# Replacement of Chromated Protections on Aluminum Structural Parts at Dassault-Aviation

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## *ABSTRACT*

*Reach Regulation is one of the main challenges today to maintain efficient corrosion protection on new and in service military airframes. Therefore, Dassault Aviation is deeply involved in finding substitutes for impacted substances in protection systems.*

*This presentation deals with the replacement of chromated protections on aluminum structural parts. Substitution solutions will be developed in this presentation. The various steps leading to a full qualification, from accelerated tests lab to in-service aircrafts experiments, will be described.*

*Not being all the time successful in one for one replacement, a focus will be done on specific applications that required several changes. Aircraft maintenance impact, when replacing with a Reach compliant protection, has been checked.*

**Keywords:** Specialists' Meeting, Chromate-free paint systems, Accelerated corrosion testing

## 1.0 INTRODUCTION

Rafale is mostly composed of aluminium alloy parts.

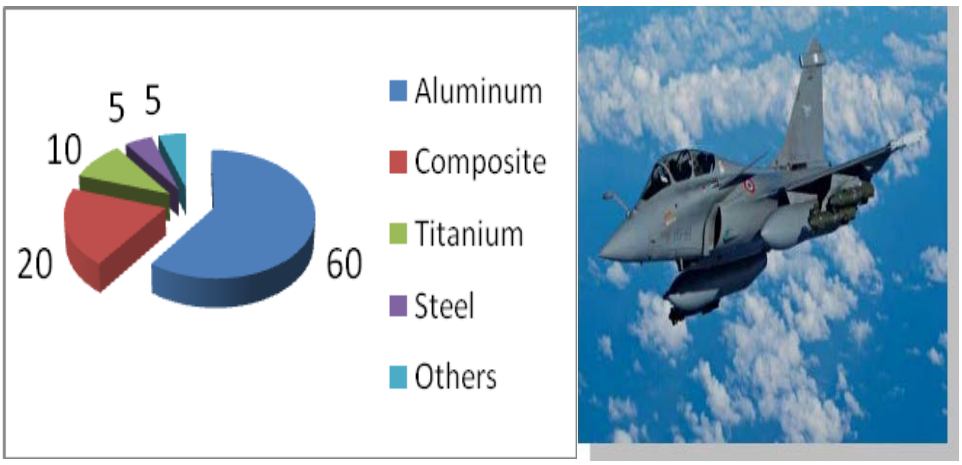


**Figure 1: Rafale omnirole materials breakdown.**

Aluminium structural parts are, for 90%, treated in unsealed CAA + Primer. Some parts, because of specific design or function, could require other treatments like:

- Sealed CAA; and
- Chromic conversion coating.

This presentation deals with the replacement of chromated paint system on aluminium structural parts. Qualification of new paint system required various steps that will be describe in this paper.

## 2.0 CHROMATED PROTECTION SUBSTITUTIONS ON ALUMINIUM STRUCTURAL PARTS

Historically, protections on Dassault Aviation aluminium structural parts were based on two protective layers: sealed chromic anodizing + chromated primer. However, adhesion of paint on sealed protection was not optimum. That is why, we decided in 2009 to change our strategy and bet on unsealed chromated anodizing + chromated primer. As unsealed anodizing allows good paint adhesion, this system ensure an efficient global protection against corrosion.

Nowadays, one of the most challenging aspects concerning structures made out aluminum alloys is certainly the chrome free alternative solutions development to maintain the same corrosion protection and industrial efficiencies.

Dassault has progressed in several stages to eliminate chromated substances.

### 2.1 Chromic Anodizing Substitution

Substitution of unsealed anodizing with direct primer application is one of the easiest steps to take in order to get rid of CrVI. As described before, principal function of chromic anodizing is to allow good paint adhesion. Therefore, substitution of chromic anodizing is not the main challenge.

Dassault Aviation has already qualified SAA NC and TSA NC to replace CAA NC on most structural aluminium parts.

This paper will focus on chromate paint substitution.

### 2.2 Chromate Primer Substitution

Second step of substitution is to replace chromated primer. This step is a main challenge for several reasons:

- Replace several functionalities : corrosion inhibition + biocide.
- Elementary tests not representative enough, testing according to specification doesn't give confidence on performances in service.
- Must be compatible with worldwide supply chain.

After screening of several solutions, Dassault Aviation has selected two chromate-free systems:

- Chromate-free paint: **CA7521** from PPG, applied on chromate-free anodizing (SAA NC or TSA NC). With this first solution, we stay in the same pattern: paint applied on unsealed anodizing. This new primer is compatible with same supply chain than today.
- Chromate-free electrodeposited primer, also called "**Ecoat**": using product Aerocron from PPG. Ecoat treatment could replace unsealed anodizing + primer in one-step. However, with this solution, supply chain has to be adapted.

