FINAL TECHNICAL REPORT

Cadmium-Free Alternatives for Brush Plating Repair Operations

ESTCP Project WP-201412

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14. ABSTRACT

Traditional brush plating is conducted using a stylus with an absorbent pad saturated with plating solution. The process of brush plating can occur on localized areas or entire parts, and is considered an "open process." This allows for the solution to flow down vertical or irregular surfaces, or drip from overhead during the plating operation leading to potential worker exposure to the solution and contamination of the surrounding area. This project focused on the elimination of toxic/carcinogenic cadmium (Cd) material for brush plating repair operations, and the reduction of solid waste associated with adsorbents used to contain solution leakage attributed with traditional brush plating repair processes. The program's technical objectives were to (1) Demonstrate the Commercial-Off-The-Shelf (COTS) Dalistick Station for selective brush plating in DoD maintenance, repair, and overhaul operations and (2) Test and evaluate the COTS Zinidal Aero zinc-nickel (Zn-Ni) brush plated coating as a Cd replacement on weapon systems parts and components.

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ACRONYMS AND SYMBOLS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
µg/m^3	micrograms per cubic meter of air
A	amps
AC	alternating current
ACGIH	American Conference of Government Industrial Hygienists
AFLCMC	Air Force Life Cycle Management Center
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
ANSI	American National Standards Institute
CAA	chromic acid anodizing
Cd	cadmium
CIB	Current Intelligence Bulletin
COTS	commercial-off-the-shelf
Cr	chromium
CTC	Concurrent Technologies Corporation
dBA	decibels
DC	direct current
DoD	Department of Defense
EHS	environmental health and safety
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESOH	Environment, Safety, and Occupational Health
ESTCP	Environmental Security Technology Certification Program
EU	European Union
EZP	Product Support Engineering Division
FRCSE	Fleet Readiness Center South East
HAP	hazardous air pollutants
HSS	high strength steels
Hz	hertz
ICBM	Intercontinental Ballistic Missile
IO	Input/output
IRR	internal rate of return
JTP	Joint Test Protocol
LHE	Low Hydrogen Embrittlement
MCL	Maximum Contaminant Level
M&S	maintenance & sustainment
MMG	Minuteman Motor Generator
NAVAIR	Naval Air Systems Command

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NIOSH	National Institute of Occupational Safety and Health
NESHAP	National Emission Standards for Hazardous Air Pollutants
OEM	original equipment manufacturer
OO-ALC	Ogden Air Logistics Complex
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PI	principal investigator
PPE	personal protective equipment
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
REACH	Registration, Evaluation, Authorization and Restriction
RoHS	Restriction of Hazardous Substances
SBIR	Small Business Innovative Research
SIFCO	SIFCO Industries, Inc.
SVHC	Substances of Very High Concern
TLV	Threshold Limit Value
TWA	time-weighted average
U.S.	United States
UDRI	University of Dayton Research Institute
USAF	United States Air Force
V	volt
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization
WR-ALC	Warner Robins Air Logistics Complex
XRF	x-ray fluorescence
Zn-Ni	zinc-nickel

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ABSTRACT:

Introduction and Objectives

This project focused on elimination of toxic/carcinogenic cadmium (Cd) material for brush plating repair operations, and reduction of solid waste associated with adsorbents used to contain solution leakage attributed with traditional brush plating repair processes. The program technical objectives were as follows:

1) Demonstrate the Commercial-Off-The-Shelf (COTS) Dalistick Station for selective brush plating in DoD maintenance, repair, and overhaul operations
2) Test and evaluate the COTS Zinidal Aero zinc-nickel (Zn-Ni) brush plated coating as a Cd replacement on weapon systems parts and components

Technology Description

The Dalistick D.2020 station (Dalistick Station) is a closed loop electroplating system that enables selective electrochemical treatments (anodizing, electroplating, and surface preparation).

The Dalistick D.2020 has been designed to control electrochemical surface treatments in regards to the electrolyte (constant flow, temperature control, display of usage rate, display of consumable life) and the electroplating process (voltage control, process control according to the required current.) The Zinidal Aero Zn-Ni brush plated coating is a possible replacement for Cd brush plating which will not embrittle high strength steels.

Performance and Cost Assessment

The Zinidal Aero Zn-Ni solution has comparable performance to qualified Zn-Ni brush plating solutions in many categories including appearance, thickness, composition uniformity, corrosion resistance, and plating adhesion. However the solution does not consistently pass hydrogen embrittlement testing, paint adhesion, or SO_2 resistance. The Dalistick D.2020 station provides excellent control of the plating process and produces very consistent results.

A sustainability analysis was performed which shows a 15 year lifecycle cost of the station is slightly greater than traditional Cd brush plating as seen in the table below.

Table 1. 15 Year Dalistick Zn-Ni Plating Lifecycle Cost

	Cd Brush Plating	Dalistick Zn-Ni Plating
Internal Cost (USD2014)	$4,138,695	$4,364,626
External Cost (USD2014)	$37,608	$19,396
Total	**$4,176,303**	**$4,384,022**

Implementation Issues

A successful technology demonstration took place in February of 2020. No major implementation issues were found during the technology demonstration and no findings from the demonstration are expected to change the sustainability analysis previously performed. Recent software updates has made the station itself more user friendly and decreased repair times. The largest limitation to implementation is with the Zinidal Aero Zn-Ni solution which does not meet or exceed cadmium brush plating performance in all instances.

1.0 INTRODUCTION

The United States Air Force (USAF) has progressed towards a cost-effective engineering mindset, wherein all operations across the USAF enterprise must be considered and evaluated to reduce life cycle costs and environmental burden while also increasing worker safety and weapon system readiness. Likewise, there is a need to leverage such engineering activities across the Tri-services. Elimination of cadmium (Cd) plating operations is one such area where cooperation across the services is required to successfully eliminate the environmental hazards and regulatory burdens for the Department of Defense (DoD). The Environmental Security Technology Certification Program, in cooperation with the Air Force Life Cycle Management Center (AFLCMC), has sponsored this Tri-services program focused on the elimination of Cd in current brush plating operations.

1.1 BACKGROUND

Cadmium (Cd) has been widely used as a coating material in the aerospace industry and the DoD because it imparts excellent corrosion resistance, adhesion, lubricity, and electrical conductivity characteristics. However, Cd is classified as a carcinogen, and long-term exposure has been linked to lung cancer and kidney disease. As a result, the U.S. Occupational Safety and Health Administration (OSHA) has set Permissible Exposure Limit (PEL) for Cd and Cd containing compounds.

Cd can be applied via immersion (tank) or brush plating. Within the DoD, immersion plating is typically used for treating large parts or larger areas on parts that must be refurbished, while brush plating is typically used for touch up, smaller area repair, and on parts requiring in situ repair.

Traditional brush plating is conducted using a stylus with an absorbent pad saturated with plating solution. The process of brush plating can occur on localized areas or entire parts, and is considered an “open process.” An “open process” system allows for the solution to flow down vertical or irregular surfaces, or drip from overhead during the plating operation. The lack of control of the solution during the process leads to potential worker exposure to the solution and contamination of the surrounding area.

Cd brush plating repair processes are still utilized within the DoD. Because Cd is regulated by the Resource Conservation and Recovery Act 1974 (RCRA), is a D-listed hazardous waste material, and has an OSHA Action Level PEL of 2.5 µg/m3 as an 8-hour TWA, a need has been identified to qualify and implement a zinc-nickel (Zn-Ni) coating as a Cd replacement for spot repair operations on military weapon systems.

To address these concerns, AFLCMC Product Support Engineering Division (AFLCMC/EZP), in conjunction with the Environmental Security Technology Certification Program (ESTCP), initiated this project to evaluate a closed loop brush plating tool that recycles plating solutions at the point of application, minimizing operator exposure to chemicals and solid waste associated with adsorbents used to contain solution leakage attributed in traditional brush plating as well as evaluate a zinc-nickel brush plating solution as a potential Cd replacement.

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1.2 OBJECTIVE OF THE PROJECT

This project focused on the elimination of toxic/carcinogenic cadmium (Cd) material for brush plating repair operations, and the reduction of solid waste associated with adsorbents used to contain solution leakage attributed with traditional brush plating repair processes. The program's technical objectives were as follows:

3) Demonstrate the Commercial-Off-The-Shelf (COTS) Dalistick Station for selective brush plating in DoD maintenance, repair, and overhaul operations

4) Test and evaluate the COTS Zinidal Aero zinc-nickel (Zn-Ni) brush plated coating as a Cd replacement on weapon systems parts and components

1.3 REGULATORY DRIVERS

Restrictions on Cd, chromium (Cr), and other air pollutants and environmental toxins have become more stringent both nationally and internationally. Due in part to its classification throughout most of the world as a carcinogen, Cd use and disposal is regulated in every media and at every governmental level. The development of Cd restrictions and legal requirements is extensive both within the United States and internationally. A brief synopsis via a timeline is summarized below.

1941	ANSI sets guideline standard of 1000 $\mu g/m^3$
1956	ACGIH assigns TLV of 100 $\mu g/m^3$ for Cd oxide fumes
1971	OSHA Act sets 8–hour TWA PELs and ceiling concentrations for Cd fumes, dust and oxides
1973-1974	ACGIH changes TLV for Cd fumes and dust to 50 $\mu g/m^3$
1974	Congress passes Safe Drinking Water Act, APS sets MCL for Cd at 5 ppb
1976	National Institute of Occupational Safety and Health (NIOSH) sets 10-hour exposure of Cd to 40 $\mu g/m^3$ and 15-minute exposure to 200$\mu g/m^3$
1984	NIOSH issues a CIB for Cd, regarding Cd an occupational carcinogen
1984	EPA lists Cd as B1 substrate a "probable human carcinogen"
1986	Emergency Planning and Community Right-to-Know Act (EPCRA) requires annual reporting of Cd releases
1987	World Health Organization (WHO) lists Cd as a 2A level substance; a "probable human carcinogen"
1990	Cd compounds added to Clean Air Act list of hazardous air pollutants (HAPs)
1992	OSHA publishes a new division of industrial workforce standards for Cd
1995	Cd emissions targeted in Aerospace Manufacturing and Rework Facilities National Emission Standards for Hazardous Air Pollutants (NESHAP)
1998	OSHA regulation requires new employee examination regulations targeting adverse health affects
2000	Executive Order (EO) 13148 requires reductions in Federal agency use and releases of toxic chemicals
2003	European Union (EU) adopts the *waste electrical and electronic equipment* (WEEE) directive at the state member level

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2004	EU Directive 2004/37/EC requires EU employers to reduce use of carcinogens such as Cd
2006	EU Restriction of Hazardous Substances (RoHS) Directive[1] bans Cd above 0.01% in new electrical and electronic equipment
2007	EO 13423 requires reductions in Federal agency use and releases of toxic chemicals
2008	Area Source NESHAP for Plating and Polishing Operations limits Cd emissions from small operations
2009	EO 13514 requires reductions in Federal agency use and releases of toxic chemicals
2011	REACH[2] restricts Cd in jewelry, brazing sticks, paints and plastics
2012	OSHA updates hazard communication requirements for Cd
2013	Cd placed on Registration, Evaluation, Authorization and Restriction (REACH) Candidate List of Substances of Very High Concern (SVHC); creates potential for banning of use in EU
2014	DoD Strategic Sustainability Performance Plan requires toxic chemicals to be reduced by 15% by 2020
2015	EO 13693 requires Federal agencies to reduce quantity of toxic chemicals and materials acquired, used, or disposed
2015	REACH proposal would further restrict Cd in certain paints
2015	Aerospace NESHAP Residual Risk Rule adds restrictions on Cd emissions from

There have been many efforts over the last 20 plus years focused on the replacement of Cd due to the increased stringency of regulations on its use and the occupational, health and safety concerns. Ogden Air Logistics Complex (OO-ALC) implemented an immersion-based low hydrogen embrittlement Zn-Ni chemistry that is suitable for use on high strength steel landing gear. With the immersion based chemistry, OO-ALC also qualified and implemented a brush plating Zn-Ni chemistry by Sifco. However, the need still exists to reduce the associated solid hazardous waste associated with traditional brush plating as well as extend the useful life of solutions to reduce maintenance costs and conserve materials. Further, qualification of an additional Zn-Ni chemistry in conjunction with the dripless tool will provide another source for solutions. This project addresses those needs.

[1] Military electrical and electronic equipment is specifically excluded from coverage under RoHS.
[2] REACH is not applicable to products imported by DoD for direct support of EU-based forces, BUT it could compromise part availability/performance.

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2.0 DEMONSTRATION TECHNOLOGY

2.1 TECHNOLOGY DESCRIPTION

Extensive work, both nationally and internationally, has been performed on zinc-nickel (Zn-Ni) alloys as replacements for Cd in immersion electroplating. Low hydrogen embrittlement (LHE) Zn-Ni coatings are implemented at OO-ALC for use on high strength steel landing gear components (per DRW No.201027456/ 201027457). This work was done through multiple Small Business Innovative Research (SBIR) contracts, including the successful demonstration of the Phase II SBIR "Development of Cd Plating Replacement with Zn-Ni on High Strength Steel Components", (FA8201-08-C-0054), that led to the demonstration/validation effort on Zn-Ni coatings that was performed through the Environmental Security Technology Certification Program (ESTCP) project #WP-201107. Also through that program, electroplated Zn-Ni alloys that meet AMS2451/9, "Plating, Brush, Zinc-Nickel Low Hydrogen Embrittlement (LHE)" have been identified as potential brush plating replacements for Cd. However, brush-plated Zn-Ni has not been widely approved nor used as a Cd replacement in military repairs, due in part to the lack of military specific qualification testing (e.g., weapon system or service specific requirements). In addition, the health and safety issues associated with traditional brush plating, including substantial liquid and solid waste (due to adsorbents used to catch dripping plating solutions) increases disposal costs.

The Dalistick D.2020 station (Dalistick Station) is a closed loop electroplating system that enables selective electrochemical treatments (anodizing, electroplating, and surface preparation). The Dalistick D2020 station's major components are shown in detail in Figure 1 and described in Table 2. The cart allows for portability of the process, allowing it to be performed in the plating shop or in the field.

The station is controlled by a touch screen computer featuring step-by-step plating steps, cleaning operations, and self- diagnostics. The Dalistick D.2020 has been designed to control electrochemical surface treatments in regards to:

- The electrolyte (constant flow, temperature control, display of usage rate, display of consumable life),
- The electroplating process (voltage control, process control according to the required current),

A rectifier with two leads provides a source of direct current for all electrochemical treatment processes. One lead is connected to the plating tool/electrode and the other is connected to the part being finished. A circuit is completed when the plating tool/electrode is in contact with the work surface.

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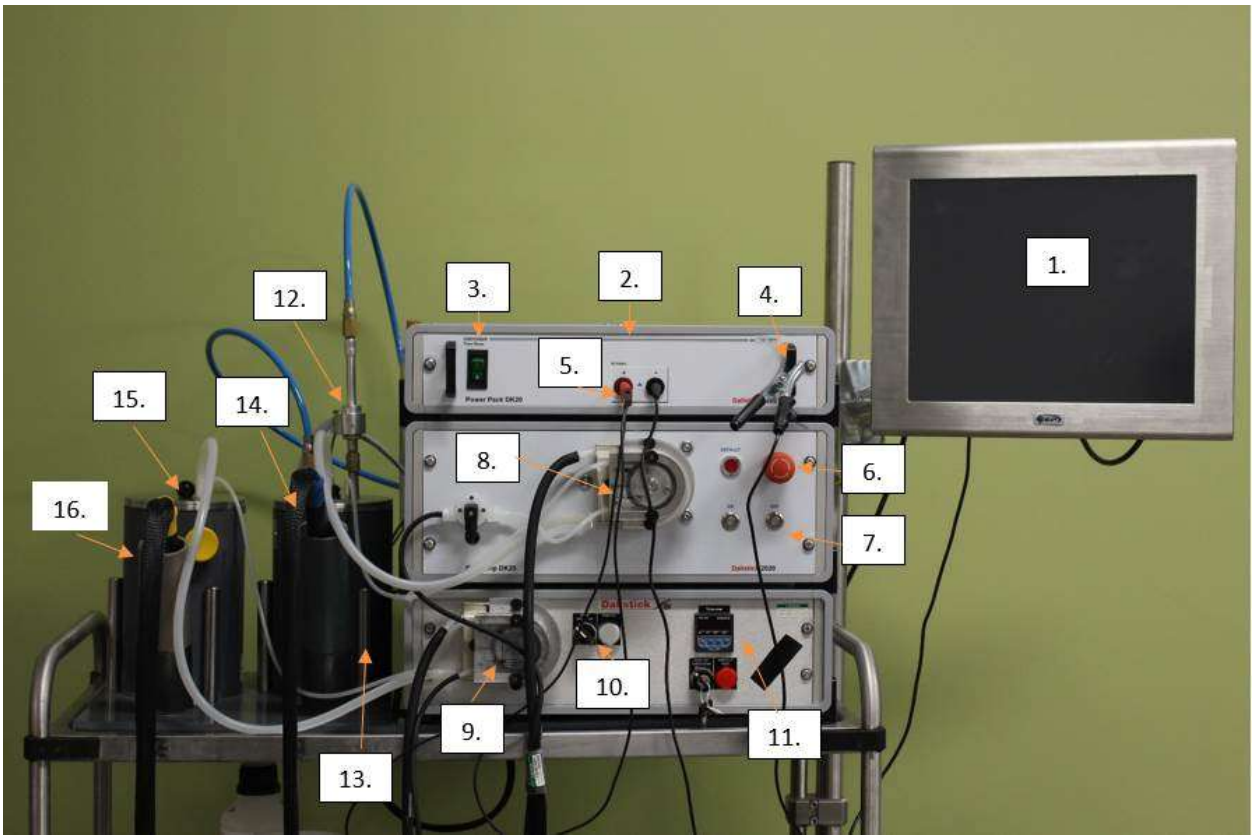

Figure 1: Dalistick D2020 and Components

Table 2: Dalistick D2020 Component Descriptions

Label	Component	Description
1.	Computer	User interface and station controller
2.	Rectifier	Controls plating voltage and amperage
3.	Rectifier Power Switch	Turns on and off power to rectifier
4.	Ground Clamp	Ground connection for part
5.	Tool Electrical Connection	Electrical connection for wands
6.	Emergency Stop	Emergency stop for Zn-Ni pump
7.	Zn-Ni Pump On/Off Switch	Turns on and off power to the Zn-Ni pump
8.	Zn-Ni Peristaltic Pump	Zn-Ni supply and vacuum pump
9.	Activator Peristaltic Pump	Activator supply and vacuum pump
10.	Activator Pump On/Off Switch	Turns on and off the activator pump
11.	Tube Wear Counter	Counter displaying the tube wear in minutes
12.	Compressed Air Vortex Chiller	Cools the compressed air used to chill the Zn-Ni tank
13	Temperature Controlled Zn-Ni Tank	Tank to hold 1L of Zn-Ni solution
14.	Zn-Ni Wand	Wand for Zn-Ni plating
15.	Activator Tank	Tank to hold 1L of activator solution
16.	Activator Wand	Wand for activator pre-treatment

The pre-treatment (Activator) tank contains the Activator XF solution which is used to prepare the surface for Zn-Ni plating.

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The Zn-Ni tank is a temperature controlled tank featuring an electric heater, compressed air vortex chiller and internal cooling coils. This tank stores and regulates the temperature of the Zinidal Aero Zn-Ni solution for Zn-Ni plating.

The solution pumps are used to supply the activator and Zn-Ni solution to the plating tools. The top pump is for the Zn-Ni and is computer controlled. The bottom pump is for the activator and is turned on manually. The pumps also recover residual brush plating solution at the point of contact with the part during plating and recycles it for reuse in a closed-loop process. Solution life/use is extended and solid waste from absorbents used to contain dripping solution is reduced.

The station contains two plating tools, one for the activator and one for the Zn-Ni solution. These two tools eliminate the need to change solutions during a Zn-Ni plating treatment. The station is also equipped with two different types of tools which can be installed for use of different components. They are in Figure 2.

Figure 2. Plating Tools

The Dalistick D.2020 is capable of performing localized repair on small areas including flat, vertical, horizontal, contoured surfaces, as well as in-situ repairs.

Zn-Ni electroplating is currently a leading candidate for Cd replacement. A Sifco 4018 Zn-Ni solution is currently qualified and additional Zn-Ni solutions are under evaluation. The Zinidal Aero Zn-Ni solution is one such solution which was tested during this project. The manufacturer claims the process deposits a coating with 10-14% weight Ni and 86-90% weight Zn at varying thicknesses, thus potentially meeting the 12-17% weight Ni required in the USAF DWG 201027457 Solutions For Use in LHE Zinc-Nickel Plating On High Strength Steel Substrate (>180 KSI) Landing Gear Components

The Zinidal Aero Zn-Ni process is similar to conventional Cd brush plating operations. Solvent degreasing is performed to remove grease, oils, and dirt from the surface to be plated. Hand sanding is not required prior to solvent cleaning unless the substrate material is damaged or the rust is significant. Next the areas not to be plated are masked with aluminum and vinyl or PVC tape. No solutions leaks from the Dalistick Station, therefore the required masking is reduced and the use of absorbent pads in adjacent area or around the part are eliminated. Next the surface is

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etched with the activator to prepare the substrate for plating with the Zinidal coating, followed by a clean water rinse. The Zinidal Aero Zn-Ni plating is performed, followed by another clean water rinse. Masking is removed next. The part is then dried with oil-free, dry compressed air. When Type II plating operations are required the conversion coating can be applied via dipping, or saturated absorbent. This is the same as applying a conversion coating for Cd plating. Lastly the manufacturer claims there is no need for hydrogen embrittlement relief of Zinidal Aero Zn-Ni plated parts.

The process flow for the Zinidal Aero Zn-Ni brush plating using the Dalistick 2020 station is in Figure 3.

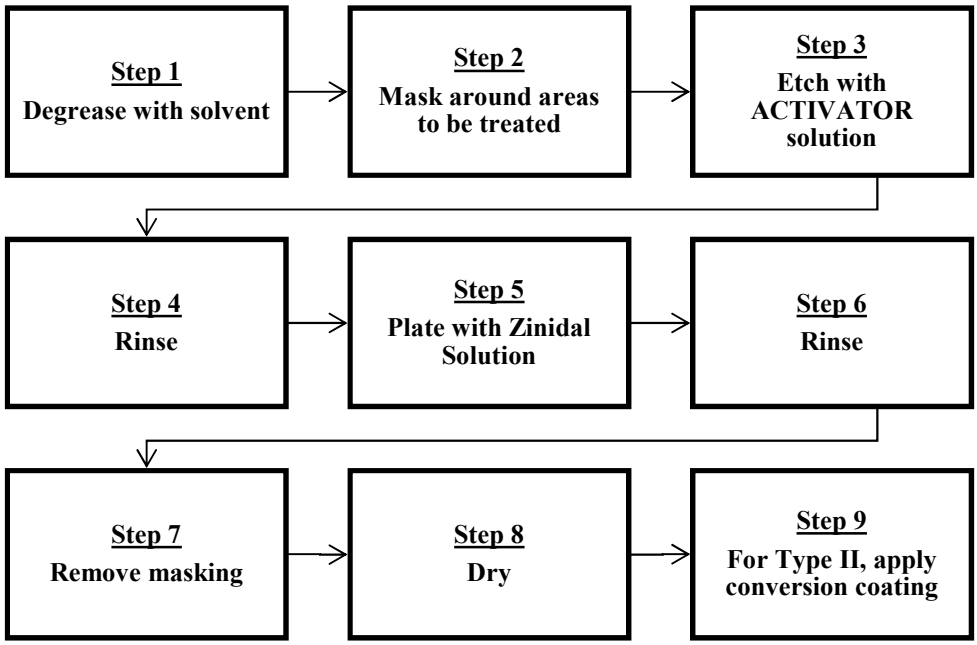

Figure 3. Zinidal Aero Zn-Ni Coating Process with Associated Pre and Post-treatments

Additionally, the Dalistick Station is capable of performing other surface finishing operations such as spot anodizing, coating removal, and rust removal with the same equipment and plating tools. This is achieved by changing the treatments solutions and selecting the new treatment type in the computer.

2.1.1 FACILITY REQUIREMENTS

Although there are no significant site preparations required prior to installing the equipment, the following sections are guidelines for the facility and operational environment and required personal protective equipment. A complete Operational Requirements Assessment can be found in **Error! Reference source not found.**.

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2.1.2 SPACE REQUIREMENTS

The Dalistick D.2020 Station and associated cart occupy a volume of 24" x 36" x 63" (600 x 900 x 1600 mm). Additional space must be allocated for movement of the operator around the cart and associated part being treated. The manufacturer recommends a workspace of 9.84 ft x 9.84 ft (3m x 3m) minimum, or approximately 100 ft^2.

2.1.3 ELECTRICAL REQUIREMENTS

The Dalistick D.2020 Station requires single phase, 110V alternating current (AC), 50 or 60 Hz, and typically pulls 5A of power (maximum of 11.3A).

The station is outfitted with a power converter which converts the 110V to 230V single phase power for the station. This is because the system is designed and fabricated in Europe so this converter is needed. The power converter is not UL listed, however if needed one can be sourced. Alternately the station will run on 230V single phase power.

2.1.4 COMPRESSED AIR

The Dalistick D.2020 Station uses 87 psi up to 145 psi maximum (7 bar up to 10 bar) at consumption rate of 6.65 cubic feet per minute (25 m^3/hr). The compressed air must be dry and oil free therefore an oil/water separator is required.

2.1.5 WATER

Water is not needed to be hooked to the machine for plating operations. Water is needed to rinse components during the plating process and approximately 4 liters of water is needed to complete the cleaning operations on the machine. The user manual states distilled water should be used, however the manufacturer confirmed treated tap water is sufficient.

It should be noted that Dalic recommends a proprietary rinsing solution for cleaning the Zn-Ni portions of the Dalistick D.2020 to prevent crystallization inside the equipment. However, they do not themselves use it, and it has been found it to be unnecessary in general. When alternating between rinsing and Zn-Ni plating, the bonnet (or pad) can become clogged with crystalline precipitates and should be replaced.

2.1.6 ENVIRONMENTAL CONDITIONS

Table 3: Dalistick D.2020 Operating Conditions contains the manufactures recommended operating conditions for the Dalistick D.2020.

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Table 3: Dalistick D.2020 Operating Conditions

Condition	Minimum	Maximum
Temperature[3]	53.6 °F (12 °C)	122 °F (50 °C)
Humidity[4]	45%	65%

The manufacturer also recommends that the unit not be used in sandy/dusty environments or workshops with airborne oil particulates, primarily because the various particulates can have an adverse effect on adhesion of the depositing coating.

2.1.7 SAFETY AND OCCUPATIONAL HEALTH CONSIDERATIONS

2.1.7.1 NOISE

When measuring noise in the operator position, including use of the cooling system and pump, noise was measured at 60 to 65 decibels (dBA) when the cooling system is operating. This is below the NIOSH recommended level of 85 dBA over 8 hr. exposure or the 90 dBA permissible exposure limit set forth by OSHA. Ultimately the local safety personnel will be responsible for determining if hearing protection is required.

2.1.7.2 VENTILATION

Although there are emissions from this operation, measured exposure to hazardous materials, such as Cd, using this Dalistick Station are below the established PEL and EU regulations. APAVE, The French Authority, has conducted air monitoring measurements of the following operations, as performed with the Dalistick Station, to confirm that all air emissions are well below the maximum authorized limit for the EU. The Table also denotes OSHA PELs 8 hr. time weighted average (TWA) for the United States.

Table 4. Emissions Data for Dalistick Station

Process	Substance	Measured (mg/m^3)	EU authorized max (mg/m^3)	OSHA PEL (mg/m^3)
Cd Plating	Cd	0.0001	0.05	0.005
Chromic Acid Anodizing	Chromic Acid	0.0005	0.05	0.005
Zn-Ni Plating	Nickel Sulfate	0.0008	0.1	0.055

Monitoring was conducted without any air extraction system over the Dalistick Station and sensors were placed at the shoulders of the operators.

[3] The minimum temperature recommendation from the manufacture is due to potential adhesion concerns with the plating. The maximum temperature limitation is due to the electrical component limitations on the station.

[4] The humidity range recommendation from the manufacture is due to potential adhesion concerns with the plating.

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Ultimately the local safety personnel are be responsible for determining if ventilation/respiratory protection is required.

2.1.7.3 RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

Dalic recommends the use of the following general personal protective equipment (PPE) while using the Dalistick D.2020 Station. The final determination will be made by the local safety personnel.

- Coveralls or long pants and shirt
- Chemical aprons - when handling concentrated chemicals, such as brush plating solutions, and cleaning solutions, etc.
- Steel toed boots
- Eye protection – safety goggles or a face shield
- Gloves – neoprene, latex, PVC, nitrile or other appropriate type

For further information refer to the "Dalistick Industrial Health Risk Assessment" in the Appendix.

2.2 TECHNOLOGY DEVELOPMENT

The Dalistick Station development initiated when a requirement was presented to Dalic in the mid-1990s from original equipment manufacturers (OEMs) performing chromic acid anodizing (CAA) during the assembly of airframe parts. They desired to have a system that did not drip solutions when conducting CAA, regardless of position, e.g., overhead, inverted, in tight spaces, etc. As a result, Dalic Inc. investigated various concepts to meet their needs. Eventually, in 1996, they settled on the design that is the basis of the Dalistick D.2020 that is being used today. Over the years, Dalic Inc. has made improvements to the materials, Dalistick tool, rectifier technology, etc., which has culminated in the current Dalistick D.2020. The Dalistick D.2020 is the unit being used under this program it was launched into production in 2012.

Today, over 30 Dalistick stations (of varying design) are in use by OEM, civil, and military operations outside of the United States for plating and anodizing operations. Use of Dalistick for Cd plating on steels have been approved by Airbus SRM 51.21.11, Boeing BAC 5854, Messier-Dowty PCS 2141, Goodrich LGPS 1102, Eurocopter, and Argusta-Westland for applications on landing gear, flap track, engine pylon, bushings, bolts, etc.

Foreign militaries are using the Zinidal solution in combination with the Dalistick Station for aerospace applications. It has been publicized that the Dalistick station and Zinidal coating are being used on Dassault aircraft, French missiles M.5, F-18 owned by the Spanish Air Force, Ariane V Booster rocket module, and Airbus aircraft. More specifically,

- Zinidal is approved as a final coat to prevent erosion on aluminum wing leading edges
- Zinidal is approved as per the EN-4826 STD for Zn-Ni on steel up to 1420 MPa
- Zinidal was applied successfully with the Dalistick Station on F-18 vertical cone face with damages of galvanic corrosion for the Spanish Air Force

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- Zinidal is approved for use on various steel and aluminum alloys by Thales, a leading supplier in electronics for defense
- Zinidal is approved for use to prevent corrosion on aluminum alloys by Nexter, a land defense equipment supplier.

Due to the promising results of the Zinidal coating as applied by the Dalistick Station, Air Force Research Laboratory (AFRL) Environment and Energy (E2) and Concurrent Technologies Corporation (CTC) evaluated it as a Cd replacement for Cd Type I replacement on mild steel parts of the ICBM Minuteman III Motor Generator (MMG) assembly. The Zinidal Zn-Ni coating applied using the Dalistick Station was tested as candidate for Cd replacement, and it outperformed other tested COTS brush plated Zn-Ni coatings in corrosion, wear and electrical resistance testing while meeting the specific requirements identified by MMG Project Team, as shown in Table 3.[5] As a result of this promising data, Zinidal was recommended as a candidate for Cd replacement for the specific MMG application, pending full-scale validation testing. The Dalistick Station has since been implemented at Portsmouth Naval Shipyard for Cd Type I and Cd Type II repair on mild steel components, while additional funding is being sought for full qualification of Zinidal Zn-Ni coating.

[5] Environmental and Energy Quality Technologies, Task Order 0007: Brush Plated Cadmium Alternative Coating For the Minuteman ICBM Motor-Generator, "Test Report", March 4, 2013.

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Table 5. Test Results Summary[6]

Test	Units	Cd	Dipsol IZ-C17+ Zn-Ni	SIFCO 4018 Zn-NI	Dalistick Zn-Ni (Traditionally Plated)	Dalistick Zn-Ni (Dalistick Station)
Appearance (AMS[2] QQ-P-416)	N/A	PASS	PASS	PASS	PASS	PASS
Bend Adhesion (ASTM B 571)	N/A	Not Tested*	PASS	PASS	PASS	PASS
Thickness, Magnetic (ASTM B 499)	Thousandth of an inch (mils)	0.53 ± 0.05	0.55 ± 0.04	0.61 ± 0.11	0.56 ± 0.03	0.49 ± 0.03
Thickness, Cross-sectional (ASTM B 487)	Mils	Not Tested*	0.59 ± 0.04	0.60 ± 0.09	0.50 ± 0.08	0.47 ± 0.06
Composition EDS[7] (ASTM E 1508, Surface)	Weight %	Cd: 100 trace atmospheric contaminants[8]	Zn: 88 ± 2 Ni: 12 ± 2 trace atmospheric contaminants	Zn: 89 ± 1 Ni: 11 ± 1 trace atmospheric contaminants	Zn: 88 ± 0.6 Ni: 12 ± 0.6 trace atmospheric contaminants	Zn: 88 ± 0.3 Ni: 12 ± 0.3 trace atmospheric contaminants
Composition EDS (ASTM E 1508 Cross-sectional)	Weight %	Cd: 100 trace atmospheric contaminants	Zn: 91 ± 4 Ni: 9 ± 0.3 trace atmospheric contaminants	Zn: 91 ± 2 Ni: 9 ± 1 trace atmospheric contaminants	Zn: 88 ± 0.6 Ni: 12 ± 0.6 trace atmospheric contaminants	Zn: 88 ± 0.3 Ni: 12 ± 0.3 trace atmospheric contaminants
Wear (500 cycles) (ASTM G 115) (ASTM F 133)	COF[9]	0.32 ± 0.06	0.20 ± 0.03	0.23 ± 0.12	Not tested	0.3 ± 0.14
	Severity Ranking	3	2	2	Not tested	3
Wear (5,000 cycles) (ASTM G 115) (ASTM F 133)	COF	0.44 ± 0.02	0.43 ± 0.07	0.45 ± 0.21	Not tested	0.7 ± 0.35
	Severity Ranking	5	3	3	Not tested	4
Salt Fog Corrosion[10] (ASTM B 117)	Scribed[11]	9	9	8	10	10
	Unscribed [12]	8	7	7	10	10

[6] The variability of the averages shown as the standard deviation of the data, which includes all specimens of the coating type

[7] EDS = Energy dispersive x-ray spectroscopy

[8] Results indicated that the average coating composition was nearly pure Cd, with the balance likely being atmospheric contaminants, such as carbon (C) and oxygen (O); however, EDS is not considered a reliable method for determining the presence of light elements such as carbon (C) and oxygen (O). Therefore, specifics related to the atmospheric contaminants could not be determined.

[9] COF = Coefficient of friction; measurements are dimensionless.

[10] ASTM D 1654 was used to rate specimens tested according to ASTM B 117. ASTM D 1654 defines "0" as the worst performance at over 75% failed, while "10" denotes the best performance with no failure being noted.

[11] Represents the average rating at the scribed area (average coating thickness for tested panels in parentheses).

[12] Represents the average rating at the unscribed area on panels that were not scribed (average coating thickness for tested panels in parentheses).

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Table 6. Test Results Summary Cont.

Test	Units	Cd	Dipsol IZ-C17+ Zn-Ni	SIFCO 4018 Zn-NI	Dalistick Zn-Ni (Traditionally Plated)	Dalistick Zn-Ni (Dalistick Station)
Electrochemical Properties (ASTM G 1, 3, 5, & 61)	OCP (mV)	-680 ± 3	-1,032 ± 2	-955 ± 93	-1,020 ± 9	-979 ± 1
Whisker Growth (After 3,000 hours) (JEDEC Standard JESD22-A121A)	N/A	No Whiskers	No Whiskers	No Whiskers	Not tested	No Whiskers

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

The primary goal of this project was to eliminate the use of Cd in brush plating repair operations and reduce operator exposure to hazardous chemicals. Implementation of the Zinidal coating, as applied by the Dalistick Station, may offer immediate and long-term regulatory and EHS benefits including the following.

- Avoidance of Cd compliance issues in military repair operations
- Environmental and operational impacts
  - Ability to perform selective electrochemical treatments and plating using a single system
  - No electrolyte/hazardous chemical solution leakage during processing
  - Ability to treat curved, horizontal, vertical surfaces, and edges either in the field or in the ALCs/Depots
- Reduction of solid waste that is generated from using absorbents
- Reduction of worker exposure to any hazardous material (including residual brush plating solution)
- Reduction of monitoring, use of personal protective equipment, permitting, and record keeping

The limitations of this technology/process lie in the following

- The capital cost of the equipment is significantly higher (at about $125,000) than a conventional brush plating system (at about $15,000).
- Having a single source provider is usually not desirable due to potential impact if the provider closes, reduces inventory, or increases prices due to a captured market.
- Importing a foreign chemical, especially from Europe where regulatory burdens are escalating, even on chemicals that are considered to be far less of an environmental and safety concern than Cd (e.g., Zn and Ni), could result in difficulty in obtaining the Zinidal chemistry in the future.
  - There is one US distributor of the system and supplies which may reduce this burden.

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However, when performing a sustainability analysis which includes a number of factors such as hazardous waste disposal costs as well environmental and occupational health and safety costs the 15 year life cycle cost of the system is comparable to a traditional Cd brush plating process.

The concern about a sole source provider of the technology remains. However, due to the ability to configure the machine, it is expected that other approved brush plating chemistries could be used with the Dalistick Station once tested.

3.0 PERFORMANCE OBJECTIVES

The following performance objectives were the primary criteria that have been established for evaluating the Dalistick Station and associated Zinidal Coating:

1. Demonstrate the usefulness of the Dalistick® D.2020 (Dalic Inc.) commercial-off-the-shelf (COTS) brush plating tool for selective plating for DoD maintenance, repair and overhaul operations.
2. Test and evaluate the Zinidal™ Aero Zn-Ni brush-plated coating (by Dalic Inc.) COTS material as a Cd replacement on mild and high-strength steels for repair applications on weapon system parts.

The success of item 1 was determined by gathering both quantitative and qualitative information during the technology demonstration. Conclusions from the demonstration can be found in the WP-201412 Demonstration Report. Item 2 follows the criteria set by the JTP. These requirements are detailed further in Table 7.

Table 7. Engineering, Performance and Testing Requirements

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Quantitative Performance Objectives		
Appearance Uniformity	AMS-QQ-P-416 USAF DWG 201027457 MIL-STD-870 BAC 5637 BAC 5664	Visual inspection of all specimens shows that coating is continuous, smooth, adherent, uniform in appearance, free from blisters, pits, nodules, burning, contaminants, excessive powder, and other apparent defects
Thickness &Alloy Composition Uniformity	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 ASTM B 530 ASTM B 568	Average coating thickness on flat areas of the specimen, measured in a minimum of three areas of each specimen is within 0.0004 to 0.0007 inch); Consistent alloy composition is obtained along the fixture cavity when tested using XRF method
Bend Adhesion	USAF DWG 201027457 AMS-QQ-P-416 ASTM B 571 BAC 5637	There is no separation (flaking, peeling, or blistering) of coating from the basis metal
Wet/Dry Tape Paint Adhesion	USAF DWG 201027457 ASTM D 3359 MIL-PRF-23377 MIL-PRF-85582 MIL-PRF-32239A (draft)	Plated specimens are coated with MIL-PRF-85582 or MIL-PRF-23377 and cured for 14 days at room temperature (RT). Specimens are either tested at RT (dry) or immersed for 24 hours (h) in DI water at 73°F than tested (wet) – an adhesion rating of 4B or better (less than 5% area removed), per ASTM D 3359

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Table 7. Engineering, Performance and Testing Requirements (Continued)

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Corrosion Resistance – Salt Spray Resistance	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 SAE AMS 2451/9 ASTM B 117 ASTM D 1654	After 96 h exposure, there is no evidence of white corrosion; Up to 500 h exposure, there is no appearance of red rust or comparable to controls (10 per coating scenario)
Corrosion Resistance - SO_2 Resistance	ASTM G 85	Must meet 168 h exposure before appearance of red rust or comparable to controls
Corrosion Resistance - Galvanic Corrosion Resistance	GMW 14872 MIL-PRF-32239A (draft) Section 4.5	Galvanic couple of Zn-Ni and Cd plated steel specimens with Cd plated screws and stainless steel screws (all dry installed). Specimens will be exposed to GMW 14872 corrosion cycle. Red rust corrosion will be comparable to control
Hydrogen Embrittlement	AMS-QQ-P-416 USAF DWG 201027457 SAE AMS 2451/9 ASTM F 519 MIL-STD-870 BAC 5637	No fracture for plated specimens within 200 h after sustained 75% notched fracture strength (NFS) load testing. Type 1a.1 notched bar and Type 1d notched C-ring specimens. All 4 specimens must pass; if one fails, remaining 3 are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture. (3 out of 4 with no fracture = pass) (2 with fracture = fail) Success conclusions will also be drawn from a hydrogen embrittlement study performed by Boeing Research and Technologies and IBECA Technologies particularly in regards to surface treatment effects on hydrogen embrittlement

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Table 7. Engineering, Performance and Testing Requirements (Continued)

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Service Chemical Hydrogen Embrittlement	USAF DWG 201027457 ASTM F 519	--Four (4) specimens Type 1a.1 notched bar per coating scenario or chemical exposure condition --Four (4) specimens Type 1d notched C-ring per coating scenario; Set 1: specimens immersed in service chemical (cleaning compound per MIL-PRF-29602) at elevated temperature for 30 min; specimen removed, air-dried, and tested for 200 h at 75% NFS (all 4 pass); Set 2: specimens immersed in service chemical (cleaning compound per MIL-PRF-29602) at room temperature while tested for 150 h at 45% NFS (all 4 pass) If one fails in Set 1 or Set 2, the remaining 3 for that Set are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture (3 out of 4 pass)
Outdoor Exposure Testing	ASTM D1014-9	Two year outdoor exposure at Kennedy Space Center. Corrosion comparable to controls
Waste Generation	Feedback from Operators during demonstration on waste generated from Dalistick Station and Zinidal Aero Zn-Ni as compared to traditional brush plating	Less hazardous waste generated than traditional brush plating
Strippability	USAF DWG 201027456 USAF DWG 201027457	Zn-Ni coating stripped using NH_4NO_3 solution (16 ounces per gallon in water; pH maintained 8.0–9.0 with NaOH). Stripping times less than 120 min at 21–27°C (4 replicates per coating scenario)

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Table 7. Engineering, Performance and Testing Requirements (Continued)

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Qualitative Performance Objectives		
Ergonomics	Feedback from Operators during demonstration on ergonomics of Dalistick Station and Zinidal Aero Zn-Ni as compared to traditional brush plating	As good or better ergonomics than controls
Ease of Use	Feedback from Operators during demonstration on usability of Dalistick Station and Zinidal Aero Zn-Ni as compared to traditional brush plating	As good or better usability than controls. Data will be collected on the areas or components where the system is most applicable and has the most promise to be implemented

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4.0 SITE/PLATFORM DESCRIPTION

4.1 TEST PLATFORMS/FACILITIES

The demonstration for this technology occurred at Corrdesa LLC in Tyrone GA. Representatives from both the Air Force Life Cycle Management Center (AFLCMC/EZP) and the Fleet Readiness Center Southeast (FRCSE) at the Naval Air Station in Jacksonville, FL were present to judge the feasibility of the station and Zinidal Aero Zn-Ni for brush plating repair operations.

5.0 TEST DESIGN

5.1 JTP TESTING

The full range of JTP testing was broken into two phases. The first phase was screening testing to ensure the Dalistick Station and Zinidal Aero solution performed as expected. A list of the screening tests can be found in Table 8, while the tests performed in the qualification can be found in Table 9. The JTP can be found in **Error! Reference source not found.**.

Table 8. Screening Tests

Requirement	Test	JTP Section
General Properties	Appearance Uniformity	3.2.1
General Properties	Thickness & Alloy Composition Uniformity	3.2.2
Adhesion	Bend Adhesion	3.2.3
Corrosion Resistance	Salt Spray Resistance	3.2.5

Table 9. Qualification Tests

Requirement	Test	JTP Section
General Properties	Appearance Uniformity	3.2.1
General Properties	Thickness & Alloy Composition Uniformity	3.2.2
Adhesion	Bend Adhesion	3.2.3
Adhesion	Wet/Dry Paint Adhesion	3.2.4
Corrosion Resistance	Salt Spray Resistance	3.2.5
Hydrogen Embrittlement	Hydrogen Embrittlement	3.2.6
Hydrogen Embrittlement	Service Chemical Hydrogen Embrittlement	3.2.7
Strippability	Stripping Method	3.2.8
Corrosion Resistance	SO2 Resistance	3.2.9
Corrosion Resistance	Galvanic Corrosion	3.2.10
Corrosion Resistance	Outdoor Exposure Testing	3.2.11

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5.2 SUBSTRATE AND PLATINGS

Testing was performed on two different types of substrates, 1008 and 4130 steel. The only exception to this was the hydrogen embrittlement and hydrogen re-embrittlement testing which was performed on 4340 steel specimens. For all of the JTP testing the Zinidal Aero Zn-Ni plated with the Dalistick station was considered the test condition. It was tested both with and without a Cr(VI) Passivateur N°3 conversion coating. Two control conditions were also tested. The first was a Sifco 4018 LHE Zn-Ni plated by traditional brush plating with a Sifco 5030 Cr(VI) conversion coating and a Sifco 2023 Cd by traditional brush plating with a Sifco 3002 Cr (VI) conversion coating. These platings were tested in several repair scenarios including on bare substrates, over tank plated simulated damaged Cd, and over tank plated simulated damaged Zn-Ni (Dipsol IZ-C17+ Zn-Ni with IZ-264 Trivalent Chromium Conversion Coating.) A matrix of these configurations are in Table 10. Screening testing was only performed on bare steel brush plated specimens whereas qualification tests were performed on brush plated specimens over bare steel and both simulated repair scenarios. All specimens plated with the Zinidal Aero Zn-Ni were plated at UDRI by trained UDRI personnel per manufacturer's instructions. Sifco 4018 Zn-Ni brush plating and Zn-Ni tank plating were performed by ES3 Inc. in Warner Robins GA per USAF Source Control Drawings 201027456 and 201027457. Lastly all Sifco 2023 Cd brush plating and Cd tank plating was performed by Hohman Plating in Dayton OH per MIL-STD-865 and MIL-STD-870.

