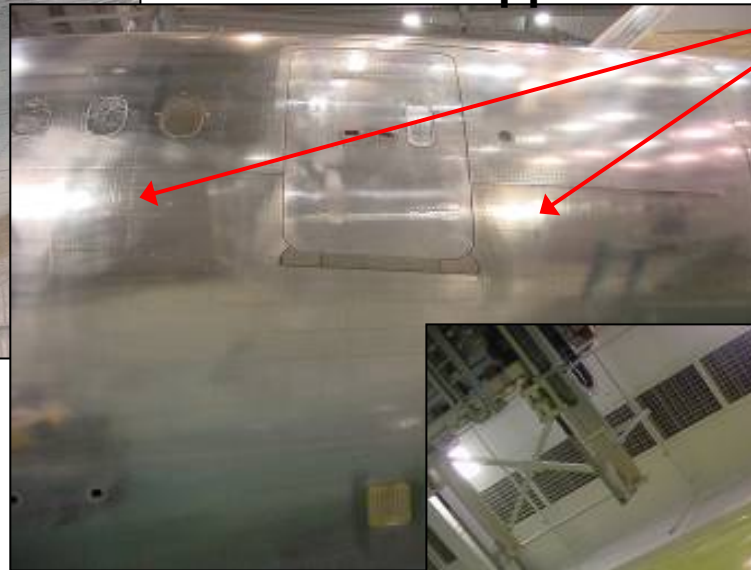
First Production Trial – 777-200LR Test Aircraft

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**AC-131 was flood applied liberally,
just like chromated conversion coating**



**Liquid Accumulated
on the Fuselage Belly**



**Some streaks were observed
after application of sol-gel**

**Streaks telegraphed
through primer and
first layer of topcoat.**



**Trial Result: Successful overall;
continue to optimize application process**

In-Service Data on 777-200LR World Tour Aircraft

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Rivet Rash on First 777-200LR
(**chromated conversion coat**)



No Rivet Rash on Second
777-200LR (**AC-131**)



Process Optimization: Eliminate Streaks

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Lap joints and bottom of doors holds up sol-gel liquid, which drips down to slowly form streaks until all evaporated



Major Causes Of Streaks

1. Lap Joins
2. Application Volume
3. Distance of Cascading

Solutions

1. Minimize application volume
2. Remove excess liquid

Boegel EPII /AC-131CB Mixing and Application

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1. Recommended usage volumes: 737 (5 GAL) & 777 (15 GAL)
2. Combine two-part kits and mix mechanically for 5 minutes
3. Use after 30 minute induction time and within 24 hour pot life
- 4. Spray to wet once by mist apply, with minimum overlaps**
5. Prime allowed 15 minutes after sol-gel applied at ambient
6. Taping and tacking allowed one hour after the sol-gel is applied



Chromated Conversion Coat for Exterior

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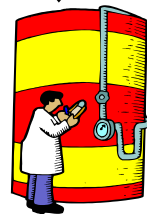
CHROMATED CONVERSION COAT

Process
Flow
or Time

1. Remove TPC
2. Solvent Clean
3. Activate Surface
4. Rinse
5. Cr⁺⁶ Pretreatment
6. Rinse
7. Mask for Prime
8. Prime
9. Topcoat



