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Supporting your Corrosion Prevention Control Plan with Compliant Computational Corrosion Analysis

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ABSTRACT

Why bother with computational corrosion analysis? Apart from the obvious impact on safety, it has been shown that globally, corrosion costs about 4% of gross domestic product. Other studies have determined that about 30% of these costs can be avoided with better upfront design and material selection. Indeed, more recently the US Navy estimated that 40% of corrosion costs can be eliminated by better design. Considering that 70% of sustainment costs are already locked in by initial design then clearly, just as in thermal, fluid and stress analysis the use of upfront computational design tools for corrosion assessment has the potential to deliver huge value by helping us to avoid costly mistakes.

Apart from the obvious benefits that computational tools can bring, enabling us to assess the impact of design and material choices on the durability of our products, it is actually mandated in law that corrosion analysis be executed for US federal military acquisitions. Corrosion Prevention Control (CPC) planning is required by Title 10 U.S.C. 2366(b) and this is incorporated as DoD policy in the directive DODD 5000.01. The DoD Instruction DODI 5000.67: *Prevention and Mitigation of Corrosion on DoD Military Equipment and infrastructure,* outlines the process for setting up a CPC plan and calls out a number of standards such as **MIL-STD-1568D** and **MIL-STD-889D** to provide further, technical detail.

MIL-STD-1568D states that "Modeling and validation testing **shall** be performed to **identify corrosion-prone locations**". Additionally, released August 2021, the new revision **MIL-STD-889D** Galvanic Compatibility of Electrically Conductive Materials (No longer 'Dissimilar Materials') actually introduces a paradigm shift, in that galvanic corrosion will no longer be estimated by the use of a table of electric potentials, but quantified by the calculation of galvanic current, based on a curated material database acquired using a consistent methodology defined in the specification.

This paper will present and discuss the challenges in implementing a consistent corrosion analysis capability across enterprises. We will introduce a workflow that incorporates a quick MIL-STD-889D-compliant analysis using the Corrosion Djinn® software. Full 3-dimensional, deeper dive analyses are then presented using the Siemens Teamcenter® and multi-physics software CCM+ combined with the Corrdesa electrochemical database to predict corrosion rate maps over 3D CAD components. This process will be demonstrated with examples of computational corrosion analysis on F/A-18 components.

Mobile, Non-Drip, Brush Plating and Anodizing Repairs

Keith Legg, Alan Rose, Corrdesa LLC

ABSTRACT

Brush plating has been used since the 1930s as a way of repairing electroplated components without disassembling, stripping and replating. It is heavily used in the aerospace and defense industry for repairing coatings such as cadmium plate for corrosion control. It has tended to be a crude, messy process, often involving toxic chemicals that drip and run. Typically it has few controls and the quality of the coating is highly operator-dependent. With the increasing emphasis on environmental and occupational health, and ensuring material and process quality, this type of approach is no longer acceptable.

Corrdesa has modified and brought to large-scale use a non-drip brush plating and anodizing technology developed by the French company Dalic. The non-drip process keeps all the chemicals in a closed-loop to protect both the operator and the vehicle being repaired. Across aerospace and defense, zinc-nickel chemistries have been developed and qualified for replacement and repair of hazardous, legacy cadmium coatings. This is a key reason why Lockheed have now purchased 50 of these non-drip plating stations for global F-35 ground support equipment, with options for an additional 120+ stations over the next three years. These units are housed in ruggedized, mobile carts, qualified for use on board ship as well as land.

Corrdesa has developed a combination of computational fluid dynamics (CFD) and computational electrodynamics modeling workflows to design custom tooling, as well as computational corrosion analysis to match coating materials to corrosion requirements. With these capabilities the potential for expanding brush plating and anodizing have gone far beyond spot repair of damaged coatings. It is now possible for Corrdesa to design and optimize processes for applying the non-drip plating approach to protect critical areas of very large components, such as spot anodizing of floor repairs for transport aircraft, repair of leading edges and nacelles, and anodizing P-8 static ports for corrosion control.

This talk will present the non-drip plating/anodizing technology, along with a roadmap of future developments.

Dr. Alan Rose, Corrdesa LLC
Author Biography

Alan's BSc is from the University of Manchester, England, and his PhD from the University of Sheffield.

As CEO of Corrdesa, Alan works with commercial and military customers, developing software tools and knowledge to enable Corrosion Resistant Design. Corrdesa has developed a unique electrochemical database which is implemented in their 1D software product Corrosion Djinn® and also in their 3D, corrosion simulation work using Siemens CCM+.

Alan has over 30 years experience transitioning computational engineering simulation tools into daily, engineering use. Starting in the 80s he adapted Computational Fluid Dynamics (CFD) software for process design and safety studies in the UK nuclear industry, moving to combustor design and optimization with Rolls-Royce in the 90s. In the 2000s, as an expert witness Alan introduced CFD into the marine industry to help investigations of freight ship fires, which demanded a very rigorous approach to the analysis process.

Over the last 15 years Alan has implemented electrochemical simulation into corrosion prediction and scale-up of electrochemical processes used in manufacturing such as electrochemical machining and surface finishing operations such as plating and anodizing.

Dr. Keith Legg, Corrdesa LLC
Author Biography

Keith's BA is from the University of Lancaster, England, and his PhD from the University of York. He is a globally acknowledged expert on coatings, and their testing and validation for aerospace and defense, Keith ensures that Corrdesa's R&D addresses the challenge of escalating material development needs in response to the increasing demand for enhanced performance requirements whilst being limited by ever more restrictive compliance legislation. Keith's role is to listen to and interpret client's needs for corrosion resistant designed products. Corrdesa then identifies and develops promising technologies to meet and satisfy those needs. He is a DoD Subject Matter Expert on chromates and advises DoD organizations on corrosion issues and REACH-compliant alternatives.