Table 10. Substrate and Plating Matrix

Substrate[13]	Plating	Conversion Coating	Repair Condition
4130 and 1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel, Zn-Ni Tank Plated Repair, Cd Tank Plated Repair
4130 and 1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel, Zn-Ni Tank Plated Repair, Cd Tank Plated Repair
4130 and 1008 Steel	Sifco 4018 Zn-Ni	Sifco 2023	Bare Steel, Zn-Ni Tank Plated Repair, Cd Tank Plated Repair
4130 and 1008 Steel	Sifco 2023 Cd	Sifco 5030	Bare Steel, Zn-Ni Tank Plated Repair, Cd Tank Plated Repair

5.3 APPEARANCE AND UNIFORMITY

5.3.1 Rationale

Specifications AMS-QQ-P-416 and MIL-STD-870 as well as USAF Source Control Drawing (USAF DWG 201027457) cite the finish quality or appearance as a quality requirement for tank-plated coatings. This is also applicable to brush-plated coatings. This visual test was performed on all candidate brush plating coating systems per the JTP.

[13] 4340 steel specimens were used for hydrogen embrittlement and hydrogen re-embrittlement testing.

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5.3.2 Test Description

Each specimen plated using the Dalistick Station was inspected visually for defects as well as the control specimens plated by outside vendors. Specimens were inspected to ensure the coating was smooth, continuous, uniform in appearance and free from blisters, pits, nodules, burning, contaminants, powder as well as other defects per AMS-QQ-P-416, USAF DWG 201027457, and MIL-STD-870. A matrix of the specimens tested can be found in the following table.

Table 11: Appearance and Uniformity Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	70
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	70
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	42
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	42
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4340 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	33
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4340 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	33
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4340 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	33

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For specimens plated with the Dalistick station a tape test was performed to ensure the coating was adhered to the substrate as directed by the Dalistick Station. This tape test consisted of applying an ASTM D 3359 compliant tape and quickly removing it from the specimen. If metallic flakes were found on the tape the specimen failed and was not used in testing. If a specimen had a conversion coating applied the specimen was also inspected post application to ensure the conversion coating was applied correctly. If there were any issues with the specimen appearance a new specimen was created. Lastly a picture of each specimen was taken before further testing occurred.

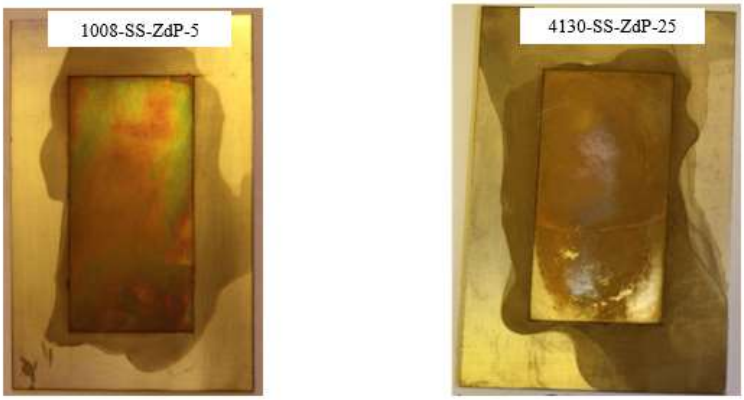

Figure 4. Appearance and Uniformity Example

5.3.3 Data Analysis

The number of specimens that did not meet the appearance and uniformity requirements were documented and the percentage rate of plating failures for specimens with and without a conversion were calculated to determine a plating failure rate.

5.4 THICKNESS

5.4.1 Rationale

Specifications MIL-STD-865 and USAF Source Control Drawings 201027457 (Para 3.3.2) cite the thickness uniformity as a quality requirements for Zn-Ni coatings. Thickness is critical to successful plating, and ultimately to the performance of the coating.

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5.4.2 Test Description

The thickness of all specimens were checked in 9 to 11 places using an Elcometer 456 coating thickness gauge depending on the specimen type, see Figure 5. The gauge was calibrated for each type of substrate being testing (1008 and 4130 steel) on the backside of the specimens per the Elcometer 456 manufacturer's recommendation. The average thickness of each specimen was calculated and checked against the thickness criteria per AMS-QQ-P-416 and USAF DWG 201027457. The control specimens were accepted if the average thickness was greater than 0.0003" (7.6 microns) per AMS-QQ-P-416. The Zinidal Aero specimens plated with the Dalistick station were accepted if the average thickness was between 0.00031" and 0.00071" (8.0-18.0 microns) per manufacturers recommendations. The test matrix showing each specimen configuration and quantity can be found in Table 12.

Figure 5. Thickness Measurement with Elcometer 456

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Table 12. Thickness Testing Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	70
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	70
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	42
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	42
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	33
			Zn-Ni Tank Plated Repair	27
			Cd Tank Plated Repair	27

5.4.3 Data Analysis

The average thickness of all specimens were calculated to determine if the thickness met the criteria in AMS-QQ-P-416 and USAF DWG 201027457. If a plating did not meet this criteria it was documented and another specimen was plated. A thickness sensitivity study was performed to determine the effects of the operator, coating, substrate, plating area size, variation across plating area, and solution recycling on plating thickness. Various statistical analysis performed in Minitab was used to analyze the results.

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5.5 COMPOSITION UNIFORMITY

5.5.1 Rationale

Specifications AMS-QQ-P-416 and USAF Source Control Drawings 201027457 (Para 3.3.2) cite the composition uniformity as a quality requirements for Zn-Ni coatings. This is critical to successful plating, and ultimately to the performance of the coating, especially on complex shapes and parts.

5.5.2 Test Description

The alloy composition was tested by X-ray Fluorescence (XRF) using a Fisherscope X-ray XAN model 607-759, manufactured by Fischer Technologies (see Figure 6). Three measurements per specimen were made. 4" x 6" x 0.050" 1008 and 4" x 6" x 0.040" 4130 steel specimens were plated with the Zinidal Aero solution using the Dalistick station as well as with the control Zn-Ni and Cd. The test matrix for the composition testing can be found in Table 13. The uniformity of the specimens was determined by comparing the relative signal intensities, zinc and nickel, in the case of the Zn-Ni control specimens as well as the Zinidal Aero specimens plated with the Dalistick Station.

Figure 6. Fischerscope X-ray XAN Model 607-759

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Table 13: Composition Uniformity Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3

5.5.3 Data Analysis

The signal peaks of each measurement were integrated to produce an area under each peak. The ratios of the zinc signal area was divided by the nickel area to determine a zinc to nickel signal ratio which could be compared across specimens to determine if the alloy composition was remaining constant. Further, a semi-quantitative analysis was performed which provides corrections for the atomic weight, absorption, and fluorescence of the elements to provide a reasonable estimate to the plating composition. These specimens were selected to encompass the full range of zinc to nickel signal ratios observed. Lastly

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cross sections of each type of repair specimen were inspected to determine the quality of the simulated repair.

5.6 BEND ADHESION

5.6.1 Rationale

Specifications AMS-QQ-P-416 and USAF Source Control Drawings 201027457 cite the importance of brush plated coatings adhesion to the substrates. Adhesion of the brush-plated coating is critical to successful plating, and ultimately to the performance of the coating.

5.6.2 Test Description

Bend adhesion testing was performed per ASTM B 571 to determine if the plating was properly adhered to the steel substrates. 1” x 4” x 0.040” 1008 and 4130 steel specimens were used in this testing. Zn-Ni and Cd control specimens were completely plated on one side, while the Zinidal Aero specimens left 0.5” bare on the 1” ends of the specimens over bare substrates. Simulated repair specimens were plated in a 0.5” bare repair area with tank plating on the outside, see Figure 7 for an example of both specimens.

Specimens were clamped in a tabletop vise and repeatedly bent 90° to 180° until a rupture of the base metal occurred. Specimens were then examined at 4x magnification for flaking or lifting of a deposit along the broken edge. A crazing of the deposit was considered acceptable. Extra care was taken on inspection of the simulated repair specimens as the repair platings were also plated to overlap a small portion of each tank plating to ensure an adequate repair. A test matrix of the bend adhesion testing can be found in Table 14.

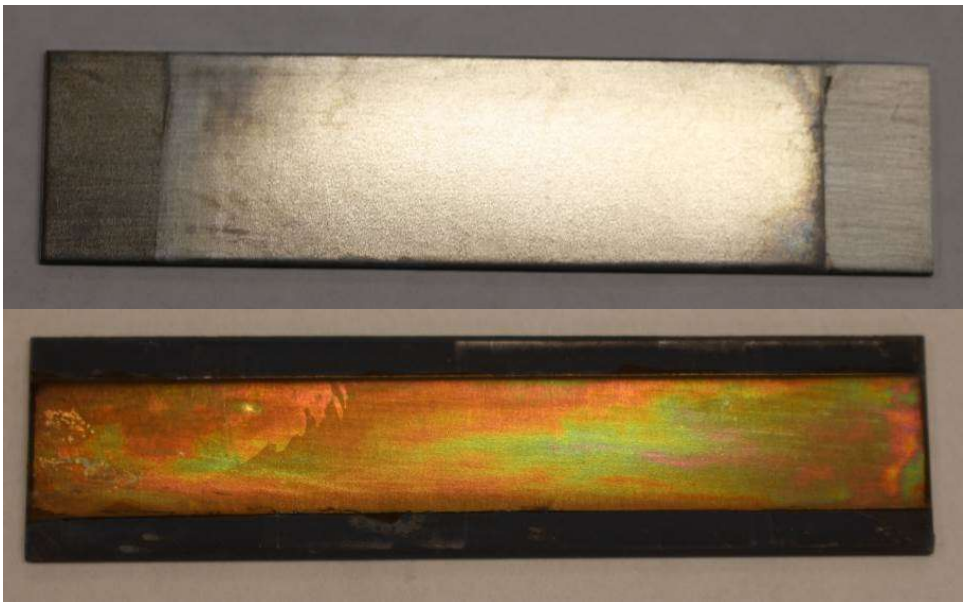

Figure 7. Zinidal Aero Bend Adhesion Specimens

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Table 14. Bend Adhesion Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3

5.6.3 Data Analysis

The bend adhesion testing is a pass/fail test. The number of failures in each condition was compared to determine if the Zinidal Aero Zn-Ni specimens performed as well or better than the control Zn-Ni and Cd specimens.

5.7 WET/DRY PAINT ADHESION

5.7.1 Rationale

Specifications AMS-QQ-P-416 and USAF Source Control Drawings 201027457 cite the importance of adhesion between the brush-plated coating and the applied MIL-PRF-85582 waterborne epoxy primer or MIL-PRF-23377 solvent-borne epoxy primer. This is critical to successful plating, and ultimately, to the performance of the coating system as a whole.

5.7.2 Test Description

Wet/Dry adhesion testing was performed to determine if primer would adequately adhere to the platings as required in USAF DWG 201027457 and AMS-QQ-P-416. 4” x 6” x 0.050” 1008 and 4” x 6” x 0.040” 4130 steel specimens were plated with the Zinidal Aero

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solution using the Dalistick station and with the control Zn-Ni and Cd platings. Specimens were then painted with PPG 44GN098 Water Reducible High Performance Epoxy Primer which meets MIL-PRF-23377, Type 1, Class N. Paint application was accomplished in Dayton, OH by UDRI personnel using a HVLP spray gun and a spray booth operated within the manufacturer's recommended temperature and humidity limits. The specimens were painted to a thickness of 0.6 to 0.9 mils in accordance with TO 1-1-8 and were cured at room temperature for 14 days before testing. A matrix of the test specimens can be found in Table 15.

Table 15. Wet/Dry Paint Adhesion Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 4018 Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 4018 Zn-Ni	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 2023 Cd	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 2023 Cd	None	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
			Zn-Ni Tank Plated Repair	3
			Cd Tank Plated Repair	3

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Half of each specimen was used for dry adhesion while the other half was used for wet adhesion. All test specimens were tested for crosshatch adhesion per ASTM D 3359 method B. The crosshatch tool had a spacing of 1 mm per the standard for coatings under 2 mils in thickness. One cross hatch was made per specimen wet/dry test area on each specimen, however if the cross hatch was not acceptable an additional cross hatch was made. An ASTM D 3359 compliant adhesion tape was used and applied per the standard. The specimens were graded per the ASTM D 3359 and results less than 4B were considered a fail. The testing kit for the adhesion testing can be seen in Figure 8.

Figure 8: Adhesion Testing Kit

The dry adhesion testing occurred first. After dry adhesion testing the opposite half of each specimen were submerged in deionized water for 24 hours at 73°F. After 24 hours the specimens were removed from the deionized water, towel dried, and tested immediately. An ASTM D 3359 compliant adhesion tape was used and applied per the standard. Any blistering of the primer was observed and documented. The specimens were graded per the ASTM D 3359 and results less than 4B were considered a fail. An example of a tested specimen can be seen in Figure 9.

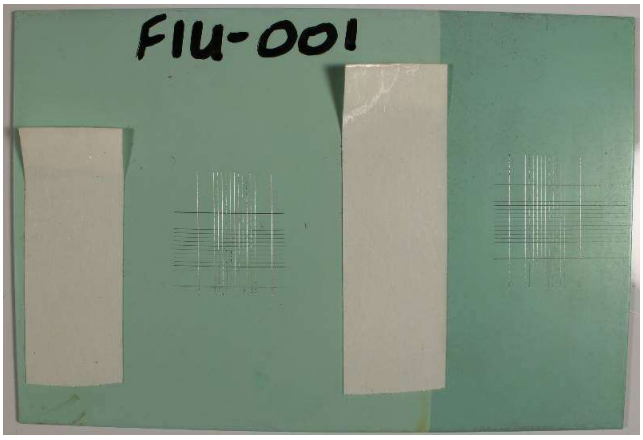

Figure 9. Wet/Dry Paint Adhesion Test Specimen Example

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5.7.3 Data Analysis

The wet/dry paint adhesion testing is a pass/fail test. The number and severity of failures in each condition were compared to determine if the Zinidal Aero Zn-Ni specimens performed as well or better than the control Zn-Ni and Cd specimens.

5.8 SALT SPRAY RESISTANCE

5.8.1 Rationale

Corrosion resistance of the brush-plated coating is critical. Salt fog corrosion resistance testing was performed to determine the ability of the brush-plated coating to protect the substrates in the presence of an aggressive corrosive environment.

5.8.2 Test Description

Salt spray corrosion resistance was performed per ASTM B 117 as required in USAF DWG 201027457 and AMS-QQ-P-416. 4” x 6” x 0.050” 1008 and 4” x 6” x 0.040” 4130 steel specimens were plated on one side and used for all plating configurations. The outside 1” and backside of each specimen was masked with 3M 1280 tape. Half of the specimens were scribed through the plating using a Gravograph 900 rotary engraver. The engraver ensured the same size, width, and depth of each scribe on each specimen. An example of a masked scribed and unscribed specimen can be seen in Figure 10. The specimen matrix can be seen in Table 16.

Figure 10. Salt Fog Resistance Test Specimen Examples

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Table 16. Salt Spray Resistance Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5 Scribed 5 Unscribed
			Zn-Ni Tank Plated Repair	5 Scribed 5 Unscribed
			Cd Tank Plated Repair	5 Scribed 5 Unscribed

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Specimens were tested in a Q-Fog CRH salt fog chamber per ASTM B 117. Daily fog collection volume, salinity, and PH were checked from five collection graduated cylinders daily except on weekends per the standard. The solution tank level, salinity, and PH were also checked at this time to ensure they met the requirements in the ASTM B 117 method. The salt spray resistance test set up can be seen in Figure 11. During the daily chamber checks specimens were visually inspected. Per the JTP no evidence of white corrosion was acceptable on conversion coated specimens. No appearance of red rust was acceptable for 500 hours or corrosion must be comparable to control specimens.

Figure 11. Salt Spray Resistance Test Set Up

5.8.3 Data Analysis

The bare steel 1008 and 4130 specimens were tested during the screening testing. Specimens were checked daily for signs of white corrosion (conversion coated only) and red rust. The specimen was removed from testing at the first sign of red rust and photographed. Screening testing was ran for 1252 hours. The failure of each specimen and average failure of each specimen group was compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

The simulated repair specimens were tested during the qualification round of testing. Specimens were checked daily for signs of white corrosion (conversion coated only) and red rust. The first appearance of red rust was documented and the test specimens were left in the chamber up to 500 hours. At this time all specimens were rinsed and photographed. The percentage of red rust in both the tank plating and brush plating regions were found using an image processing software (ImageJ). An example of this ImageJ processing can be seen in Figure 12. The occurrences of first failure and rust percentages were compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

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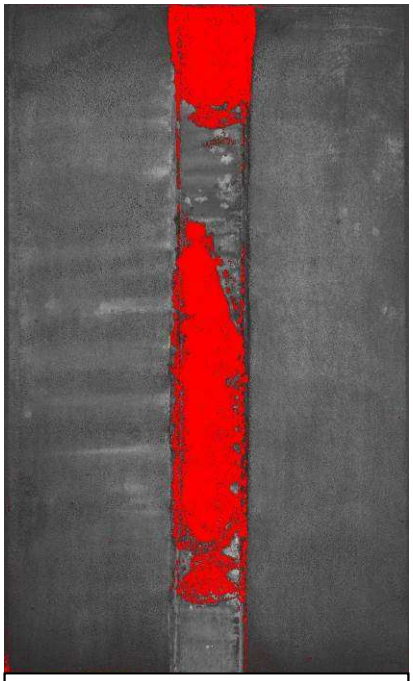

Figure 12. Example of ImageJ Analysis

5.9 HYDROGEN EMBRITTLEMENT

5.9.1 Rationale

This test will be performed to determine the susceptibility of a brush plating process to cause hydrogen embrittlement of steel substrates. It is critical that the tested brush-plated coatings pass testing for the coating to be considered for implementation.

5.9.2 Test Description

Hydrogen embrittlement testing was performed per ASTM F 519. Two specimen types were used, type 1a.1 and type 1d. Four specimens of each plating configuration were tested. The test matrix for the hydrogen embrittlement testing can be seen in Table 17.

Table 17. Hydrogen Embrittlement Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4340 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4 1a.1
				4 1d
4340 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4 1a.1
				4 1d
4340 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4 1a.1
				4 1d

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All specimens were machined from 4340 steel, sourced from Green Specialty Services and were of the same lot for each specimen type. Specimens were plated in the entire notch area and 0.5-inch on either side of the notch as shown in Figure 13.

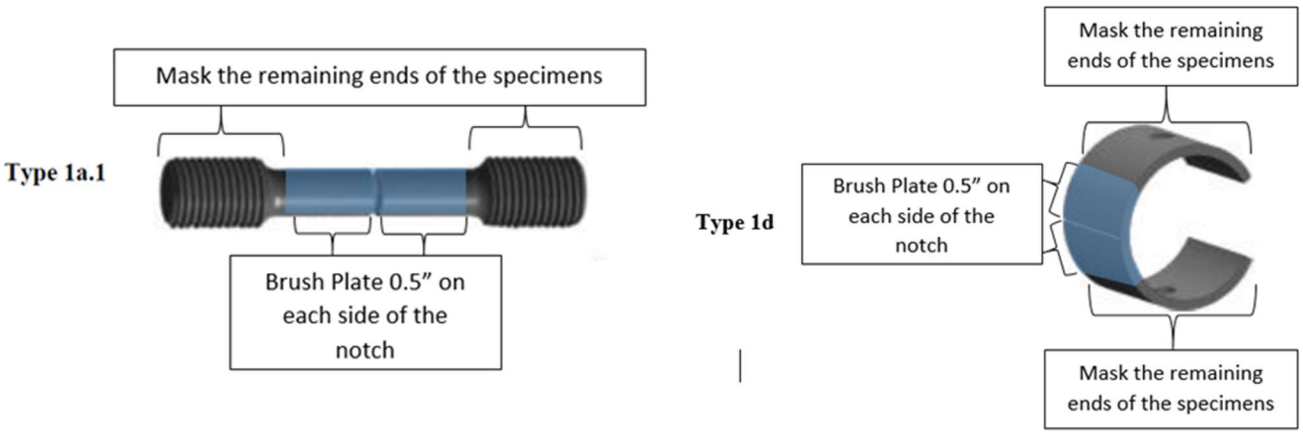

Figure 13. Hydrogen Embrittlement Masking Strategy

Type 1a.1 specimens were soaked for 5 min in acetone and lightly scrubbed using a soft nylon brush to remove packing oils before plating. The type 1d specimens were soaked for 5 min in MEK and lightly scrubbed using a soft nylon brush to remove the heavy packing grease before testing. Acetone would not successfully remove this grease which was shown to cause adhesion issues with the plating. The recommended surface preparation was followed per the Zinidal Aero Zn-Ni data sheet including a Scothbrite preparation, solvent rinse, compressed air dry, masking, and surface activation using Activator XF. The flat wand tool (top tool in Figure 2) was used to plate the 1d rings as the other tool would not fit in the inside diameter of the ring. A turning head was used to rotate the specimens at 12 m/min per Dalic Inc. recommendation for the Zinidal Aero Zn-Ni plating.

Although the notched fracture strength (NFS) was provided for the specimens from Green Specialty Services this was verified for the 1a.1 specimens by conducting four tensile tests on unplated specimens. The data collected from the four tensile tests were used in calculating the sustained load for all the 1a.1 tests.

A total of four 1a.1 specimens from each plating configuration were loaded in creep frames in ambient air at 75% NFS for 200 hours per ASTM F 519 within 48 hours of plating. The creep frames can be seen in Figure 14 below. If all four specimens did not break after 200 hr of loading the plating was considered non-embrittling. If one broke the remaining specimens were then step-loaded after 200 hours of loading every 2 h in 5% increments to 90% NFS followed by a 2 hold. If the three specimens passed this additional loading the plating was considered non-embrittling. If two specimens broke at any point the plating was considered embrittling.

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Figure 14. Hydrogen Embrittlent Load Frame

The 1d specimens were tested using a calibrated digital micrometer and a loading fixture designed to hold the specimen while tightening the nut of the loading bolt. Four baseline specimen's load bolts and nuts were turned slowly and the displacement was documented until failure. The four specimen failures were documented and then the data was used to calculate the overall displacement to failure. This data was then used to calculate the needed displacement for every tested 1d specimen based on the diameter of the unplated specimens.

A total of four 1d specimens from each plating configuration were in ambient air to 75% of the full displacement to failure. The specimens were left to sit in ambient air for the duration of the test. The following figure shows the loaded 1d specimens.

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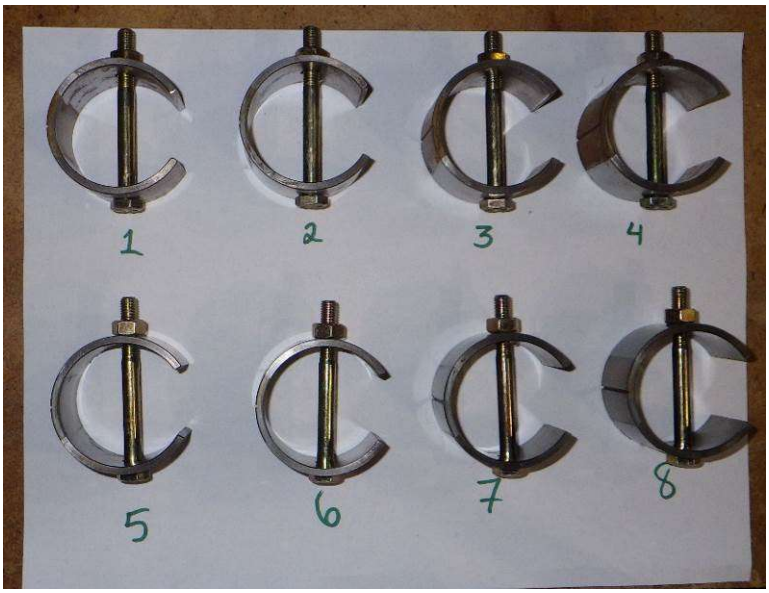

Figure 15. 1d Specimens Loaded in Ambient Air

5.9.3 Data Analysis

All 1a.1 and 1d specimens were documented for the duration of the test using a time lapse camera. The camera was set to take a photo every hour for 200 hours. Failures were easily identified by going through the pictures and seeing the change in location or from the view of the specimens. This is a pass/fail test. All data was recorded and a pass/fail determination was made for each plating configuration per ASTM F 519.

5.10 SERVICE CHEMICAL HYDROGEN EMBRITTLEMENT

5.10.1 Test Description

Service chemical hydrogen embrittlement testing will be conducted to detect possible hydrogen embrittlement of steel parts, brush-plated with tested coating system due to contact with chemicals during overhaul and service life.

5.10.2 Test Description

The plating and specimen masking was the same for the service chemical hydrogen embrittlement testing as the hydrogen embrittlement testing. Two chemical exposure conditions were tested. The first exposure condition immersed in the cleaning solution at the manufacturer's maximum recommended temperature and appropriate cleaning concentration for 30 min. The specimens are then removed, air dried, and then loaded to 75% NFS for 200 h, in accordance with ASTM F 519. The second exposure condition was loaded to 45% NFS and left the specimens immersed in the cleaning solution at ambient temperature and appropriate cleaning concentration for the full 200 hours. ZipChem Calla 296 cleaner was used as the service chemical for all embrittlement testing An elevated temperature of 170°F used for service condition 1. The testing matrix can be seen in Table 18.

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Table 18. Hydrogen Re-Embrittlement Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty	Exposure Condition
4340 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4 1a.1	30 min Elevated Temp
					200 hr Ambient Temp
				4 1d	30 min Elevated Temp
					200 hr Ambient Temp
4340 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4 1a.1	30 min Elevated Temp
					200 hr Ambient Temp
				4 1d	30 min Elevated Temp
					200 hr Ambient Temp
4340 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4 1a.1	30 min Elevated Temp
					200 hr Ambient Temp
				4 1d	30 min Elevated Temp
					200 hr Ambient Temp

The failure and step loading criteria remained the same for the service chemical hydrogen embrittlement testing as the hydrogen embrittlement testing. Type 1d specimens were loaded the same as the hydrogen embrittlement testing however the bare steel, loading bolt and nut was dipped in bee's wax to protect from exposure to the cleaning solution. Figure 16 shows the loaded 1d specimens in the Calla 296 cleaning solution at ambient temperature.

Figure 16. 1d Specimens in Calla 296 Cleaning Solution at Ambient Temperature

The 1a.1 specimens were loaded in stressing rings designed in previous work with UDRI and the Air Force Research Labs (Figure 17). The stressing rings were loaded by

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applying a compressive force to the rings and using an extensometer and correlating the data from the tensile tests to that of the specimen as shown in Figure 18.

Figure 17. 1a.1 Stressing Ring

Figure 18. Extensometer of 1a.1 Stressing Ring

The rings were dipped in Bee's wax in order to keep the threads and ring from being in direct contact with the cleaning solution similarly to the 1d specimens.

5.10.3 Data Analysis

All 1a.1 and 1d specimens were documented for the duration of the test using a time lapse camera. The camera was set to take a photo every hour for 200 hours. Failures were easily identified by going through the pictures and seeing the change in location or from the view of the specimens. This is a pass/fail test. All data was recorded and a pass/fail determination was made for each plating configuration per ASTM F 519.

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5.11 Strippability

5.11.1 Rationale

USAF Source Control Drawings 201027456 (Para 4.10) and 201027457 (Paras 2.5.11 & 3.2.9) cite acceptable Zn-Ni stripping time as a performance requirement for tank-plated Zn-Ni coatings.

5.11.2 Test Description

Strippability testing was performed to evaluate how well the platings were able to be stripped from steel specimens per USAF DWG 201027456 and USAF DWG 201027457. Testing was coordinated with the Hill AFB plating shop to ensure their requirements were met and testing conditions were replicated in a lab environment as closely as possible. For this testing only round bars of 4130 steel (4" length, 0.375" diameter) were used. The complete test matrix for this testing can be found in Table 19. An example of plated simulated repair specimens can be seen in Figure 19.

Table 19. Strippability Test Matix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	4
			Zn-Ni Tank Plated Repair	4
			Cd Tank Plated Repair	4
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4
			Zn-Ni Tank Plated Repair	4
			Cd Tank Plated Repair	4
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4
			Zn-Ni Tank Plated Repair	4
			Cd Tank Plated Repair	4
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4
			Zn-Ni Tank Plated Repair	4
			Cd Tank Plated Repair	4

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Figure 19. Simulated Repair Strippability Specimens

A stripping solution was made of 16 oz of ammonium nitrate per 1 gallon of deionized water. This is the same solution which Hill AFB uses for their Zn-Ni and Cd tank plating. The PH of this solution was kept between 8.0 and 9.0. If required the PH was balanced with sodium hydroxide. One gallon of solution was made at a time and the PH was measured before each stripping event. Stripping solution was placed in a plastic 0.5 gallon container. Four aeration stones and two aquarium sized pumps were used to agitate the solution during stripping. Air agitation is used a Hill AFB and was found to be critical when removing Zn-Ni platings. The stripping bath set up can be seen in Figure 20.

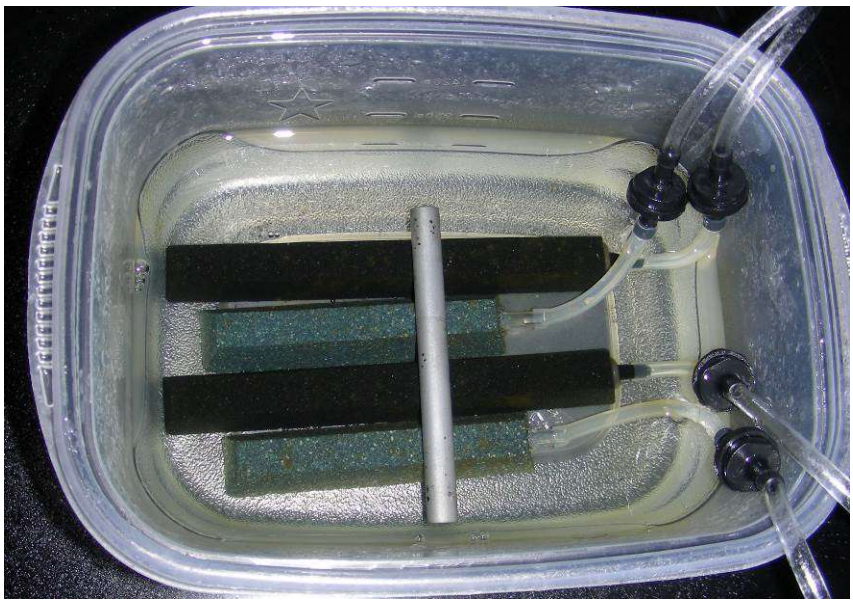

Figure 20. Strippability Bath Set Up

Before testing each specimen was weighed with a five place balance. Four specimens were tested at a time and plating/substrate configurations were not mixed during stripping events. A timer was set for each stripping event. The specimens were rotated over 180° after 30 min to ensure even stripping. Specimens were inspected every 30 min up to 2 hours to determine if the coating was visibly removed. Light scrubbing with a scotch

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brite pad was performed when black residue was present. This was advised per Hill AFB. The amount of time for the plating to be removed as well as if the specimen had to be scrubbed was noted. The specimens were rinsed with DI water and dried with compressed air. Lastly the final weight of each specimen was taken with a five place balance.

5.11.3 Data Analysis

Plating removal time up to two hours was acceptable per Hill AFB. If the stripping time was over two hours specimens were considered a failure. The average stripping time and if each specimen required to be scrubbed were compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

5.12 SO_2 RESISTANCE

5.12.1 Rationale

Corrosion resistance to sulfur dioxide (SO_2) as a performance requirement for brush-plated Zn- Ni coatings has been included for consideration by the US Navy stakeholders. Corrosion resistance of the brush plated coating is critical to the performance of the coating.

5.12.2 Test Description

SO_2 resistance was an additional US Navy stakeholder requirement in which red rust should not appear before 168 hours or should be comparable to Cd controls. This testing was performed to determine the SO_2 resistance of the platings. Testing was performed per ASTM G 85 Annex A4. 4” x 6” x 0.050” 1008 and 4” x 6” x 0.040” 4130 steel specimens were plated on one side and used for all plating configurations. The outside 1” and backside of each specimen was masked with 3M 1280 tape. The specimen test matrix is in Table 20.

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Table 20. SO_2 Resistance Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5
			Zn-Ni Tank Plated Repair	5
			Cd Tank Plated Repair	5

The specimens were split into two separate test runs as the Singleton Model SCCH22 chamber (see Figure 21) was only able to hold 60 specimens at a time. The specimens could not be inspected daily as outlined in the JTP due to a multiple hour purge cycle which would have disrupted the test. The specimens were instead inspected at the end of the test. The SO_2 gas flow and pH were monitored daily per ASTM G 85 Annex A4. The salt spray chamber temperature was maintained at 95° F ± 3° F and a chamber pH was maintained between 2.5 to 3.2.

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Figure 21. SO_2 Test Chamber

5.12.3 Data Analysis

At the conclusion of the SO_2 testing the specimens were rinsed, dried, and photographed. The percentage of red rust in both the tank plating and brush plating regions were found using an image processing software (ImageJ). An example of this ImageJ processing can be seen in Figure 12. The rust percentages were compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

5.13 GALVANIC CORROSION

5.13.1 Rationale

MIL-PRF-32239A (draft), cites galvanic corrosion resistance, particularly with fasteners, as a performance requirement for coating systems for consideration by the USAF. Corrosion resistance of the brush-plated coating is critical to the performance of the coating.

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5.13.2 Test Description

Galvanic corrosion testing was performed as an additional JTP requirement. The testing outlined in the JTP was a combination of several standards including MIL-PRF-32239 (draft) and GMW 14872. 1” x 6” x 0.125” 1008 and 4130 steel specimens were manufactured with three countersunk holes to accommodate the dry installation of fasteners as shown in Figure 22.

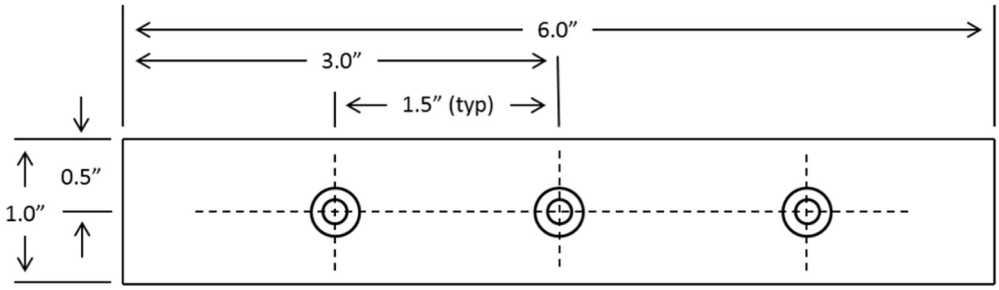

Figure 22. Galvanic Corrosion Test Specimen

5/8” long 10-24 Cadmium plated steel fasteners (NASM24693) with a 10-24 cadmium plated nuts as well as 5/8” long 10-24 18-8 stainless steel fasteners with a 10-24 18-8 stainless steel nuts were installed in the test specimens and torqued using a digital torque wrench to 24 in-lbs.

All test specimens were only plated on one side. Specimen back and edges were masked using 3M 1280 tape as shown in Figure 23. The test specimen matrix is in Table 21. Galvanic Corrosion Test Matrix.

Figure 23. Masked Galvanic Test Specimens

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Table 21. Galvanic Corrosion Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty and Fastener Type
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
1008 Steel	Sifco 4018 Zn-Ni	Sifco 50320	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3 Stainless Steel 3 Cd Plated
			Zn-Ni Tank Plated Repair	3 Stainless Steel 3 Cd Plated
			Cd Tank Plated Repair	3 Stainless Steel 3 Cd Plated

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Specimens were all tested in a Q-Fog model CRH salt fog chamber per GMW 14872. Daily fog collection volume, salinity, and PH were checked from two collection graduated cylinders except on weekends per the standard. The solution tank level, salinity, and PH were also checked at this time to ensure they met the requirements in the GMW 14872 method.

Thirty SAE 1008-1010 carbon steel mass loss coupons measuring 1” x 2” x 0.125” per the GWM 14872 method were also installed in the test chamber to monitor the mass loss of the test. The mass loss coupons were sourced from Q-Lab part number CXB-12. Due to the number of specimens placed in the chamber only thirty mass loss coupons could be used. Mass loss coupons were pulled every ten cycles. The number of specimens pulled was alternated between two and three at a time to ensure three specimens were pulled at the end of testing (120 cycles). One specimen was pulled from each mass loss rack for a pull of two specimens. Two specimens from one rack and one from the other rack was pulled if three specimens were removed. Specimens were prepared and cleaned per the GMW 14872 standard. The galvanic corrosion test set up from the test while in progress is in Figure 24.

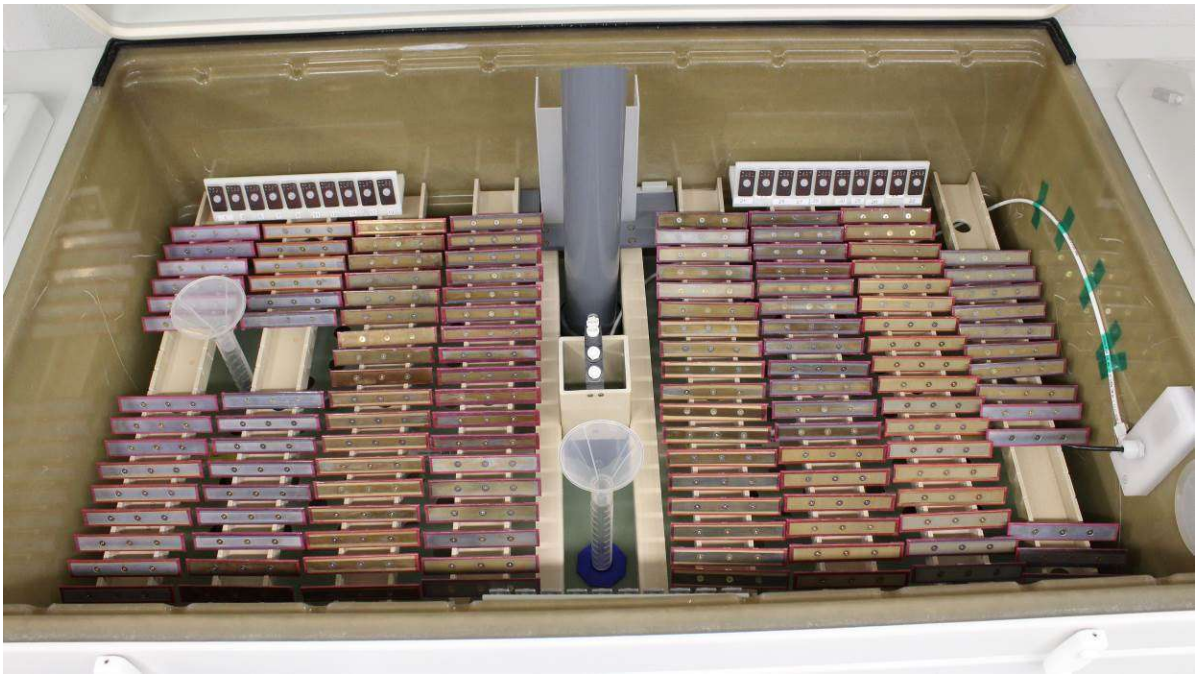

Figure 24. Galvanic Corrosion Test Set Up

5.13.3 Data Analysis

Mass loss was measured using a five place balance and compared to the expected mass loss per the GMW 1478 standard. The mass loss vs. number of cycles was also documented.

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After testing all specimens were rinsed, dried, and photographed. The percentage of red rust in both the tank plating and brush plating regions were found using an image processing software (ImageJ). An example of this ImageJ processing can be seen in Figure 12. The masked area and fasteners were excluded from this analysis. The rust percentages were compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

5.14 OUTDOOR EXPOSURE TESTING

5.14.1 Rationale

There are known correlation issues between laboratory accelerated corrosion testing and real world exposure. Outdoor exposure testing is the most realistic corrosion test method as the severe environmental conditions replicate the conditions a plated coating might encounter.

5.14.2 Test Description

Outdoor exposure testing was an additional test which was not a part of the JTP. This testing was used to determine the real world performance of the brush platings in severe environments. NASA's Kennedy Space Center Beachside Atmospheric Corrosion Test Site was chosen due to the location's Environmental Severity Index Rating of Severe and well documented environmental conditions. The specimens were tested for two years and the test set up can be seen in Figure 25.

Figure 25. Outdoor Exposure Test Set Up

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Unscribed 4” x 6” x 0.050” 1008 and 4” x 6” x 0.040” 4130 steel specimens were plated on one side and used for all plating configurations. The outside 1” and backside of each specimen was masked with 3M 1280 tape. The tape was inspected during testing and replaced if needed. The specimen matrix for this testing can be seen in Table 22. Outdoor Exposure Test Matrix

Table 22. Outdoor Exposure Test Matrix

Substrate	Plating	Conversion Coating	Repair Condition	Qty
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	3
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	3
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	3
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	3
1008 Steel	Sifco 2023 Cd	Sifco3002	Bare Steel	3

5.14.3 Data Analysis

After two years of exposure the specimens were photographed in place and then rinsed and dried. Photographs were also taken after the specimens were cleaned. The percentage of red rust were found using an image processing software (ImageJ). An example of this ImageJ processing can be seen in Figure 12. Any corrosion caused by masking failures was excluded from this analysis. The rust percentages were compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

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6.0 PERFORMANCE ASSESSMENT

This section describes the results of all of the screening and qualification testing as outlined in the JTP. Additional hydrogen embrittlement characterization work was performed by Boeing Research and Technology along with IBECA technologies. The results of that testing can be found in APPENDIX G: No-Bake Brush Plating Zinc-Nickel Processes.

6.1 APPERARANCE AND UNIFORMITY

All plated specimens were inspected to ensure the coating is smooth, continuous, and adherent to the base metal. The coating must also be visually free from any defects that might be detrimental to the coating performance. In total 477 Zinidal Aero Zn-Ni specimens plated with Dalistick Station, 207 Sifco 2023 traditionally brush plated Cd specimens, and 207 Sifco 4018 traditionally brush plated Zn-Ni specimens for a total of 891.

6.1.1 Failure Rates

Control specimens all passed supplier quality checks and were accepted as passing the appearance and uniformity test unless there were areas of missing plating where improper masking occurred on the simulated repair specimens or they were damaged in shipping. Any control specimens that were not used for these reasons were replaced by the vendors.

Throughout all of the Zinidal Aero platings there were only eight instances of appearance failures. The table below shows the calculated failure rates for each type of failure.

Table 23. Appearance and Uniformity Failures

Number of Failures	Total Number of Specimens	Failure Type	Failure Percentage
6	192	Inconsistent Conversion Coating	0.021%
1	473	Plating Adhesion Failure	0.002%
7	**473**	**Cumulative Failures**	**0.015%**

As can be seen in the table the plating failures due to the appearance and uniformity were very low. The station and manufactures processes proved to be very consistent and yielded good plating results.

The majority of the failures occurred on conversion coated specimens where the conversion coating was inconsistent and was not present on area of the specimens. An examples of these failures can be seen in Figure 26. Five of these failures were caused by operator error in which the panel was not properly dried or residual acetone was present on the operators gloves when applying the conversion coating with a saturated cotton ball. All failed specimens were discarded and new specimens were made. In some instances the conversion coating was very light, but was able to be seen under lighted magnification. In these instances the specimen was considered to have adequate appearance.

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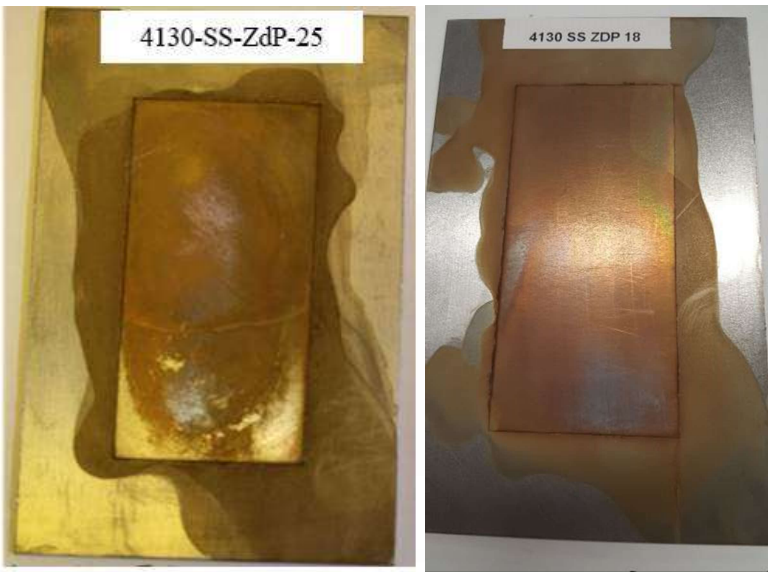

Figure 26. Failed Conversion Coating Application

From these failures it was found that the most effective means of applying the conversion coating was to dip the specimens, however this is not necessarily practical for larger components or spot repairs. Care must be taken to ensure a completely dry surface and clean gloves before applying the conversion coating.