**Chromated
Compound**



**Chromated
Wastewater**

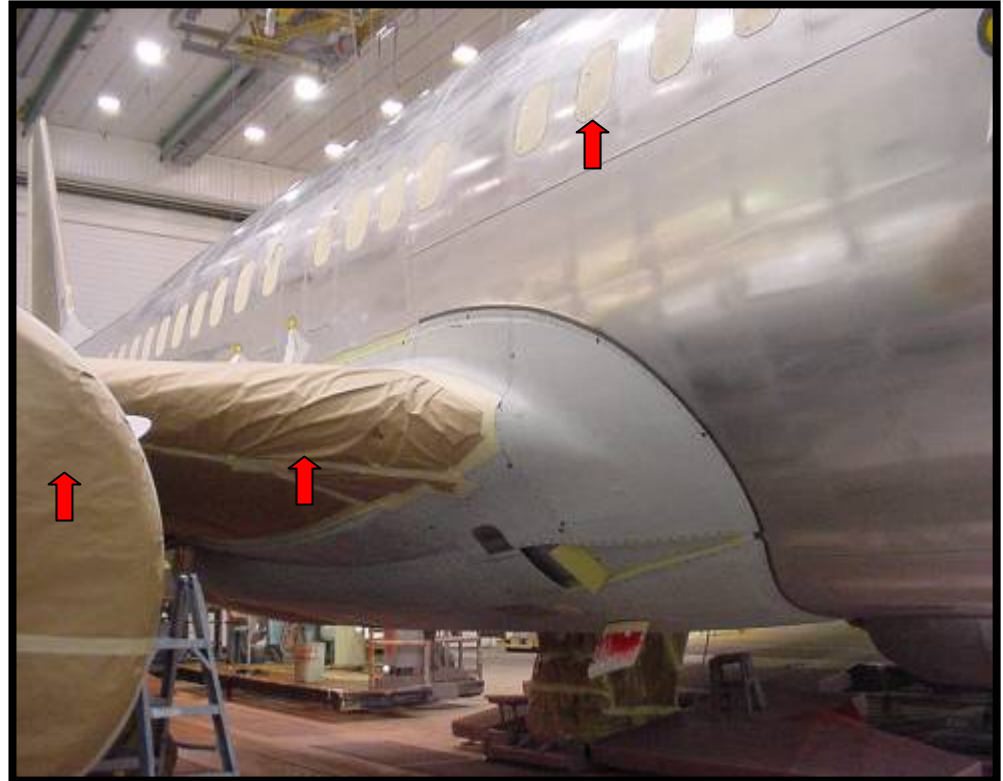
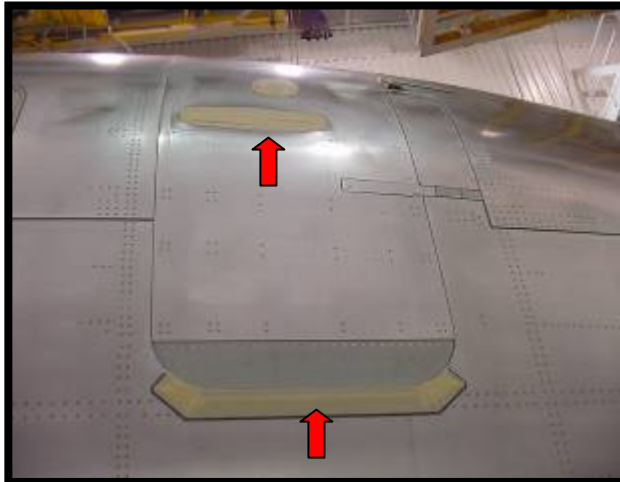
BOEGEL EPII PROCESS

1. Remove TPC
2. Solvent Clean
3. Activate Surface
4. Rinse
5. Mask for Prime
6. Boegel/AC-131
- ~~7. No Rinse~~
7. Prime
8. Topcoat



Mask for Prime Prior to Applying AC-131/Boegel

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↑ Mask areas required for prime. Mist spray of sol-gel does not impact masking

Implementation: After AC-131/Boegel EPII and Primer

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Good appearance on aluminum and after paint



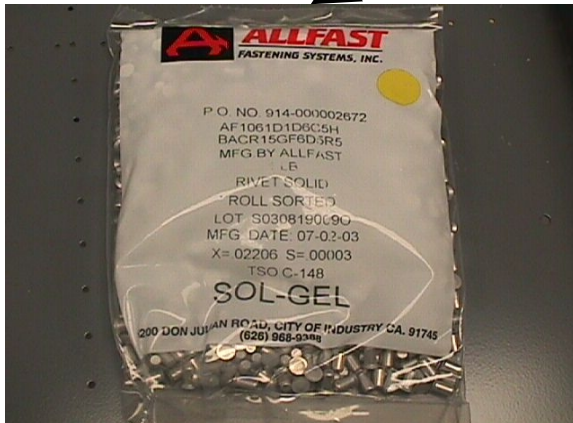
No liquid flow; no accumulation on lap joints and fuselage belly