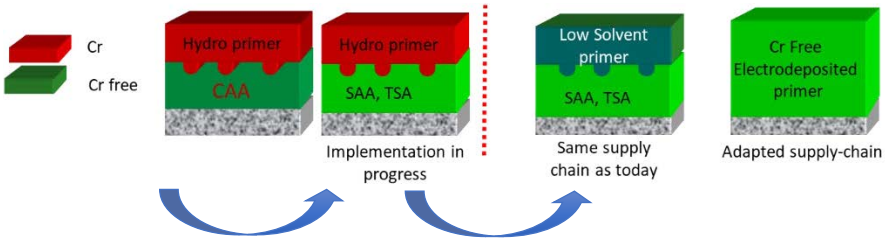


**Figure 2: Protection system evolutions.**

## 3.0 PROCESS FOR QUALIFICATION

Protections based on chromate solutions are validated over more than 30 years of experience. Now we have to face the suppression of Chrome VI with targeted sunset dates from REACH regulations: rapid changes will have to be performed. Compared to the toolbox that we have in mechanics (static behavior, crack initiation and propagation simulation, fatigue spectrum of a given aircraft), the difficulty in corrosion technical area is that there is no strong knowledge and modeling experience to qualify a Chrome free alternative. Dassault Aviation deployed a "De-risking process" with several steps to qualify new protection:

- R&D to support all changes. We need to understand mechanisms of in service corrosion, inhibitors behavior, etc. to identify best protections. For the Cr free primer major challenge, need to specify to suppliers refine behavior (permeability, speed of inhibitors extraction…) and not in service specification which are not enough pertinent.
- Adapted specification based on in-service corrosion environment monitoring.
- **Accelerated Lab tests.** Classical tests are always run as thermal chocs, humidity, UV, fatigue of joints, Salt Spray, etc. but we are also working on more representative tests of in service conditions.
- **Natural exposure on representative assemblies.**
- **Field experiments on aircraft to confirm lab tests results.**

The aim at each testing step is to demonstrate no-regression between chromate and chromate-free systems.

In addition to technical aspects, we must take into account following points, when choosing potential chromate-free substitutions:

- Supply chain compatibility. Dassault-Aviation is totally committed to eliminate hazardous substances. This activity is performed in a very collaborative way, since all the airframe manufacturers rely on the same worldwide supply chain.
- Authorizations (REACH).

### 3.1 Accelerated Lab Tests

Accelerated lab tests is the first step of the De-risking process. During this step, new paint systems are compared to our chromate reference. Purpose of these tests is to evaluate behavior and mechanism of chrome-free primer.

Various tests are carried out:

- Environment tests: thermal shocks, humidity, UV, salt spray, adhesion, etc.
- Mechanical tests: fatigue, bending, etc.
- Combined laboratory tests: mechanical ageing + environment. We also try to develop in-house combined ageing tests for structure primer more representatives of in-service solicitations.

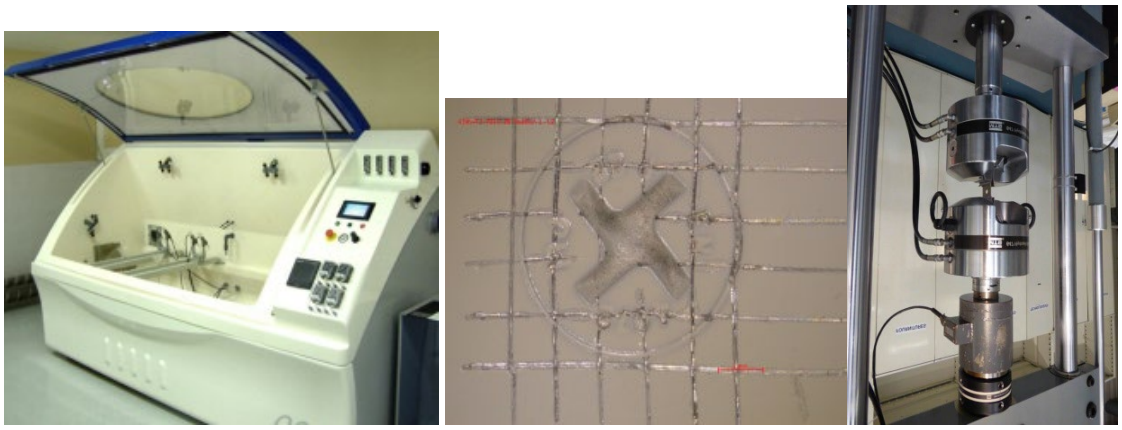

**Figure 3: Examples of accelerated lab tests.**

Elementary tests required in technical specification are based on chromate mechanisms. We know that no real chrome free candidate is capable to be mimetic to chromates. To select a chrome free candidate, we chose to give priority to **adhesion** and **impermeability** vs inhibition/leaching. All accelerated lab tests give us confidence in SAA/TSA NC + CA7521 and Ecoat, but they are not sufficient.