The last failure was a plating adhesion failure seen on one specimen. This specimen failed the tape test which is a part of the Zinidal Aero Zn-Ni plating process. This failure was likely caused by an interruption in the plating process. During the Zn-Ni application of this specimen the bonnet fell out of the wand when it caught a corner of the specimen. This caused the solution to no longer be vacuumed up and re-circulated. Instead the solution spilled on the specimen and sat while the spilled solution was cleaned up. The plating was then resumed. The Zinidal Aero Zn-Ni process states that interruptions in plating is not recommended. In this instance the process checks caught the failure and the expected rate of failures of this type is very low.

6.1.2 Variation in Appearances

Several variations in appearances were seen in the Zinidal Aero Zn-Ni especially early in the plating for the screening testing. The variations can be seen in Figure 27. Most specimens plated yielded a dull appearance as expected. On several specimens a shiny appearance was observed. The root cause of this appearance change was not able to be determined however it was noticed that a faster plating wand speed may have caused the difference. This was tracked through screening testing and no effects due to this appearance was observed. Lastly a swirled appearance was noticed on a specimen. This was caused by pushing down on the plating wand too hard and the plastic edges dragged on the panel. The swirls were superficial and did not cause any issues.

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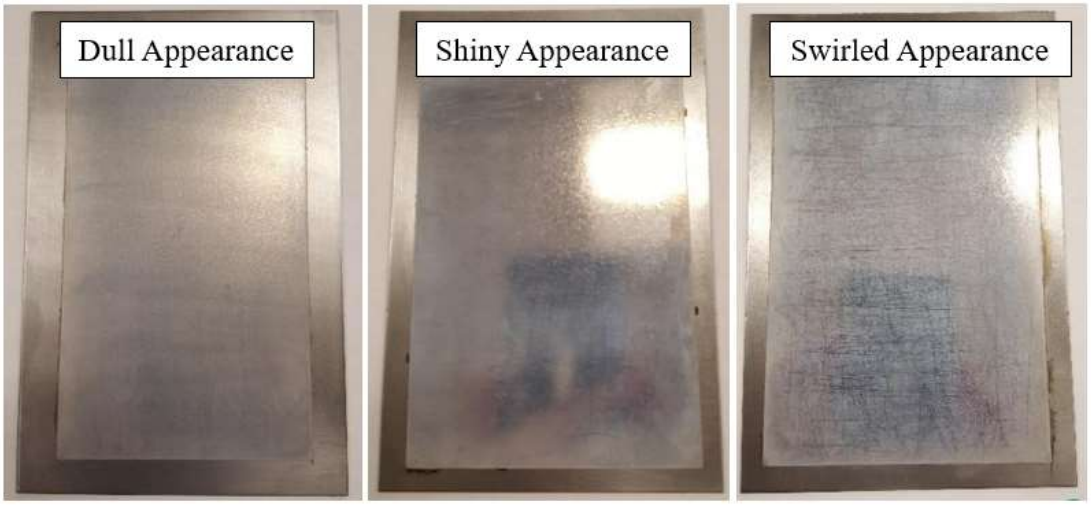

Figure 27. Zinidal Aero Zn-Ni Appearance Variation

6.2 THICKNESS

Plating thickness was tested against MIL-STD-865D and USAF Source Control Drawings 201027457, which requires a class II thickness greater than 0.0003" (7.6 µm). The target thickness of the Zinidal Aero Zn-Ni plated with the Dalistick Station was 0.0003" to 0.0007" (7.6 µm to 18 µm).

The average thickness of the specimens were calculated and a boxplots were created in a statistical analysis software (Minitab) to determine the mean average thickness and to determine if the population ranges were different. Figure 28 shows that on average both the Sifco 5030 Cd and Sifco 4018 Zn-Ni were plated thicker than the Zinidal Aero Zn-Ni with average thicknesses of 16.66 µm and 17.32 µm respectively. The Zinidal Aero Zn-Ni plated with the Dalistick station was set to plate 13 µm and on average plated 12.01 µm. The variation in average thickness can also be seen in Figure 28. The average thickness varied much more in the Sifco 5030 Cd and Sifco 4018 Zn-Ni plated traditionally than the Zinidal Aero Zn-Ni plated with the Dalistick station. The standard deviation of these platings were found to be 4.62, 4.55, and 1.74 respectively. The greater thickness of the Sifco specimens appear to be due to the inherent variation in the traditional brush plating process and not due to the Plating Factor being incorrect on the Sifco chemistries. Both vendors checked their brush plating processes and confirmed no issues were found during the plating of these specimens.

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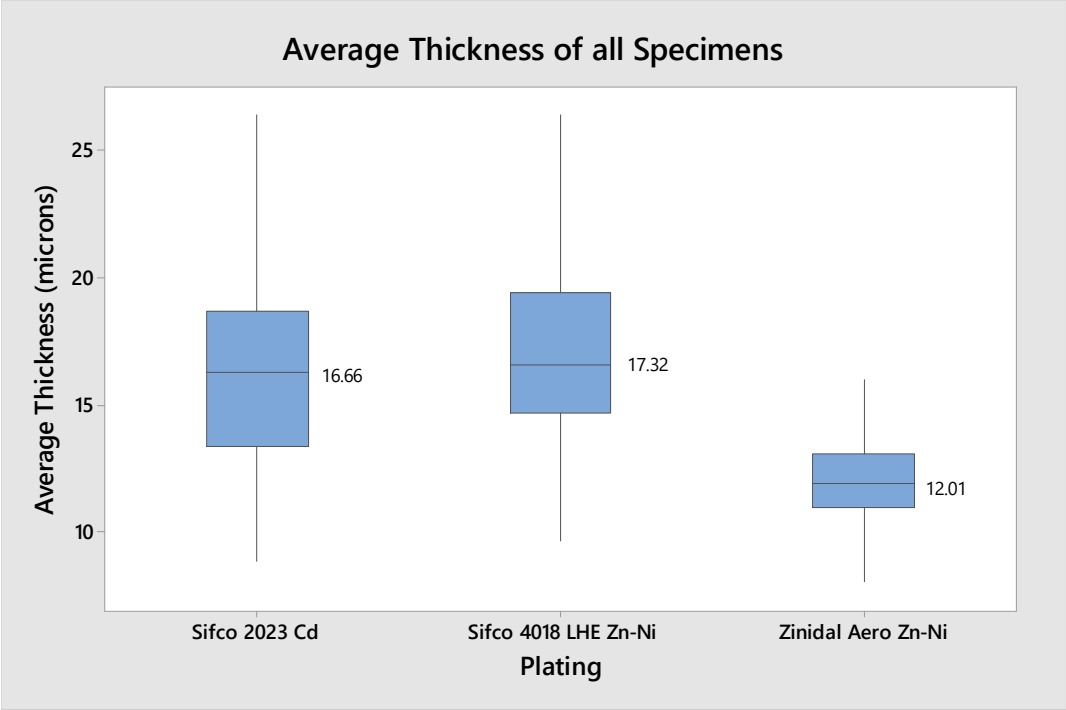

Figure 28. Average Thickness of all Specimens

The average thickness of the specimens per substrate was also calculated and a boxplots were created in Minitab to determine the effects of the substrate on plating thickness. Figure 29 shows that mean and standard deviation trends follow what was seen in Figure 28. It also shows that there is no distinguishable difference between the average thicknesses between substrates for any of the platings.

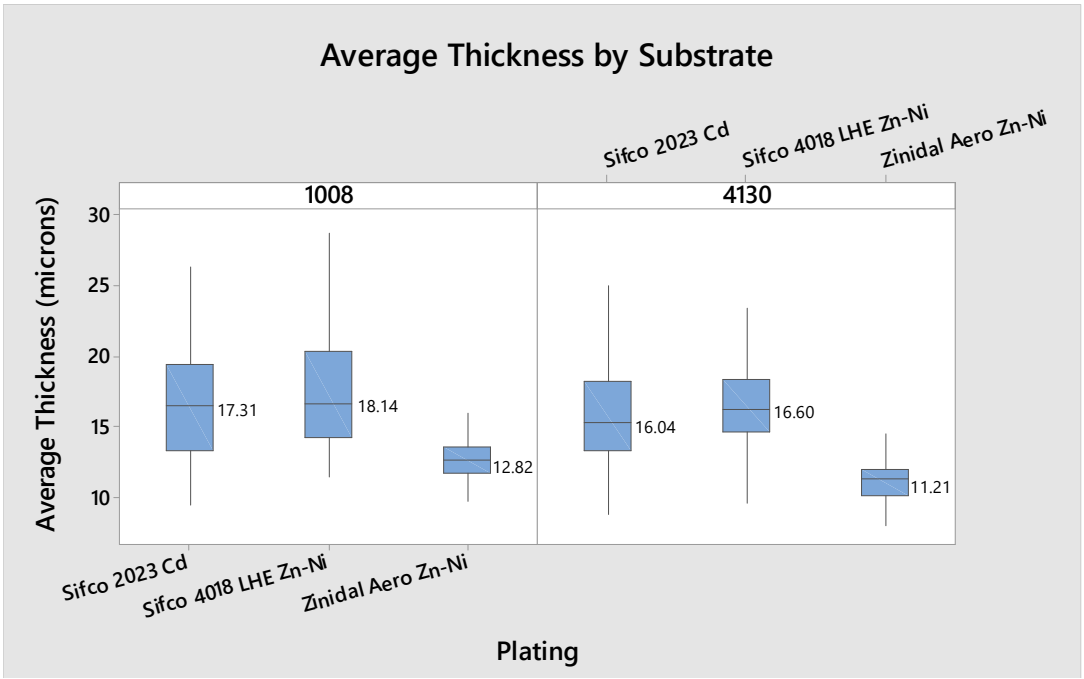

Figure 29. Average Thickness by Substrate

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6.2.1 Thickness for Round Specimens

Eddy current methods for measuring coating thickness of round substrate with small diameters is difficult and can be inaccurate. For this reason cross sections of representatively-plated round strippabity specimens and hydrogen embrittlement specimens were made to confirm the plating thickness using microscopy. From these cross sections it was confirmed the station accurately plated the Zinidal Aero Zn-Ni plating to the proper thickness. One of these cross sections on the round strippability specimen can be seen below.

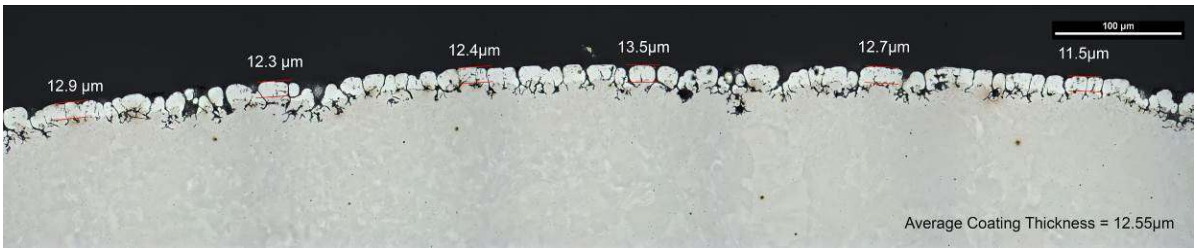

Figure 30. Thickness Cross Section of Round Bar

6.2.2 Thickness Sensitivity Study

During the plating of the screening test specimens the plating process factors such as operator and solution use were recorded to determine if they had any effect on the plating quality or test results. The station instructs the operator to check three things during the plating process, appearance, thickness, and tape adhesion. All of the panels which properly followed the station's process passed appearance and tape adhesion. The thickness varied between the test specimens, and was studied to better understand the stations control of the plating process.

First the measuring system instrument (Elcometer 456) was checked to ensure repeatability through a Gage Repeatability and Reliability study. The result of this study showed a 96% confidence that the measuring instrument could measure the plating thickness accurately.

6.2.2.1 Operator Effects on Thickness

It is critical that the plating process remains consistent from operator to operator. The plating of screening test specimens was performed by two different operators using the Dalistick station. Histograms of the average plating thicknesses were created in Minitab to determine whether the plating process remained consistent between operators. Figure 31 and Figure 32 show that there is very little variation in plating thickness between operators. The thickness means and standard deviation showed the station controlled the thickness very well.

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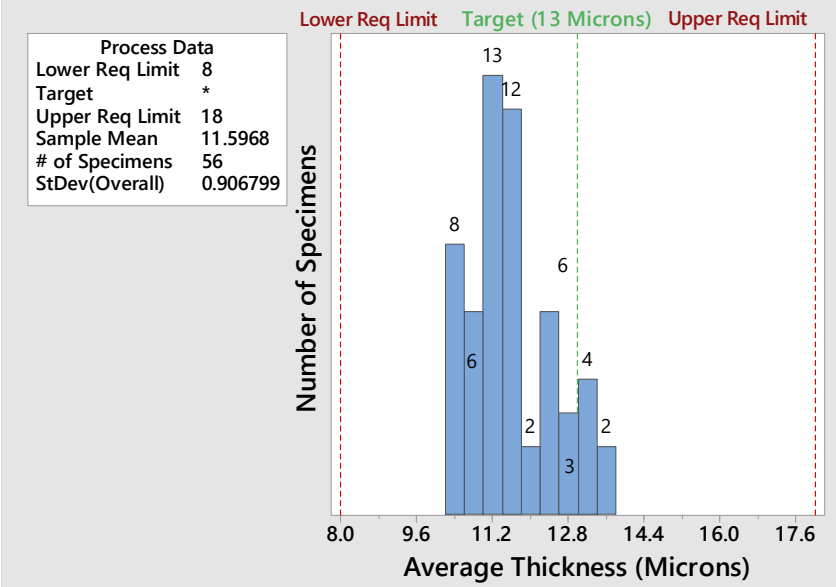

Figure 31. Operator 1 Plated Specimens

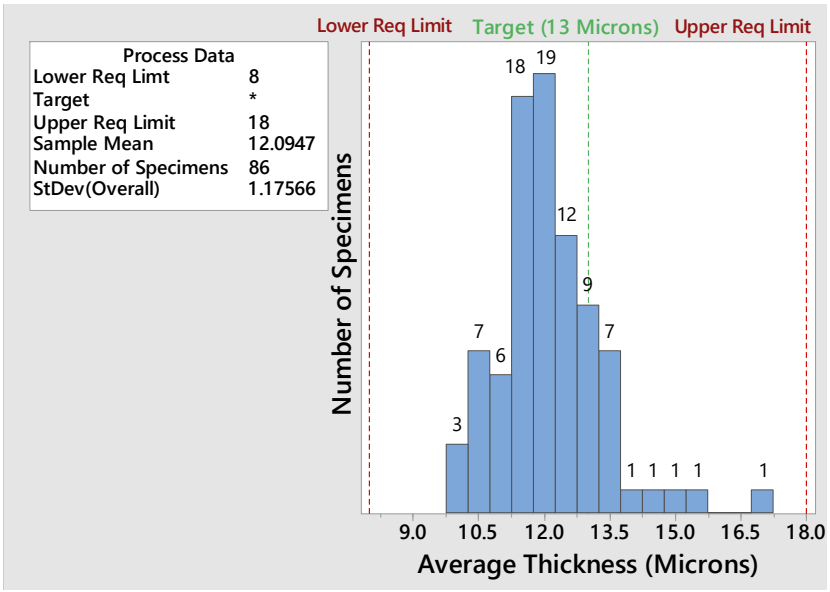

Figure 32. Operator 2 Plated Specimens

6.2.2.2 Thickness Variation Throughout Area Plated

When plating specimens with the Dalistick Station the operator had a tendency to spend more time in the center of the specimens vs. the edges near masked regions. The average thickness distribution between the inside and outside points of the test specimens was studied to determine the uniformity of platings in a variety of specimen sizes. The variation in specimens can be seen in the following figure.

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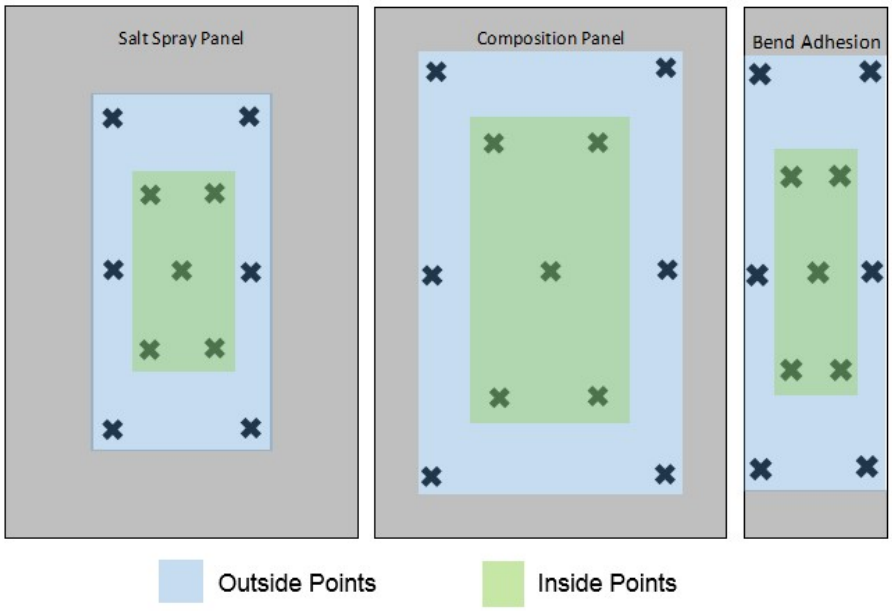

Figure 33. Specimen Variation and Thickness Measurement Locations

Histograms of the average thickness were created in Minitab which revealed the specimens inside thickness was slightly greater at an average of 12.4 microns vs. an outside thickness average of 11.6 microns. The inside measurements also showed slightly more variation (2.2 standard deviation vs. 1.5). All average thicknesses were greater than the MIL-STD-865D specification of greater than 7.6 µm. Figure 34 and Figure 35 show the variation described.

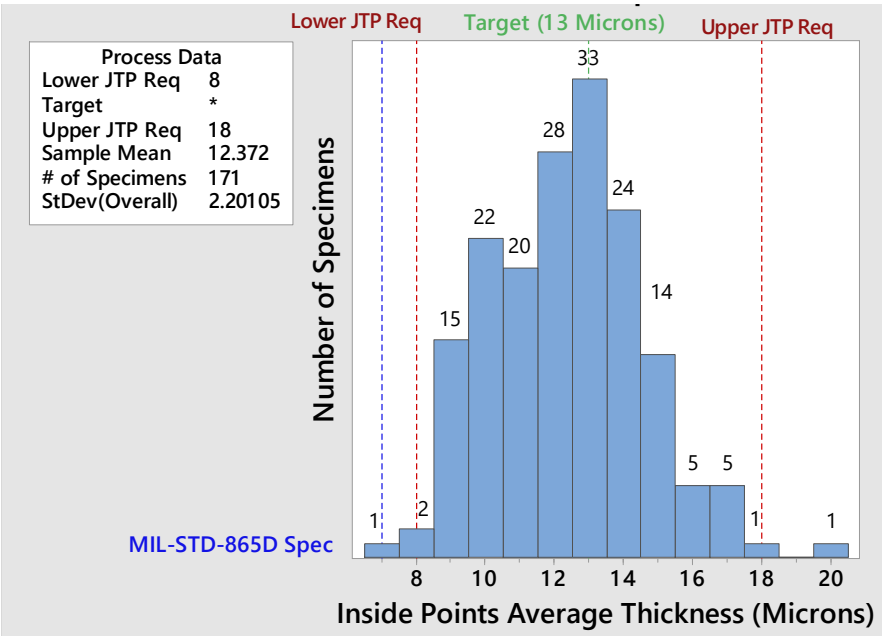

Figure 34. Inside Measurements of Zinidal Aero Zn-Ni Specimens

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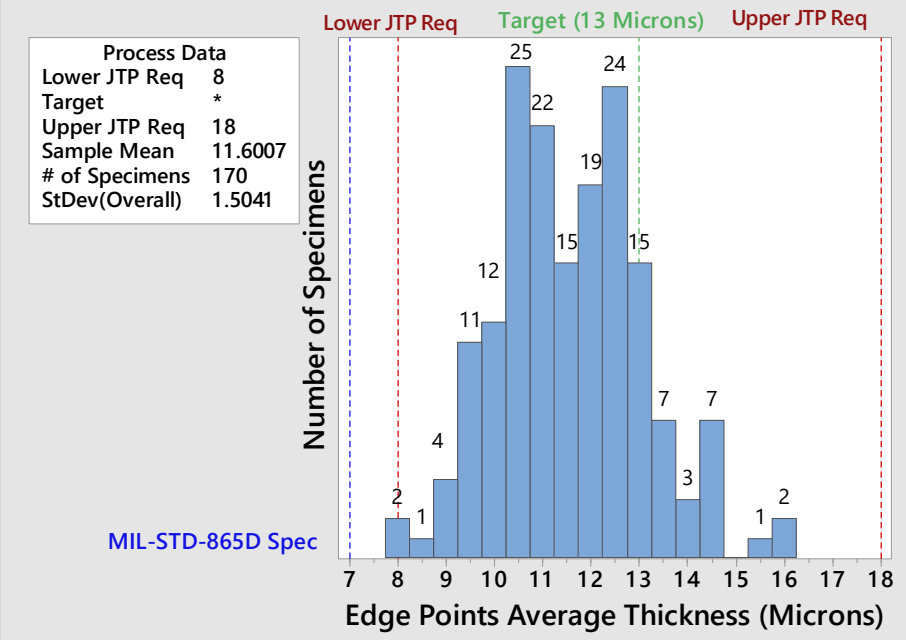

Figure 35. Outside Measurements of Zinidal Aero Zn-Ni Specimens

6.2.2.3 Thickness Variation for Different Plating Areas

It is important to have a consistent plating thicknesses especially across different repair area sizes. The wand of the Dalistick station is currently only available in one size (approximately 1 $in^{2)}$ so the plating thickness variation was studied for the three different size specimens in the screening study. Figure 36 shows that the thickness remains very consistent across the areas plated which included 3 in^2, 8 in^2, and 19.25 in^2. From this data it can be concluded that the Dalistick plating process provides consistent plating thickness across a range of repair areas up to and likely greater than 19.25 in^2.

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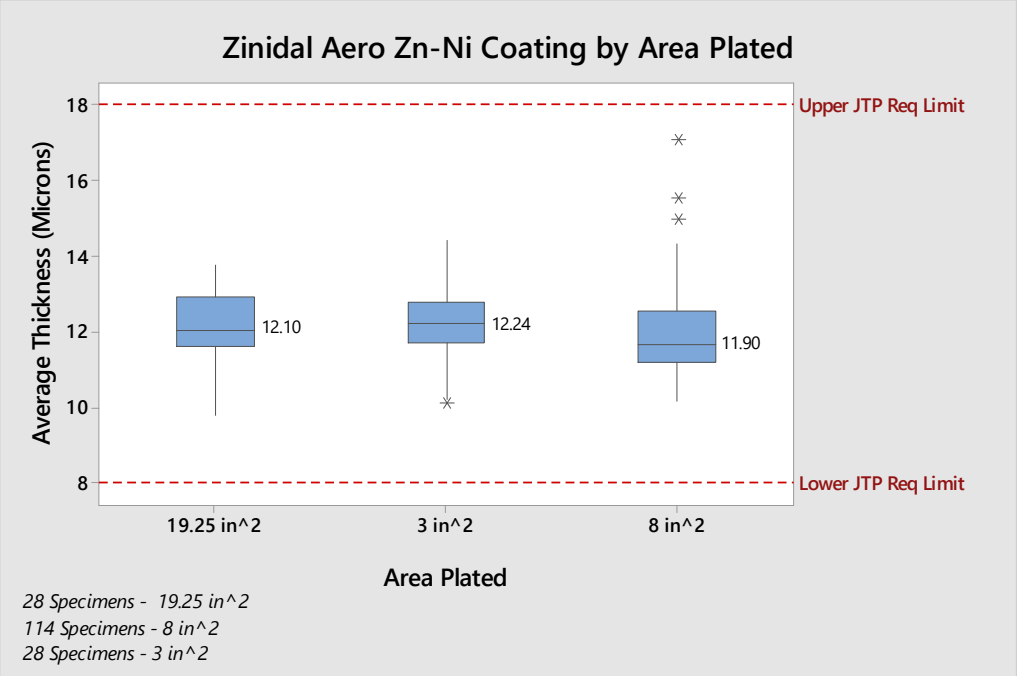

Figure 36. Average Thickness by Plating Area

6.2.2.4 Thickness Variation As Solutions are Recycled

One advantageous feature of the Dalistick station is that it recycles both the activator and Zn-Ni solution at the point of the plating which reduces waste and masking requirements. It is critical to have a quality plating throughout the solution recycling range. The manufacturer places a limit on Activator XF of 17 Ahr and a Zinidal Aero Zn-Ni limit of 10 Ahr. The solution recycling was studied to determine the impact on the plating thickness for both solutions.

Scatter plots were created to show any trends in thickness throughout the solution range using Minitab. Recycled activator from the chosen coating did not show any thickness difference from new activator throughout the solution life range as seen in Figure 37. Recycled plating solution from the Zn-Ni coating did tend to form slightly thinner coatings, but still well within the thickness specifications as seen in Figure 38.

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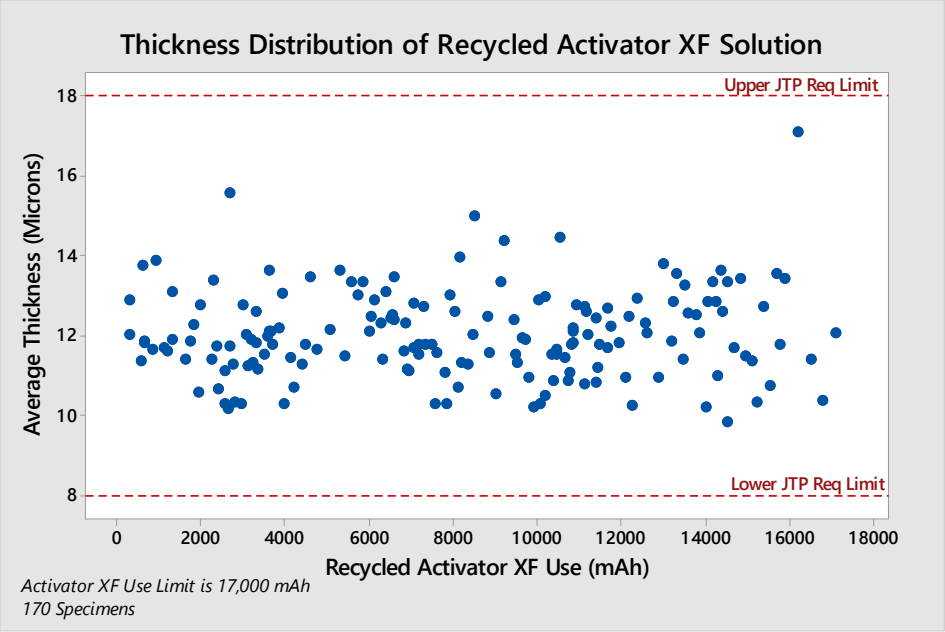

Figure 37. Thickness Variation from Activator XF Use

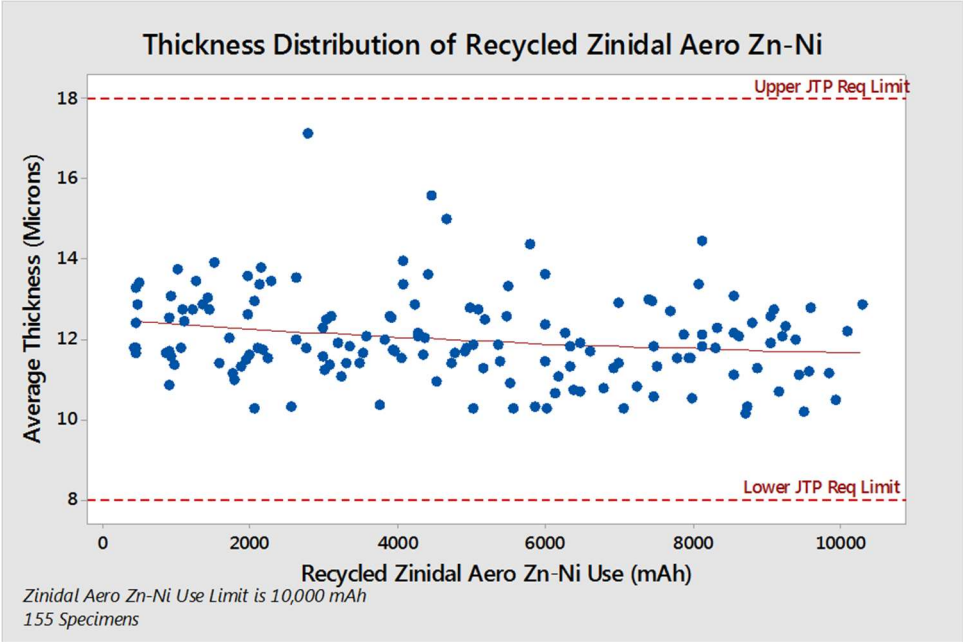

Figure 38. Thickness Variation from Zinidal Aer Zn-Ni Use

6.3 COMPOSITION UNIFORITY

The alloy composition was tested by X-ray Fluorescence (XRF). Three measurements were made for fully brush plated specimens and two measurements were made for tank plated repair specimens. The uniformity of the specimens was determined by comparing the relative signal intensities, zinc and nickel, in the case of the Zn-Ni control specimens as well as the Zinidal

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Aero specimens plated with the Dalistick Station. Iron (Fe) was also present in these signal intensities which was caused by the x-ray detecting the steel substrate. This intensity varied depending on the thickness of the Zn-Ni coating and the x-ray penetration into the substrate. The iron intensities were documented but not used in determining the uniformity of the Zn-Ni composition.

An overlay of the signal intensities can be seen in Figure 39. The peak of both the Zn and the Ni signals was integrated and the ratio of peak areas was used to compare the relative Zn-Ni ratio. This ratio is not a true Zn or Ni weight percentage but is useful in determining the composition ratios.

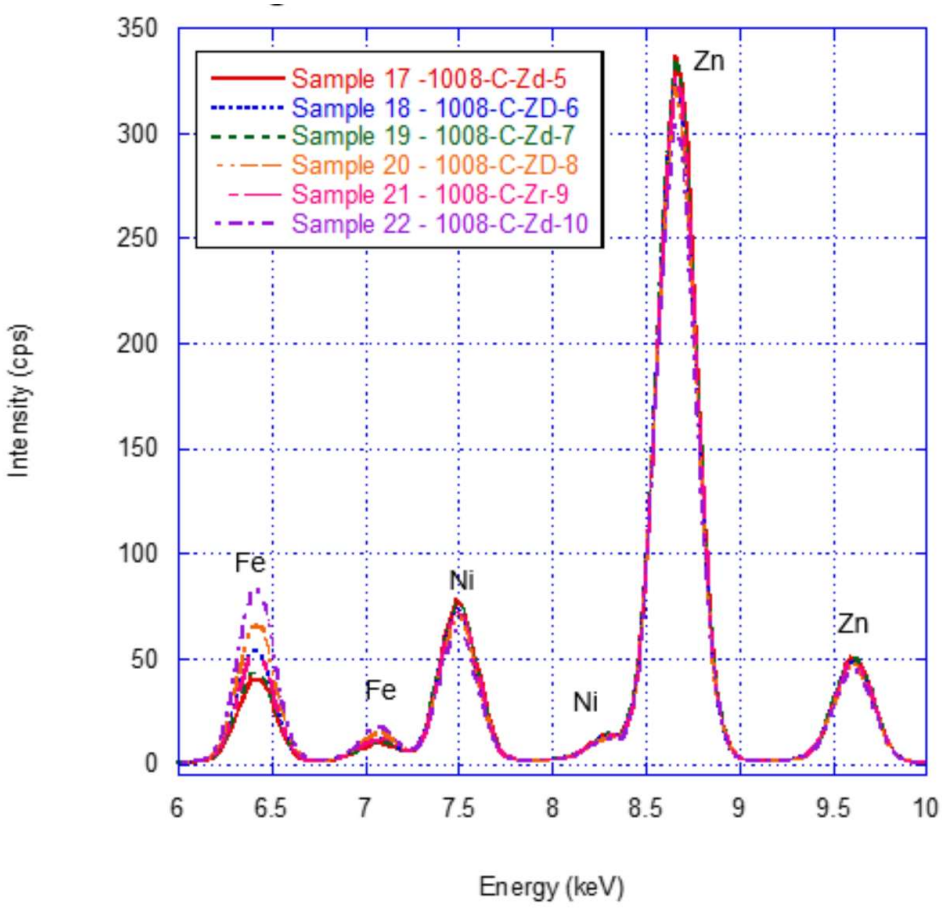

Figure 39. Example of Overlayed XRF Signal Intensities

The Ni to Zn ratio for both the Sifco 4018 and Zinidal Aero Zn-Ni were plotted in Minitab to determine the range of Ni to Zn ratios between Zn-Ni platings. It can be seen in Figure 40 that the Ni to Zn ratio of the Zinidal Aero Zn-Ni is higher than the Sifco 4018 for both the 1008 and 4130 steels. This indicates the Zinidal Aero Zn-Ni plating has a higher Nickel percentage. From the boxplots it can also be shown the composition of the Zinidal Aero plated with the Dalistick station is more consistent than the qualified Sifco 4018 Zn-Ni. Lastly the figure shows the compositions for both platings remains constant for both substrates.

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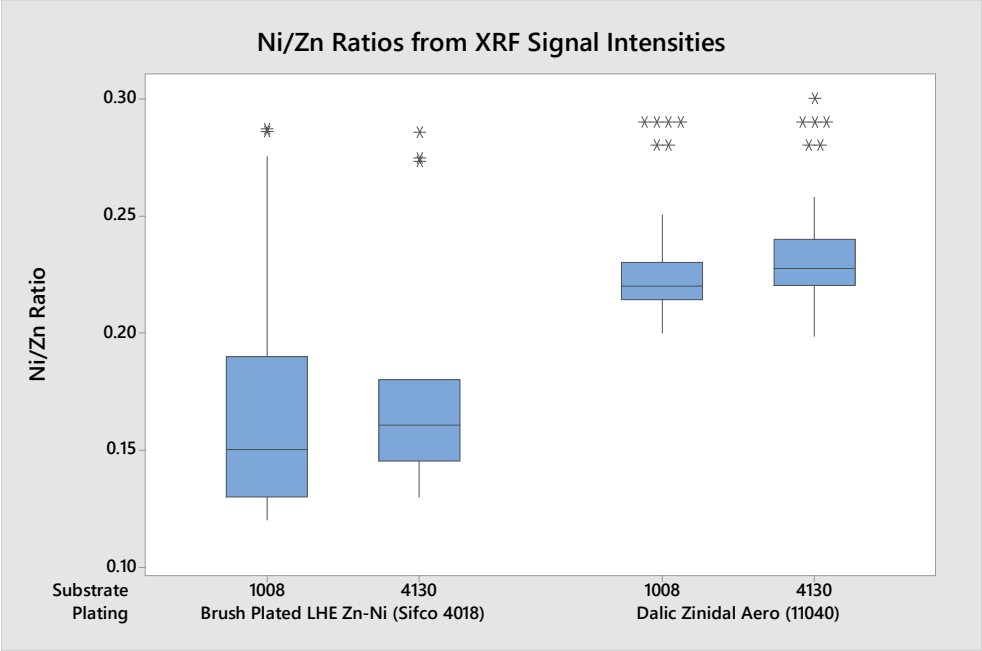

Figure 40, Ni/Zn Ratios from XRF Signal Intensities

A semi-quantitative analysis was performed which provides corrections for the atomic weight, absorption, and fluorescence of the elements to provide a reasonable estimate to the plating composition. Figure 41 and Figure 42 show the estimated Ni and Zn weight percentages respectively. As was inferred from the XRF analysis the average weight Nickel weight percentage is higher for the Zinidal Aero Zn-Ni than the Sifco 4018 Zn-Ni. The Figure also shows the composition of the Zinidal Aero Zn-Ni is more consistent than the Sifco 4018 Zn-Ni.

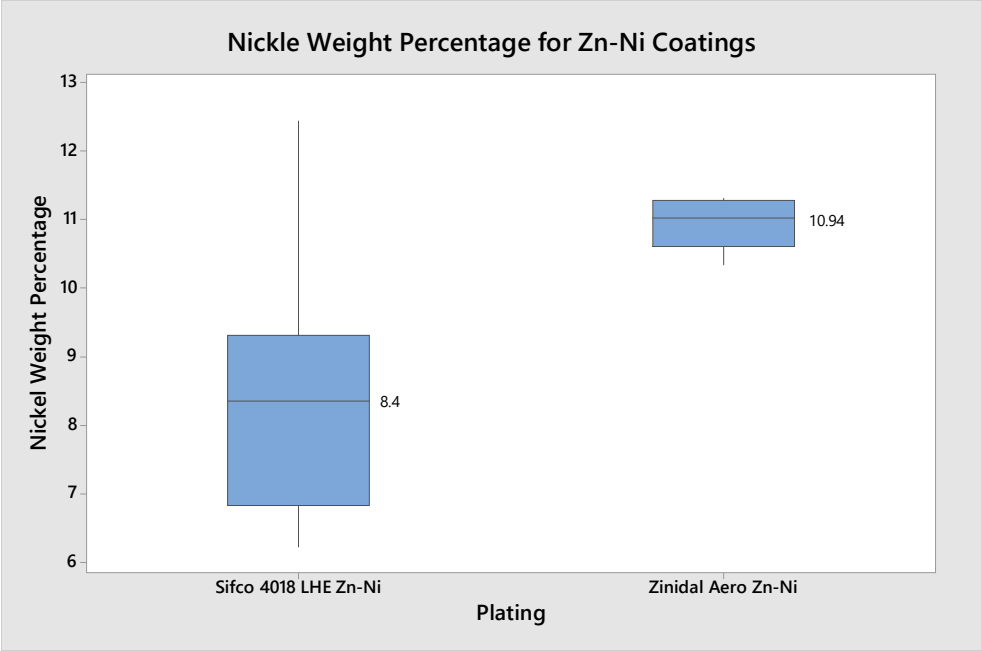

Figure 41. Nickel Weight Percentage

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As can be inferred from the previous figure, the average Zinc weight percentage is lower for the Zinidal Aero Zn-Ni than the Sifco 4018 Zn-Ni. Again the figure also shows the composition of the Zinidal Aero Zn-Ni is more consistent than the Sifco 4018 Zn-Ni.

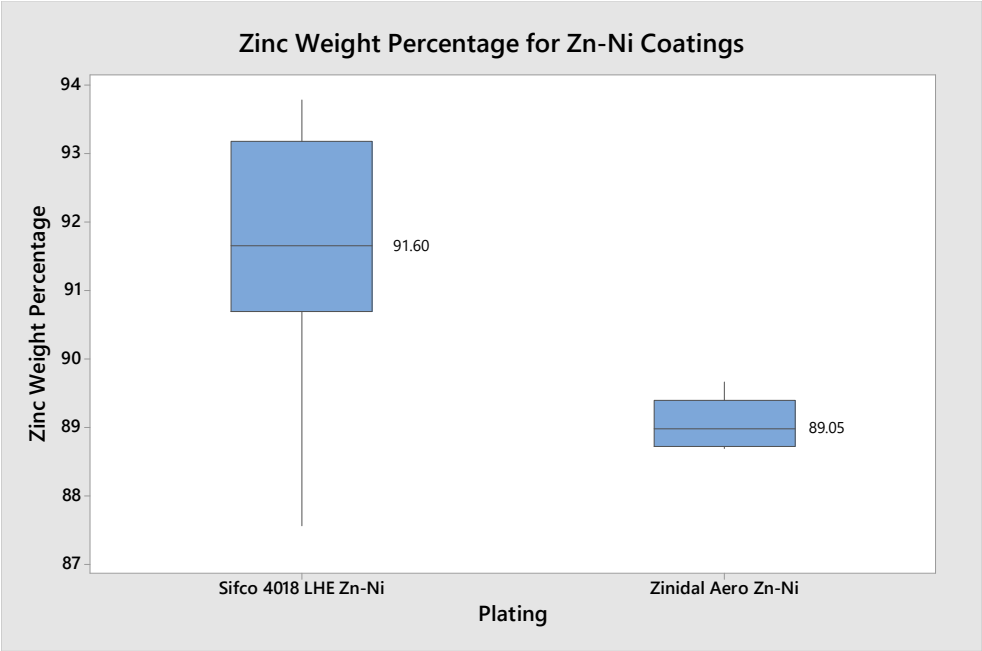

Figure 42. Zinc Weight Percentage

6.3.1 Specimen Cross Sections

Cross sections of Zn-Ni specimens were made to study the morphology of each coating including the repair specimens to determine the quality of repairs. These specimens were prepared using the plating process outlines in the Zinidal Aero Zn-Ni data sheet. The repair area of the specimens were degreased with acetone, deoxidized with Scotchbite until the surface exhibited a water break-free surface, rinsed with acetone, dried with compressed air and treated with the Activator XF for surface preparation.

Cross section of the Zinidal Aero Zn-Ni shows a very dense coating with occasionally a few cracks extending to the substrate for both the 4130 and 1008 steel specimens (see Figure 43 and Figure 44). In contrast the Sifco 4018 Zn-Ni plating shows a much more porous plating throughout for both the 1008 and 4130 steels (Figure 45 and Figure 46).

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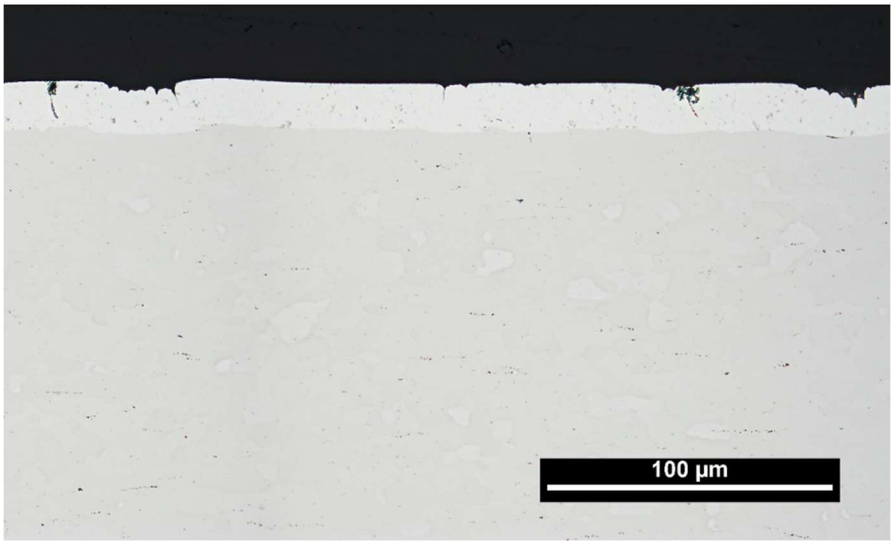

Figure 43. Zinidal Aero Zn-Ni Cross Section on 1008 Steel

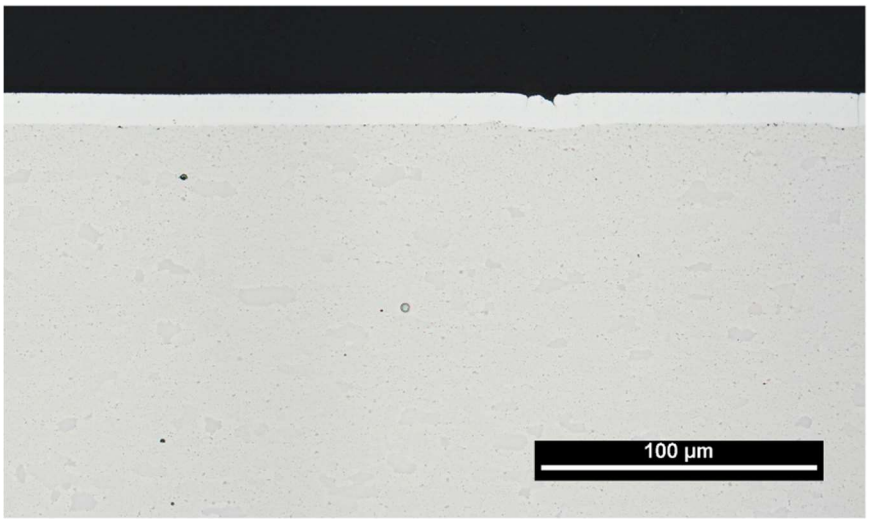

Figure 44. Zinidal Aero Zn-Ni Cross Section on 4130 Steel

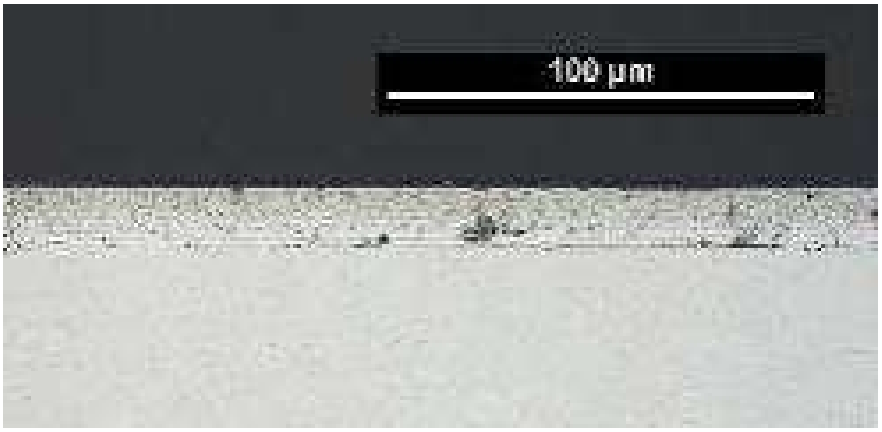

Figure 45. Sifco 4018 Zn-Ni Cross Section on 1008 Steel

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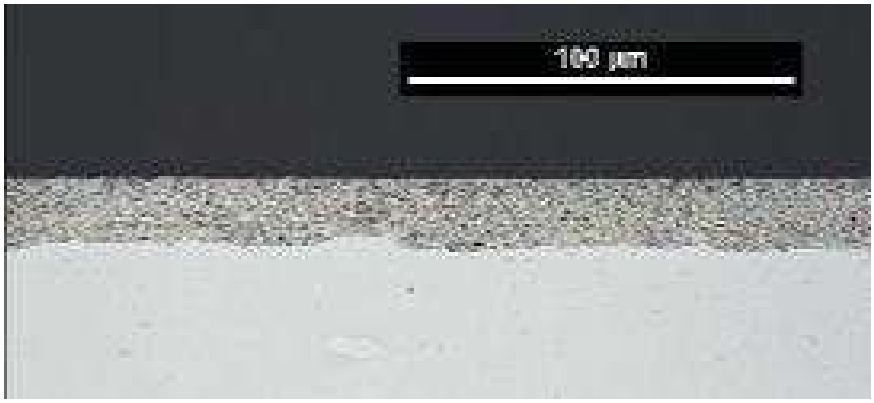

Figure 46. Sifco 4018 Zn-Ni Cross Section on 1008 Steel

The ability to repair a damaged previously tank-plated Zn-Ni component is critical for the Zinidal Aero Zn-Ni plated with the Dalistick station. The concern lies in the transition region between the Zn-Ni brush plating and the Zn-Ni tank plating. This region was cross sectioned and inspected under an SEM to ensure a quality coating where the platings overlapped. Figure 47 shows an SEM composite image of the transition region. It shows a quality smooth transition between the tank plating and the brush plated region. Figure 48 shows the cross section of the same region and shows the Zinidal Aero Zn-Ni is building upon the previous tank plating homogenously. From this study it can be concluded that at least visually the Zinidal Aero coating can be used to repair previously tank plated Zn-Ni specimens.