Materials to Reduce Rivet Rash

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Improved Adhesion Primers
CA7700 (PRC-DeSoto)
10P20-44M (Akzo Nobel)

**3 material changes
to address rivet rash**



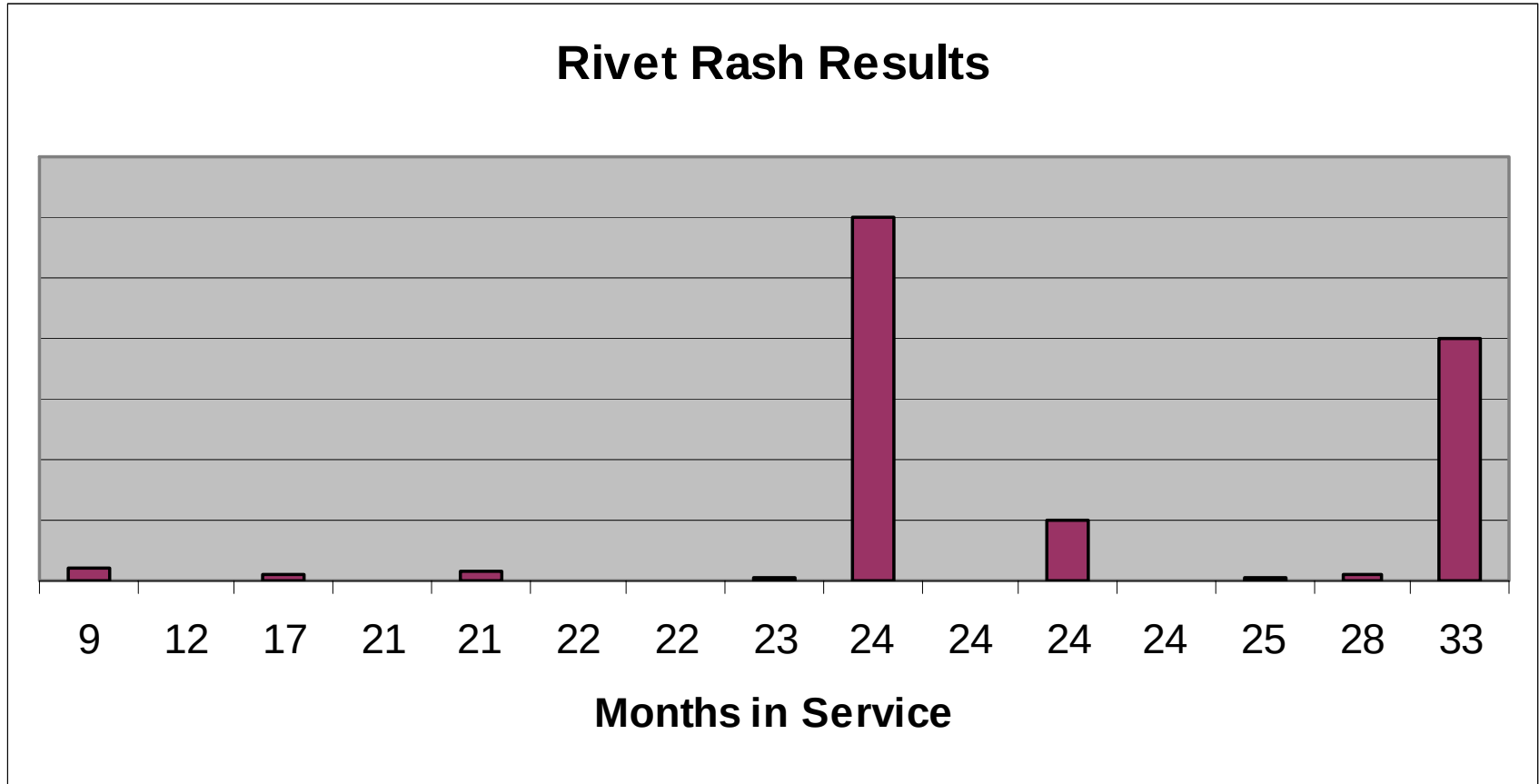
Sol-gel coated Rivets



**AC-131-CB
conversion coating**

Fleet Survey Results of Improvements

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- Most airplanes surveyed had only AC-131 rivets and improved primer