## 3.2 Natural Exposure on Representative Assemblies

At the same time, some samples or representative assemblies are exhibited in natural exposed environment, like seaside, during months. Corrosion resistance of new paint systems is compared to old chrome free system in real environment.

**Figure 4: Paint panels exhibited in Brest.**

No-regression in corrosion resistance was observed for both new chromate-free systems compared to Chrome VI protection.

## 3.3 Field Experiments

When a chromate-free paint system passed previous steps (accelerated lab tests and natural exposure), field experiments have to be done to verify lab result performances in real conditions. Some parts of in service aircraft are protected with new system and regularly checked.

Fields tests campaigns for chromate-free paint:

- **ATL2 :** experiments on 10 aircrafts. External areas parts.

  Two Chromate free systems:

  - For production: concentrated SAA thin film + PPG CA 7049 or CA7521 + external top coat.
  - For maintenance: Pickling +Sol gel + PPG CA 7049 or CA7521 + external top coat.

  → After 5 years : no corrosion, no erosion.

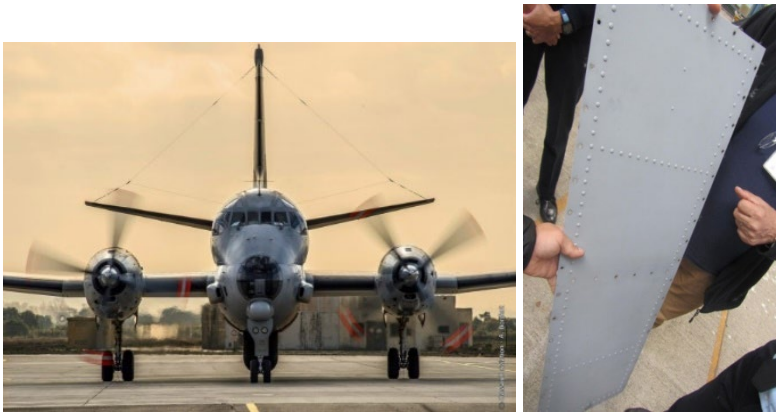

**Figure 5: Field experiments on ATL2 external parts.**

- **Rafale** : experiments on 5 aircrafts. Access doors parts.
  - For production: concentrated SAA thin film + PPG CA7521 or Ecoat + external top coat.
  - For maintenance: Pickling +Sol gel + PPG CA7521 + external top coat.

  → After 5 years : no corrosion, no erosion.

**Figure 6: Field experiments on Rafale access doors.**

Next, final experiments have to be launched on more exposed parts: in progress for chromate-free paint system (fuel tank area, parts susceptible to corrosion, etc.).

# 4.0 FOCUS ON SPECIFIC APPLICATIONS

## 4.1 Parts with Singularities

One for one substitution is not always possible. Parts with singularities were still protected with sealed CAA + paint because some areas, like bores, have to remain unpainted for functional purpose (tight tolerances) but are exposed to corrosion.

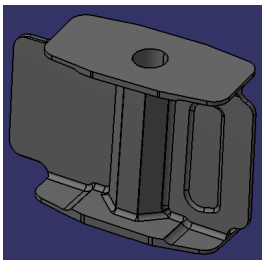

**Figure 7: Example of exception part: FERRURE LONG. 12A.**

For those parts, we had to find protection system that combines no regression performance for adhesion paint and for corrosion resistance, included in unpainted areas, while respecting part tolerances.

Specifics tests, representatives of parts and their environment were developed to evaluate and qualify efficient chrome-free alternatives.

**Figure 8: Axis and bore assembly specimen.**

Specimens consisting of one axis and one part with bore has been drawn, manufactured and tested in fretting and corrosion tests.

Tests showed that:

- If there is no friction between axis and bore, Ecoat or unsealed + chromate free paint is better than sealed CAA regarding corrosion resistance,
- But if there is friction Ecoat or paint are damaged and don't protect against corrosion anymore. Regarding fretting, Ecoat treatment plays sacrificial role.