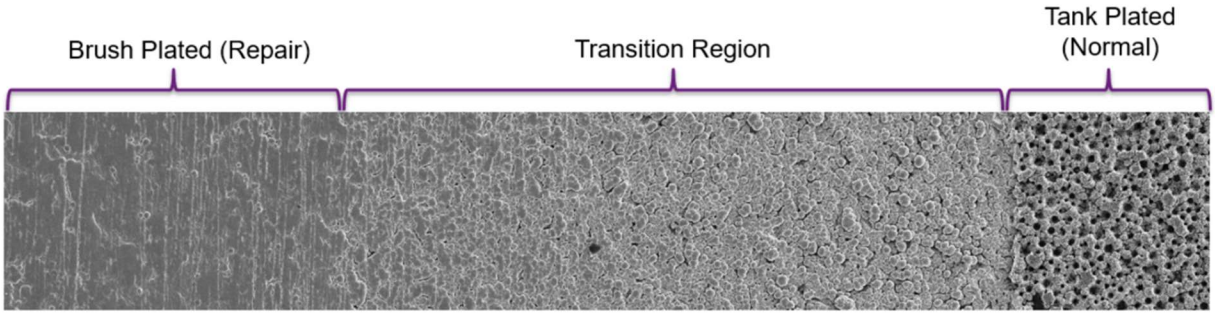

Figure 47. Composite SEM Image of Zinidal Aero Zn-Ni Repair of Tank Plated Zn-Ni, 4130 Steel

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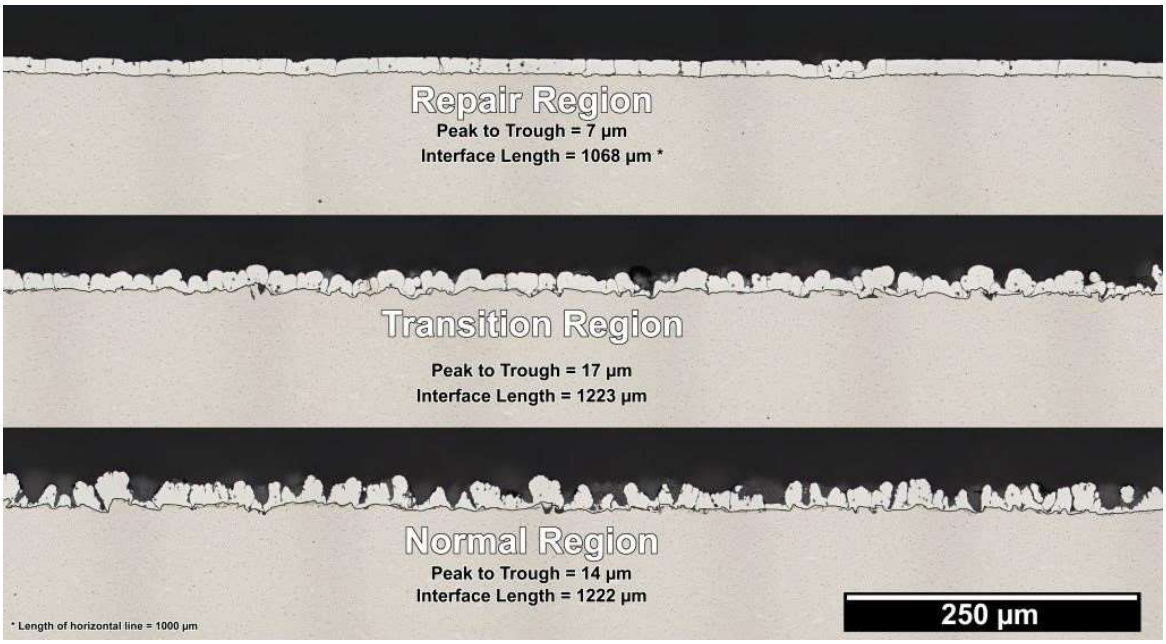

Figure 48. Composite SEM Image of Zinidal Aero Zn-Ni Repair of Tank Plated Zn-Ni, 4130 Steel

6.4 Bend Adhesion

Adhesion of the brush-plated coating is critical to successful plating, and ultimately to the performance of the coating. This bend adhesion testing determines if the plating is adequately adhered to the substrates. The Zinidal Aero ZN-Ni, Sifco 4018 Zn-Ni, and Sifco 2023 Cd were all tested on bare substrates and in tank plated Zn-Ni and Cd repair scenarios. All specimens were inspected under 4x magnification and photographed after breaking. The platings on bare substrates were tested during screening testing and all passed, the results are in Table 24.

Not all repair scenarios passed. All Sifco 2023 Cd brush plating plated over the simulated damaged Cd tank plating failed. All 1008 Sifco 4018 Zn-Ni brush plated specimens plated over simulated damaged Cd tank plating failed as well, however the Sifco 4018 Zn-Ni plated on 4130 steel passed. All Zinidal Aero specimens plated over simulated damaged Cd tank plating passed for both 1008 and 4130 steel. The results can be seen in Table 24.

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Table 24. Bend Adhesion Test Results

Panel Type	Plating	Conversion Coating	Substrate	Result	%
Bare	Sifco 2023 Cd	Sifco 3002	1008	3 of 3 Passed	100%
			4130	3 of 3 Passed	100%
			All	**6 of 6 Passed**	**100%**
	Sifco 4018 LHE Zn-Ni	Sifco 5030	1008	3 of 3 Passed	100%
			4130	3 of 3 Passed	100%
			All	**6 of 6 Passed**	**100%**
	Zinidal Aero Zn-Ni	None and Passivateur N3	1008	7 of 7 Passed	100%
			4130	7 of 7 Passed	100%
			All	**14 of 14 Passed**	**100%**
Tank Plated Damaged Cd	Sifco 2023 Cd	Sifco 3002	1008	0 of 3 Passed	0%
			4130	0 of 3 Passed	0%
			All	**0 of 6 Passed**	0%
	Sifco 4018 LHE Zn-Ni	Sifco 5030	1008	0 of 3 Passed	0%
			4130	3 of 3 Passed	100%
			All	**3 of 6 Passed**	50%
	Zinidal Aero Zn-Ni	None and Passivateur N3	1008	6 of 6 Passed	100%
			4130	6 of 6 Passed	100%
			All	**12 of 12 Passed**	100%
Tank Plated Zn-Ni Repair	Sifco 2023 Cd	Sifco 3002	1008	2 of 3 Passed	66%
			4130	1 of 3 Passed	33%
			All	**3 of 6 Passed**	50%
	Sifco 4018 LHE Zn-Ni	Sifco 5030	1008	0 of 3 Passed	0%
			4130	0 of 3 Passed	0%
			All	**0 of 6 Passed**	0%
	Zinidal Aero Zn-Ni	None and Passivateur N3	1008	6 of 6 Passed	100%
			4130	6 of 6 Passed	100%
			All	**12 of 12 Passed**	100%

For the simulated damaged tank plated Zn-Ni specimens repaired with Sifco 2023 Cd brush plating two of three 1008 specimens passed and 1 of three 4130 specimens passed. All the Sifco 4018 Zn-Ni brush plating specimens failed. Again all of the Zinidal Aero Zn-Ni specimens passed for both substrates as seen in Table 24.

An example of the Zinidal Aero Zn-Ni plated over both the ZN-Ni tank plating and Cd Tank plating can be seen in Figure 49. Zinidal Aero Zn-Ni repair on Zn-Ni Tank Plating, 4130 Steel and Figure 50. Both of these specimens passed. Crazing can be seen, but there is no separation of the plating from the base substrate. Damage seen on the ends of the specimens which was caused by clamping in the vise.

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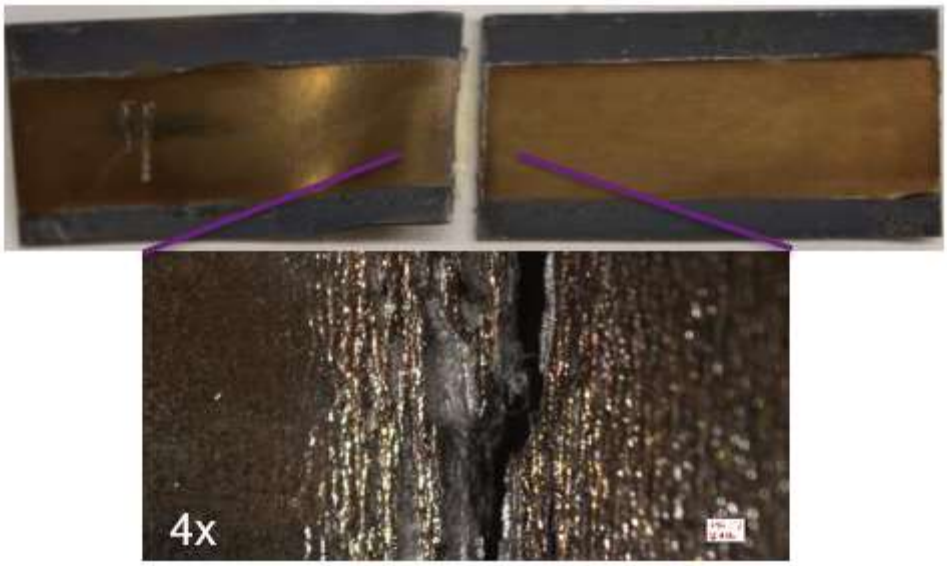

Figure 49. Zinidal Aero Zn-Ni repair on Zn-Ni Tank Plating, 4130 Steel

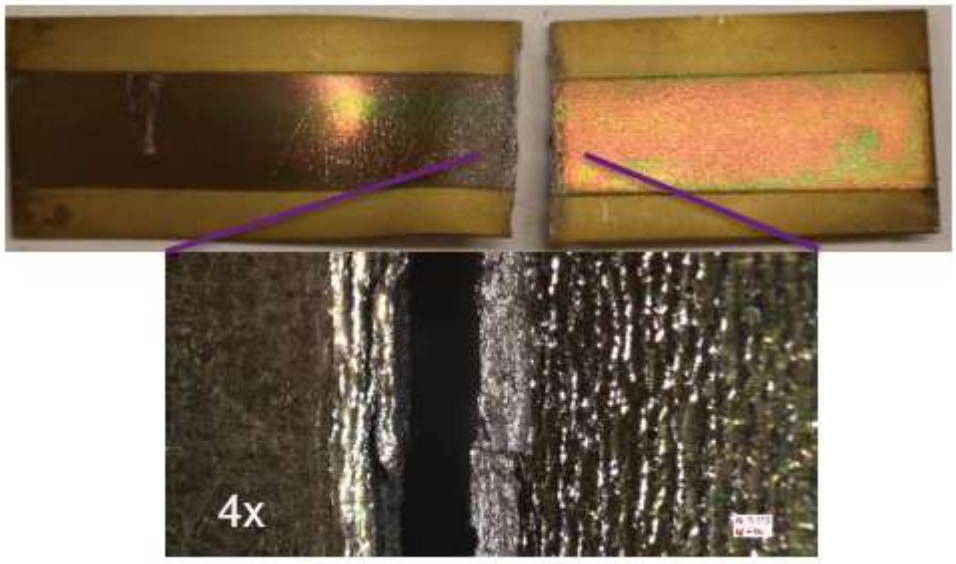

Figure 50. Zinidal Aero Zn-Ni repair on Cd Tank Plating, 4130 Steel

Examples of a Sifco 4018 Zn-Ni repair over Cd tank plating that passed as well as a Sifco 2023 Cd repair on Zn-Ni tank plating can be seen be seen in Figure 51 and Figure 52 respectively. Again crazing can be seen, but there is no separation of the plating from the substrate.

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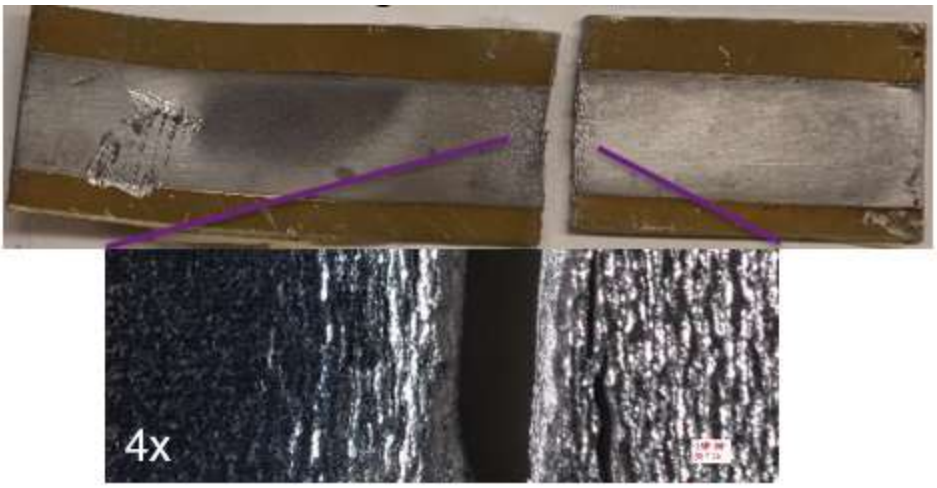

Figure 51. Sifco 4018 Zn-Ni repair on Cd Tank Plating, 4130 Steel

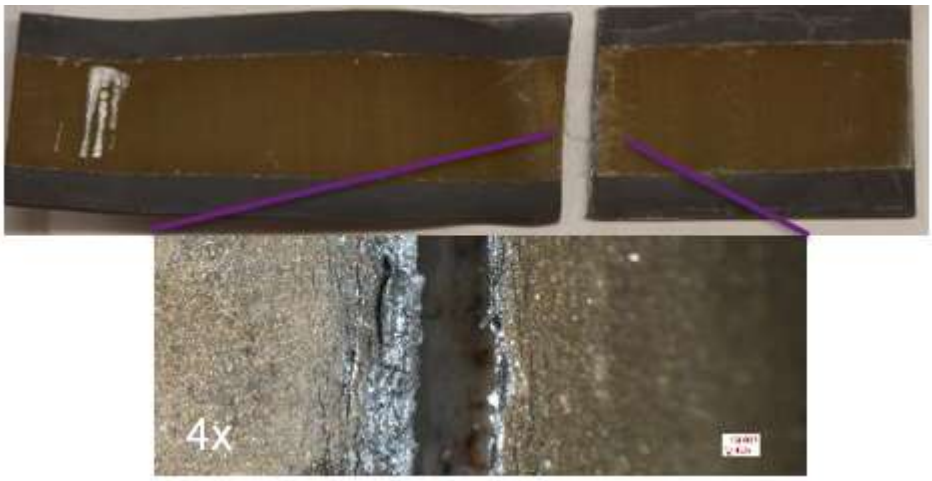

Figure 52. Sifco 2023 Cd repair on Zn-Ni Tank Plating, 1008 Steel

A failure of both the Sifco 4018 Zn-Ni brush plating and Zn-Ni tank plating can be seen in Figure 53. As can be seen in the figure there is a separation of both platings from the substrate.

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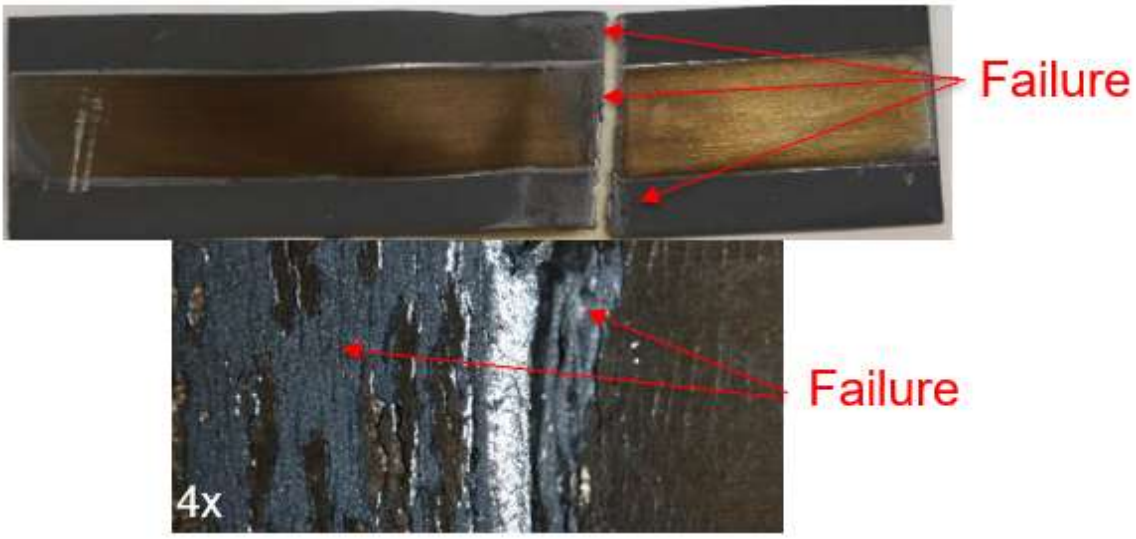

Figure 53. Sifco 4018 Zn-Ni repair on Zn-Ni Tank Plating, 1008 Steel

A failure of the Sifco 2023 Cd brush plating and can be seen in Figure 54. As can be seen in the figure there is a separation of the brush plating from the substrate, however the tank plating is adequately adhered to the substrate with no flaking or seperation from the substrate.

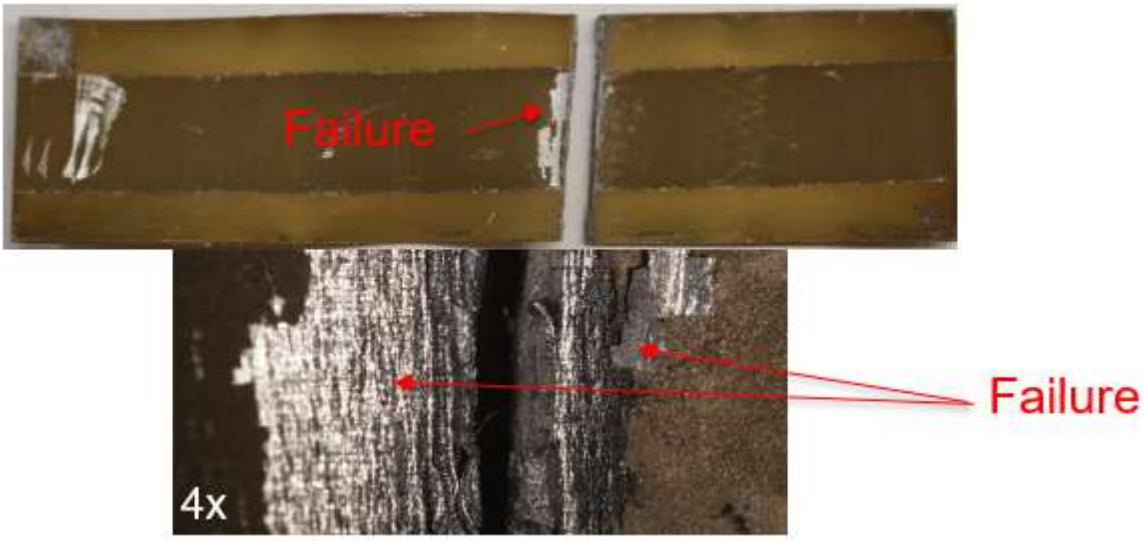

Figure 54. Sifco 2023 Cd repair on Cd Tank Plating, 4130 Steel

A failure of the Sifco 2023 Cd brush plating and Zn-Ni tank plating can be seen in Figure 55. As can be seen in the figure there is a separation of the brush and tank plating from the substrate.

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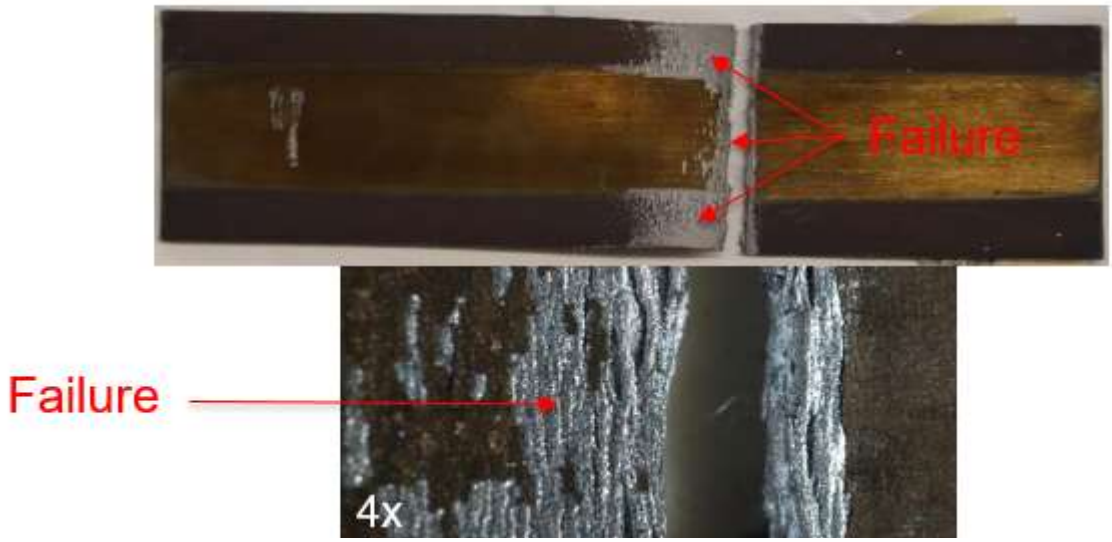

Figure 55. Sifco 2023 Cd repair on Zn-Ni Tank Plating, 4130 Steel

From this testing the Zindal Aero Zn-Ni outperformed both the Sifco 4018 Zn-Ni and the Sifco 2023 Cd bush plating. The root cause of the control failures is unknown. All control specimens passed quality control checks from there respective vendors, which, at a minimum, was a tape adhesion test.

6.5 WET/DRY PAINT ADHESION

Wet/Dry adhesion testing was performed to determine if primer would adequately adhere to the platings as required in USAF DWG 201027457 and AMS-QQ-P-416. A grading of 4B was required for both the wet and dry adhesion specimens as graded per ASTM D 3359. An example of the grading scale can be seen in Figure 56.

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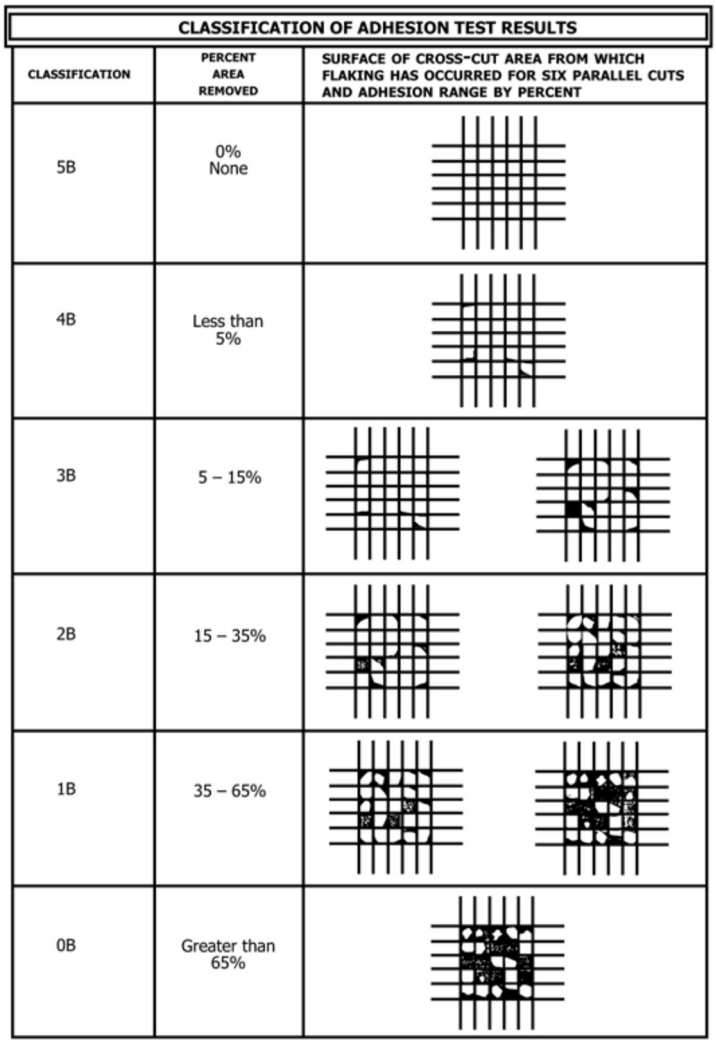

Figure 56. ASTM D 3359 Method B Grading Scale

Tabulated results of the dry adhesion testing with and without conversion coatings can be seen in the following two tables. Table 25 shows the dry adhesion without a conversion coating. 67% of Sifco 2023 Cd specimens passed with a rating of 4B or better. 100% of the Sifco 4018 Zn-Ni specimens passed and only 50% of the Zinidal Aero Zn-Ni specimens passed with a rating of 4B or better.

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Table 25. Dry Adhesion Results for Specimens without a Conversion Coating

Panel Type	Plating	Conversion Coating	Substrate	Result	%
Bare Steel	Sifco 2023 Cd	None	1008	2 of 3 Passed	67%
			4130	2 of 3 Passed	67%
			All	**4 of 6 Passed**	**67%**
	Sifco 4018 LHE Zn-Ni	None	1008	3 of 3 Passed	100%
			4130	3 of 3 Passed	100%
			All	**6 of 6 Passed**	**100%**
	Zinidal Aero Zn-Ni	None	1008	2 of 3 Passed	67%
			4130	1 of 3 Passed	33%
			All	**3 of 6 Passed**	**50%**

There were similar results for the dry adhesion testing with conversion coatings. 100% of the Sifco 2023 Cd specimens passed with a rating of 4B or better. 50% of the Sifco 4018 Zn-Ni specimens passed, and again only 50% of the Zinidal Aero Zn-Ni specimens passed.

Table 26. Dry Adhesion Results for Specimens with a Conversion Coating

Panel Type	Plating	Conversion Coating	Substrate	Result	%
Bare Steel	Sifco 2023 Cd	Sifco 3002	1008	3 of 3 Passed	100%
			4130	3 of 3 Passed	100%
			All	**6 of 6 Passed**	**100%**
	Sifco 4018 LHE Zn-Ni	Sifco 5030	1008	2 of 3 Passed	67%
			4130	1 of 3 Passed	33%
			All	**3 of 6 Passed**	**50%**
	Zinidal Aero Zn-Ni	Passivateur N3	1008	1 of 3 Passed	33%
			4130	2 of 3 Passed	67%
			All	**3 of 6 Passed**	**50%**

Tabulated results of the wet adhesion testing with and without conversion coatings can be seen in the following two tables. Table 27 shows the results for the specimens without a conversion coating. 50% of the Sifco 2023 Cd specimens passed. 100% of the Sifco 4018 Zn-Ni specimens passed on 1008 steel but only 1 of the three specimens passed on 4130 steel. Only one of the Zinidal Aero Zn-Ni specimens passed. Multiple specimens experienced blistering of the paint as well.

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Table 27. Wet Adhesion Results for Specimens without a Conversion Coating

Panel Type	Plating	Conversion Coating	Substrate	Result	%
Bare Steel	Sifco 2023 Cd	None	1008	1 of 3 Passed	33%
			4130	2 of 3 Passed	67%
			All	**3 of 6 Passed**	**50%**
	Sifco 4018 LHE Zn-Ni	None	1008	3 of 3 Passed	100%
			4130	1 of 3 Passed	33%
			All	**4 of 6 Passed**	**67%**
	Zinidal Aero Zn-Ni	None	1008	1 of 3 Passed	33%
			4130	0 of 3 Passed	0%
			All	**1 of 6 Passed**	**17%**

Table 28 shows the results for the specimens with a conversion coating. These specimens did not perform as well as the specimens without a conversion coating. None of the Sifco 2023 Cd specimens passed. Only one of the Sifco Zn-Ni specimens passed on 4130 steel. None of the Zinidal Aero Zn-Ni specimens passed. Again with these specimens experienced blistering of the paint as well.

Table 28. Wet Adhesion Results for Specimens with a Conversion Coating

Panel Type	Plating	Conversion Coating	Substrate	Result	%
Bare Steel	Sifco 2023 Cd	Sifco 3002	1008	0 of 3 Passed	0%
			4130	0 of 3 Passed	0%
			All	**0 of 6 Passed**	**0%**
	Sifco 4018 LHE Zn-Ni	Sifco 5030	1008	0 of 3 Passed	0%
			4130	1 of 3 Passed	33%
			All	**1 of 6 Passed**	**17%**
	Zinidal Aero Zn-Ni	Passivateur N3	1008	0 of 3 Passed	0%
			4130	0 of 3 Passed	0%
			All	**0 of 6 Passed**	**0%**

The Zinidal Aero Zn-Ni performed worse than the control specimens for both the dry and wet paint adhesion testing. No specimens performed well in the wet paint adhesion testing especially in specimens with a conversion coating. It is unknown why the Zinidal Aero Specimens did not do as well as the control specimens. Adhesion promotors such as PreKote were not used before applying the primer. From the plating cross sections the surface of the Zinidal Aero coating also appears to be smoother then the control specimens, this may be negatively affecting the paint adhesion. No roughening of the surface before primer application was tested.

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6.6 SALT SPRAY RESISTANCE

6.6.1 Salt Spray Resistance Screening Testing

Corrosion resistance is a critical requirement for the Zinidal Aero Zn-Ni. Screening testing was performed on the fully brush plated specimens on bare steel substrates to first determine if additional testing was warranted. Salt spray corrosion resistance was performed per ASTM B 117 as required in USAF DWG 201027457 and AMS-QQ-P-416. All panels were inspected during daily salt fog chamber checks. If white corrosion was found on conversion coated specimens before 96 hours (per JTP requirement) it was recorded and photographed.

None of the Sifco 4018 conversion coated specimens or the Zinidal Aero Zn-Ni conversion coated specimens exhibited white corrosion before 96 hours of exposure. Half of the specimens were scribed and the other half were unscribed. Table 29 shows the white corrosion results.

Table 29. White Corrosion Results for Platings of Bare 1008 and 4130

Substrate	Plating	Conversion Coating	Repair Condition	Qty	Results
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	14 Scribed	14 of 14 Passed
				14 Unscribed	14 of 14 Passed
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	14 Scribed	14 of 14 Passed
				14 Unscribed	14 of 14 Passed
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5 Scribed	5 of 5 Passed
				5 Unscribed	5 of 5 Passed
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5 Scribed	5 of 5 Passed
				5 Unscribed	5 of 5 Passed
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5 Scribed	5 of 5 Passed
				5 Unscribed	5 of 5 Passed
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5 Scribed	5 of 5 Passed
				5 Unscribed	5 of 5 Passed

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If red rust was found before 500 hours (per JTP requirement) the specimen was pulled from testing, the exposure hours were recorded and each specimen was photographed. Table 30 shows the red rust results. Some specimens did not reach 500 hours of exposure so data for 250 hours of exposure was also tabulated.

Table 30. Red Rust Results for Platings of Bare 1008 and 4130 Steel

Substrate	Plating	Conversion Coating	Repair Condition	Qty	250 hr. Results	500 hr. Results
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	14 Scribed	0 of 14 Passed	0 of 14 Passed
				14 Unscribed	0 of 14 Passed	0 of 14 Passed
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	14 Scribed	0 of 14 Passed	0 of 14 Passed
				14 Unscribed	0 of 14 Passed	0 of 14 Passed
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	14 Scribed	14 of 14 Passed	6 of 14 Passed
				14 Unscribed	14 of 14 Passed	13 of 14 Passed
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	14 Scribed	14 of 14 Passed	1 of 14 Passed
				14 Unscribed	14 of 14 Passed	13 of 14 Passed
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5 Scribed	4 of 5 Passed	1 of 5 Passed
				5 Unscribed	5 of 5 Passed	4 of 5 Passed
1008 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	5 Scribed	5 of 5 Passed	3 of 5 Passed
				5 Unscribed	5 of 5 Passed	5 of 5 Passed
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5 Scribed	5 of 5 Passed	5 of 5 Passed
				5 Unscribed	5 of 5 Passed	5 of 5 Passed
1008 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	5 Scribed	5 of 5 Passed	5 of 5 Passed
				5 Unscribed	5 of 5 Passed	5 of 5 Passed

The Zinidal Aero Zn-Ni specimens without a conversion coating all showed the first signs of red rust from 116 hours to 164 hours of exposure for both the scribed and unscribed specimens. A bar chart was made for all of the conversion coated specimens. Figure 57 contains the 1008 steel results. This figure shows that both the Zinidal Aero Zn-Ni and Sifco 4018 Zn-Ni scribed specimens did not all meet the JTP requirement of 500 hours. The unscribed Zinidal Aero Zn-Ni, unscribed Sifco 4018 Zn-Ni, and all Sifco 2023 Cd specimens met the JTP requirement of no red rust for 500 hours of exposure.

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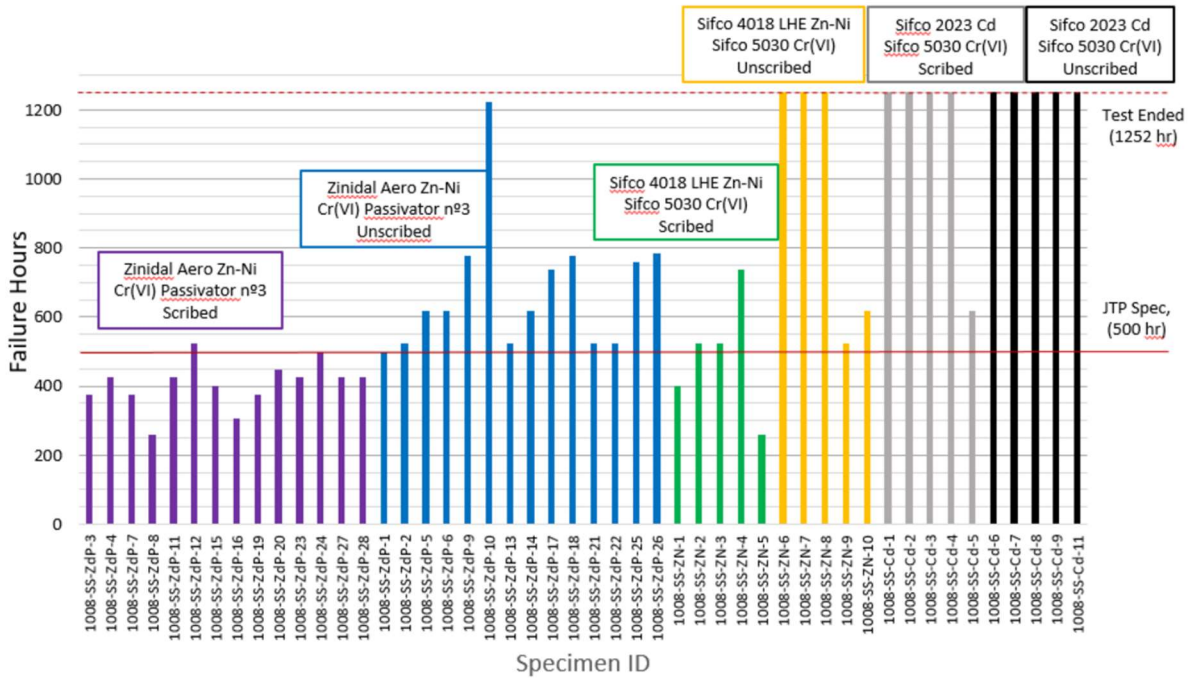

Figure 57. Red Rust Results, 1008 Steel

Figure 58 contains the 4130 steel results. This figure shows that both the Zinidal Aero Zn-Ni and Sifco 4018 Zn-Ni scribed specimens did not all meet the JTP requirement of 500 hours similarly to the 1008 steel. The unscribed Zinidal Aero Zn-Ni and unscribed Sifco 4018 Zn-Ni met the JTP requirement except for one specimen each. Again all the Sifco 2023 Cd specimens met the JTP requirement of no red rust for 500 hours of exposure.

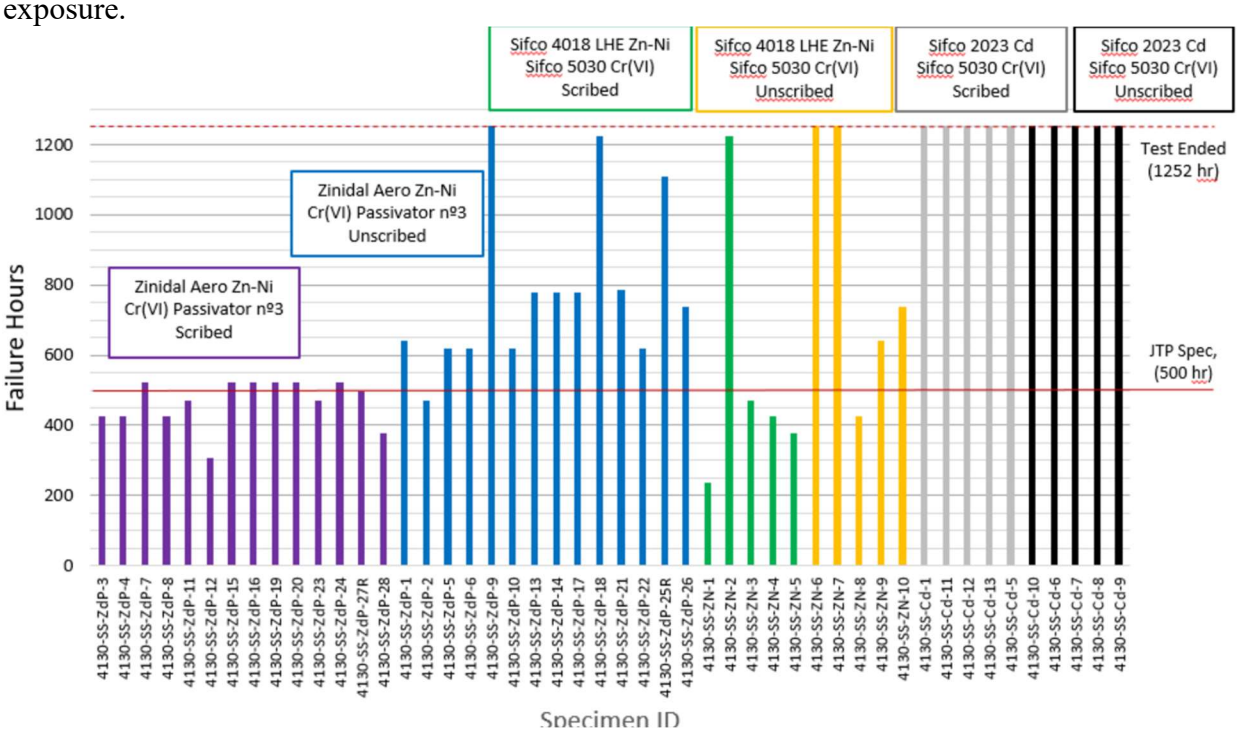

Figure 58. Red Rust Results, 4130 Steel

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Further analysis was performed to determine the differences in the means of the red rust failures between plated specimens. Analysis showed that there was not a statistical difference between substrates however in some instances there were differences between platings when looking at the difference among scribed and unscribed panels. Boxplots of the data as well as an analysis of the means at a 95% confidence interval was performed in Minitab. Figure 59 shows that the means of the red rust failures are different between plating types. The Cd outperformed both Zn-Ni platings, and the Sifco 4018 Zn-Ni outperforms the Zinidal Zn-Ni. This is further iterated in the analysis of means which can be seen in Table 31

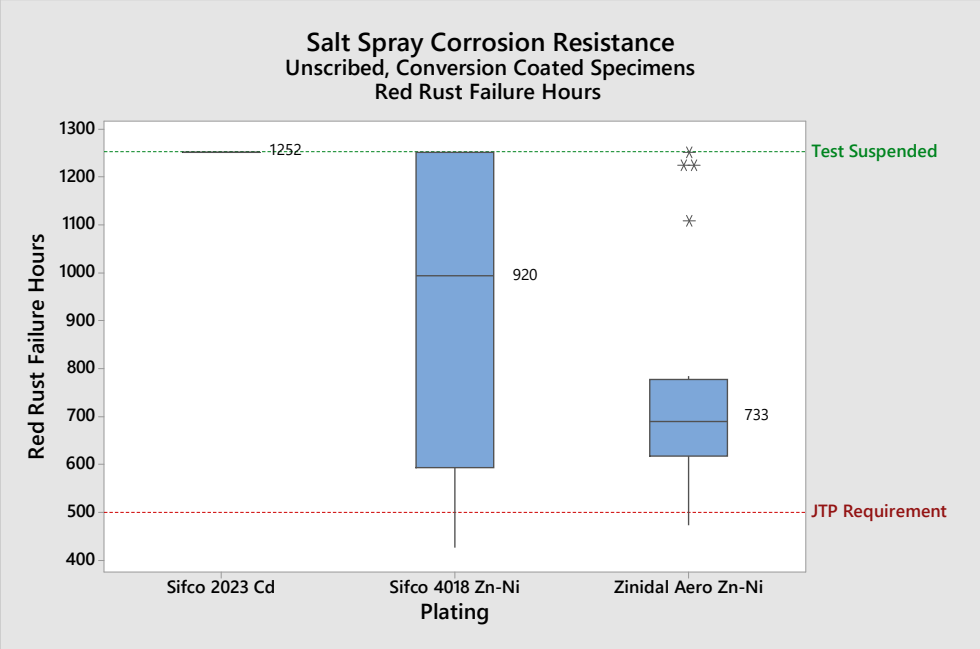

Figure 59. Boxplot of Unscribed Conversion Coated Salt Spray Resistance Specimens[14]

Table 31. Unscribed Conversion Coated Salt Spray Resistance Specimens, Analysis of Means at 95% Confidence Interval (Hours to Failure)

Plating	Number of Specimens	Failure Mean (hr)	Standard Deviation	95% Confidence Interval of Failure Hours	
				Lower Bound	Upper Bound
Sifco 2023 Cd	10	1252	0	1103	1402
Sifco 4018 Zn-Ni	10	920	359	771	1069
Zinidal Aero Zn-Ni	28	733	220	644	822

[14] The Sifco 2023 brush plated Cd specimens all showed no sign of red rust when the test was suspended at 1252 hours. This is why only a single line is shown on the boxplot in Figure 59.

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The analysis was repeated for the scribed conversion coated specimens. Figure 60 shows that the means of the red rust failures are different between plating types. The Cd outperformed both Zn-Ni platings as was similar with the unscribed specimens. The mean of Sifco 4018 Zn-Ni is greater than the Zinidal Zn-Ni, however their confidence intervals greatly overlap. They are statistically similar with a slight edge in salt spray corrosion performance for the Sifco 4018 Zn-Ni as shown in Table 32.