- No coating loss beyond high erosion areas
- Zero to a handful of rivets missing coating on most surveyed airplanes
- Three airplanes had more loss but no cause has been discovered for this

Adhesion Failures to Fasteners

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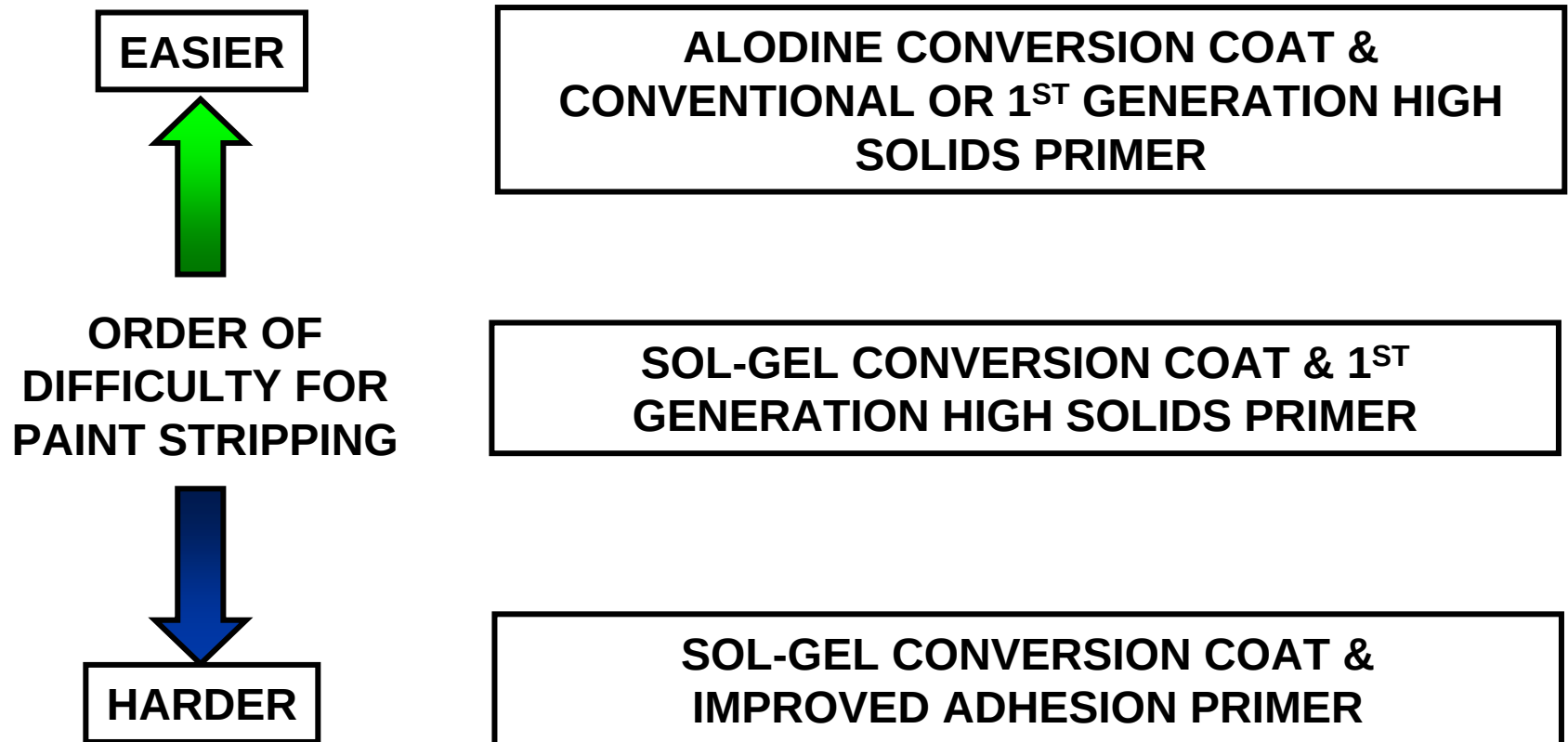
- **With rivet rash eliminated, what remains is Phillips head fastener appearing dark**