Depending on dimensions of bore, spray paint is not compatible to protect all surface of the bore contrary to Ecoat.

For these kind of parts, choice of chrome free system substitution will depend on behavior of assembly in real conditions and if there is friction or not between different parts of assembly.

Two solutions are qualified:

- Ecoat on all part when there is no friction → Ecoat thickness have to be taken into account to allow assembly.
- SAA NC + CrIII post-treatment (touch up) + temporary protection when there is friction.

Deployment of these protections are in progress.

## 4.2 Circuit Parts

Circuits parts in 2000 or 7000 alloys was also protected with sealed CAA + paint because of functional areas unpainted like seal grooves. For those parts, paint in grooves was not acceptable because various thickness of spray paint could lead to lack of airtightness.

For unpainted or partially paint part, sealing solutions REACH compatible were investigated. Although we qualified sealed SAA (sealed with TCS + PACS) for pipes in 5000 and 6000 alloys, a decrease of performance is observed with this protection for other aluminum alloys like 2000 and 7000 families. This will request strong analysis and justification to eventually accept a drop in acceptance criteria.

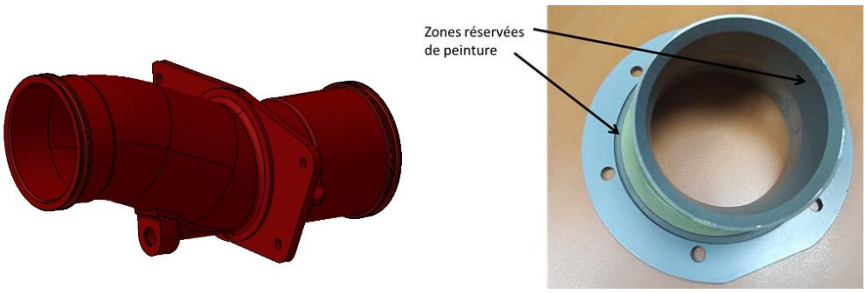


**Figure 9: Examples of circuit pats with unpainted areas.**

Therefore, for those parts, Ecoat was the only candidate to substitute sealed CAA with no corrosion resistance regression. As Ecoat allow regular thickness layer on all the surface of the part, we were confident that we could also treat functional areas like seal grooves. Airtightness tests has to be developed and performed to qualify this treatment and new definition.

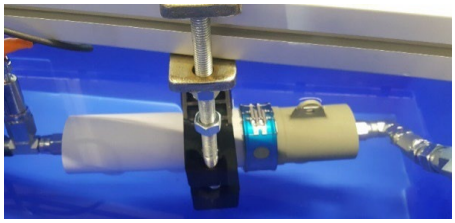

**Figure 10: Airtightness tests for circuit parts.**

As all results were good, Ecoat treatment is now qualified for almost all 2000 and 7000 aluminum circuits parts and deployment in supply chain is coming. In this case, chrome free treatment leads also to industrial improvement as Ecoat treatment saves supply chain time by removing masking steps.

## 5.0 MAINTENANCE IMPACTS

Maintenance is a key economical objective for Cr free alternatives. It is mandatory to not increase the maintenance cost with qualification of chromate-free paint system. As no regression was observed during De-risking process concerning corrosion resistance, maintenance frequencies should not be impacted.

Dassault validated only one repair paint system compatible with old and new protection: sol-gel + CA7521

This repair solution was also evaluated with the de-risking process.

## 6.0 CONCLUSION

For years, our technical specifications were based on chromate without questioning about functionalities necessary in service, like inhibitors leaching efficacy. But those specifications are not adapted to new chromate-free paints. Moreover, the absence of simple or combined tests perfectly representatives of all environments met in service imposed to launch experiments on aircrafts in reels conditions to confirm results lab tests. Consequences are:

- Longer schedule;
- Necessity that aircraft users collaborate for field experiments.

Thanks to no regression regarding corrosion resistance observed during de-risking process and particularly in fields experiments we are confident in our chromate-free systems choices.

One other important point in chromate-free paint qualification is not to minimize implementation time after qualification:

- Listing of specific parts;
- Updating of definition;
- Updating of manufacturing documentation;
- Supply chain qualification.

Dassault Aviation will be on time for chromated paint substitution before January 2026. However, we are now looking for a second chrome-free spray primer in alternative to CA7521 to secure supply chain.

We all have to keep in mind that regulations are scalable and we will have to deal with more or less important reformulations, while adapting test spectrum to the criticality of those reformulations.