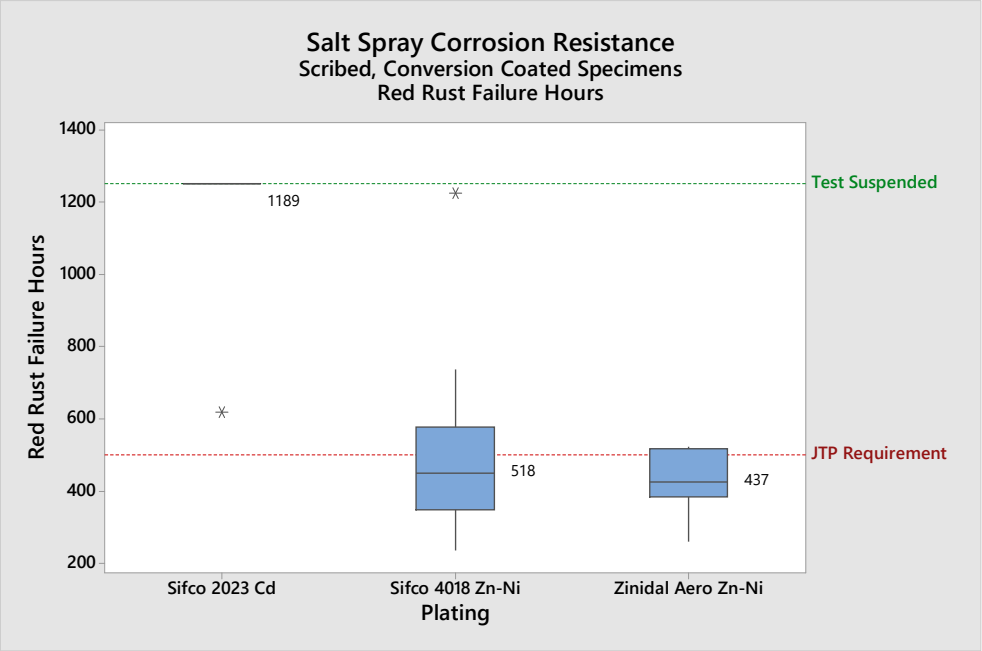

Figure 60. Boxplot of Scribed Conversion Coated Salt Spray Resistance Specimens[15]

Table 32. Scribed Conversion Coated Salt Spray Resistance Specimens, Analysis of Means at 95% Confidence Interval (Hours to Failure)

Plating	Number of Specimens	Failure Mean (hr)	Standard Deviation	95% Confidence Interval of Failure Hours	
				Lower Bound	Upper Bound
Sifco 2023 Cd	10	1189	201	1083	1295
Sifco 4018 Zn-Ni	10	518	286	412	624
Zinidal Aero Zn-Ni	28	437	73	374	500

6.6.2 Salt Spray Resistance Repair Specimen Testing

Salt spray corrosion resistance was performed per ASTM B 117 as required in USAF DWG 201027457 and AMS-QQ-P-416 on both simulated tank plated Cd and tank plated

[15] The Sifco 2023 brush plated Cd specimens all showed no sign of red rust when the test was suspended at 1252 hours except for one specimen failing at just over 600 hours. This is why only a single line and in "*" is shown on the boxplot in Figure 60.

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Zn-Ni repair specimens. All panels were inspected during daily salt fog chamber checks. No white corrosion was found on conversion coated specimens before 96 hours (per JTP requirement). All specimens were allowed to continue to run up to 500 hours of salt fog exposure. This round of testing was slightly changed to further quantify the corrosion performance of the platings after the first sign of red rust. At the end of testing all specimens were graded using ImageJ software to quantify the amount of red rust in the tank plated and bush plated regions.

The percentage of red rust was analyzed in the brush plated repair regions of tank plated Zn-Ni can be seen in Figure 61. Sifco 2023 Cd repairs showed worse performance then both the Sifco 4018 Zn-Ni and the Zinidal Aero Zn-Ni in both scribed and unscribed specimens. The Zinidal Aero Zn-Ni performed well. No red rust was found on the unscribed specimens and an average of 2% red rust was found on the scribed specimens.

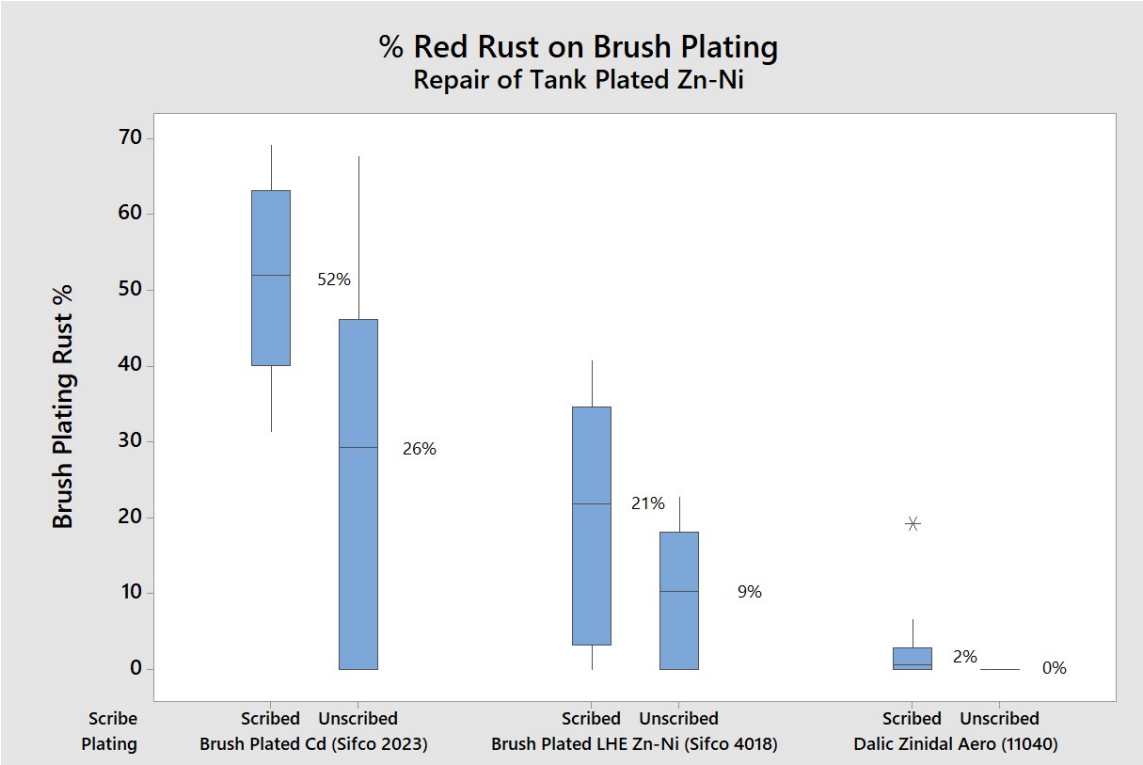

Figure 61. Percent of Red Rust in Brush Plated Region of Zn-Ni Tank Plated Salt Spray Specimens

The percentage of red rust was also analyzed in the tank plated regions of the Zn-Ni tank plated specimens as shown in Figure 62. Again the specimens repaired with Sifco 2023 Cd showed worse performance then both the Sifco 4018 Zn-Ni and the Zinidal Aero Zn-Ni in both scribed and unscribed specimens. Both Zn-Ni brush plating repaired specimens performed well. The Zinidal Aero Zn-Ni slightly outperformed the Sifco 4018 Zn-Ni Specimens.

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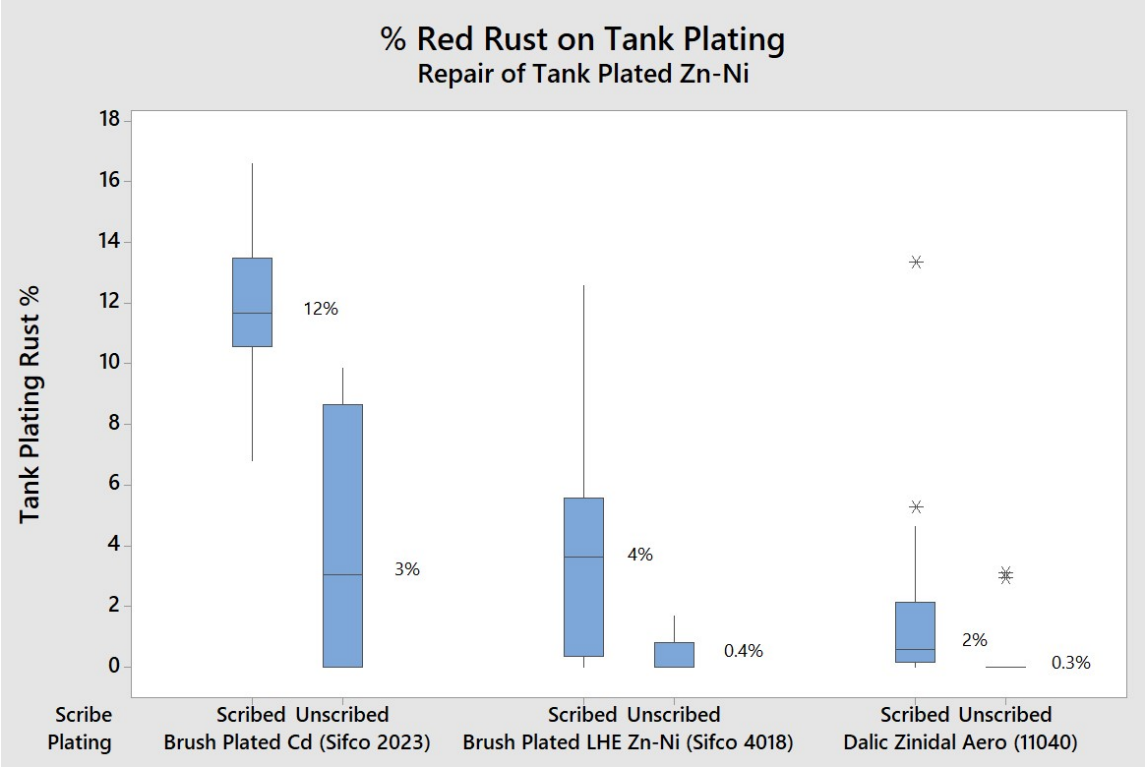

Figure 62. Percent of Red Rust in Tank Plated Region of Zn-Ni Tank Plated Salt Spray Specimens

The Cd tank plated specimens were also analyzed. All brush plating repairs on Cd Tank plating performed well. Only one Sifco 2023 Cd plated specimen showed any sign of red rust which was found to be under 0.2% of the repair area.

The percentage of red rust in the tank plated regions of the Cd tank plated specimens is shown in Figure 63. Again all specimens performed well. The Sifco 2023 Cd plated specimens only had one specimen show a sign of red rust. The Sifco 4018 Zn-Ni specimens showed no signs of red rust in the tank plated regions. The Zinidal Aero Zn-Ni performed worst then the other specimens, but could still be considered to perform well with the majority of specimens falling under 1% red rust seen in the tank plated regions.

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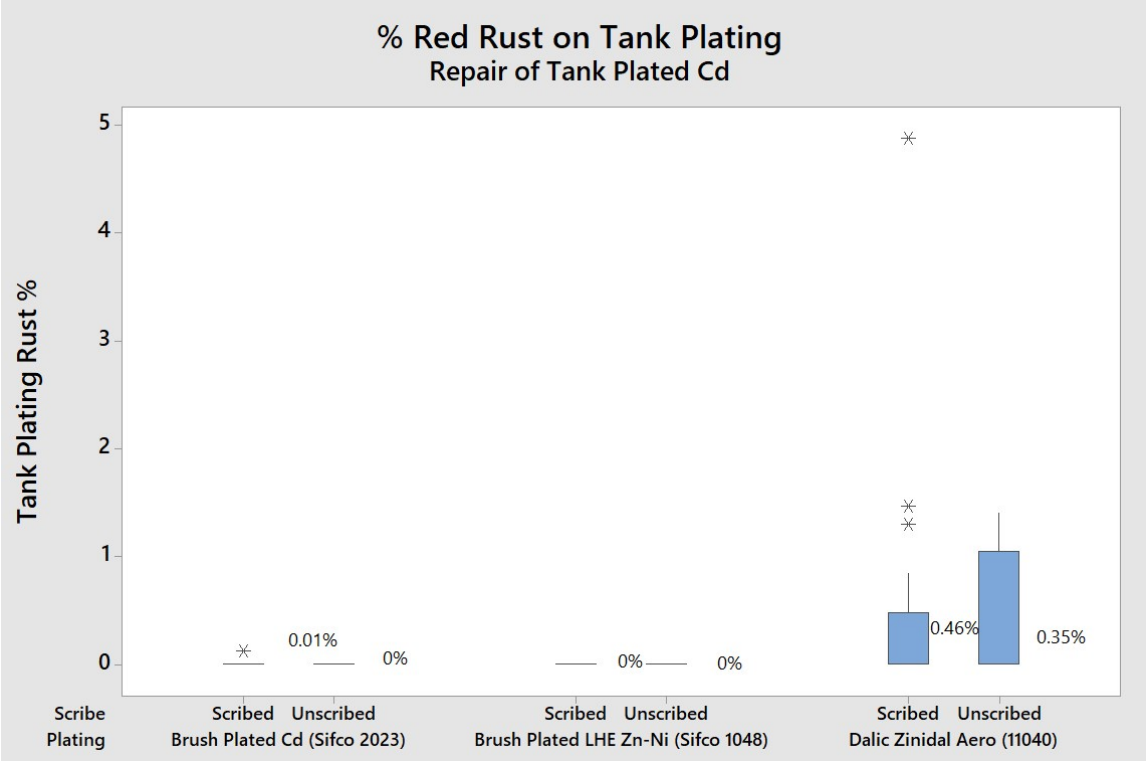

Figure 63. Percent of Red Rust in Brush Plated Region of Zn-Ni Tank Plated Salt Spray Specimens

6.7 HYDROGEN EMBRITTLEMENT

A total of four 1a.1 and 4d brush plated specimens were tested within 48 hours for hydrogen embrittlement per ASTM F 519. The specimens were tested in ambient air at 75% of the notched fracture strength (1a.1) or 75% if the full displacement to failure (1d).

The results from the hydrogen embrittlement testing can be seen in Table 33. The 1a.1 specimens plated with the Zinidal Aero Zn-Ni failed hydrogen embrittlement testing. Two of the four specimens failed within 1 hour of testing. All of the 1d specimens failed. Two of the specimens broke completely and the other two failed based on a crack which was visible with the naked eye.

The 1a.1 specimens plated with the Sifco 4018 Zn-Ni failed hydrogen embrittlement testing as well. Two of the four specimens failed before 200 hours of loading. The 1d specimens passed the testing. The only failure was caused by an overloading error, which is why only three were tested.

Three of the four 1a.1 Sifco 2023 Cd brush plated specimens passed the hydrogen embrittlement testing. The remaining specimens were step loaded successfully and the plating was considered non-embrittling per the ASTM F 519 standard. All of the 1d specimens also passed.

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Table 33. Hydrogen Embrittlement Results

Substrate	Plating	Conversion Coating	Repair Condition	Specimen	Result	Conclusion
4340 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4 1a.1	2 of 4 Passed	Embrittled
				4 1d	0 of 4 Passed	Embrittled
4340 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4 1a.1	2 of 4 Passed	Embrittled
				4 1d	3 of 3 Passed	Non-Embrittled
4340 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4 1a.1	3 of 4 Passed	Non-Embrittled
				4 1d	4 of 4 Passed	Non-Embrittled

The only plating which fully passed the hydrogen embrittlement testing was the Sifco 2023 Cd brush plating. The Sifco 4018 Zn-Ni plating did not embrittle the 1d specimens but embrittled the 1a.1 specimens. Both the 1a.1 and 1d specimens were embrittled when plating the Zinidal Aero solution with the Dalistick.

ASTM F 519 is a pass/fail test. It does not assist with determining the root cause of the hydrogen embrittlement. An additional task was been added to this project which investigated the root causes of hydrogen embrittlement in Zn-Ni brush plating and worked towards identifying a plating process which allows Zn-Ni plating to continually pass hydrogen embrittlement testing. This hydrogen embrittlement characterization was performed with Boeing Research and Technology as well as IBECA Technologies. The results of this testing can be found in Appendix G: No-Bake Brush Plating Zinc-Nickel Processes Report.

6.8 SERVICE CHEMICAL HYDROGEN EMBRITTLEMENT

Two chemical exposure conditions were tested for the service chemical hydrogen embrittlement testing. The first exposure condition immersed in the specimens in ZipChem Calla 296 at 175°F for 30 min. The specimens were then removed, air dried, and then loaded to 75% NFS for 200 h, in accordance with ASTM F 519. The second exposure condition was loaded to 45% and left the specimens immersed in the ZipChem Calla 296 cleaner at ambient temperature for the full 200 hours. The pass/fail criteria was the same as the hydrogen embrittlement testing.

The results of the first exposure condition which exposed the specimens to the cleaner at elevated temperature can be seen in Table 34.

Two for the four 1a.1 specimens plated with the Zinidal Aero Zn-Ni failed the first exposure condition testing and were considered embrittled. All of the 1d specimens passed which leads to a mixed result.

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Two of the four 1a.1 and 1d specimens plated with the Sifco 4018 Zn-Ni failed as well. The Sifco 4018 Zn-Ni was considered embrittled.

Two of the four 1a.1 and 1d specimens plated with the Sifco 2023 Cd failed as well and the plating was considered embrittled.

Table 34. Elevated Temperature Service Chemical Hydrogen Embrittlement Test Results

Substrate	Plating	Conversion Coating	Repair Condition	Specimen	Result	Conclusion
4340 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4 1a.1	2 of 4 Passed	Embrittled
				4 1d	4 of 4 Passed	Non-Embrittled
4340 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4 1a.1	2 of 4 Passed	Embrittled
				4 1d	2 of 4 Passed	Embrittled
4340 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4 1a.1	2 of 4 Passed	Embrittled
				4 1d	2 of 4 Passed	Embrittled

The results of the second exposure condition can be seen in Table 35. All of the platings passed the 45% loading while being soaked in the Calla 296 for 200 hours. Only one failure occurred with the Sifco 4018 plating on a 1a.1 specimen. The remaining three passed step loading.

Table 35. Full Soak Service Chemical Hydrogen Embrittlement Test Results

Substrate	Plating	Conversion Coating	Repair Condition	Specimen	Result	Conclusion
4340 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4 1a.1	4 of 4 Passed	Non-Embrittled
				4 1d	4 of 4 Passed	Non-Embrittled
4340 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4 1a.1	3 of 4 Passed	Non-Embrittled
				4 1d	4 of 4 Passed	Non-Embrittled
4340 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4 1a.1	4 of 4 Passed	Non-Embrittled
				4 1d	4 of 4 Passed	Non-Embrittled

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No plating fully passed the service chemical hydrogen embrittlement testing. No plating was able to pass the elevated temperature exposure condition. Again this testing is a pass/fail test and does not determine the root cause of the hydrogen embrittlement.

6.9 STRIPPABILITY

Strippability testing was performed to evaluate how well the platings were able to be stripped from steel specimens per USAF DWG 201027456 and USAF DWG 201027457. In discussions with Hill AFB the plating must be removed in two hours. Heavy aeration of the ammonium nitrate stripping solution is allowed as well as a light scrub of the specimens. All specimens passed and a summary of the results can be seen in Table 36. Representative before and after stripping photographs can be seen in Figure 64. Zinidal Aero Zn-Ni Repair of Zn-Ni Tank Plating, Before and After Stripping, Figure 65, and Figure 66 showing the coatings are fully removed and the substrates remain in good condition.

Table 36. Strippability Test Results

Substrate	Plating	Conversion Coating	Repair Condition	Qty	Stripping Time (Hr)	Scrubbed (Yes/No)
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	4	1	No
			Zn-Ni Tank Plated Repair	4	2	Yes
			Cd Tank Plated Repair	4	2	Yes
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	4	2	Yes
			Zn-Ni Tank Plated Repair	4	2	Yes
			Cd Tank Plated Repair	4	2	Yes
4130 Steel	Sifco 4018 Zn-Ni	Sifco 5030	Bare Steel	4	2	Yes
			Zn-Ni Tank Plated Repair	4	1	Yes
			Cd Tank Plated Repair	4	2	Yes
4130 Steel	Sifco 2023 Cd	Sifco 3002	Bare Steel	4	1	Yes
			Zn-Ni Tank Plated Repair	4	2	Yes
			Cd Tank Plated Repair	4	1.5	Yes

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Figure 64. Zinidal Aero Zn-Ni Repair of Zn-Ni Tank Plating, Before and After Stripping

Figure 65. Sifco 2023 Cd Repair of Cd Tank Plating, Before and After Stripping

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Figure 66. Sifco 4018 Zn-Ni Repair of Zn-Ni Tank Plating, Before and After Stripping

6.10 SO_2 RESISTANCE

SO_2 resistance was an additional US Navy stakeholder requirement in which red rust should not appear before 168 hours or should be comparable to Cd controls. Testing was performed per ASTM G 85 Annex A4. The percentage of red rust on both the brush plated areas and tank plated areas of specimens were determined using ImageJ.

The first set of specimens were ran to 168 hours which included all of the Zinidal Aero Zn-Ni specimens except the Cd tank plated repair specimens on 4130 steel. The fully brush plated Cd specimens on 1008 and 4130 steel were also tested. After 168 hours all specimens failed and were almost entirely corroded. A summary of the percentage of red rust on the 1st test specimens can be found in Table 37. The Cd specimens performed slightly better than the Zinidal Aero but still did not meet the JTP requirement.

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Table 37. SO_2 Resistance Test Results, Run 1: 168 hr Exposure

Substrate	Plating	Conversion Coating	Repair Condition	Average Brush Plating % Red Rust	Average Tank Plating % Red Rust
4130 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	98%	NA
			Zn-Ni Tank Plated Repair	100%	100%
1008 Steel	Zinidal Aero Zn-Ni	None	Bare Steel	100%	NA
			Zn-Ni Tank Plated Repair	100%	100%
			Cd Tank Plated Repair	100%	89%
4130 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Bare Steel	100%	NA
			Zn-Ni Tank Plated Repair	100%	100%
			Cd Tank Plated Repair	100%	97%
1008 Steel	Zinidal Aero Zn-Ni	Passivateur N°3	Zn-Ni Tank Plated Repair	100%	99%
			Cd Tank Plated Repair	100%	100%
4130 Steel	Sifco 2023 Cd	Sifco 5030	Bare Steel	98%	NA
1008 Steel	Sifco 2023 Cd	Sifco 5030	Bare Steel	94%	NA

The second set of specimens were ran to 72 hours because all specimens failed the JTP requirement of 168 hours. The only Zinidal Aero Zn-Ni specimens which were ran in the second run was the Cd tank plated repair specimens without a conversion coating. Again no specimens passed 72 hours of exposure with no red rust. The Sifco 4018 Zn-Ni performed better overall then the Sifco 2023 Cd, however in the Cd tank plated repair specimens no tank plating showed signs of red rust in specimens repaired with Sifco 2023 Cd brush plating. The only Zinidal Aero Zn-Ni specimens performed worse than both the Sifco 4018 Zn-Ni and 2023 Cd platings. A summary of the percentage of red rust on the 2nd run of test specimens can be found in Table 38.

Table 38. SO_2 Resistance Test Results, Run 2: 72 hr Exposure

Substrate	Plating	Conversion Coating	Repair Condition	Average Brush Plating % Red Rust	Average Tank Plating % Red Rust
4130 Steel	Zinidal Aero Zn-Ni	None	Cd Tank Plated Repair	96%	89%
4130 Steel	Sifco 4018 Zn-Ni	Sifco 2023	Bare Steel	43%	NA
			Zn-Ni Tank Plated Repair	81%	73%
			Cd Tank Plated Repair	16%	21%
1008 Steel	Sifco 4018 Zn-Ni	Sifco 2023	Bare Steel	26%	NA
			Zn-Ni Tank Plated Repair	75%	70%
			Cd Tank Plated Repair	12%	36%
4130 Steel	Sifco 2023 Cd	Sifco 5030	Zn-Ni Tank Plated Repair	57%	41%
			Cd Tank Plated Repair	57%	0%
1008 Steel	Sifco 2023 Cd	Sifco 5030	Zn-Ni Tank Plated Repair	94%	91%
			Cd Tank Plated Repair	80%	0%

As was seen from the results no platings performed well enough to meet the JTP requirement of 168 hr of SO_2 exposure without red rust. The Zinidal Aero Zn-Ni appears to perform worse than the Sifco 4018 Zn-Ni and Sifco 2023 Cd platings, however full conclusions cannot be made. If

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this is a critical requirement additional testing should be performed at lower exposure intervals potentially starting at 36 hr of exposure.

6.11 Galvanic Corrosion

Galvanic corrosion testing was performed per GMW 14872 for 120 cycles. After testing all specimens were rinsed, dried, and photographed. The percentage of red rust in both the tank plating and brush plating regions were found using an image processing software (ImageJ). The masked area and fasteners were excluded from this analysis. The rust percentages were compared to determine if the Zinidal Aero solution preformed equivalent to the control specimens.

Figure 67 shows a box plot of the percentage of red rust for the fully brush plated specimens with Cd fasteners. The plot was created in Minitab. Both 1008 and 4130 steel are shown. The average red rust percentage is labeled. As can be seen in the figure the Zinidal Aero Zn-Ni with and without the Passivateur N°3 conversion coating performed almost well as the Sifco 2023 Cd brush plating and only a small amount of corrosion on 4130 steel was observed. The Sifco 4018 Zn-Ni showed no corrosion on 4130 steel but exhibited an average of 11.41% of red rust over the plated area of the specimens.

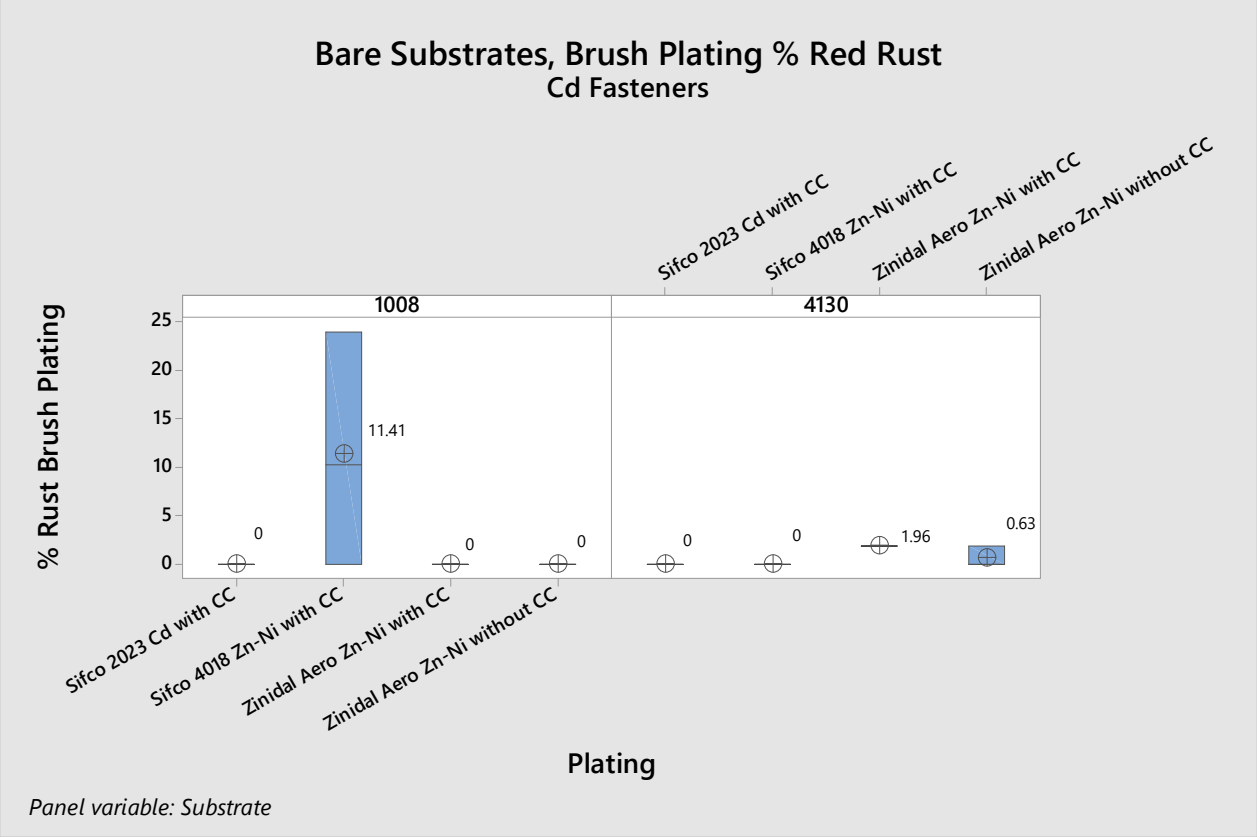

Figure 67. Percent Red Rust for Brush Plated Specimens with Cd Plated Fasteners

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Figure 68 shows a box plot of the percentage of red rust for the fully brush plated specimens with stainless steel fasteners. The plot was created in Minitab and both 1008 and 4130 steel are shown. The average red rust percentage is labeled. As can be seen in the figure the Zinidal Aero Zn-Ni performed well for both the 1008 and 4130 steels. Only a small percentage of red rust was observed. The Sifco 2023 Cd brush plated specimens exhibited no red rust on 1008 steel specimens, but an average of 6.6% red rust on 4130 steel specimens. Both the Zinidal Aero Zn-Ni and Sifco 2023 Cd performed better than the Sifco 4018 Zn-Ni which exhibited an average of 15.62% and 5.69% red rust on 1008 and 4130 steels respectively. It should be noted that the 4130 Zinidal Aero Specimens with the Passivateur N°3 conversion coating exhibited masking failures that led to inaccurate grading. They are not included in this analysis, however they would be expected to perform better than the specimens without a conversion coating.

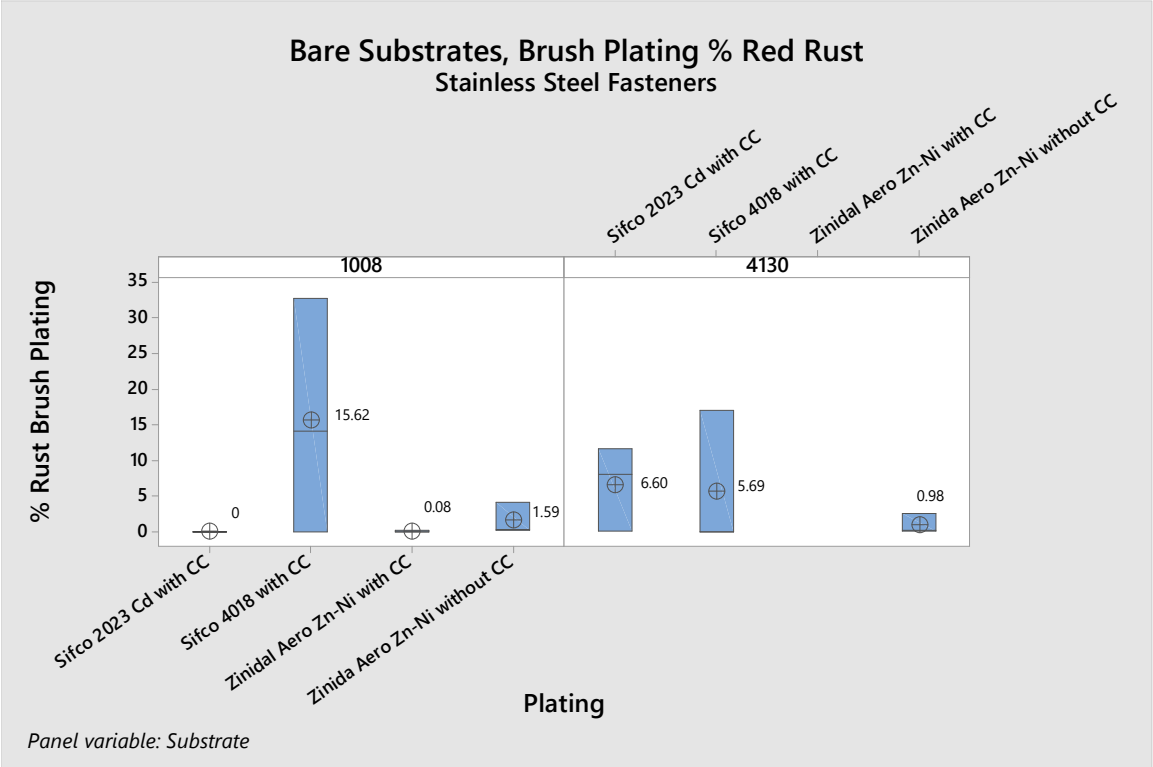

Figure 68. Percent Red Rust for Brush Plated Specimens with Stainless Steel Fasteners

Figure 69 and Figure 70 show a box plot of the percentage of red rust for the tank plated Cd repair specimens with Cd plated and stainless steel fasteners. The plot was created in Minitab and both 1008 and 4130 steel are shown as well as the percentage of red rust in the brush plated repair region and tank plated region. The average red rust percentage is labeled. As can be seen in the figures very little red rust was observed for all conversion coated specimens and they all can be considered to have performed equally. The only specimens that exhibited red rust were the Zinidal Aero Zn-Ni specimens without a conversion coating which showed very little red rust for the 1008 steels, but showed red rust in both the brush repair and tank plated regions of the 4130 specimens.

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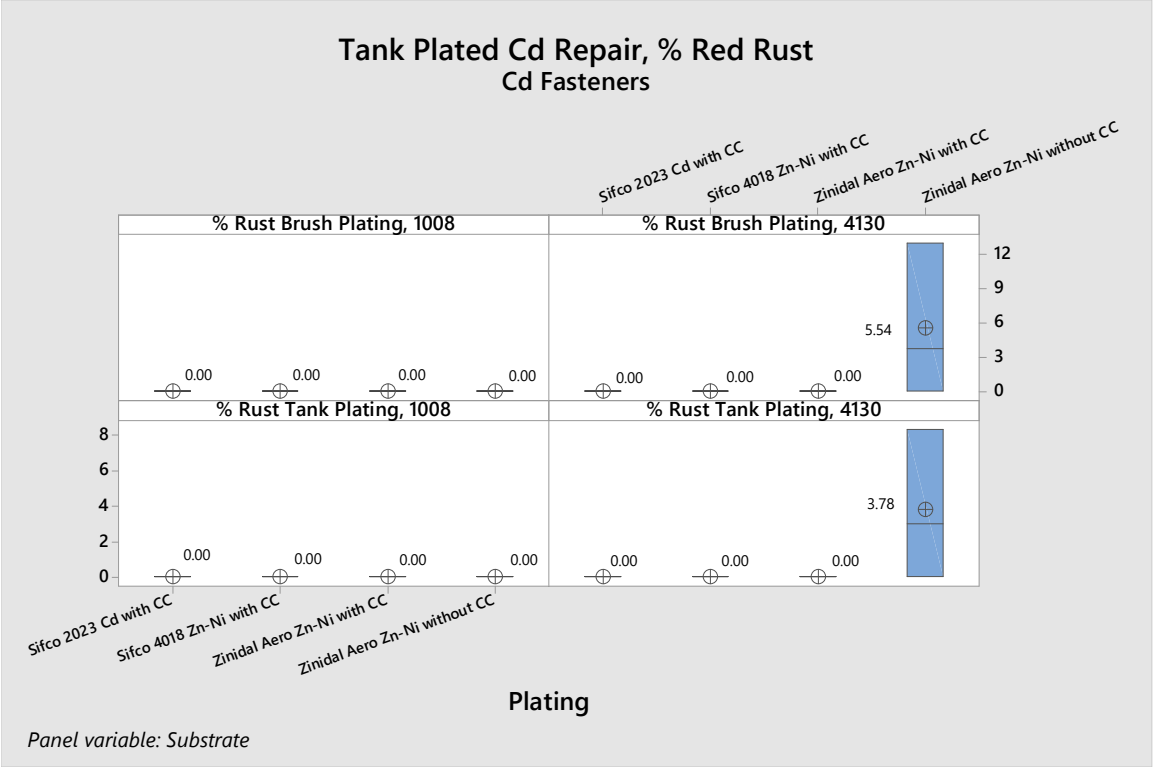

Figure 69. Percent Red Rust for Cd Tank Plated Repair Specimens with Cd Plated Steel Fasteners

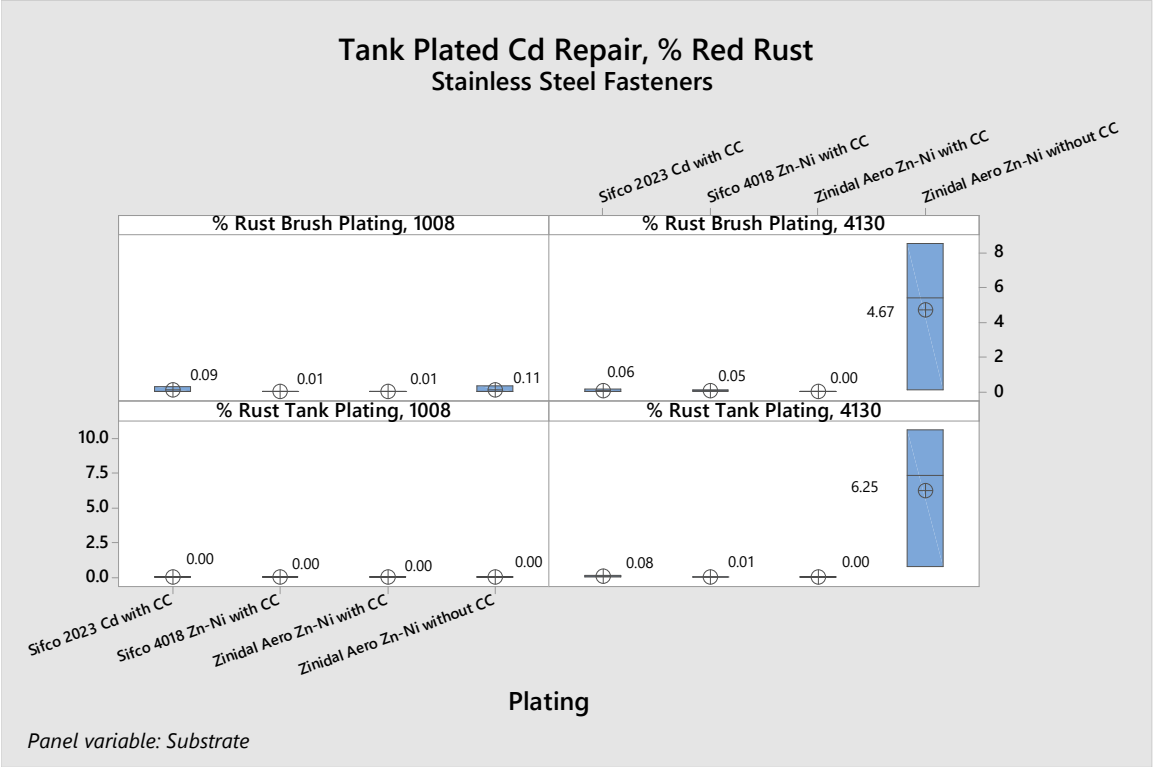

Figure 70. Percent Red Rust for Cd Tank Plated Repair Specimens with Stainless Steel Fasteners

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Figure 71shows a box plot of the percentage of red rust for the tank plated Zn-Ni repair specimens with Cd plated fasteners. The plot was created in Minitab and both 1008 and 4130 steel are shown as well as the percentage of red rust in the brush plated repair region and tank plated region. The average red rust percentage is labeled. It can be seen from the figure that no red rust was seen on any conversion coated specimens and only a minor amount of red rust was observed for the Zinidal Aero Zn-Ni specimens on 1008 steel without a conversion coating. It should be noted that the 1008 Zinidal Aero Specimens with the Passivateur N°3 conversion coating exhibited masking failures that led to inaccurate grading. They are not included in this analysis.

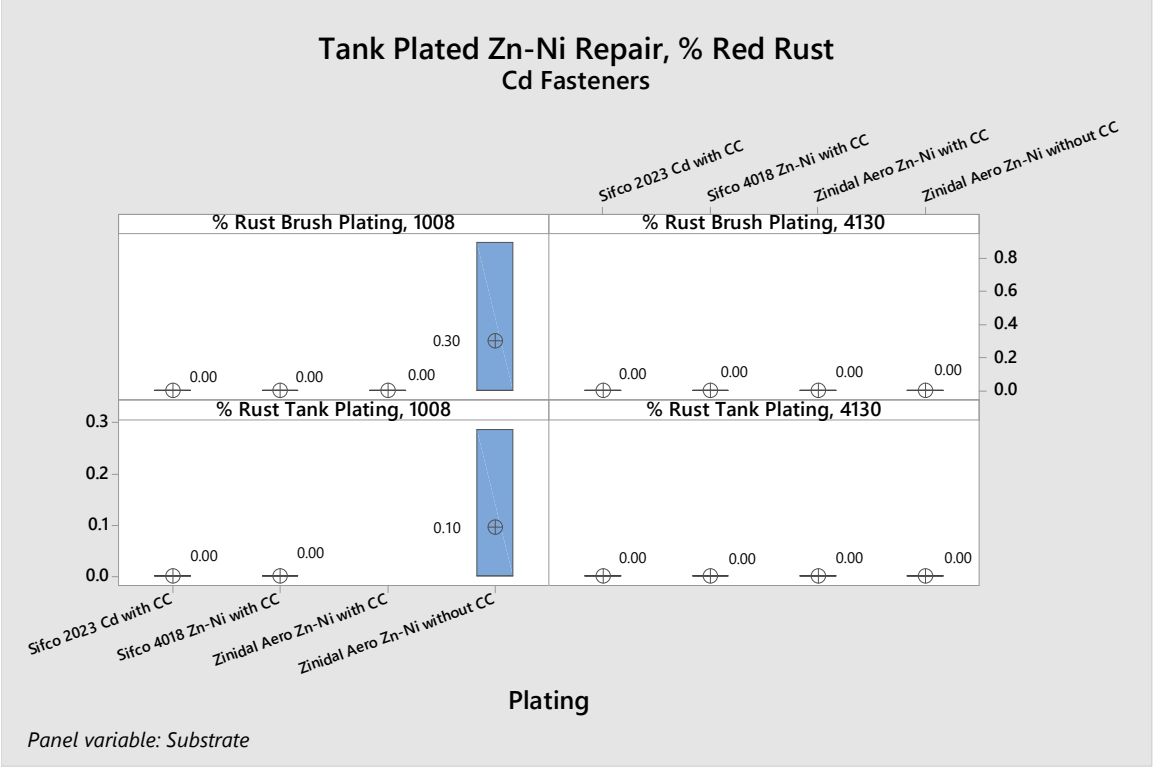

Figure 71. Percent Red Rust for Zn-Ni Tank Plated Repair Specimens with Cd Plated Steel Fasteners

Figure 72 contains a box plot of the percentage of red rust for the tank plated Zn-Ni repair specimens with Cd plated fasteners. The plot was created in Minitab and both 1008 and 4130 steel are shown as well as the percentage of red rust in the brush plated repair region and tank plated region. The average red rust percentage is labeled. It can be seen from the figure that very little red rust was observed for the platings with conversion coatings. The Zinidal Aero Zn-Ni specimens without the Passivateur N°3 conversion coating had an average of 19.7% red rust on 1008 steel specimens in the brush plated repair region, and an average of 4.29% red rust in the tank plated region. The Zinidal Aero Zn-Ni specimens without the Passivateur N°3 conversion coating had less red rust on 4130 steel specimens, an average of 6.65% on brush plated repair regions, and an average of 0.9% on tank plated regions. Again it should be noted that the 1008 Zinidal Aero Specimens with the Passivateur N°3 conversion coating exhibited masking failures that led to inaccurate grading. They are not included in this analysis.

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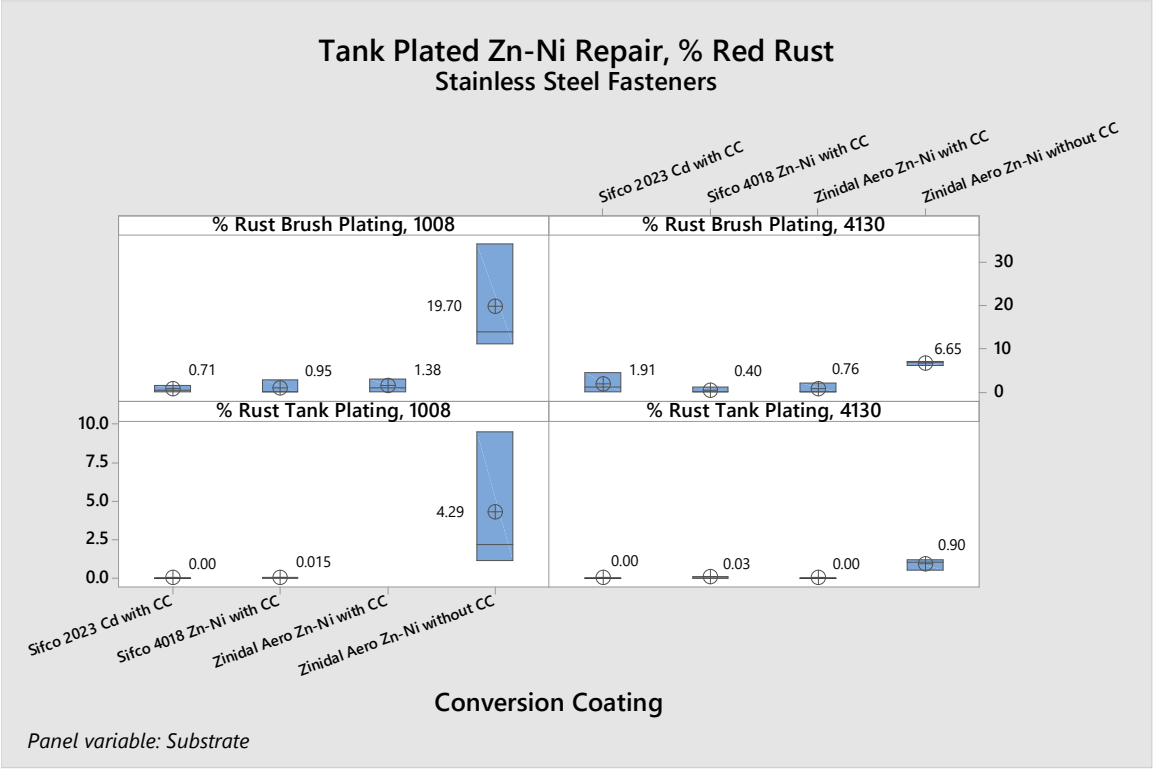

Figure 72. Percent Red Rust for Zn-Ni Tank Plated Repair Specimens with Stainless Steel Fasteners

The Zinidal Aero Zn-Ni with the Passivateur N°3 conversion coating performed as well as the Sifco 2023 Cd control specimens in the galvanic corrosion testing. It also outperformed the Sifco 4018 Zn-Ni plating.