AC-131 and Paint Stripping Considerations

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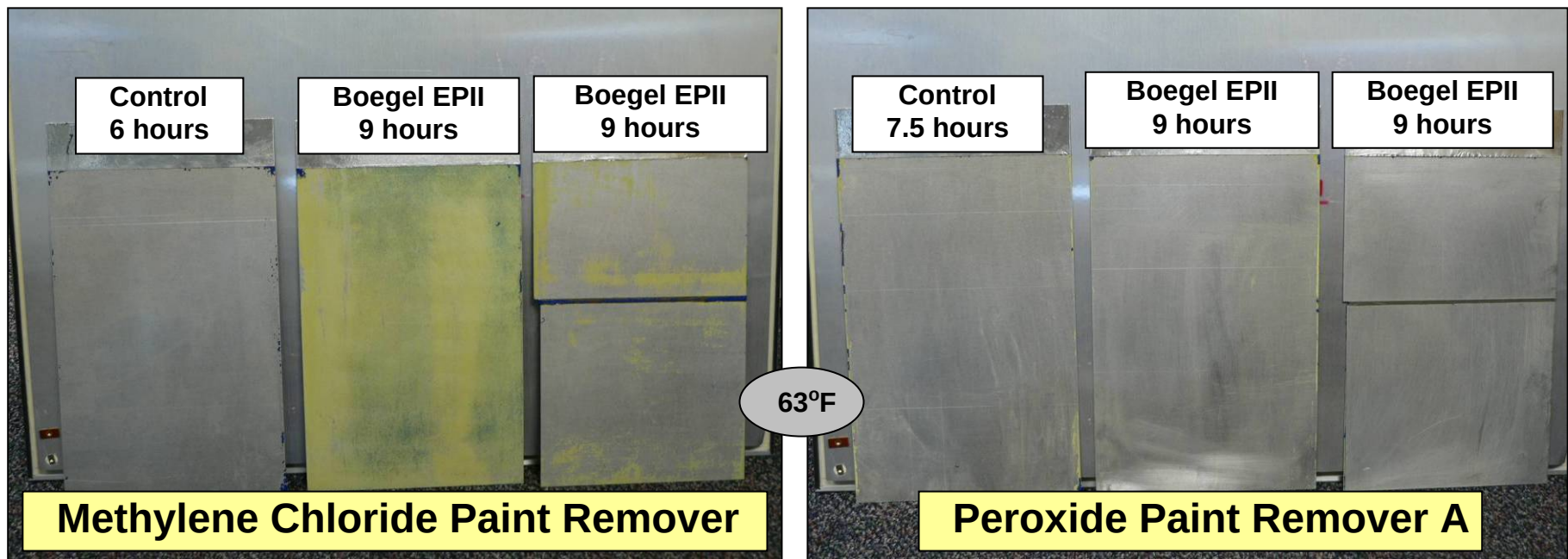
The improved adhesion provided by the sol-gel coating will increase the amount of time and selection of materials used for paint stripping



Depainting Panels with Peroxide Based Paint Remover

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- On sol-gel panels, peroxide based paint remover performed better than methylene chloride remover
- Performance is reversed on chromated conversion coated panels
In general, paint removal was quicker on chromated conversion coat panels than on sol-gel panels



All panels were 9" x 16" and had been coated for 6 months minimum

Depainting 777-200 Freighter – Peroxide-based Remover B

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3-9 mils of paint



1st Strip coat



1st Strip coat &
1.5 hours dwell



Squeegee after 2nd full
application coat



Alkaline cleaned 26
hours after 3rd application



Abrade and rinse

Future work to Improve Stripping Rates

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- **Work with paint stripper suppliers – they need to understand the challenge of the Boegel technology.**
- **Temperature during the stripping process is critical – 25 C or warmer.**
- **Sol-gel technology will end the use of Phenol/MeCl₂ paint strippers for exterior surfaces Boeing aircraft.**

Summary

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- **In-service data shows the improvements in adhesion are working**
 - Fleet surveys will continue to monitor the full life cycle of the coatings system
 - More in-service data on the sol-gel conversion coating performance will be collected
- **Some limited non-systematic rivet rash has occurred**
 - Root cause has not been determined.
 - Localized touch-up can successfully address this defect
- **The sol-gel conversion coating is the first practical treatment for titanium in a paint hangar environment**
 - Compared to acid etching and abrading
- **The team effort with airline customers has been a key to the success of these improvements**

Impact to Boeing

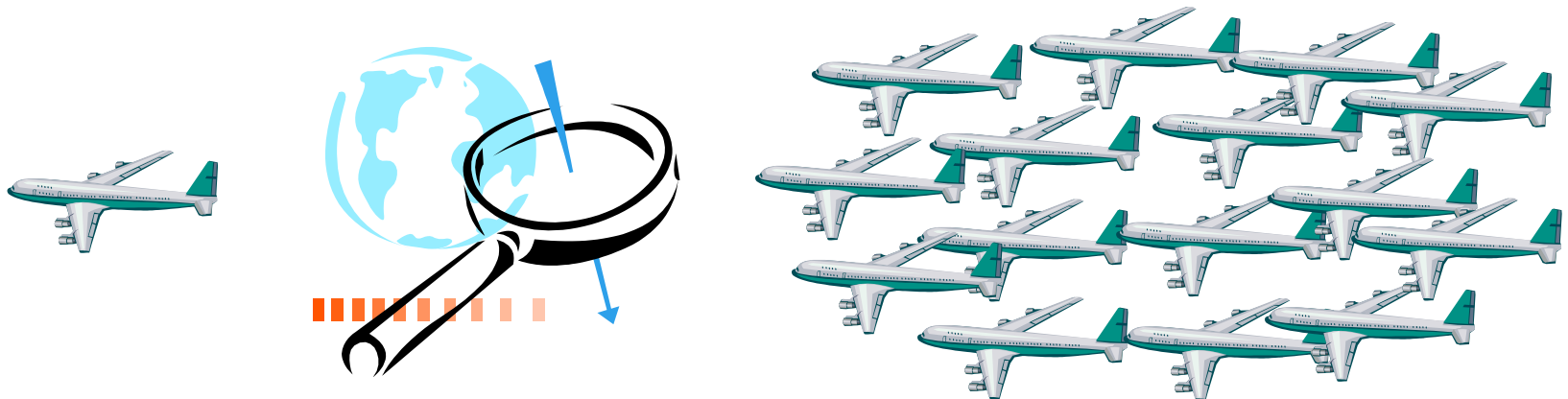
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	Conventional	Boegel EP-II/AC-131-CB
Health & Safety	Contains Hexavalent chromium pH = 2.1	No Hexavalent chromium pH= 4
Environmental Impact	Volume of chromated coating: ~100 gallons/twin aisle ~25 gallons/single aisle Rinse water that requires remediation: ~300 gallons/twin aisle ~75 gallons/single aisle	Volume of chromated coating: None Rinse water that requires remediation: None
Durability	Rivet Rash is Problematic	Reduces Rivet Rash