6.12 OUTDOOR EXPOSURE TESTING

Outdoor exposure testing was an additional test which was not a part of the JTP. This testing was used to determine the real world performance of the brush platings in severe environments. NASA's Kennedy Space Center Beachside Atmospheric Corrosion Test Site was chosen due to the location's Environmental Severity Index Rating of Severe and well documented environmental conditions. The specimens were tested for two years. Figure 73 and Figure 74 show the initial set up of the plated specimens and the specimens after two years of exposure respectively. The 4130 steel specimens are on the left and the 1008 steel specimens are on the right. The top row contains the Sifco 2023 Cd brush plated specimens with a Sifco 3002 conversion coating. The second row contains the Zinidal Aero Zn-Ni specimens without a conversion coating. The third row contains the Sifco 4018 Zn-Ni Specimens with a Sifco 5030 conversion coating. The last row contains the Zinidal Aero Zn-Ni specimens with the Passivateur N°3 conversion coating. As can be seen in Figure 74 there is no sign of red rust after two years of exposure.

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Figure 73. Initial Outdoor Exposure Specimen Picture

Figure 74. Outdoor Exposure Specimens after 2 years Exposure

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Figure 75 through Figure 82 show closer views of the specimen group. No corrosion is seen on any of the specimens and they have performed well. Some specimens exhibited a masking failure and green masking tape was applied. Red rust can be seen on several specimens due to masking failures which were not considered a failure in this analysis.

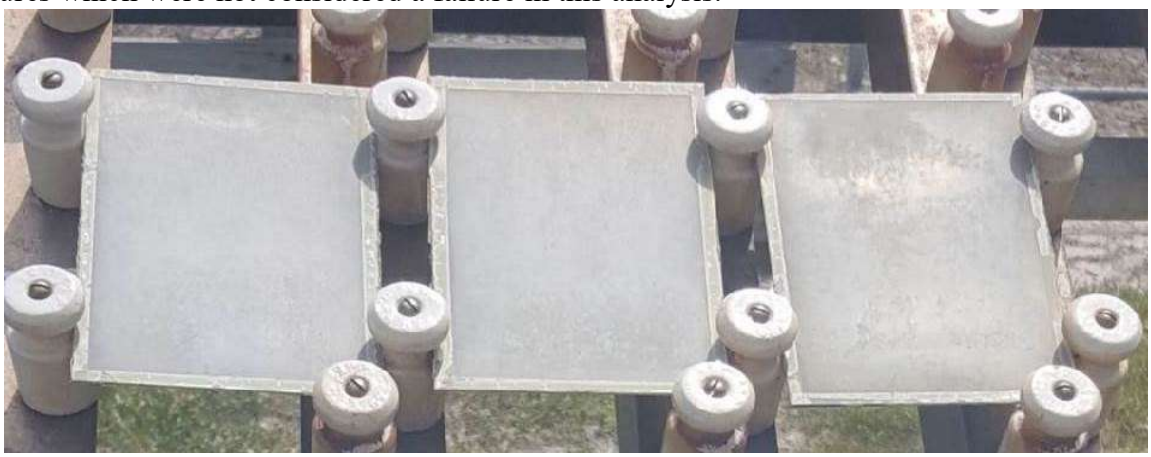

Figure 75. Sifco 2023 Brush Plated Cd Specimens, 4130 Steel

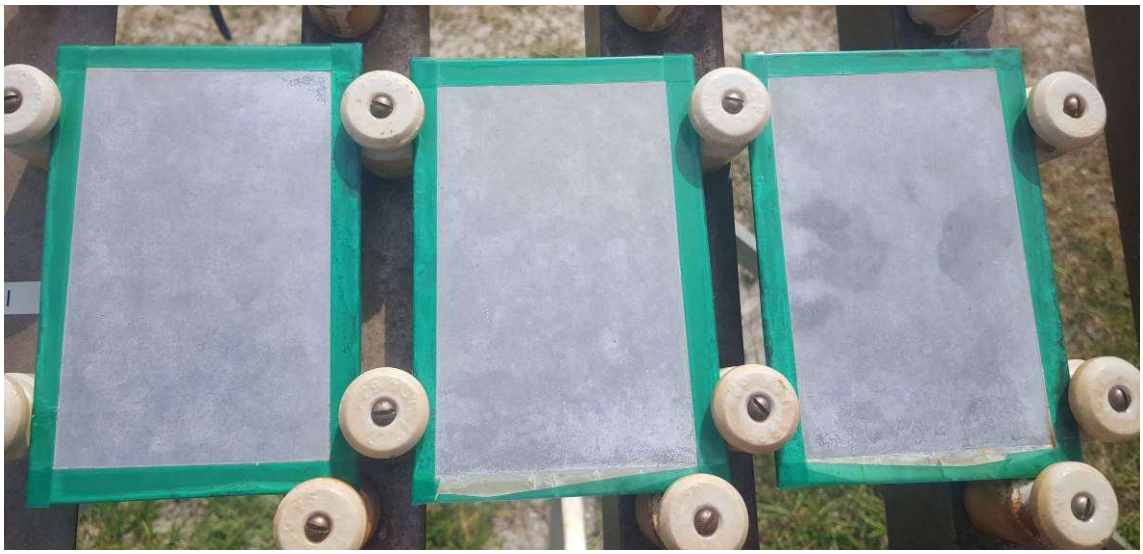

Figure 76. Zinidal Aero Zn-Ni Specimens without Conversion Coating, 4130 Steel

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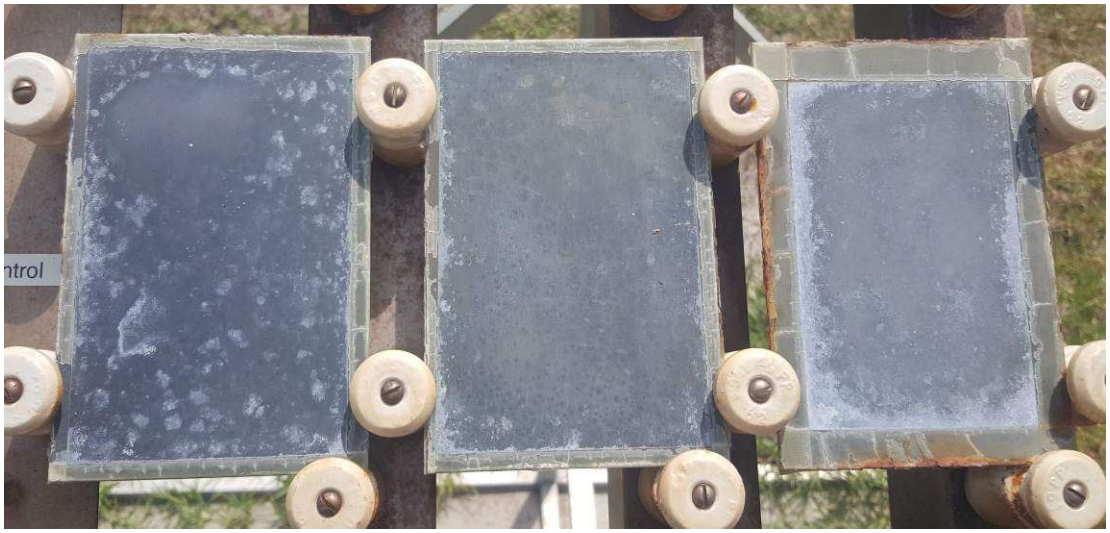

Figure 77. Sifco 4018 Brush Plated Zn-Ni Specimens, 4130 Steel

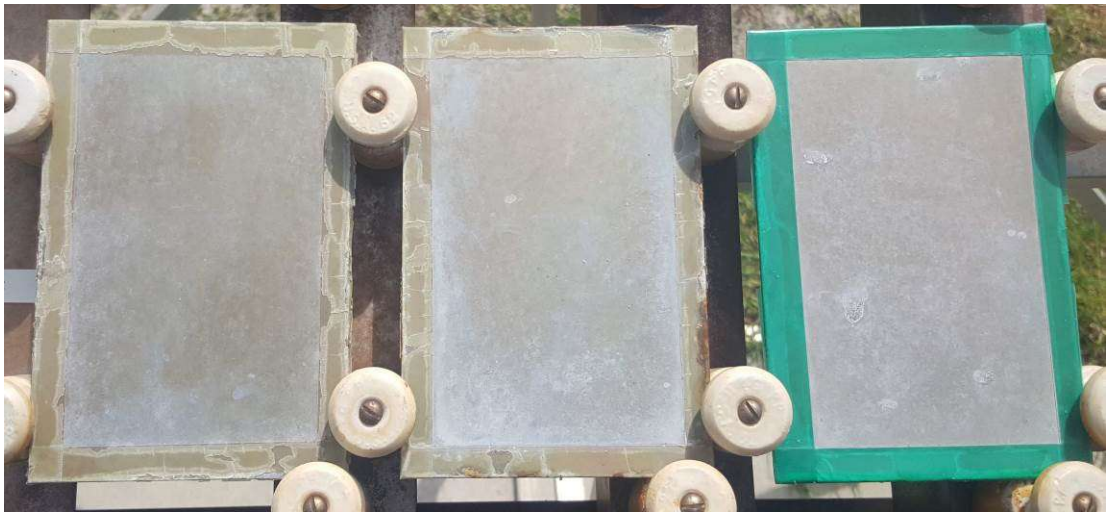

Figure 78. Zinidal Aero Zn-Ni Specimens with Conversion Coating, 4130 Steel

Figure 79. Sifco 2023 Brush Plated Cd Specimens, 1008 Steel

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Figure 80. Zinidal Aero Zn-Ni Specimens without Conversion Coating, 1008 Steel

Figure 81. Sifco 4018 Brush Plated Zn-Ni Specimens, 1008 Steel

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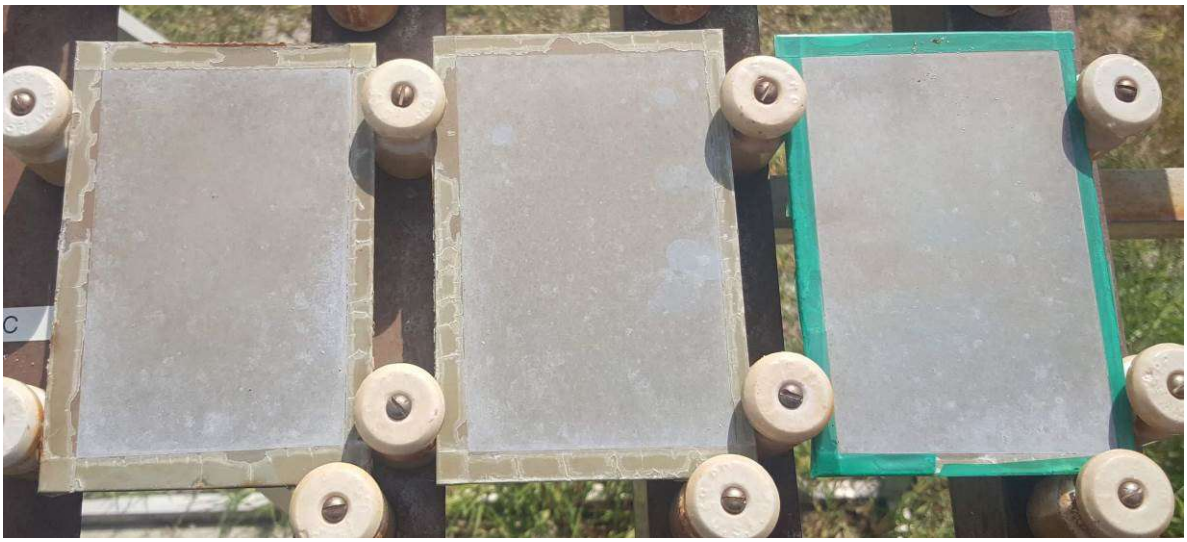

Figure 82. Zinidal Aero Zn-Ni Specimens with Conversion Coating, 1008 Steel

7.0 TECHNOLOGY DEMONSTRATION

7.1 Objective of the Demonstration

The technical objectives for the demonstration and implementation of the Dalistick® Station (Dalic Inc.) were as follows.

1. Demonstrate the usefulness of the Dalistick® D.2020 (Dalic Inc.) commercial-off-the-shelf (COTS) brush plating tool for selective plating for DoD maintenance, repair and overhaul operations.

2. Test and evaluate the Zinidal™ Aero Zn-Ni brush-plated coating (by Dalic Inc.) COTS material as a Cd replacement on mild and high-strength steels for repair applications on several decommissioned weapon system parts. (T-45 arresting hook pivot assembly, F-18 arresting hook pivot assembly, and F-18 arresting hook shank)

This technology was demonstrated at the North American Distributor of the Dalistick station, Corrdesa LLC, located in Tyrone GA. Representatives from the Fleet Readiness Center Southeast (FRCSE) at the Naval Air Station in Jacksonville, FL were present during the demonstration and provided the parts for the plating demonstration.
FRCSE uses conventional brush plating for aircraft maintenance and repair within their plating facilities, following QQ-P-416 and MIL-STD-865D in their application procedures. Brush plating is used to primarily repair high strength and low strength steel items, such as tail hooks, on the P-3 Orion, T-45 Goshawk Trainer, F/A-18A-D Hornets, F/A-18 E/F Super Hornets EA-6B Prowler, and SH-60 Seahawk.

The repairs were logged in order to provide insight into the usefulness of the station to DoD brush plating repair operations. The log contained the following information.

- Operator
- Repair description

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- Ease of repair
- Quality of repair
- Ergonomics
- Consumables used
- Issues/errors

7.2 Demonstration Design

Figure 83. Demonstration Parts shows the decommissioned high strength steel parts provided by FRCSE for the demonstration. The F-18 pivot assembly is coated in IVD aluminum, while the T-45 launch bar and T-45 pivot assembly are tank plated with Zn-Ni. Multiple locations on each part were stripped of their coatings to simulate repair areas and plated using the Dalistick D.2020 station. These areas can be seen in
Figure 84, Figure 85 and Figure 86. The areas chosen were selected to determine the functional limits of areas where the station and tools could reliably plate.

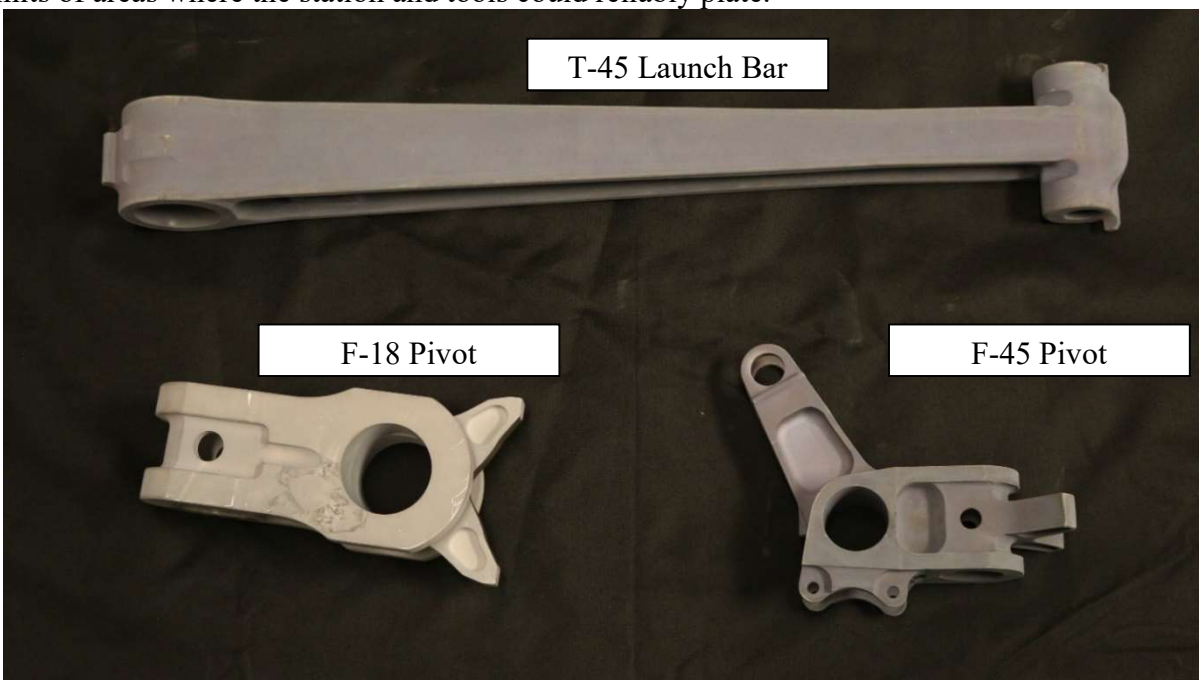

Figure 83. Demonstration Parts

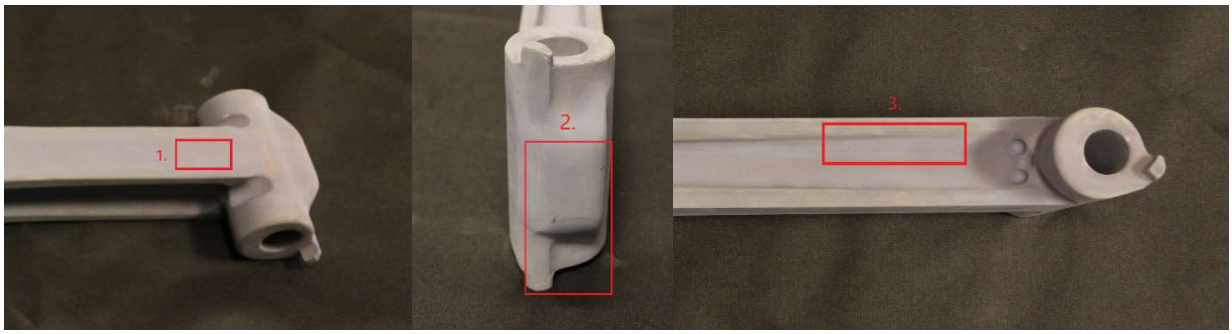

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Figure 84. T-45 Launch Bar Repair Locations

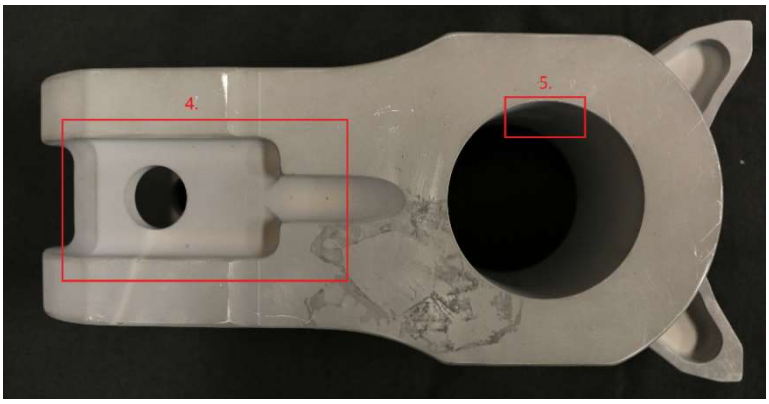

Figure 85. F-18 Pivot Assembly Repair Locations

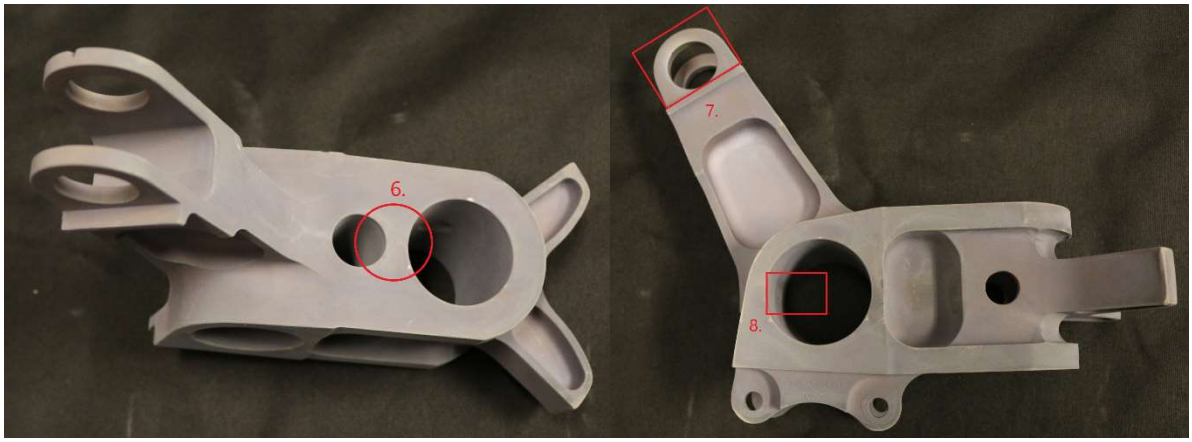

Figure 86. T-45 Pivot Assembly Repair Locations

All plating was performed UDRI and checked by representatives from FRCSE and AFLCMC/EZP. Plating quality was checked by performing tape adhesion testing. Plating thickness was not confirmed in curved areas, or areas where a coating thickness gauge could not reach (areas 3, 5, 7, and 8).

7.3 Demonstration Results

Zinidal Aero Zn-Ni plating using the Dalistick D.2020 station proved to be capable of plating quality small area repairs on both IVD aluminum and Zn-Ni tank plated high strength steel components. The demonstration was designed to push the limits of the existing tools and station due to the complexity of repairs chosen. Overall the station and tools performed well on all but the smallest radii and inside corners. Tool size and shape was the limiting factor on being able to reach these difficult areas. During plating some dripping of solutions was observed, especially in areas with through holes which were not masked. This limitation can likely be overcome through better masking strategies. The full WP-201412 Demonstration Report can be found in the Appendix.

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8.0 COST ASSESSMENT

8.1 COST MODEL

The Defense Acquisition Guidebook (DAG) requires program managers to consider sustainability in acquisition and select more sustainable systems, i.e., systems that meet performance requirements; have fewer negative impacts on resource availability, climate change, human health, ecosystem quality; and has a lower total ownership costs (TOC). The Office of the Deputy Under Secretary of Defense for Installations & Environment (DUSD (I&E)) has developed a framework and draft guidance document for performing a Sustainability Analysis, which integrates life cycle cost (LCC) estimating and life cycle assessment (LCA). The LCC estimate quantifies the financial internal cost to DoD. LCA quantifies natural resource requirements and environmental releases through each life cycle stage of a system and evaluates the following resulting impacts:

- **Resource Availability:** Evaluates the potential impact of natural resource use (e.g., land, water, mineral, and fossil resources) on resource quality and availability.
- **Climate Change**: Evaluates the contribution of greenhouse gas (GHG) emissions to global warming and the associated potential impacts, including changes in net agricultural productivity, human health, flood risk, and ecosystem services.
- **Human Health**: Evaluates the potential impact of environmental releases (other than GHG emissions), water use, and noise emissions on human health and productivity.
- **Ecosystem Quality**: Evaluates the potential impact of environmental releases (other than GHG emissions), land use, and water use on biodiversity and ecosystem services.

These impacts are monetized to estimate the external cost to society. At this time, the DoD Sustainability Analysis framework does not consider impacts from occupational illnesses, injuries, and fatalities.

This Sustainability Analysis was performed by Noblis and is based on the selective electroplating throughput at Warner Robins Air Logistics Complex (WR-ALC). Part and throughput information obtained from Warner Robins Air Logistic Complex (WR-ALC) Commodities Maintenance Group (CMXG) plating technicians from a previous CBA was used to define two representative parts for the cost model analysis.

The study assumed a 15-year life and that WR-ALC would either replace the Cd brush plating equipment or purchase the Dalistick station at the start of the study period. All costs are evaluated in 2014 USD. This sustainability analysis report produced by Noblis can be found in the Appendix

8.2 COST ANALYSIS AND COMPARISON

The sustainability analysis developed by Noblis was not after the technology demonstration. The findings from the demonstration do not show any changes are required at this time. The

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sustainability analysis report can be updated by any user with more specific process data to determine the life cycle costs of a given process.

9.0 IMPLEMENTATION ISSUES

9.1 INDUSTRIAL HEALTH RISK ASSESSMENT

An industrial health risk assessment (IHRA) was completed for the Zinidal Aero Zn-Ni solution as plated with the Dalistick station. The objective of this industrial health risk assessment (IHRA) document is to compare the solutions used in the baseline Cd traditional brush plating process and the alternative Dalistick-applied Zinidal Aero Zn-Ni process in terms of work environment requirements and environmental, health, and safety (EH&S) regulations. Within this IHRA document, the solution properties, EH&S considerations, deposited alloy properties, and assessment of individual components of the baseline and alternative plating solutions are discussed. The IHRA is attached in the Appendix.

9.2 RELIABILITY ISSUES

9.2.1 Station Failure

On 25 Jan 17 the Dalistick 2020 station experienced the following issues while plating test specimens:

- Sporadic counting of the mAh and timer
- Temperature notification/ Air flow errors
- Temperature jumping between 23 and 0 degree C
- Error messages regarding communication of the temperature controller

With these issues the station could not be operated. Dalic Inc. was contacted, and the initial troubleshooting was performed remotely. After unsuccessful repair attempts, the rectifier, computer, Zn-Ni pump, and tanks were shipped to France on 13 Feb 17 for repairs. There were multiple issues with UPS and French Customs, which caused the station to be delivered to Dalic Inc. on 9 Mar 17. Dalic Inc. sent replacement components to UDRI, which arrived at UDRI on 20 Apr 17.

9.2.1.1 Station Validation

The replacement Dalistick 2020 station operability was validated. The following tests were used to determine if the station was plating specimens properly.

- Zinc and nickel composition (three 4130 steel and three 1008 steel)
- Bend Adhesion (three 4130 steel and three 1008 steel)
- Thickness (all specimens)
- Appearance (all specimens)

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The replacement station passed all of the validation testing and was returned to service. A summary of the results can be found in the Appendix.

9.2.2 Zn-Ni Pump Shutdown

On 28 April 17 The Zn-Ni pump turned off while plating at 136.175 mAh when it needed to reach 219.23 mAh. The pump was turned back on manually and the plating was continued. After completing the Zn-Ni process, the specimen failed the tape test. The thickness of the panel passed at 9.59. No error messages were present. This was a one time issue.

9.2.3 Software Issue

On 28 Nov 16 the Dalistick software would not open on the Dalistick 2020 station. Dalic Inc. remotely troubleshot the issue and determined the software was likely corrupted by abruptly losing power to the station. The moment the station lost power was not able to be determined. Two revisions of software were sent to repair this issue. The second revision installed in the station on 16 Jan 17 repaired the failure.

9.3 IMPLEMENTATION ISSUES

No major implementation issues were learned during the technology demonstration. and were documented in the WP-201412 Demonstration Report which can be found in the Appendix.

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9.0 REFERENCES

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2. Air Force Drawing 201027457, Solutions for Use in LHE Zinc-Nickel Plating on High Strength Steel Substrate (>180 ksi) Landing Gear Components (May 2012)
3. AMS-QQ-P-416 Plating, Cadmium (Electrodeposited) (2009)
4. ASTM B 117 Standard Practice for Operating Salt Spray (Fog) Apparatus (2011)
5. ASTM B 530 Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates (2014)
6. ASTM B 568 Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry (2014)
7. ASTM B 571 Standard Practice for Qualitative Adhesion Testing of Metallic Coatings (2013)
8. ASTM D 1014 Standard Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates (2009)
9. ASTM D 1654 Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments (2008)
10. ASTM D 3359 Standard Test Methods for Measuring Adhesion by Tape Test (2009)
11. ASTM F 519 Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments (2013)
12. ASTM G 85 Standard Practice for Modified Salt Spray (Fog) Testing (2011)
13. BAC 5637 Zinc Nickel Alloy Plating (2008)
14. BAC 5664 Low Hydrogen Embrittlement Stylus Zinc-Nickel Alloy Plating (2005)
15. BSS 7235 Adhesion Test Method, Plating (1987)
16. GMW 14872 General Motors Accelerated Corrosion Test Method (2013)
17. MIL-PRF-23377J Performance Specification, Primer Coatings: Epoxy, High-Solids (2005)
18. MIL-PRF-32239A Performance Specification, Coating System, Advanced Performance for Aerospace Applications (DRAFT May 2014)
19. MIL-PRF-85285E Performance Specification, Coating: Polyurethane, Aircraft and Support Equipment (2012)
20. MIL-PRF-85285J Performance Specification, Coating: Polyurethane, Aircrft and Support Equipment (2012)
21. MIL-STD-870 Military Standard, Cadmium Plating, Low Embrittlement, Electro-deposition (2007)
22. Resource Conservation and Recovery Act (1974)
23. SAE AMS 2451/9; Plating, Brush, Zinc-Nickel, Low Hydrogen Embrittlement (September 2012)

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APPENDICES

Appendix A: Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone Fax E-mail	Role in Project
Randy Straw	AFLCMC/EZP	937-255-7730; randall.straw@us.af.mil	Principal Investigator
Chris Venturella	UDRI	937-229-3407 Christopher.venturella@udri.udayton.edu	Technical Execution

Appendix B: Operational Requirements Assessment

Operational Requirements Assessment

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ACRONYMS, ABBREVIATIONS, AND NOMENCLATURE

"	inch
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
A	amp
ACGIH	American Conference of Government Industrial Hygienists
Cd	cadmium
COTS	commercial-off-the-shelf
Cr	Chromium
dBA	decibels
DoD	Department of Defense
DC	direct current
EN	European norm
EPA	Environmental Protection Agency
GB	Gigabytes
GHz	Gigahertz
HSS	high-strength steels
IPA	Isopropyl alcohol
kg	kilogram
kHz	kilohertz
lbs	pounds
I/O	input/output
mm	millimeter
MEK	Methyl ethyl ketone
MRO	Maintenance, repair, and overhaul
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Association
PPE	personal protective equipment
psi	pounds per square inch
PVC	polyvinyl chloride
RAM	random access memory
RPM	revolutions per minute
SQL	Structured Query Language
UCDK	Unit, temperature regulation unit
USAF	Unites States Air Force
U. S.	United States
V	volt
W	watt
Zn-Ni	zinc-nickel

EXECUTIVE SUMMARY

Because Cadmium (Cd) is classified as a carcinogen, and long-term exposure has been linked to lung cancer and kidney disease, it has been highly scrutinized by the United States (U.S.) Environmental Protection Agency (EPA), the National Institute of Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the American Conference of Government Industrial Hygienists (ACGIH), with regulations on its use being imposed or recommended by many of these organizations. Nevertheless, Cd is extensively used in plating operations to enhance corrosion resistance and cathodic protection on United States Air Force (USAF), as well as Navy and Army, weapon systems. Maintenance, repair, and overhaul (MRO) operations are required to address Cd coatings for field plating repairs. In efforts to reduce the use of Cd throughout USAF and Department of Defense (DoD) operations, various potential alternative processes have been evaluated. One such technique is a novel brush plating tool named the Dalistick® Station, hereafter referred to as the "Dalistick." The Dalistick is a commercial-off-the-shelf (COTS) tool that can be used to electrochemically (i.e., brush plating) apply Zinidal Aero (Code 11040), a zinc-nickel (Zn-Ni) coating. During a recent evaluation sponsored by the USAF, the Dalistick-applied Zinidal Zn-Ni coating, as well as rust removal and coating removal via the Dalistick Station, was evaluated for use on high-strength steels (HSS).

This document has been assembled by Concurrent Technologies Corporation to provide an Operations Planning Assessment for DoD institutions considering the procurement and implementation of the Dalistick Station and the associated pretreatments and Zinidal Zn-Ni coating process. The primary objective of this document is to provide in a single location for ease of reference:

- A physical and functional description of the system and its subsystems,
- Information related to the chemical solutions that are associated with its use for this primary Cd replacement application (including solution components and associated hazards, handling and storage considerations),
- Facility requirements for use of the system,
- Regulatory, safety, and occupational health considerations and requirements,
- Necessary environmental controls for equipment use,
- Ancillary equipment/miscellaneous supplies list,
- Procurement and warranty documentation, and
- Maintenance requirements.

Note that an assessment of the system by new operators also has been conducted and provided for reference and consideration when procuring a similar system.

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1.0 BACKGROUND

1.1 Introduction

Cadmium (Cd) is widely used in the aerospace industry and the Department of Defense (DoD) because it imparts excellent corrosion resistance, adhesion, and lubricity characteristics. Brush electroplating (e.g., brush plating) is used to repair worn and corroded parts often in situ (i.e., while still installed on the aircraft). This project is evaluating a zinc-nickel (Zn-Ni) repair coating applied using a closed loop brush plating tool that recycles at point of application, which minimizes operator exposure to chemicals and solid waste associated with adsorbents used to contain solution leakage attributed in traditional brush plating.

1.2 Objective

The focus of this project is to eliminate the use of Cd in brush plating repair operations and minimize solid and liquid hazardous waste generation associated with conventional brush plating. Specifically, this project will:

1. Demonstrate the use of a commercial-off-the-shelf (COTS), closed loop brush plating tool, the Dalistick® Station (manufactured by Dalic SAS Inc.), for selective plating, while ensuring the safety and cost effectiveness of the technology for DoD maintenance, repair and overhaul operations.

2. Test and evaluate COTS material, Zinidal Aero Zn-Ni brush-plated coating (by Dalic Inc.), as a Cd replacement on mild and high-strength steels for repair applications on weapon system parts and components (landing gear, landing gear doors, terminal assemblies, bushings, etc.)

2.0 System Description

2.1 Physical and Functional Description of Dalistick Station

The Dalistick Station (shown on cart in Figure 1) is manufactured by Dalic, Inc. (Vitre, France) and distributed by Corrdesa LLC (Newnan, Georgia, U.S.) [Dalistick North American agent]. The Dalistick Station 2020 was the specific model chosen for use in this program. In general, the Dalistick Station technology is a portable, closed loop, brush plating unit that recycles electrochemical treatment solutions at the point of contact to dramatically reduce or eliminate operator exposure to hazardous chemicals, reduce solid and liquid hazardous waste generation, and reduce chemical consumption. It can be used to conduct a variety of selective plating operations (e.g., Cd, chromium [Cr], Ni, Zn-Ni, etc.), anodizing operations, as well as surface preparation (e.g., activation, rust removal, and coating removal). Its portability and clean operation enable safe use in a controlled environment or in the field including use on complicated surfaces (edges, curved, inclined

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surfaces), in situ parts, and inverted areas (e.g., overhead). Small volumes of solution are used in treatments and limited masking is required.

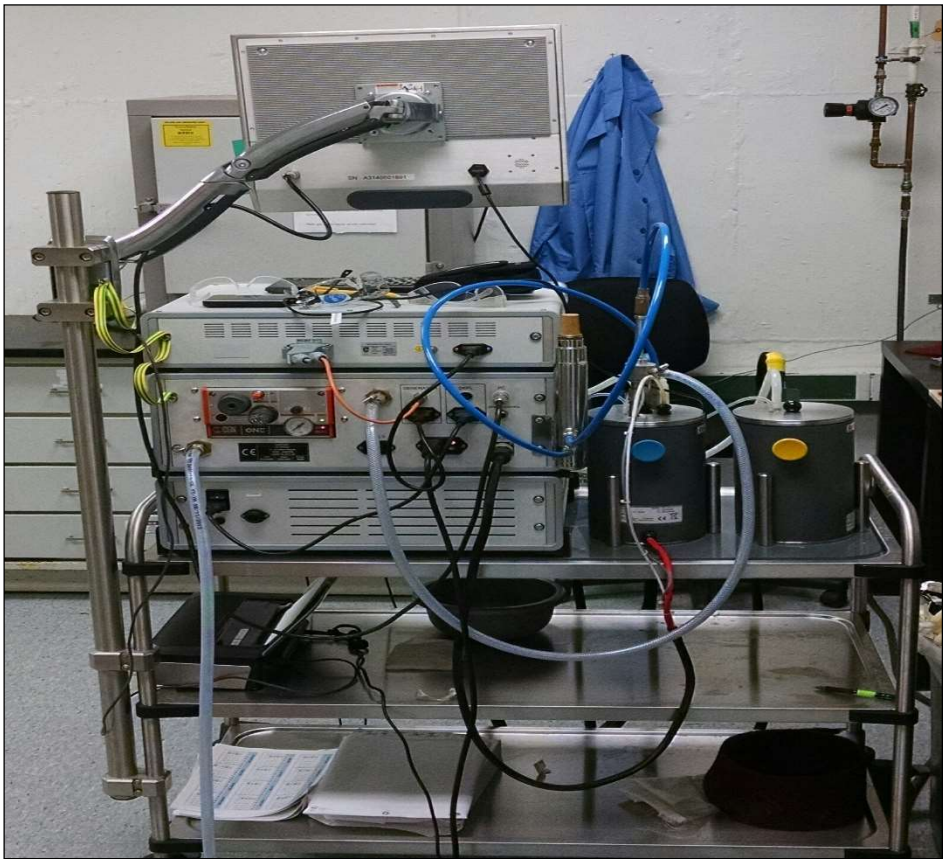

Figure 87. Dalistick 2020 on Cart

General information about the Dalistick D.2020 System, heretofore referred to as the Dalistick Station unless related to the specific model, and its ancillary parts is summarized in Appendix A for ease of reference as well as described in the sections to follow.

2.1.1 Dalistick Station Subsystem Description

The Dalistick Station combines a control pack, a temperature regulating unit, a power pack (i.e., a rectifier), the Dalipump (i.e., circulation unit including the tool – anode), and a trolley. Each subsystem and its features are explained below:

Control Pack Features

- 17 inch (”) Touchscreen, uses Microsoft Windows 7 Ultimate software, 4 gigabytes (GB) of random access memory (RAM), Hard Drive: 300GB, Processor: Intel® Atom™ CPUD525 at 1.80 Gigahertz (GHz); 64-bit operating system, and Microsoft Structured Query Language (SQL) Server, printer

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Dimensions: 432 millimeter (mm) x 358 mm x 68 mm (~17” x 14” x 2.7”)
Weight: 8.8 kilograms (kg) (19.4 pounds [lbs])

Features:
- Dampproof – Nema 4.1P65.66.67.68
- Shockproof – hardened with Kevlar
- Ergonomically friendly and adaptive – articulated arm
- Glove friendly – resistive technology enables use with gloved hands
- Remote control ability

Inputs:
- Surface treatment to be conducted (e.g., plating and metal type, anodizing, pretreatment)
- Client (e.g., for whom the work is being performed)
- Substrate – material to which the treatment is being applied
- Tool type – such as Dalistick
- Range being followed (e.g., specific client inputs)[16]
- Part reference and designation (part identification and specific region being treated)
- Surface area being treated

Temperature Control Unit

Possesses tank and air cooling system
Dimensions: 160 mm d x 520 mm high (h) (~6.3” deep [d] x 20.5” long [l])
Weight: 8.8 kg (18.9 lbs)
Features:
- Regulates solution temperature from 0 to 50 degree(s) Celsius (°C)
- 250 watt (W) heater
- Detects critical level of electrolyte
- Compressed air regulation with oil separator
- Vortex air cooling

Inputs:
- 250 W heating
- 7 bar (100 pounds per square inch [psi]) air

Power Pack

Possesses 1000 W power generator
Dimensions: 120 mm x 530 mm x 400 mm (~4.7”x 20.9 x 15.8”)
Weight: 10.7 kg (23.5 lbs)
Features:
- Control communication via RS485 mode
- Auto-protection
- Pulse width adjustment – 66 kilohertz (kHz)

[16] In the D.2020 station several possible ranges (treatment, maintenance and cleaning) are possible. For example, in a treatment range, all the steps are provided to describe what an operator must do, and automatic computer calculations are performed to establish flow rate of solution and current necessary to reach the targeted thickness.

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Mode modification – normal for plating, reverse for anodizing
Adjustable voltage and amperage – 0 to 10 amps (A) and 0 to 50 volt (V)

Inputs:
Voltage or amperage, depending on treatment

Dalipump and Associated Parts

Possesses closed loop pumping system, flow meter, and platinized dalistick tool (e.g., cathode or anode, depending on mode)
Dimensions: 230 mm x 530 mm x 400 mm (~9"x 20.9 x 15.8")
Weight: 17.5 kg (38.6 lbs)
Features:
Double head pump – 0 to 1200 revolutions per minute (rpm)
Flow – 0 to 160 L/hr
No leaking or dripping from tool head
Inputs: Developed as a result of process range selection in Control Pack

Trolley

Stainless steel construction
Dimensions: 1070 mm x 570 mm x 950 mm (42.1"x 22.4" x 37.4")
Weight: 19 kg (41.9 lbs)
Features:
Capable of carrying 80 kg/shelf (e.g.,176 lbs/shelf)
Maximum carrying capacity for entire trolley is 150 kg (330 lbs)

2.2 Chemical Solution Description

The treatment steps and associated chemicals being used in this project, with the focus of replacing Cd brush plating, include the following.

1. Degrease with acetone, rinse with water, clean with red scotch brite pad, rinse
2. Apply necessary masking
3. Etch with Activator XF and rinse with distilled[17] water
4. Plate with Zn-Ni solution (Zinidal Aero) and rinse with distilled[2] water
5. Remove masking and dry with compressed air
6. Apply chormate conversion coating (Dalic Passivator No. 3) with swab application (no need to use Dalistick tool)

The following is a technical description of the chemicals of concern in each solution. Chemicals that are lower than the minimal level of danger, as noted in the Safety Data Sheets (SDSs) are not listed herein.

- Methyl ethyl ketone (MEK) – 100% 2-butanone
- Isopropyl alcohol (IPA) – 100% 2-propanol

[17] Dalic SAS noted that city water could be used to rinse parts, but only distilled/demineralized water for rinsing out the system.

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- Activatator ST2 (Dalic, Inc.) - <5% sulfuric acid
- Activator XF (Dalic, Inc.) – weakly acidic, no hazardous components per EC regulations
- Zinidal Aero Zn-Ni Solution Product 11040 (Dalic, Inc.) – zinc chloride, nickel dichloride (1-5%), ammonium (NH_4^+; < 10%)
- Passivator No. 3 (SIFCO 5030) – Cr (VI) trioxide (< 2.5%)

Details on the handling, storage, required personal protective equipment (PPE), and regulations associated with each solution are detailed in Section 3.5.2.

3.0 FACILITY INSTALLATION AND USE CONSIDERATIONS

A general questionnaire about the use and maintenance of the Dalistick D.2020 was provided to operational personnel to execute an operational assessment. The general information that has been gathered is presented in Appendix B. Details about the installation of the system, operation, and use are provided in the sections to follow.

3.1 Facility Requirements

Because this system is relatively lightweight (i.e., approximately 100 lbs without the cart) and mobile, no significant improvements are expected to be necessary for most DoD plating facilities procuring this technology. Most DoD plating shops have ample space to negotiate movement of the cart; however, in field use will require that the current Dalistsick D.2020 have a footprint for use of approximately 100 ft^2 to enable the operator sufficient mobility around the system. No water connections are required for the system; however, air and electrical supply are necessary, as detailed in Section 3.6. No additional utility connections are needed for preventative maintenance. The system is supplied with an 8.2 ft (2.5 m) standard power supply cable and the converter is supplied with a 5 ft (1.5 m) cable. However, longer cables could be obtained, if found to be necessary.

3.2 Regulatory Considerations

The Dalistick Station meets all the requirements of the European norm (EN) 60204, which is applicable to the electrical in machines. The individual solutions used with the Dalistick Station have individual regulatory considerations that should be reviewed and updated often. For reference, the expected emissions of current chemicals of concern, Cd, chromic acid, and nickel sulfate, are identified in Section 3.5.5, including current recommended exposure limits. Additionally, Section 3.5.2 lists all chemicals that are expected to be used with the Zinidal process, including pre- and post-treatment. Some regulatory notations are provided therein.

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3.3 Safety Considerations

The Dalistick Station is designed to ensure operator safety both physically and operationally. The system physically prevents operator contact with electrolytes during metal finishing operations and the pump enclosure separates the operator from moving parts. Operationally, the station is guided by the software with integrated controls of the procedures for which the operators have been trained.

3.4 Environmental Controls

Although optimum conditions for use are established by the manufacturer as being 68 degree(s) Fahrenheit (°F) (20 °C) and 45-65% relative humidity, some additional guidelines for use are established in the sections that follow.

3.4.1 Temperature

Optimum plating temperature is approximately 68 °F (20 °C); however, Dalic also expresses concern with low or high temperature operation. Dalic SAS does not recommend using the system for plating if the temperature is below 53.6 °F (12 °C) because adhesion problems have been experienced. Similarly, the manufacturer does not recommend using the system at temperatures in excess of 122 °F (50 °C) due to potential equipment issues arising.

Conversely, the system itself generates very little heat; therefore, there is no expected impact to the ambient room temperature.

3.4.2 Humidity

As noted above, optimum relative humidity for equipment use is between 45-65%; however, Dalic does not recommend the use of equipment in high humidity atmospheres because of the potential adverse effect of humidity on the adhesion of the resulting coating. This may include high ambient humidity or even use when snowing.

3.4.3 Cleanliness

Although the moving parts of the system are enclosed, the manufacturer still recommends that the unit not be used in sandy or dusty environments or workshops with airborne oil particulates, primarily because the various particulates can have an adverse effect on adhesion of the depositing coating.

3.4.4 Noise

The sound from this unit is considered to be minimal. When measuring noise in the operator position, including use of the cooling system and pump, noise was measured at 60 to 65 decibels (dBA). This is well below the NIOSH recommended

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level of 85 dBA over 8 hr exposure or the 90 dBA permissible exposure limit set forth by OSHA. Therefore, there is no need for operator hearing protection.