Impact to Commercial Airplane Fleet

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- When Boeing qualifies or otherwise approves a new technology for commercial use, it is added to the Aircraft Maintenance Manuals and authorized for use on the existing Boeing fleet of ~8,000 active airplanes
- Any operator repainting heritage Boeing aircraft is authorized to use Boegel EPII as an option to chromate conversion coatings
- This translates into a significant reduction in chromated materials and wastewater for the approximately eight hundred aircraft which are stripped and repainted each year.



Looking to the Future

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- **Boeing continues to implement Boegel technology in place of chromated conversion coats for both interior and exterior finishes**
- **Boeing is actively pursuing improvements in all the materials and processes associated with finishes technology**
 - Nonchromate primers for selected applications
 - Nonchromate exterior primer testing well with AC-131/Boegel
 - KLM using nonchromate system



Acknowledgements

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Boeing delivers KLM's 777-300ER with chrome-free paint

Boeing Technology

- This KLM 777-300ER is painted with a chrome-free exterior decorative paint. In addition to simplifying health and safety monitoring requirements, a chrome-free primer reduces the environmental impact of the paint and stripping process. Removing chrome from the paint and primer eliminates special handling of paint waste, clean up and designated offsite disposal areas.
- Aug 25, 2009



Exterior Decorative Paint Systems

- **Nonchrome primer:**
CA7502 made by PPG/PRC-DeSoto
- **Available Topcoats:**
BMS10-72 Type VIII (Desothane HS)
BMS10-72 Type IX (Eclipse)

Qualification Process

- **Screen test candidates**
- **Perform qualification tests – Engineering and Manufacturing**
- **Perform large scale application validation**
- **Production trials: validate the primer application in paint hangar environment on production airplanes**
- **List material as a qualified product in BMS10-72**
- **In-Service Evaluations: validate in-service performance of the primer in various in-service environments**
- **Offer the product in the Catalog**

Summary of Key Test Results

- **Adhesion**
No adhesion failures even on fasteners
- **Fluid resistance** (fuel, hydraulic fluid, oil)
Similar to currently qualified system
- **Corrosion resistance**
 - Acceptable corrosion performance on 2024 clad
 - Acceptable corrosion performance on 2024 bare
 - Corrosion performance on 7075 clad is not equivalent to chromated control
- **Removability**
 - Acid activated benzyl alcohol strippers required.
 - Boeing will incorporate acid stripper into maintenance manuals.
- **Large scale application**
Easy application, good appearance



Paint removal rate of xenon (500KJ) aged paint systems

paint system	Peroxide 1	Peroxide 2	acid
10P20-44M Eclipse	tc - 9 hrs p - >13 hrs	tc - 9 hrs p - 11 hrs	tc&p - 7 hrs
CA7502 Desothane HS	Failed to strip	Failed to strip	tc&p - 7 hrs
CA7700 Desothane HS	tc&p - 9 hrs	tc - 7 hrs p - >13 hrs	tc&p - 9 hrs

Acid activated benzyl alcohol strippers are required to remove the non-chromated primer. Several of these strippers have been used successfully in repaint facilities and Boeing currently lists two approved acid strippers in an internal stripping document. Boeing will incorporate these two acid strippers into the maintenance manuals.

- **To summarize, CA7502 non-chromated paint system showed good laboratory test results.**
 - **For 7075 clad aluminum, used on non-pressurized fuselage areas, testing indicates that for some in-service environments, the CA7502 primer may not provide the same level of corrosion protection as today's chromated primers.**
 - **Nominal use of 7075 clad aluminum on 737 exterior.**
 - **Boeing will continue to use chromated primer on all non-clad aluminum surfaces of the airplane. (e.g., window plugs, 747/767 fin).**

Questions?