3.5 Safety and Occupational Health Requirements

Safety engineering is designed into the Dalistick Station and associated equipment to prevent physical contact with harmful electrical and mechanical hazards during operation. These enclosures and interlocks reduce potential hazards at their source and must not be manipulated or removed unless directed by the manufacturer upon their supervision. Additionally, Dalic SAS recommends the use of good housekeeping practices, specifically by keeping areas clean, practicing good hygiene by operators, and not smoking or eating near plating areas. The operators always must be aware of their surroundings, reporting anything that seems amiss in the equipment or the work area. Ensure that operators or anyone else in the general vicinity do NOT allow solvents in the area as you are using direct current (DC); therefore, if a connection is broken or disturbed during plating, arcing may occur, which could result in an explosion or fire. Lastly, never do anything alone when the system malfunctions.

3.5.1 Recommended Personal Protective Equipment

Dalic recommends the use of the following general PPE while using the Dalistick Station.

- Clean and contaminant-free cotton or cotton-polyester blend overalls
- Chemical aprons when using concentrated chemicals, such as brush plating solutions, cleaning and deoxidizing solutions, etc.
- Steel capped gum boots – overalls outside the boots to avoid liquid splashing into boots
- Eye protection – safety goggles or a face shield when conducting brush plating operations due to close proximity to mists and fumes
- Heavy polyvinyl chloride (PVC) gloves that have a heavy cotton lining bonded to the PVC when working in the pretreatment stages of brush plating. Long shirt sleeves are to be worn over gloves, not tucked into gloves to avoid solutions entering into glove and contacting operator hands.
- Rubber gloves may be worn by platers because they are thinner and allow the plater to “feel” the part being treated, but they are not considered safety equipment in the strictest sense.

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3.5.2 Safe Handling of Manufacturer Solutions

The following table denotes required PPE when handling the solutions for this process. Note that the substances of concern within solutions are listed in Section 2.2. For full information on any chemical in this process, please refer to the "Dalic Zinidal Aero Solution Industrial Health Risk Assessment".

Table 39. Required Personal Protective Equipment (PPE)

Chemical	Use	PPE	Storage	Handling	Health Hazards	Regulations
IPA	Cleaning	Face shield/safety glasses; gloves; impervious, flame-retardant, antistatic clothing; respirator if risk assessment demonstrates need[18]	Tightly closed container in a dry, well-ventilated area	Avoid inhalation skin/eye contact, ignition sources; prevent electrostatic charge build up	CNS depression; prolonged exp. – nausea, headache, vomiting, narcosis, drowsiness; overexposure – mild, reversible liver effects; aspiration – can lead to lung edema or pneumonia	Superfunds Amendments Reauthorization Act (SARA) Title III[19]
MEK	Cleaning	Face shield/safety glasses; gloves; impervious, flame-retardant, antistatic clothing; respirator if risk assessment demonstrates need[1]	Tightly closed container under inert gas; store in a dry, well-ventilated area; reseal open containers and keep upright (hygroscopic)	Avoid inhalation skin/eye contact, ignition sources; prevent electrostatic charge build up	Potential CNS depression, gastrointestinal disturbance, or narcosis	SARA Title III[2]

[18] Multipurpose respirator cartridges or type ABEK (EN 14387) respirator cartridges as back up to engineering controls
[19] Not subject to SARA Title III Section 302, but is subject to Section 313 reporting in select states.

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Table 1. PPE Required (Continued)

Chemical	Use	PPE	Storage	Handling	Health Hazards	Regulations
Act. ST2		Effective laboratory ventilation system or ventilated room using protective breathing mask[20]; face shield or safety glasses; gloves; overalls, safety shoes; eye wash basin; shower, powerful tap, and sink unit near station	Original polyethylene containers/lids only – tightly closed – in spill-containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; avoid contact with strong alkaline products or oxidizing agents and temperatures > 150-170 °F	Do not wear contact lenses; weak irritant to skin/eyes; slight irritant to respiratory system; sulfuric acid is weakly carcinogenic to and demonstrated mutagenic results on animals	Follows Registration Evaluation Authorization of Chemicals (REACH)[21]
Act. XF		Effective laboratory ventilation system or ventilated room using protective breathing mask[3]; face shield or safety glasses; gloves; overalls, safety shoes; eye wash basin; shower, powerful tap, and sink unit near station	Original polyethylene containers/lids only – tightly closed – in spill-containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; avoid contact with strong alkaline products or oxidizing agents and temperatures > 150-170 °F	Do not wear contact lenses; eye irritant if not rinsed immediately; slight irritant to respiratory system without proper ventilation	Follows REACH[4]

[20] A2B2P3 cartridge (EN405:2902 standard) or a filtering FFP3 mask (EN 149:2009 standard)
[21] EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC established product labeling. No substances are subject to authorization per annex XIV of Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), and no restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles are currently in place. The solution does not contain substances that deplete the ozone layer, are persistent organic pollutants.

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Table 1. PPE Required (Continued)

Chemical	Use	PPE	Storage	Handling	Health Hazards	Regulations
Zinidal Aero	Zn-Ni plating	Effective laboratory ventilation system or if ventilated room is insufficient use protective breathing mask[22]; face shield or safety glasses; gloves[23]; overalls, safety shoes; eye wash basin; shower, powerful tap, and sink unit near station; breathing mask for emergency interventions if large quantities are present	Original polyethylene containers/lids only – tightly closed – in spill-containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; keep away from strong acids, powerful mineral or oxidizing agents, strong bases, and products reactive with NH_4^+ gas (e.g., salts of Au, Ag, Hg, Cd, and halogen derivatives); avoid temperatures > 104 °F (40 °C); dispose spent solutions and rinse waters as hazardous waste according to facility guidelines for pH value and metal content; contaminated packaging disposed as solid hazardous waste per facility rules. Firefighting – use dry ice (for metal fires) NOT water; Accidental release of vapors/sprays – use respiratory mask with K2P3 cartridge and wash contaminated items with water and dispose properly; release of solutions – wash area with slightly acidic or slightly alkaline produce to remove zinc hydroxide and prevent corrosion product formation – collect rinse water and dispose properly	Do not wear contact lenses or eat, drink or smoke near work station; eye, skin, and respiratory irritant; potential eczema due to allergens; carcinogenic with prolonged exposure[24]; asthma or asthmatic dyspnea[25]; ingestion concerns include headache, nausea, asthenia (abnormal physical weakness), digestive disorders, vomiting, diarrhea, tachycardia; eye contact - rinse immediately with water; skin contact – remove clothing and shoes, wash immediately with plenty of soap/water or shower; inhalation – take victim to well-ventilated area and seek medical attention/advice; minor ingestion – give water, call doctor for pain, nausea, vomiting; major ingestion – do not give anything to drink or induce vomiting – seek immediate medical attention.	Follow REACH regulations[26]

[22] Filtering FFP3 mask (EN 149:2009 standard)
[23] Can be neoprene, latex or polyvinyl chloride (PVC)
[24] Cancer risk depends on length and exposure level.
[25] Nickel salts may cause sensitization by inhalation, but may disappear immediately or after several hours of exposure.
[26] Product labeling has been established for the Zinidal Aero solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. Restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles (annex XVII of REACH up to commission regulation EC No. 474/2014 of May 8, 2014 (OJ L136 dated 09.05.2014) include the following.

- Nickel shall not be used in articles intended to come into direct and prolonged contact with the skin if the rate of nickel release from them is greater than 0.5 micrograms per square centimeter per week (µg/cm^2/week). It can be allowed if it is covered with an efficient coating permitting to be below this limit for a period of at least 2 years of normal use of the article. The rate of nickel release is lowered to 0.2 µg/cm^2/week in the case of articles inserted into the human body.
- Products classified as carcinogen, mutagen, or toxic to reproduction of categories 1 or 2 (substances or mixtures) shall not be supplied to the general public. The packaging should be marked "Restricted to Professional Users."

It is noted that a chemical safety assessment and a chemical safety report (per the EU REACH) have not been performed for this mixture because the solution is not produced at a quantity greater than 10 tons per year nor used at a quantity greater than 1 ton per year.

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Table 1. PPE Required (Continued)

Chemical	Use	PPE	Storage	Handling	Health Hazards	Regulations
Passivator No. 3	Conversion Coating	Ventilated area (no extra protection required if applied with cotton or via soaking); face shield or safety glasses; gloves[27]; overalls, safety shoes; eye wash basin; shower, powerful tap, and sink unit near station	Original polyethylene containers/lids only tightly closed in spill containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; keep away from alkaline, reducing, or combustible products; Avoid temperatures > 200 °C.	Do not wear contact lenses; observe strict cutaneous hygiene; change clothing after work – especially before eating; eye, skin, and respiratory irritant; carcinogen (1st category); mutagen (2nd category); reproductive toxin (3rd category)	Follow REACH regulations[28]

Overall, although the Zinidal Aero does have some more serious health concerns, they are dramatically reduced when compared to the concerns of Cd. Please refer to the "Dalic Zinidal Aero Solution Industrial Health Risk Assessment" for details of the comparison.

[27] Can be neoprene, latex, polyvinyl chloride (PVC), or nitrile

[28] Product labeling has been established for the Passivator No. 3 solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. Chromium trioxide is subject to authorization per annex XIV of REACH 31, and ECHA's consolidated list of 16.06.2014, 155 substances, and has restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles (annex XVII of REACH up to commission regulation EC No. 474/2014 of May 8, 2014 (OJ L136 dated 09.05.2014):

- Products classified as carcinogen, mutagen, or toxic to reproduction of categories 1 or 2 (substances or mixtures) shall not be supplied to the general public. The packaging should be marked "Restricted to Professional Users."

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3.5.3 Enclosures

The Dalistick Station is equipped with a plastic enclosure over the peristaltic pump to ensure against operator contact with the pump while rotating. Operators are not to attempt to remove the enclosure. Only a qualified electrical technician, under manufacturer supervision, should attempt to do so if absolutely necessary. There are no other exposed gears or rotating parts that would allow any part of the operator's body access to the moving parts.

3.5.4 Interlocks

Interlocks were designed into the Dalistick Station to such that current must be switched off on the unit and the unit must be disconnected from the grid prior to removing the enclosure. Operators should not attempt to defeat interlocks. Only qualified technicians should perform any interlock/electrical work on the unit, but while under manufacturer supervision. Prevent irreversible damage to the equipment.

3.5.5 Venting

Although there are emissions from this operation, measured exposure to hazardous materials, such as Cd, using this Dalistick Station and has found them to be well below the established PEL and EU regulations. APAVE, The French Authority, has conducted air monitoring measurements of the following operations, as performed with the Dalistick Station, to confirm that all air emissions are well below the maximum authorized limit for the EU. The Table also denotes OSHA PELs 8 hr time weighted average (TWA) for the United States. As can be seen, the exposure is also well below OSHA PELs.

Table 40. Emissions Data for Dalistick Station

Process	Substance	Measured (mg/m^3)	EU authorized max (mg/m^3)	OSHA PEL (mg/m^3)
Cd Plating	Cd	0.0001	0.05	0.005
Chromic Acid Anodizing	Chromic Acid	0.0005	0.05	0.005
Zn-Ni Plating	Nickel Sulfate	0.0008	0.1	0.05[29]

Monitoring was conducted without any air extraction system over the Dalistick Station and sensors were placed at the shoulders of the operators.

[29] For soluble compounds – nickel sulfate is soluble in water.

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3.6 Utility Requirements

3.6.1 Electrical

The Dalistick Station requires single phase, 230V alternating current (AC), 50 Hz, and typically pulls 5A of power (maximum of 11.3A), given that the system is designed and fabricated in Europe. The Dalistick Station then produces the DC for plating operations. When this system is procured for use in the United States, a power converter is required to enable use of 110V power. Therefore, when procuring such a system, please work with the manufacturer to obtain the proper power converter for your industrial setting, which may have different electrical requirements than 110V.

3.6.2 Air

The Dalistick Station uses 87 psi up to 145 maximum (7 bar up to 10 bar) oil-free, dry compressed air at consumption rate of 6.65 cubic feet per minute (25 m^3/hr).

3.6.3 Water

Although the user manual states that distilled water should be used to rinse parts, the manufacturer confirmed that city water is sufficient. Usage of water is dependent upon the area being treated and the specific treatment being conducted and is often operator dependent. However, water use rate should be very low.[30]

3.7 Space Requirements

The Dalistick Station and associated cart occupy a volume of 24” x 36” x 63” (600 x 900 x 1600 mm). Therefore, additional space must be allocated for movement of the operator around the cart and associated part being treated. The manufacturer recommends a workspace of 9.84ft x 9.84 ft (3m x 3m) minimum.

3.8 Ancillary Equipment and Miscellaneous Supplies Requirements

The items that are considered to be consumables for the Dalistick Station are listed in Table 2 along with general guidelines for replacement. Note that this does not include consumables from a PPE perspective.

[30] It is estimated that when rinsing a1 ft^2 area on a part that approximately 1.5L (50.9 oz) are used. However, when rinsing piping in the system, typically 500 mL (16.9 oz) is sufficient.

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Table 41. Process Consumables and Replacement Considerations

Materials	Replacement Considerations
Plating Tool AX	TBD - may last for years if cleaned routinely
Bonnette Nø 21 Diam 4	Daily replacement
Anode T4[31]	TBD – may last 2-3 years
Anode X13[32]	TBD – may last 2-3 years
Bonnette Nø 13	Daily replacement
Activator XF (1, 5, or 20L)	Replace after 17 A/hr passed through 1L solution; monitored by D.2020 software
Activator ST2 (1, 5, or 20L)	Replace after 17 A/hr passed through 1L solution; monitored by D.2020 software
Zinidal Aero (1, 5, or 20L)	Replace after 10 A/hr passed through 1L solution; monitored by D.2020 software
Passivator 3 (1, 5, or 20L)	No reuse option
Adhesive Tape Vinyl W12.3 P306 (12.3 mm w x 30.5 m l)	Depends on area treated - disposable
Adhesive Tape Vinyl W.25 P306 (25 mm w x 30.5 m l)	Depends on area treated - disposable
Adhesive Tape Aluminum N425 (12.7mm w x 55 m l)	Depends on area treated - disposable
Adhesive Tape Aluminum N425 (25.4 mm w x 55 m l)	Depends on area treated - disposable
Adhesive Tape 895 W25mm (25 mm w x 50 m l)	Depends on area treated - disposable
Cotton Wool (200 g)[33]	Depends on area treated - disposable
Scotch Brite Red (ML)	Depends on area treated - disposable
Optosil (900 mL)	Depends on surface area of openings near area to be treated
Activator – 66LMACT1[34]	Depends on surface area of openings near area to be treated
Polyethylene Sprayer 500 mL	Should last life time –used just to contain spray water
Meraklon Fabric 160 g/m (135 cm w)[35]	Depends on surface area treated and amount of anodizing conducted
Paper 220 (50 pieces, 9” x 11” [230 mm x 280 mm])	For surface preparation/cleaning – depends on use
Paper 120 (50 pieces, 9” x 11” [230 mm x 280 mm])	For surface preparation/cleaning – depends on use
Lead AX	TBD - may last for years if cleaned routinely
Lead NG	TBD - may last for years if cleaned routinely

[31] Anode T4 is used for small treatments when the Dalistick tool cannot access a specific area; it is 4.8mm x 65mm.
[32] Anode X13 is used for big treatments when the Dalistick tool cannot access a specific area; it is 12.7 mm x 108 mm.
[33] Use approximately 1 in^2 for 8 in^2 area treated during passivation.
[34] This activator is for optosil (not an electrolyte activator). Optosil is the 2 part mix/putty used to fill openings that the plating technician does not want to be coated. This putty mixture can be removed after coating. It is mixed at a ratio of 1 mL activator to 15 mL Optosil.
[35] Used almost exclusively for anodizing to dress a small electrode; it is disposed after each use.

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Table 3. Process Consumables and Replacement Considerations (Continued)

Materials	Replacement Considerations
Pkt Abrasive CC115 (2 kg)	For surface preparation/cleaning – depends on use
Pkt Glass Sphere 0,55 (2 kg)	For cleaning after Cd treatment – depends on Cd use, if any
Turcoform Mask 522 (1L)	Depends on area treated - disposable
Steel 15CDV6 Sample	Used for training only – dependent on number of trainees
Tank Cleaner	Replace after 10 uses

4.0 PROCUREMENT DOCUMENTATION

The Dalistick D. 2020 product information for the system procured under this contract is as follows:

Model Number: E15200
Serial Number: 201409001

4.1 Vendor Contact Information

The Dalistick Model D.2020 and associated equipment is made and marketed by Dalic SAS.
Dalic SAS
Dalic SAS
Z.I. du Plagné – 41 rue des Eaux
35501 Vitre, France

The technical point of contact at Dalic is listed below.
Antoine Le Roux
(33) 2.99.75.36.99

The product representative for Dalic is listed below Mr. Nicholas Hurault (sales manager)
(33) 2.99.75.53.81 (business phone)
(33) 6.75.92.86.74 (mobile phone)

General service inquiries can be referred to the following.
(33) 2.99.75.36.99
Service@dalicworld.com

4.2 Warranty Information

The Dalistick Station D.2020 is guaranteed by Dalic SAS for twelve months after its delivery. If a manufacturing defect is detected during this time period, Dalic will

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replace parts and put the product back into service free of charge, excluding any other indemnity. The warranty does not cover the following:

- Adaptations, modifications, or transformations of the equipment in order to meet international, local, or security standards of a country which are not the same for which the device has been designed and supplied. The guarantee also does not cover the expenses bound to such adaptations, modifications, transformations, nor experimentations, properly performed or not, nor the expenses related to the replacement of pieces having been damaged at the time of these manipulations.[36]
- Regular inspections, maintenance or exchange of pieces having undergone normal wear.
- Transport, the expenses and risks of transport directly or indirectly linked to this warranty.
- Damages caused by the following::
  - Non-suitable use, such as an electrochemical process not recommended by Dalistick or use of electrolytes not supplied by Dalistick.
  - Non-observation of use and maintenance instructions, as well as the connections and use of the device, including use in a country having other technical and safety standards.
  - Repairs in non-authorized workshops or repairs performed without previous information of Dalistick, notably the interventions performed inside the equipment.
  - Accidents, shocks, or other damages for which Dalistick cannot be held responsible, such as damages caused by climate, water, fire, or any other outside disorder.

5.0 MAINTENANCE REQUIREMENTS

5.1 Preventative Maintenance Requirements

The following preventative maintenance should be adhered to:

- Rinse all parts contacting solutions with distilled[37] at the completion of the operation.
- Clean system parts that contact solutions at least once per week.
- Change hoses, as deemed necessary by experienced operators.
- Change rotating pump tubing after every 12 hrs of operation.
- Conduct electrical continuity examination between the banana plug and electrodes on the Dalistick tool once per month.

[36] This does not mean that integrating the power converter supplied by Dalic SAS will void the warranty.

[37] Note that the manufacturer does recommend the use of distilled water for rinsing out the equipment.

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- Conduct calibration of the rectifier, unit cooling Dalistick unit, temperature regulation unit (UCDK), flowmeter, Dalistick tool, input/output (I/O) module, and Dalipump annually per the instruction manual.

5.2 Unscheduled Maintenance Issues

Per the manufacturer, it is highly advisable to contact Dalic support to report any system anomalies, including any parameters being outside specifications during maintenance controls. Dalic will provide either phone support, consign a new part, or repair the system on site or in their shop. Dalic maintains that it is highly inadvisable to disassemble the system without their support or supervision.

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Appendix C: Joint Test Protocol

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Joint Test Protocol

Cadmium-Free Alternatives for Brush Plating Repair Operations

ESTCP Project Number #201412

September 26, 2014

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LIST OF ACRONYMS AND SYMBOLS

COTS	Commercial Off The Shelf
DoD	Department of Defense
JTP	Joint Test Protocol
NFS	Notched Fracture Strength
PEL	Permissible Exposure Limit
RCRA	Resource Conservation and Recovery Act
RT	Room Temperature
XRF	X-Ray Fluorescence

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1.0 INTRODUCTION

Problem Statement: Cadmium (Cd) has been widely used in the aerospace industry and the Department of Defense (DoD) due to its excellent corrosion resistance, adhesion, and lubricity characteristics. Cd brush electroplating is used to repair worn and corroded parts, in many cases while the components are still installed on the aircraft. However, Cd is a toxic metal and human carcinogen, which is heavily regulated in the United States and the European Union. With traditional brush plating, localized areas or entire parts are plated using a brush saturated with a hazardous plating solution. Because traditional brush plating is an "open" process, the solution tends to flow down vertical or irregular surfaces or drip from overhead surfaces during plating operations. This leads to potential worker exposure and contamination of surrounding areas. Thus, the environmental, health, and safety issues associated with Cd coatings in general, and Cd plating operations specifically, are still prevalent. Large volumes of generated solid waste (absorbent materials/pads used to contain dripping solutions) significantly increase disposal costs, along with the actual disposal cost of the Cd waste solutions themselves.

Cd is regulated by the Resource Conservation and Recovery Act 1974 (RCRA) and is a D-listed hazardous waste material. The Action Level Permissible Exposure Limit (PEL) for Cd is of 2.5 $\mu g/m^3$. Target HazMat information is given in Table 1.

Table 1. Target HazMat Summary

Target HazMat	Current Process	Applications	Current Specifications	Affected Programs	Candidate Parts and Substrates
Cd	Traditional brush plating	Steel components	QQ-P-416 Mil-STD-865D	C-5, C-17, C-130, F-15,etc.	Landing gear & other weapon system parts and components

Because Cd brush plating repair processes are still utilized within the DoD, a need has been identified to (***a***) qualify and implement a Zn-Ni coating as a Cd replacement for spot repair operations on military weapon systems; and (***b***) demonstrate/validate a novel brush electroplating system that enables selective electrochemical treatment without leakage of the electrolyte/hazardous chemical solution during processing.

The project focuses on elimination of toxic/carcinogenic Cd material in brush plating repair operations and the reduction of hazardous waste associated with adsorbents that are used to contain solution leakage attributed with traditional brush plating repair processes. The programs technical objectives are as follows:

1) Demonstrate the Commercial-Off-The-Shelf (COTS) brush plating tool Dalistck® Station (Dalic Inc.) for selective plating, ensuring the safety and cost effectiveness of the novel brush plating technology for DoD maintenance, repair, and overhaul operations;
2) Test and evaluate COTS material Zinidal Aero zinc-nickel (Zn-Ni) brush-plated coating (Dalic Inc.) as a Cd replacement on mild and high-strength steels for repair applications

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on weapon system parts and components (landing gear, terminal assemblies, landing gear doors, bushings, etc.).

This Joint Test Protocol (JTP) contains the critical requirements and tests necessary to qualify potential Zn-Ni alternatives to Cd-brush plating for DoD maintenance, repair, and overhaul operations, using the novel Dalistick® brush plating technology. These tests and requirements were derived from engineering and performance requirements defined by a consensus of DoD stakeholders, listed in Table 2.

Table 2. List of Stakeholders

Name	Organization	Phone #	e-mail
Debbie Naguy	AFLCMC/EZP	937-255-7705	Debora.naguy@us.af.mil
Richard Slife	WR-ALC/QPE	478-926-0209	Richard.slife@robins.af.mil
Jeff Zemke	AFSC/ENRW OL Hill	801-777-7771	Jeffrey.zemke.1@us.af.mil
Chad Hogan	AFMC 417 SCMS/GUEA, Supply Chain	801-7775739	Chad.hogan@us.af.mil
Dave Frederick	AFMC 417 SCMS/GUEA, Hill LG	801-777-7352	David.frederick.1.@us.af.mil
Gene Kourtei	AFSC OO-ALC/ESOH, Hill Depot	801-586-4375	Gene.Kourtei.civ@mail.mil
Nathan Hughes	AFMC 532 CMMXS/ENLC, Hill Depot	801-775-2270	Nathan.hughes@us.af.mil
Melanie Johnson	AFSC 776 MXSS/MXDEB, Tinker Depot	405-582-4814	Melanie.johnson@us.af.mil
Van Nguyen	AFMC 72 ABW/CEIEA, Tinker Depot	405-582-4802	Thanhvan.nguyen.1@us.af.mil
Clayton Elliott	AFLCMC C-5 SPO	478-926-6778	Clayton.elliott@us.af.mil
Lt. Austin Williamson	AFLCMC E-3 SPO	405-734-3873	Austin.williamson.2@us.af.mil
Gary Lan	AFLCMC KC-135 SPO	405-736-1868	Gary.lan@us.af.mil
Mark Forbes	AFMC 309 MMXG/EN, ICBM Trailers	801-586-5928	Mark.forbes@us.af.mil
Alex Steele	AFMC 309 MMXG/EN, ICBM Trailers	801-586-3551	Alexander.steele@us.af.mil
Ed Hermes	AFRL	937-255-3366	Edward.hermes@us.af.mil
Chad Hunter	AFRL	937-255-2222	Chad.hunter@us.af.mil
Robert (Bob) Ware	AFRL	937-656-9146	Robert.Ware.4@us.af.mil
Elizabeth Berman	AFRL	937-656-5700	Elizabeth.berman@us.af.mil
Mark Feathers	AMCOM G-4	256-842-7355	Mark.g.feathers@conus.army.mil
Michael Johnson	AMCOM G-4	256-842-7719	Michael.l.johnson17.ctr@mail.com
Robert (Yogi) Kestler	FRC-East	252-464-9888	Robert.kestler@navy.mil
Luc Doan	FRC-Southwest	619-545-9756	Luc.doan@navy.mil
Aaron Rains	FRC-Southwest	619-545-7304	Aaron.rains@navy.mil
John (Jack) Benfer	FRC-Southeast	904-790-6405	John.benfer@navy.mil
Ruben Prado	FRC-Southeast	904-542-3444	Ruben.prado@navy.mil

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2.0 PERFORMANCE AND TESTING REQUIREMENTS

The JTP includes inputs from Air Force, Army, and Navy stakeholders as well as industry experts for Cd replacement in brush plating repair applications on high-strength and mild steels. This protocol describes the minimum test procedures and performance requirements necessary to consider implementation of brush plated Zn-Ni coatings deposited using Dalistick Station (Attachment A-B). The JTP lists references on Cd and Cd alternatives replacement technical reports, drawings, and specifications. Performance of tests outlined in this JTP may involve the use of hazardous materials, operations, and equipment. The JTP does not address all safety issues associated with the use of such hazardous materials, operations or equipment. Rather, it is the responsibility of each user of this JTP to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use of the equipment or materials, or conducting the operations.

The major performance and testing requirements are derived based on specifications and technical orders currently used for brush repair operations at DoD depots:

AMS QQ-P-416 *Federal Specification Plating, Cadmium (Electrodeposited)*
MIL-STD-870C *(USAF) Cadmium Plating, Low Embrittlement, Electrodeposition* MIL-STD-865D *(USAF) Department of Defense Standard Practice Selective, Brush Plating, Electrodeposition*
USAF DWG 201027457 *Solution For Use In LHE Zinc – Nickel Plating On High Strength Steel Substrate (>180 KSI) Landing Gear Components*
SAE-AMS-2451/9 *Plating, Brush, Zinc-Nickel Low Hydrogen Embrittlement*
BAC 5637 *Zinc-Nickel Alloy Plating*
BAC 5664 *Low Hydrogen Embrittlement Stylus Zinc-Nickel Alloy Plating*

The major testing requirements that have been identified are as follows:

General properties, such as appearance, thickness, compositional uniformity
Adhesion
Corrosion resistance
Hydrogen embrittlement
Strippability.

Table 3 lists all engineering and testing requirements with acceptance criteria identified for qualification of Zn-Ni (Type II, Class 1 – Class 2) in brush plating repair application using the Dalistick Station.

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Table 3. Engineering, Performance and Testing Requirements

Requirement	Test	JTP Section	Acceptance Criteria	References
General Properties	Appearance Uniformity	3.2.1	Visual inspection of all specimens that coating is continuous, smooth, adherent, uniform in appearance, free from blisters, pits, nodules, burning, contaminants, excessive powder, and other apparent defects	AMS-QQ-P-416 USAF DWG 201027457 MIL-STD-870 BAC 5637 BAC 5664
	Thickness &Alloy Composition Uniformity	3.2.2	Average coating thickness (targeted thickness 0.0004 to 0.0007 inch) on flat areas of the specimen, measured in a minimum of three areas of each specimen; Consistent alloy composition along the fixture cavity when tested using XRF method (3 replicates per coating scenario)	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 ASTM B 530 ASTM B 568
Adhesion	Bend Adhesion	3.2.3	No separation (flaking, peeling, or blistering) of coating from the basis metal (3 replicates per coating scenario)	USAF DWG 201027457 AMS-QQ-P-416 ASTM B 571 BAC 5637 BSS 7235
Adhesion	Wet/Dry Tape Paint Adhesion	3.2.4	Plated specimens coated with MIL-PRF-85582 or MIL-PRF-23377 and cured for 14 days at room temperature (RT). Specimens either tested at RT (dry) or immersed for 24 hours (h) in DI water at 73°F then tested (wet); Adhesion rating 4B or better (less than 5% area removed), per ASTM D 3359 (3 replicates per test and coating scenario)	USAF DWG 201027457 ASTM D 3359 MIL-PRF-23377 MIL-PRF-85582 MIL-PRF-32239A (draft)
Corrosion Resistance	Salt Spray Resistance	3.2.5	96 h no evidence of white corrosion / 500 h exposure before appearance of red rust comparable to Cd control (examined daily for red rust); exposure until failure (10 per coating scenario)	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 SAE AMS 2451/9 ASTM B 117 ASTM D 1654
Hydrogen Embrittlement	Hydrogen Embrittlement	3.2.6	No fracture for plated specimens within 200 h after sustained 75% notched fracture strength (NFS) load testing --Four (4) specimens Type 1a.1 notched bar per coating scenario --Four (4) specimens Type 1d notched C-ring per coating scenario All 4 pass); if one fails, remaining 3 are steploaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture (3 out of 4 with no fracture = pass) (2 with fracture = fail)	AMS-QQ-P-416 USAF DWG 201027457 SAE AMS 2451/9 ASTM F 519 MIL-STD-870 BAC 5637

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Requirement	Test	JTP Section	Acceptance Criteria	References
Hydrogen Embrittlement	Hydrogen Reembrittlement (ReHE)	3.2.7	--Four (4) specimens Type 1a.1 notched bar per coating scenario or chemical exposure condition --Four (4) specimens Type 1d notched C-ring per coating scenario; Set 1: specimens immersed service chemical (cleaning compound per MIL-PRF-29602) at elevated temperature for 30 min; specimen removed, air-dried, and tested for 200 h at 75% NFS (all 4 pass); Set 2: specimens immersed in service chemical (cleaning compound per MIL-PRF-29602) or 3.5% NaCl solution at room temperature while tested for 150 h at 45% NFS (all 4 pass) If one fails in Set 1 or Set 2, remaining 3 for that Set are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture (3 out of 4 pass)	USAF DWG 201027457 ASTM F 519
Strippability	Stripping Method	3.2.8	Zn-Ni coating stripped using NH_4NO_3 solution (16 ounces per gallon in water; pH maintained 8.0–9.0 with NaOH). Stripping times less than 60 min at 21–27°C (4 replicates per coating scenario)	USAF DWG 201027456 USAF DWG 201027457
Additional Requirements				
Corrosion Resistance	SO_2 Resistance (Navy req)	3.2.9	168 h exposure before appearance of red rust comparable to Cd control (examined daily for red rust, scribed and unscribed specimens (3 replicates per coating scenario)	ASTM G 85
	Galvanic Corrosion Resistance	3.2.10	Galvanic couple of plated steel specimens with Cd plated screws and stainless steel screws (all dry installed); mass loss comparable to control; checked at 80 and 120 cycles (9 replicates per coating scenario)	GMW 14872 MIL-PRF-32239A (draft)

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3.0 TEST DESCRIPTIONS

3.1 Substrates Materials and Coatings Applications

The Dalistick® Station will be used to apply brush coating materials. Type II, Class 1 – Class 2 coatings with the targeted plated thickness of 0.0004 to 0.0007 inch (AMS QQ-P-416, AMS 2451/9, BAC 5637) will be used in repair scenarios. Substrates will include 4130 high-strength steel and 1008/1010 cold-rolled mild steel, size 4 x 6 x 0.040 inch. Substrate materials for hydrogen embrittlement and re-embrittlement tests will be 4340 steel Type 1a.1 (notched, round, tension) specimens and Type 1d (notched C-rings) per ASTM F 519.
A schematic of the coating process is provided in Figure 1. Specific process parameters and steps recommended by vendor will be documented and followed for each plating process and recorded in the final report.

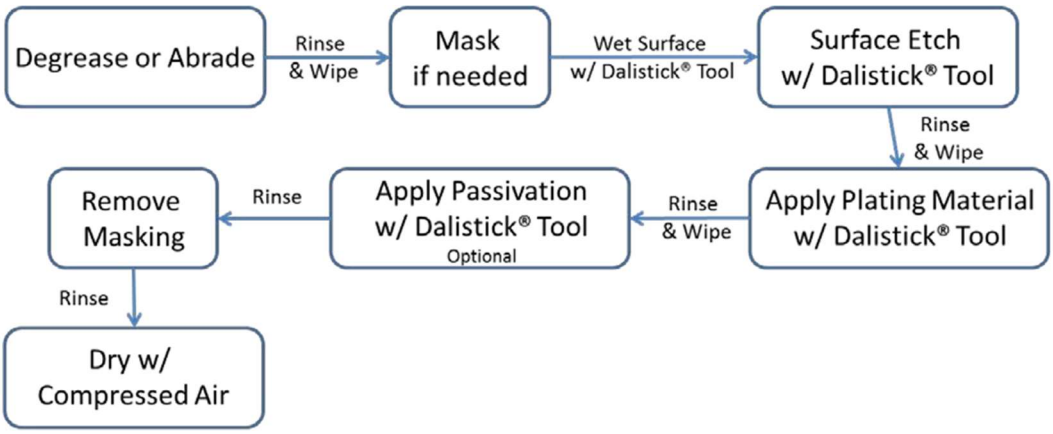

Figure 1: Schematic of Dalistick® Station brush plating application

The Zinidal Aero LHE Zn-Ni solution using the Dalistick® plating process from Dalic Inc. will be tested for brush plating application (Attachment C). Two traditional brush plating controls/baselines will be used during testing for comparison to the Zinidal Aero LHE Zn-Ni and Dalistick process. These are the currently used Sifco 2023 Cd traditional brush-plated coating and Sifco 4018 LHE Zn-Ni traditional brush-plated with Sifco 5030 Cr(VI) conversion coating.

Table 4: Dalistick® Brush Plating Processes

Pre-Clean	Surface Etch	Plating Solution	Conversion Coating
Acetone/Scrub/Rinse	Dalic Activator XF, Product 10054	Zinidal Aero LHE Zn-Ni, Product 11040	No conversion coating (per vendor's recommendation)
			Sifco 5030

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Several coating repair scenarios will be employed for Zn-Ni coating deposition by brush plating using Dalistick Station:

- on bare steel substrates
- over tank-plated, simulated damaged Cd area (per USAF DWG 201027457, para 3.2.7 Brush Plating)
- over ion vapor deposited aluminum (IVD Al), simulated damaged IVD Al area (per USAF DWG 201027457, para 3.2.7 Brush Plating)
- over LHE Zn-Ni tank-plated, simulated damaged LHE Zn-Ni area (per USAF DWG 201027457, para 3.2.7 Brush Plating).

The simulated damage area will be created by masking off a 0.5-inch strip lengthwise down the center of the coupon prior to coating with Cd and LHE Zn-Ni using the standard plating tanks and IVD Al using ion vapor deposition method.

3.2 Test Methods

Test Methods and the Test Specimens Matrix are presented in Table 5 and are summarized in the following sections.

Table 5. Test Specimen Matrix (per tested process)

Test Method	JTP Section	Substrate	Coating Repair Scenario	Number of Panels	Reference
Appearance	3.2.1	4130 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	All brushed plated coupons	AMS-QQ-P-416 USAF DWG 201027457 MIL-STD-870 BAC 5637 BAC 5664
		1008 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni		
Thickness and Composition	3.2.2	4130 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	3 3 3 3	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 ASTM B 530 ASTM B 568
		1008 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	3 3 3 3	
Bend Adhesion	3.2.3	4130 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	3 3 3 3	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 BSS 7235 ASTM B 571
		1008 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	3 3 3 3	

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Test Method	JTP Section	Substrate	Coating Repair Scenario	Number of Panels	Reference
Paint Adhesion Dry/Wet Tape	3.2.4	4130 steel plate	Brush plated bare steel coated with MIL-PRF-85582 or MIL-PRF-23377	3/3 3/3	USAF DWG 201027457 ASTM D 3359 MIL-PRF-85582 MIL-PRF-23377 MIL-PRF-32239A (draft)
Salt Spray (unscribed/ scribed)	3.2.5	4130 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	5/5 5/5 5/5 5/5	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 AMS 2451/9 ASTM B 117 ASTM D 1654
		1008 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	5/5 5/5 5/5 5/5	
Hydrogen Embrittlement	3.2.6	4340 steel ASTM F 519 Type 1a.1 & Type 1d	Brush plated notched area of bare steel specimen	4 (Type 1a.1) 4 (Type 1d)	AMS-QQ-P-416 USAF DWG 201027457 AMS 2451/9 BAC 5637 ASTM F 519 MIL-STD-870
Re-HE; Cleaning comp & 3.5% NaCl	3.2.7	4340 steel, ASTM F 519 Type 1a.1 & Type 1d	Brush plated notched area of bare steel specimen	4/4/4 (Type 1a.1) 4/4/4 (Type 1d)	USAF DWG 201027457 ASTM F 519
Stripping	3.2.8	4130 steel bar	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	4 4 4 4	USAF DWG 201027456, USAF DWG 201027457
SO_2 Resistance	3.2.9	4130 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	5 5 5 5	ASTM G 85
		1008 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	5 5 5 5	
Galvanic Corrosion	3.2.10	4130 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	9 9 9 9	GMW 14872 MIL-PRF-32239A (draft)
		1008 steel plate	On bare steel Damaged Cd Damaged IVD Al Damaged LHE Zn-Ni	9 9 9 9	

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3.2.1 Appearance

Rationale
Specifications, Standard Practices (AMS-QQ-P-416, MIL-STD-870, BAC 5637, BAC 5664) and USAF Source Control Drawing (USAF DWG 201027457) cite the finish quality or appearance as a quality requirement for tank-plated coatings. This will also be applicable to brush-plated coatings. This test will be performed as a screening test on all candidate brush plating coating systems.

Description
This is a visual examination of the test coupon after it has been subjected to the plating process.

Acceptance Criteria
Brush-plated candidate coatings must be smooth, continuous, adherent to the basis metal, and visually free from porosity, blisters, nodules, pits, and other imperfections that are detrimental to the performance of the plating. Slight staining or discoloration is permissible.

Reference Document(s)
AMS-QQ-P-416, MIL-STD-870, BAC 5637, BAC 5664, USAF DWG 201027457

Table 6. Test Description, Appearance

Parameters	Visual inspection of uniform appearance
Number and type of specimens per candidate alternative	All plated specimens
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Smooth, continuous, adherent to basis metal, visually free from porosity, blisters, nodules, pits, and other imperfections.

3.2.2 Thickness and Alloy Composition Uniformity

Rationale
USAF Source Control Drawings 201027456 (Para 5.5.2) and 201027457 (Para 3.3.2) cite the composition and thickness uniformity as a quality requirements for tank-plated Zn-Ni coatings. Alloy composition and uniformity, particularly in complex parts or shapes, are critical to successful plating, and ultimately to the performance of the coating.

Description
Coating thickness will be measured using nondestructive magnetic coating thickness gage PosiTector 6000 per ASTM B 530, *Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates*. Multiple measurements will be taken at varying locations to determine the overall coating thickness and consistency of plating.

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Composition will be determined using the X-ray fluorescence (XRF) method by the energy or wavelength dispersion of secondary X-ray emissions emanating from the coating that has been excited to fluorescence using a high-energy X-ray tube. This method follows ASTM B 568, *Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry*.

Acceptance Criteria
Coating composition determined by XRF method shall be uniform across the entire panel with coating in the 12-17 percent nickel composition range. The targeted plating thickness shall be in a range of 0.0004 to 0.0007 inch as it specified in AMS QQ-P-416, AMS 2451/9, BAC 5637, and USAF DWG 201027457.

Reference Document(s)
AMS QQ-P-416, SAE-AMS-2451/9, BAC 5637, USAF DWG 201027457, ASTM B 530, ASTM B 568

Table 7. Test Description, Thickness and Alloy Uniformity

Parameters	Coatings will be evaluated by Magnetic Method and XRF for coating thickness and alloy uniformity
Number and type of specimens per candidate alternative	3 per coating scenario, flat panels 4x6x0.040 inch
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Consistent alloy composition in the 12-17 percent nickel composition range, with the targeted plated thickness in a range of 0.0004 to 0.0007 inch

3.2.3 Bend Adhesion
Rationale
Adhesion of the brush-plated coating is critical to successful plating, and ultimately to the performance of the coating. This test will be performed to determine the ability of the Zn-Ni coating plated with Dalistick® Station to adhere to the substrate.

Description
Test specimens of 4130 and 1008 steel (approximately 1 x 4 x 0.040 inch) are plated with the candidate coating system are clamped in a vise and repeatedly bent through 90°–180° until rupture of the basis metal occurs. Specimens are examined at 4X magnification for lifting of the deposit along the broken edge.

Acceptance Criteria
Crazing of the deposit is acceptable, but flaking or lifting of the deposit is considered to be a failure.

Reference Document(s)
AMS-QQ-P-416, USAF DWG 201027457, BAC 5637, BSS 7235**,** ASTM B 571

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Table 8. Test Description, Bend Adhesion

Parameters	Specimens will be coated using the brush plating process; coatings will be bent repeatedly until rupture of the basis metal; coatings will be evaulated at 4x for adhesion of the deposit
Number and type of specimens per candidate alternative	3 per coating scenario; size 1 x 4 x 0.040 inch
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	No separation of the coating from the basis metal

3.2.4 Wet/Dry Tape Paint Adhesion

Rationale

Adhesion between the brush-plated coating and the applied MIL-PRF-85582 waterborne epoxy primer or MIL-PRF-23377 solvent-borne epoxy primer is critical to successful plating, and ultimately, to the performance of the coating system as a whole. This test will be performed as a validation test on all candidate brush plating coating systems.

Description

Test specimens of 4130 and 1008/1010 (4 x 6 x 0.040 inches) are brush-plated using the candidate coating systems. Specimens are coated with either MIL-PRF-85582 or MIL-PRF23377 primer and left to cure at room temperature for 14 days. Half of the prepared specimens are then tested for crosshatch adhesion per ASTM D 3359 Method B. The other half of the prepared specimens are immersed in de-ionized water at 73°F for 24 h. Specimens are then removed from the de-ionized water, towel dried, and then tested for adhesion per ASTM D 3359 Method A.

Acceptance Criteria

Typical coating system testing, per MIL-PRF-32239A (draft) *Performance Specification, Coating System, Advanced Performance for Aerospace Applications*, defines organic coating adhesion to a pretreatment or inorganic coating on a metallic surface as acceptable when the test result is either no lower than 4A (Method A, X-cut used in wet-tape test) or 4B (Method B, crosshatch cut used in dry tape test) when tested and evaluated per ASTM D 3359. For this test, the requirements provided by MIL-PRF-32239A (draft) will be applicable.

Reference Document(s)

USAF DWG 201027457, ASTM D 3359, MIL-PRF-32239A (draft), MIL-PRF-85582, MILPRF-23377

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Table 9. Test Description, Wet/Dry Tape Paint Adhesion

Parameters	Specimens will be coated using the brush plating process; coatings will be exposed to neutral salt spray for 96 h and then until 1000 h
Number and type of specimens per candidate alternative	6 specimens per coating scenario
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Coatings will show adhesion values no lower than 4A or 4B as evaluated using ASTM D 3359

3.2.5 Salt Spray Resistance

Rationale

Corrosion resistance of the brush-plated coating is critical. Salt fog corrosion resistance testing will be performed to determine the ability of the brush-plated coating to protect the substrates in the presence of an aggressive corrosive environment.

Description

The test will be conducted in accordance with ASTM B 117, *Standard Practice for Operating Salt Fog Apparatus*. Ten test specimens (5 scribed / 5 unscribed) per processing scenario will be subjected to a continuous salt fog, maintained at 95°F (35°C) with daily inspections. The test specimens will be visually inspected for the presence and severity of general corrosion, pitting, undercutting, and coating delamination. Specimens will be tested until failure. Corrosion products within ¼-inch of the edge of the specimen will not be evaluated. The data points will be recorded and used to rank the coatings per the ranking criteria presented in ASTM D 1654, *Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*.

Acceptance Criteria

Specimens must show no sign of white corrosion product after 96 h of exposure to neutral salt spray. Specimens must show no sign of red rust on the basis metal after 500 h of continuous exposure to neutral salt spray.

Reference Document(s)

AMS-QQ-P-416, USAF DWG 201027457, SAE-AMS-2451/9, BAC 5637, ASTM B 117, ASTM D 1654

Table 10. Test Description, Salt Spray Resistance

Parameters	Specimens will be inspected for the presence and severity of general corrosion, pitting, undercutting, and coating delamination
Number and type of specimens per candidate alternative	10 specimens per coating scenario: 5 scribed/ 5 unscribed
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Coatings will show no evidence of white corrosion product after 96 hours of exposure and no evidence of red rust after 500 hours of exposure to neutral salt spray

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3.2.6 Hydrogen Embrittlement

Rationale

This test will be performed to determine the susceptibility of a brush plating process to cause hydrogen embrittlement (HE) of steel substrates. It is critical that the tested brush-plated coatings pass HE testing for the coating to be considered for implementation.

Description

(1) Type 1a.1 notched bar specimens per ASTM F 519, *Standard Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/ Coating Processes and Service Environments*, machined from 4340 steel and heat-treated to 260-280 ksi, will be brush-plated using the candidate coating system. Brush plating will be applied to the entire notch area and 0.5-inch on either side of the notch. Specimens will be tested for 200 h of static loading at 75% NFS without failing. Per ASTM F 519, if one of the 4 specimens fails, the remaining specimens are tested for the remaining test duration to 200 h of static loading at 75% NFS. These remaining specimens are then step-loaded every 2 h in 5% increments to 90% NFS and held for 2 additional hours. If the three remaining specimens all sustain 90% NFS for 2 h, the plating/coating process will be considered non-embrittling. If two or more specimens fracture within the sustained load exposure time, the plating/ coating process will be considered embrittling.

(2) Type 1d notched C-ring specimens per ASTM F 519, machined from 4340 steel and heattreated to 260-280 ksi, will be brush-plated using the candidate coating system. Brush plating will be applied to the entire notch area and 0.5-inch on either side of the notch. Specimens will be tested for 200 h of static loading at 75% NFS without failing. Per ASTM F 519, if one of the 4 specimens fails, the remaining specimens are tested for the remaining test duration to 200 h of static loading at 75% NFS. These remaining specimens are then step-loaded every 2 h in 5% increments to 90% NFS and held for 2 additional hours. If the three remaining specimens all sustain 90% NFS for 2 h, the plating/coating process will be considered non-embrittling. If two or more specimens fracture within the sustained load exposure time, the plating/coating process will be considered embrittling. Per ASTM F 519, notched C-ring specimens may need to be examined using magnetic particle per ASTM E 1444, *Standard Practice for Magnetic Particle Testing*, or liquid penetrant per ASTM E 1417, *Standard Practice for Liquid Penetrant Testing*, to determine if a crack initiated but did not propagate due to load relaxation.

Acceptance Criteria

If none of the 4 specimens fail (for the set of Type 1a.1 and the set of Type 1d) the initial 200 h of static loading at 75% NFS, or if 3 out of 4 do not fail after the 200 h at 75% NFS followed by step loading every 2 h by 5% increments to 90% NFS and held for another 2 h, the specimens are considered to have passed.

Reference Document(s)

AMS-QQ-P-416, USAF DWG 201027457, SAE-AMS-2451/9, BAC 5637, ASTM F 519, MILSTD-870

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Table 11. Test Description, Hydrogen Embrittlement

Parameters	Specimens of Type 1a.1 and Type 1d will be coated using the brush plating process; coatings will be tested for 200 h at 75% NFS (all 4 pass); if one specimen fails within the Type 1a.1 set or the Type 1d set, the remaining 3 of that set are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture (3 out of 4 pass)
Number and type of specimens per candidate alternative	4 specimens per coating scenario per specimen type
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	All 4 specimens pass at 200 h at 75% NFS or 3 out of 4 pass 90% NFS for 2 additional hours.

3.2.7 Hydrogen Re-embrittlement (Service Environment: Cleaning Compound and 3.5% NaCl Solution)

Rationale

Hydrogen re-embrittlement testing will be conducted to detect possible hydrogen embrittlement of steel parts, brush-plated with tested coating system due to contact with chemical during overhaul and service life.

Description

Type 1a.1 notched bar specimens and Type 1d notched C-ring specimens per ASTM F 519, machined from 4340 steel and heat-treated to 260-280 ksi, will be brush-plated using the candidate coating system. Two service environments will be tested:

Set 1: Four each of Type 1a.1 and Type 1d specimens are immersed in the cleaning compound Calla 296 (ZipChem Products) at the manufacturer's maximum recommended temperature and appropriate cleaning concentration for 30 min. The specimens are then removed, air dried, and then loaded to 75% NFS for 200 h, in accordance with ASTM F 519. Per ASTM F 519, if one specimen of the 4 fails, the remaining specimens are tested for the duration of 200 h of static loading at 75% NFS. These remaining specimens are then step-loaded every 2 h in 5% increments to 90% NFS and held for an additional 2 h. This test is listed in ASTM F 519 under A5, Details of Testing In Service Environments.

Set 2: Four each of Type 1a.1 and Type 1d specimens are loaded to 45% NFS at constant room temperature (RT) and exposed to either (*I*) the cleaning compound Calla 296 (ZipChem Products) or (*II*) a 3.5% NaCl solution for 150 h. Per ASTM F 519, if one specimen of the 4 fails, the remaining specimens are tested for the duration of 150 h of static loading at 45% NFS. These remaining specimens are then step-loaded every 2 h in 5% increments to 90% NFS and held for an additional 2 h. This test is listed in ASTM F 519 under A5, Details of Testing In Service Environments.

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Acceptance Criteria
If none of the 4 specimens fail (for the set of Type 1a.1 and the set of Type 1d) the initial 200 h of static loading at 75% NFS, or if 3 out of 4 do not fail after the 200 h at 75% NFS followed by step loading every 2 h by 5% increments to 90% NFS and held for another 2 h, the specimens are considered to have passed.

Reference Document(s)
USAF DWG 201027457, ASTM F 519

Table 12. Test Description, Hydrogen Re-embrittlement

Parameters	Specimens of Type 1a.1 and Type 1d will be coated using the brush plating process; Set 1 specimens will be immersed in the cleaning compound at elevated temperature, dried, and then tested for 200 h at 75% NFS (all 4 pass); Set 2 specimens will be immersed in the cleaning compound or 3.5% NaCl solution at room temperature while tested for 150 h at 45% NFS (all 4 pass) If one fails in Set 1 or Set 2, remaining 3 for that Set are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture (3 out of 4 pass)
Number and type of specimens per candidate alternative	4 specimens per coating scenario per specimen type
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	All 4 specimens in Set 1 pass at 200 h at 75% NFS or all 4 specimens in Set 2 pass at 150 h at 45% NFS; if any fail, then 3 out of 4 pass 90% NFS for an additional 2 h

3.2.8 Stripping Method

Rationale
USAF Source Control Drawings 201027456 (Para 4.10) and 201027457 (Paras 2.5.11 & 3.2.9) cite acceptable Zn-Ni stripping time as a performance requirement for tank-plated Zn-Ni coatings. The ability to remove the Zn-Ni coating in 30 min using ammonium nitrate (NH_4NO_3) at a pH between 8.0 and 9.0 is critical to a successful process, and ultimately to the performance of the coating system as a whole. This test will be performed as a validation test on all candidate brush plating coating systems.

Description
Round bar specimens of 4130 (sized 4 inches by 0.375 inch diameter) will be brush-plated with the candidate Zn-Ni coating system to a thickness of 0.0005 inches (Class 1 per USAF DWG 201027457). The coating will be stripped in a solution of NH_4NO_3 (16 ounces per gallon of water); pH maintained between 8.0–9.0 with sodium hydroxide (NaOH); stripping time is 30 min at 21–27°C.

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Acceptance Criteria
When using one liter of stripping solution for four plated specimens to give a total stripped coating weight of 4.0 g of Zn-Ni coating, the coating weight after 30 min of immersion will not exceed 0.00017 g ($1.7x10^{-4}$) per square centimeter of plated surface.

Reference Document(s)
USAF DWG 201027456, USAF DWG 201027457

Table 13. Test Description, Stripping Method

Parameters	Specimens will be coated using the brush plating process; coatings will be exposed to stripping solution for 30 min; Coated specimens will be evaluated for coating weight after stripping process
Number and type of specimens per candidate alternative	4 per coating scenario, repair, or other iteration; Substrate 4130
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Coating weight remaining after 30 min of immersion will not exceed $1.7x10^{-4}$ grams per square centimeter of plated surface

3.2.9 SO_2 Resistance

Rationale
Corrosion resistance to sulfur dioxide (SO_2) as a performance requirement for brush-plated ZnNi coatings has been included for consideration by the US Navy stakeholders. Corrosion resistance of the brush plated coating is critical to the performance of the coating. This test will be performed as a validation test on all candidate brush-plated coating systems.

Description
Scribed and unscribed specimens of brush-plated 4130 and 1008/1010 will be exposed for 168 h to ASTM G 85 Annex 4 Salt/SO_2 Spray and checked daily for red rust.

Acceptance Criteria
Performance similar to Cd control after exposure for 168 h; no red rust is permissible.

Reference Document(s)
ASTM G 85

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Table 14. Test Description, SO_2 Resistance

Parameters	Scribed and unscribed specimens of brush plated 4130 exposed to ASTM G 85 A4, SO_2 for 168 h
Number and type of specimens per candidate alternative	3 specimens per coating scenario, repair, or other iteration; Substrate 4130 and 1008/1010
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Performance similar to Cd control; no red rust within 168 h

3.2.10 Galvanic Corrosion Resistance

Rationale

MIL-PRF-32239A (draft), *Performance Specification, Coating System, Advanced Performance for Aerospace Applications*, cites galvanic corrosion resistance, particularly with fasteners, as a performance requirement for coating systems for consideration by the USAF. Corrosion resistance of the brush-plated coating is critical to the performance of the coating. This test will be performed as a validation test on all candidate brush-plated coating systems.

Description

Galvanic couples will be prepared between brush-plated 4130 and 1008/1010 substrates and Cdplated screws and stainless steel screws (all dry installed). The prepared specimens will be exposed to GMW 14872 *Accelerated Corrosion Resistance Test* for 120 cycles. Both Dalistick® brush-plated and traditional brush plated panels will be generated. Mass loss coupons (with no fasteners) will be checked at 80 and 120 cycles against Cd and Zn-Ni brush-plated specimens, using traditional brush plating.

Acceptance Criteria

Performance must be similar to Cd and Zn-Ni brush-plated specimens, using traditional brush plating.

Reference Document(s)

GMW 14872, MIL-PRF-32239A (draft)

Table 15. Test Description, Galvanic Corrosion Resistance

Parameters	Specimens will be coated using the brush plating process; coatings will be exposed to 120 cycles of GMW 14872; coatings will be evaluated for mass loss at 80 and 120 cycles as compared to control; coatings will also be evaluated for galvanic corrosion damage as compared to control.
Number and type of specimens per candidate alternative	9 per coating scenario or other iteration; Substrate 4130 and 1008/1010
Experimental control specimens	Cd and Zn-Ni brush-plated specimens, using traditional brush plating
Acceptance criteria	Coatings will show galvanic corrosion resistance compared to control

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4.0 REFERENCE DOCUMENTS

4.1 Attachment A: Reference Document Table

Table 16. Reference Documents

Reference Document	Title	Date	Applicable Sections of Reference Document	JTP Test	JTP Section
1	RCRA	1974	All	N/A	Introduction
2	DWG No. 201027456	2012	Para 4.10	Strippabiilty	3.2.8
3	DWG No. 201027457	2012	All	Appearance Uniformity, Thickness/Composition, Bend Adhesion, Wet/Dry Tape Adhesion, Salt Spray Resistance, Hydrogen Embrittlement, Re-HE, Stripping Method,	3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.8
4	AMS-QQ-P-416	2009	Para 3.5.2 Para 3.3.1 Para 4.6.2 Para 4.6.3 Para 4.6.4.1	Appearance Thickness/Composition Bend Adhesion Salt Spray Resistance Hydrogen Embrittlement	3.2.1, 3.2.2, 3.2.3 3.2.5 3.2.6
5	MIL-STD-870	2014	Para 4.5	Appearance Hydrogen Embrittlement	3.2.1, 3.2.6
6	ASTM B 530	2014	All	Thickness/Composition	3.2.2
7	ASTM B 568	2014	All	Composition	3.2.2
8	ASTM B 571	2013	All	Bend Adhesion	3.2.3
9	SAE-AMS-2451/9	2012	Para 3.2.3	Salt Spray Resistance	3.2.5
10	ASTM F 519	2013	All	Hydrogen Embrittlement	3.2.6, 3.2.7
11	ASTM D 3359	2009	All	Paint Adhesion	3.2.4
12	ASTM G 85	2011	Annex 5	SO_2 Resistance	3.2.9
13	GMW 14872	2013	All	Galvanic Corrosion	3.2.10
14	MIL-PRF-32239A (draft)	2014	Para 3.6.11, 4.5	Galvanic Corrosion	3.2.10
15	ASTM B 117	2011	All	Salt Spray Resistance	3.2.5
16	BAC 5637	2008	Para 11.2-11.5,	Appearance Uniformity, Thickness/Composition, Bend Adhesion, Salt Spray Resistance,	3.2.1 3.2.2 3.2.3 3.2.5 3.2.6
17	BAC 5664	2005	All	Appearance Uniformity, Thickness/Composition, Salt Spray Resistance	3.2.1
18	BSS 7235	1987	All	Adhesion	3.2.3

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4.2 Attachment B: References List

(1) Resource Conservation and Recovery Act (1974)

(2) Air Force Drawing 201027456, Low Hydrogen Embrittlement Plating Process Specification Zinc-Nickel (May 2012)

(3) Air Force Drawing 201027457, Solutions for Use in LHE Zinc-Nickel Plating on High Strength Steel Substrate (>180 ksi) Landing Gear Components (May 2012)

(4) AMS-QQ-P-416 Plating, Cadmium (Electrodeposited) (2009)

(5) MIL-STD-870 Military Standard, Cadmium Plating, Low Embrittlement, Electro-deposition (2007)

(6) ASTM B 530 Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates (2014)

(7) ASTM B 568 Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry (2014)

(8) ASTM B 571 Standard Practice for Qualitative Adhesion Testing of Metallic Coatings (2013)

(9) SAE AMS 2451/9; Plating, Brush, Zinc-Nickel, Low Hydrogen Embrittlement (September 2012)

(10) ASTM F 519 Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments (2013)

(11) ASTM D 3359 Standard Test Methods for Measuring Adhesion by Tape Test (2009)

(12) ASTM G 85 Standard Practice for Modified Salt Spray (Fog) Testing (2011)

(13) GMW 14872 General Motors Accelerated Corrosion Test Method (2013)

(14) MIL-PRF-32239A Performance Specification, Coating System, Advanced Performance for Aerospace Applications (DRAFT May 2014)

(15) ASTM B 117 Standard Practice for Operating Salt Spray (Fog) Apparatus (2011)

(16) BAC 5637 Zinc Nickel Alloy Plating (2008)

(17) BAC 5664 Low Hydrogen Embrittlement Stylus Zinc-Nickel Alloy Plating (2005)

(18) BSS 7235 Adhesion Test Method, Plating (1987)

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Appendix D: Technology Demonstration Report

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DEMONSTRATION REPORT

Cadmium-Free Alternatives for Brush Plating Repair Operations

ESTCP Project WP-201412

Randy Straw
Air Force Life Cycle Management Center

Chris Venturella
University of Dayton Research Institute

Draft Version 2

May 2020

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Acronyms and Symbols

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
µg/m^3	micrograms per cubic meter of air
A	amps
AC	alternating current
ACGIH	American Conference of Government Industrial Hygenists
AFLCMC	Air Force Life Cycle Management Center
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
AFSC	Air Force Sustainment Center
AMCOM	Aviation and Missile Command
ANSI	American National Standards Institute
CAA	chromic acid anodizing
Cd	cadmium
COTS	commercial-off-the-shelf
Cr	chromium
dBA	decibels
DC	direct current
DoD	Department of Defense
EHS	environmental health and safety
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESOH	Environment, Safety, and Occupational Health
ESTCP	Environmental Security Technology Certification Program
EU	European Union
EZP	Product Support Engineering Division
FRCSE	Fleet Readiness Center South East
HAP	hazardous air pollutants
HSS	high strength steels
Hz	hertz
ICBM	Intercontinental Ballistic Missile
IO	Input/output
IRR	internal rate of return
JTP	Joint Test Protocol
LHE	Low Hydrogen Embrittlement
M&S	maintenance & sustainment
MMG	Minuteman Motor Generator
NAVAIR	Naval Air Systems Command
NIOSH	National Institute of Occupational Safety and Health
NESHAP	National Emission Standards for Hazardous Air Pollutants

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OEM	original equipment manufacturer
OO-ALC	Ogden Air Logistics Complex
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PI	principal investigator
PPE	personal protective equipment
PVC	polyvinyl chloride
REACH	Registration, Evaluation, Authorization and Restriction
RoHS	Restriction of Hazardous Substances
SBIR	Small Business Innovative Research
SIFCO	SIFCO Industries, Inc.
SVHC	Substances of Very High Concern
TWA	time-weighted average
U.S.	United States
UDRI	University of Dayton Research Institute
USAF	United States Air Force
V	volt
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization
WR-ALC	Warner Robins Air Logistics Complex
XRF	x-ray fluorescence
Zn-Ni	zinc-nickel

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1.0 INTRODUCTION

The United States Air Force (USAF) is progressing towards a cost-effective engineering mindset, wherein all operations across the USAF enterprise must be considered and evaluated to reduce life cycle costs and environmental burden while also increasing worker safety and weapon system readiness. Likewise, there is a need to leverage such engineering activities across the Tri-services. Elimination of cadmium (Cd) plating operations is one such area where cooperation across the services is required to successfully eliminate the environmental hazards and regulatory burdens for the Department of Defense (DoD). The Environmental Security Technology Certification Program, in cooperation with the Air Force Life Cycle Management Center (AFLCMC), is sponsoring a Tri-services program focused on the elimination of Cd in current brush plating operations.

*1.1 **Background***

Cadmium (Cd) is widely used as a coating material in the aerospace industry and the DoD because it imparts excellent corrosion resistance, adhesion, lubricity, and electrical conductivity characteristics. However, Cd is classified as a carcinogen, and long-term exposure has been linked to lung cancer and kidney disease. As a result, the U.S. Occupational Safety and Health Administration (OSHA) has set Permissible Exposure Limit (PEL) for Cd and Cd containing compounds.

Cd can be applied via immersion (tank) or brush plating. Within the DoD, immersion plating is typically used for treating large parts or larger areas on parts that must be refurbished, while brush plating is typically used for touch up, smaller area repair, and on parts requiring in situ repair.

Traditional brush plating is conducted using a brush saturated with plating solution. The process of brush plating can occur on localized areas or entire parts, and is considered an “open process.” An “open process” system allows for the solution to flow down vertical or irregular surfaces, or drip from overhead during the plating operation. The lack of control of the solution during the process leads to potential worker exposure to the solution and contamination of the surrounding area.

Cd brush plating repair processes are still utilized within the DoD. Because Cd is regulated by the Resource Conservation and Recovery Act 1974 (RCRA), is a D-listed hazardous waste material, and has an OSHA Action Level PEL of 2.5 µg/m3 as an 8-hour TWA, a need has been identified to qualify and implement a zinc-nickel (Zn-Ni) coating as a Cd replacement for spot repair operations on military weapon systems.

To address these concerns, AFLCMC Product Support Engineering Division (AFLCMC/EZP), in conjunction with the Environmental Security Technology Certification Program (ESTCP), initiated this project to evaluate a closed loop brush plating tool that recycles plating solutions at the point of application, minimizing operator exposure to chemicals and solid waste associated with adsorbents used to contain solution leakage attributed in traditional brush plating as well as evaluate a zinc-nickel brush plating solution as a potential Cd replacement.

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1.2 Objective of the Demonstration

This project focuses on the elimination of toxic/carcinogenic Cd material in brush plating repair operations and the reduction of hazardous waste associated with adsorbents used to contain solution leakage attributed with traditional brush plating repair processes. The technical objectives for the demonstration and implementation of the Dalistick® Station (Dalic Inc.) are as follows.

3. Demonstrate the usefulness of the Dalistick® D.2020 (Dalic Inc.) commercial-off-the-shelf (COTS) brush plating tool for selective plating for DoD maintenance, repair and overhaul operations.

4. Test and evaluate the Zinidal™ Aero Zn-Ni brush-plated coating (by Dalic Inc.) COTS material as a Cd replacement on mild and high-strength steels for repair applications on several decommissioned weapon system parts. (T-45 arresting hook pivot assembly, F-18 arresting hook pivot assembly, and F-18 arresting hook shank)

This technology was demonstrated at the North American Distributor of the Dalistick station, Corrdesa LLC, located in Tyrone GA. Representatives from the Fleet Readiness Center Southeast (FRCSE) at the Naval Air Station in Jacksonville, FL were present during the demonstration and provided the parts for the plating demonstration.

FRCSE uses conventional brush plating for aircraft maintenance and repair within their plating facilities, following QQ-P-416 and MIL-STD-865D in their application procedures. Brush plating is used to primarily repair high strength and low strength steel items, such as tail hooks, on the P-3 Orion, T-45 Goshawk Trainer, F/A-18A-D Hornets, F/A-18 E/F Super Hornets EA-6B Prowler, and SH-60 Seahawk.

The proposed technology is portable and has a relatively small footprint and working area. It can easily be moved around within the plating shop. Additionally, due to its portability, it may be able to be used in the field, as may be desired by other DoD facilities. FRCSE has some brush plating processes that require Level II (Depot) capabilities that are not available at Level I/II maintenance sites. As a result, the FRCs must send repair technicians into the field to repair the assets. FRCSE's evaluation of the technology will determine its usefulness in field repair applications as well as to Level II depot applications.

Integration of the Dalistick Station into the DoD depots will reduce overall operator exposure to residual brush plating solutions, allow for the re-use of plating solution to reduce solid waste, and may eliminate the use of Cd in this military repair operation. This will substantially aid in DoD goals to reduce operator exposure to chemicals in general, reduce maintenance costs (through extended solution use), and reduce solid hazardous waste. Table 1 provides a summary on Cd, including applicable specifications and the candidate parts that could be repaired using the Dalistick tool and associated Zinidal Aero Zn-Ni coating.

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Table 42. Target Hazardous Material (HazMat) Summary

Target HazMat	Current Process	Applications	Current Specifications	Affected Programs	Candidate Parts and Substrates
Cd	Traditional brush plating	Steel components	QQ-P-416 MIL-STD-865D	P-3, F/A -18, T-45, EA-6B, SH-60, C-5, C-17, C-13, F-15, etc.	Landing gears, tail hooks, & other weapon system parts and components

1.3 Regulatory Drivers

Restrictions on Cd, chromium (Cr), and other air pollutants and environmental toxins are becoming more stringent both nationally and internationally. Due in part to its classification throughout most of the world as a carcinogen, Cd use and disposal is regulated in every media and at every governmental level. The development of Cd restrictions and legal requirements is extensive both within the United States and internationally.

1941	ANSI sets guideline standard of 1000 µg/m^3
1956	ACGIH assigns TLV of 100 µg/m^3 for Cd oxide fumes
1971	OSHA Act sets 8–hour TWA PELs and ceiling concentrations for Cd fumes, dust and oxides
1973-1974	ACGIH changes TLV for Cd fumes and dust to 50 µg/m^3
1974	Congress passes Safe Drinking Water Act, APS sets MCL for Cd at 5 ppb
1976	National Institute of Occupational Safety and Health (NIOSH) sets 10-hour exposure of Cd to 40 µg/m^3 and 15-minute exposure to 200µg/m^3
1984	NIOSH issues a CIB for Cd, regarding Cd an occupational carcinogen
1984	EPA lists Cd as B1 substrate a “probable human carcinogen”
1986	Emergency Planning and Community Right-to-Know Act (EPCRA) requires annual reporting of Cd releases
1987	World Health Organization (WHO) lists Cd as a 2A level substance; a “probable human carcinogen”
1990	Cd compounds added to Clean Air Act list of hazardous air pollutants (HAPs)
1992	OSHA publishes a new division of industrial workforce standards for Cd
1995	Cd emissions targeted in Aerospace Manufacturing and Rework Facilities National Emission Standards for Hazardous Air Pollutants (NESHAP)
1998	OSHA regulation requires new employee examination regulations targeting adverse health affects
2000	Executive Order (EO) 13148 requires reductions in Federal agency use and releases of toxic chemicals
2003	European Union (EU) adopts the *waste electrical and electronic equipment* (WEEE) directive at the state member level
2004	EU Directive 2004/37/EC requires EU employers to reduce use of carcinogens such as Cd

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2006	EU Restriction of Hazardous Substances (RoHS) Directive[38] bans Cd above 0.01% in new electrical and electronic equipment
2007	EO 13423 requires reductions in Federal agency use and releases of toxic chemicals
2008	Area Source NESHAP for Plating and Polishing Operations limits Cd emissions from small operations
2009	EO 13514 requires reductions in Federal agency use and releases of toxic chemicals
2011	REACH[39] restricts Cd in jewelry, brazing sticks, paints and plastics
2012	OSHA updates hazard communication requirements for Cd
2013	Cd placed on Registration, Evaluation, Authorization and Restriction (REACH) Candidate List of Substances of Very High Concern (SVHC); creates potential for banning of use in EU
2014	DoD Strategic Sustainability Performance Plan requires toxic chemicals to be reduced by 15% by 2020
2015	EO 13693 requires Federal agencies to reduce quantity of toxic chemicals and materials acquired, used, or disposed
2015	REACH proposal would further restrict Cd in certain paints
2015	Aerospace NESHAP Residual Risk Rule adds restrictions on Cd emissions from specialty coating operations

There have been many efforts over the last 20 plus years focused on the replacement of Cd due to the increased stringency of regulations on its use and the occupational, health and safety concerns. Ogden Air Logistics Complex (OO-ALC) implemented an immersion-based low hydrogen embrittlement Zn-Ni chemistry that is suitable for use on high strength steel landing gear. With the immersion based chemistry, OO-ALC also qualified and implemented a brush plating Zn-Ni chemistry by SIFCO. However, the need still exists to reduce the associated solid hazardous waste associated with traditional brush plating as well as extend the useful life of solutions to reduce maintenance costs and conserve materials. Further, qualification of an additional Zn-Ni chemistry in conjunction with the dripless tool will provide another source for solutions. This project addresses those needs.

1.4 Stakeholder/End-User Issues

This project is a Tri-services project with stakeholder input having been provided by each stakeholder, shown in Table 2. The stakeholders have interest in the successful integration of the Dalistick Station to aid in pollution prevention and hazardous materials management in their depot and field operations. This team has participated in project update teleconferences, and documentation review / acceptance including the Joint Test Protocol, and the first draft of the Demonstration Plan. As a result of such collaborative participation in demonstrating and validating the use of the Zinidal Zn-Ni chemistry with the Dalistick process, it can be utilized across the DoD services.

[38] Military electrical and electronic equipment is specifically excluded from coverage under RoHS.

[39] REACH is not applicable to products imported by DoD for direct support of EU-based forces, BUT it could compromise part availability/performance.

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Table 43. Stakeholders

Name	Organization	Phone #	e-mail
Randy Straw	AFLCMC/EZP	937-255-7730	dandall.straw.1@us.af.mil
Caroline LeClair	309 CMXG/MXDEC	801-586-7258	caroline.leclair.1@us.af.mil
Dave Frederick	AFMC 417 SCMS/GUEA Hill LG	801-777-7352	david.frederick.1.@us.af.mil
Mark Forbes	AFMC 309 MMXG/EN ICBM Trailers	801-586-5928	mark.forbes@us.af.mil
Luzmarie Youngers	NAVAIR ISSC, 4.3.4.2		luzmarie.youngers@navy.mil
Mark Feathers	AMCOM G-4	256-842-7355	mark.g.feathers@conus.army.mil
Michael Johnson	AMCOM G-4	256-842-7719	michael.l.johnson17.ctr@mail.com
Robert (Yogi) Kestler	FRC-East	252-464-9888	robert.kestler@navy.mil
Luc Doan	FRC-Southwest	619-545-9756	luc.doan@navy.mil
Aaron Rains	FRC-Southwest	619-545-7304	aaron.rains@navy.mil
John (Jack) Benfer	FRC-Southeast	904-790-6405	john.benfer@navy.mil
Ruben Prado	FRC-Southeast	904-542-3444	ruben.prado@navy.mil
Chris Venturella	University of Dayton Research Institute (UDRI)	937-229-3407	christopher.venturella@udri.udayton.edu

AFMC=Air Force Materiel Command; AMCOM = Aviation and Missile Command; FRC=Fleet Readiness Center

FRCSE is the lead participant in this technology demonstration because they conduct a significant amount of Cd brush plating within their shop to repair P-3 Orion, F/A-18A-D Hornets, F/A-18 E/F Super Hornets EA-6B Prowler, and SH-60 Seahawk weapon systems. They also have brush plating processes that require Level II (Depot) capabilities that are not available at Level I/II maintenance sites. The FRCs then send repair technicians into the field to repair the assets. FRCSE has an existing plating infrastructure with experienced repair personnel. They are currently leading a project to look at using alternative solutions in the Dalistick D.2020 Station, as well develop new tools for the process. This demonstration will give them initial hands on experience with the station early into their project.

Ogden Air Logistics Complex (OO-ALC) participates in this effort as a stakeholder because they, too, conduct Cd brush plating operations to support the maintenance and repair of the F-35 Lightning II, F-22 Raptor, F-16 Fighting Falcon and A-10 Thunderbolt, C-130 Hercules, and T-38 Talon weapon systems. OO-ALC is offering their technical support and input on this project. Pending the demonstration results from FRCSE, OO-ALC may also conducting an on-site demonstration and validation of the technology.

AFLCMC is participating in this effort because they have been charged with the mission to implement technologies that offer operational, occupational, economic, and environmental benefits associated with weapon system maintenance and sustainment (M&S) processes, and enable enterprise-wide implementation for cost reduction, increased worker safety, and enhanced

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weapon system readiness. Furthermore, the SPOs that fall under AFLCMC, also denoted in Table 1, are an active, and imperative component to this program.
AFMC is participating in this effort though 1) the ALC community (e.g., WR-ALC, OC-ALC, OO-ALC), 2) the cognizant landing gear approval authority (e.g., the 417 SCMS/GUEA), and 3) the cognizant intercontinental ballistic missile (ICBM) trailer authority (e.g., the 309 MMXG/EN). ALC interest has been noted as eliminating the use of a hazardous material, while reducing overall operator exposure to chemicals. Similar to the SPOs, the 417 SCMS/GUEA and 309 MMXG/EN, are focused on eliminating the use of hazardous materials on the assets that they oversee, which include landing gear/wheels, struts, etc, and ICBM trailer components. Elimination of the hazardous material and reduced occupational exposure greatly reduces the costs and liability associated with current refurbishment operations.
Aviation and Missile Command (AMCOM) G-4 is participating in this effort because Cd repair is conducted extensively in the AMCOM depots and field unit operations throughout the Army. As a result, AMCOM maintains some of the same environmental, health, and safety concerns as have been expressed by the USAF. Therefore, this partnership will help to ensure that critical Army requirements are addressed for all candidate replacement applications. Upon successful completion of this ESTCP program, AMCOM will consider implementing the successful coating and/or brush plating replacement process.
In addition to possibly transitioning the technology to the Tri-service repair facilities, the technology also has the ability to be used in the field with little environmental concerns, as compared to conventional brush plating. It will afford the ability to repair essential aircraft components for minor issues (corrosion/wear) in the field what will reduce transportation/energy costs due to in-field repair capability. The decision of implementation to in-field repair will be at the discretion of the individual stakeholders.

2.0 TECHNOLOGY

2.1 Technology Description

Extensive work, both nationally and internationally, has been performed on zinc-nickel (Zn-Ni) alloys as replacements for Cd in immersion electroplating. Low hydrogen embrittlement (LHE) Zn-Ni coatings have been implemented at OO-ALC for use on high strength steel landing gears (per DRW No.201027456/ 201027457). This work was done through multiple Small Business Innovative Research (SBIR) contracts, including the successful demonstration of the Phase II SBIR "Development of Cd Plating Replacement with Zn-Ni on High Strength Steel Components", (FA8201-08-C-0054), that led to the demonstration/validation effort on Zn-Ni coatings that was performed through the Environmental Security Technology Certification Program (ESTCP) project #WP-201107. Also through that program, electroplated Zn-Ni alloys that meet AMS2451/9, "Plating, Brush, Zinc-Nickel Low Hydrogen Embrittlement (LHE)" have been identified as potential brush plating replacements for Cd. However, brush-plated Zn-Ni has not been widely approved nor used as a Cd replacement in military repairs, due in part to the lack of military specific qualification testing (e.g., weapon system or service specific requirements). In addition, the health and safety issues associated with traditional brush plating, including substantial liquid and solid waste (due to adsorbents used to catch dripping plating solutions) increases disposal costs.

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The Dalistick Station development initiated when a requirement was presented to Dalic in the mid-1990s from original equipment manufacturers (OEMs) performing chromic acid anodizing (CAA) during the assembly of airframe parts. They desired to have a system that did not drip solutions when conducting CAA, regardless of position, e.g., overhead, inverted, in tight spaces, etc. As a result, Dalic Inc. investigated various concepts to meet their needs. Eventually, in 1996, they settled on the design that is the basis of the Dalistick D.2020 that is being used today. Over the years, Dalic Inc. has made improvements to the materials, Dalistick tool, rectifier technology, etc., which has culminated in the current Dalistick D.2020. The Dalistick D.2020, launched into production in 2012, is the unit being used under this program.

Today, over 30 Dalistick stations (of varying design) are in use by OEM, civil, and military operations outside of the United States for plating and anodizing operations. Use of Dalistick for Cd plating on steels have been approved by Airbus SRM 51.21.11, Boing BAC 5854, Messier-Dowty PCS 2141, Goodrich LGPS 1102, Eurocopter, and Argusta-Westland for applications on landing gear, flap track, engine pylon, bushings, bolts, etc.

The Dalistick D.2020 station is a closed loop electroplating system that enables selective electrochemical treatments (anodizing, electroplating, and surface preparation). Figure 1 displays the Dalistick D.2020 unit and associated cart. The cart allows for portability of the process so it can be performed in the plating shop or in the field.

The station is controlled by a touch screen computer which features step-by-step plating steps, cleaning operations, and self- diagnostics. The Dalistick D.2020 has been designed to control electrochemical surface treatments in regards to:

- The electrolyte (constant flow, temperature control, display of usage rate, display of consumable life),
- The electroplating process (voltage control, process control according to the required current),

A rectifier with two leads provides a source of direct current for all electrochemical treatment processes. One lead is connected to the plating tool/electrode and the other is connected to the part being finished. A circuit is completed when the plating tool/electrode is in contact with work surface.

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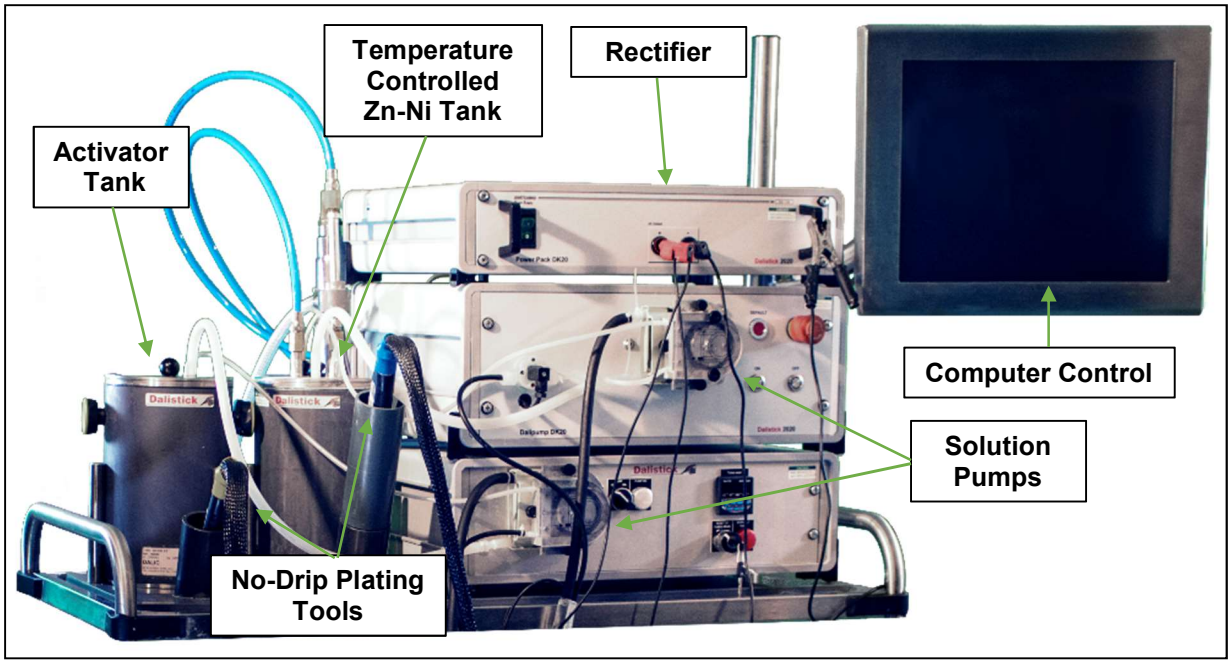

Figure 88. Dalistick 2020 on Cart

The pre-treatment (Activator) tank contains the Activator XF solution which is used to prepare the surface for Zn-Ni plating.

The Zn-Ni tank is a temperature controlled tank featuring an electric heater, compressed air vortex chiller and internal cooling coils. This tank stores and regulates the temperature of the Zinidal Aero Zn-Ni solution for Zn-Ni plating.

The solution pumps are used to supply the activator and Zn-Ni solution to the plating tools. The top pump is for the Zn-Ni and is computer controlled. The bottom pump is for the activator which is turned on manually on older model stations and computer controlled on newer stations. The pumps also recovers residual brush plating solution at the point of contact with the part during plating and recycles it for reuse in a closed-loop process. Solution life/use is extended and solid waste from absorbents used to contain dripping solution is reduced.

The station contains two plating tools, one for the activator and one for the Zn-Ni solution. These two tools eliminate the need to change solutions during a Zn-Ni plating treatment. The station is also equipped with two different types of tools which can be installed for use of different components. They can be seen in Figure 2.

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Figure 89. Plating Tools

The Dalistick D.2020 is capable of performing localized repair on small areas including flat, vertical, horizontal, contoured surfaces, as well as in-situ repairs.

Zn-Ni electroplating is currently a leading candidate for Cd replacement. A SIFCO 4018 Zn-Ni solution is currently qualified and additional Zn-Ni solutions are under evaluation. The Zinidal Aero Zn-Ni solution is one such solution which will be tested during this demonstration. The process deposits a coating with 10-20% weight Ni and 80-90% weight Zn at varying thicknesses, thus meeting SAE AMS2451/9 “Plating, Brush, Zinc-Nickel Low Hydrogen Embrittlement” requirements for Ni and Zn content (6-20% Ni with balance essentially Zn).

The Zinidal Aero Zn-Ni process is similar to conventional Cd brush plating operations. Solvent degreasing is performed to remove grease, oils, and dirt from the surface to be plated. Hand sanding is not required prior to solvent cleaning unless the substrate material is damaged or the rust is significant. Next the areas not to be plated are masked with aluminum and vinyl or PVC tape. Due to the Dalistick Station affording no leaking solutions, the required masking is reduced and the use of absorbent pads in adjacent area or around the part are eliminated. Next the surface is etched with the activator to prepare the substrate for plating with the Zinidal coating, followed by a clean water rinse. The Zinidal Aero Zn-Ni plating is performed, followed by another clean water rinse. Masking is removed next. The part is then dried with oil-free, dry compressed air. When Type II plating operations are required the conversion coating can be applied via pen, or saturated absorbant. This is the same as applying a conversion coating for Cd plating. Lastly there is no need for hydrogen embrittlement relief of Zinidal Aero Zn-Ni plated parts.

The process flow for the Zinidal Aero Zn-Ni brush plating using the Dalistick 2020 station is shown in Figure 3.

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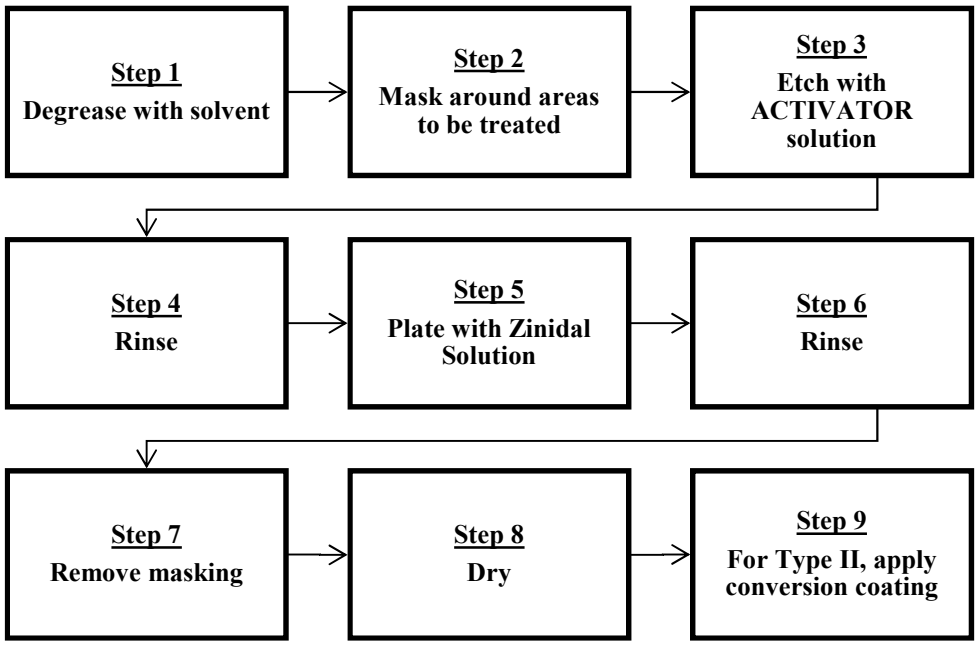

Figure 90. Zinidal Aero Zn-Ni Coating Process with Associated Pre and Post-treatments

Additionally, the Dalistick is capable of performing other surface finishing operations such as spot anodizing, coating removal, and rust removal with the same equipment and plating tools. This is achieved by changing the treatments solutions and selecting the new treatment type in the computer.

2.2 Technology Development

As noted previously, over 30 Dalistick stations are in use by OEM, civil, and military operations outside of the United States for plating and anodizing operations. Use of Dalistick for Cd plating on steels have been approved by Airbus SRM 51.21.11, Boeing BAC 5854, Messier-Dowty PCS 2141, Goodrich LGPS 1102, Eurocopter, and Argusta-Westland for applications on landing gear, flap track, engine pylon, bushings, bolts, etc.

Foreign militaries are using the Zinidal solution in combination with the Dalistick Station for aerospace applications. It has been publicized that the Dalistick station and Zinidal coating are being used on Dassault aircrafts, French missiles M.5, F-18 owned by the Spanish Air Force, Ariane V Booster rocket module, Airbus aircraft. More specifically,

- Zinidal is approved as a final coat to prevent erosion on aluminum wing leading edges
- Zinidal is approved as per the EN-4826 STD for Zn-Ni on steel up to 1420 MPa
- Zinidal was applied successfully with the Dalistick Station on F-18 vertical cone face with damages of galvanic corrosion for the Spanish Air Force
- Zinidal is approved for use on various steel and aluminum alloys by Thales, a leading supplier in electronics for defense
- Zinidal is approved for use to prevent corrosion on aluminum alloys by Nexter, a land defense equipment supplier.

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Due to the promising results of the Zinidal coating as applied by the Dalistick Station, Air Force Research Laboratory (AFRL) Environment and Energy (E2) and Concurrent Technologies Corporation (CTC) evaluated it as a Cd replacement for Cd Type I replacement on mild steel parts of the ICBM Minuteman III Motor Generator (MMG) assembly. The Zinidal Zn-Ni coating applied using the Dalistick Station was tested as candidate for Cd replacement, and it outperformed other tested COTS brush plated Zn-Ni coatings in corrosion, wear and electrical resistance testing while meeting the specific requirements identified by MMG Project Team, as shown in Table 3.[40] As a result of this promising data, Zinidal was recommended as a candidate for Cd replacement for the specific MMG application, pending full-scale validation testing. The Dalistick Station has since been implemented at Portsmouth Naval Shipyard for Cd Type I and Cd Type II repair on mild steel components, while additional funding is being sought for full qualification of Zinidal Zn-Ni coating.

Both the Zinidal coating and Dalistick brush plating station have a high level of maturity as an alternative candidate to replace conventional brush plated Cd on HSS, based on the accepted and in-use applications being conducted in the international market. Therefore, there is a strong belief that there is enough evidence that this is a successful technology for potential approve for USAF use. Additionally, the tool can be used to conduct other plating operations (e.g., Ni, Cr) or anodizing operations for DoD applications, if desired.

Table 44. Test Results Summary

Test	Units	Cd	Vendor 1 Zn-Ni	Vendor 2 Zn-NI	Dalistick Zn-Ni (Traditionally Plated)	Dalistick Zn-Ni (Dalistick Station)
Appearance (AMS QQ-P-416)	N/A	PASS	PASS	PASS	PASS	PASS
Bend Adhesion (ASTM B 571)	N/A	Not Tested*	PASS	PASS	PASS	PASS
Thickness, Magnetic (ASTM B 499)	Thousandth of an inch (mils)	0.53 ± 0.05	0.55 ± 0.04	0.61 ± 0.11	0.56 ± 0.03	0.49 ± 0.03
Thickness, Cross-sectional (ASTM B 487)	Mils	Not Tested*	0.59 ± 0.04	0.60 ± 0.09	0.50 ± 0.08	0.47 ± 0.06
Composition EDS (ASTM E 1508, Surface)	Weight %	Cd: 100 trace atmospheric contaminants	Zn: 88 ± 2 Ni: 12 ± 2 trace atmospheric contaminants	Zn: 89 ± 1 Ni: 11 ± 1 trace atmospheric contaminants	Zn: 88 ± 0.6 Ni: 12 ± 0.6 trace atmospheric contaminants	Zn: 88 ± 0.3 Ni: 12 ± 0.3 trace atmospheric contaminants
Composition EDS (ASTM E 1508 Cross-sectional)	Weight %	Cd: 100 trace atmospheric contaminants	Zn: 91 ± 4 Ni: 9 ± 0.3 trace atmospheric contaminants	Zn: 91 ± 2 Ni: 9 ± 1 trace atmospheric contaminants	Zn: 88 ± 0.6 Ni: 12 ± 0.6 trace atmospheric contaminants	Zn: 88 ± 0.3 Ni: 12 ± 0.3 trace atmospheric contaminants

*Bend adhesion, cross-sectional composition and thickness testing were not conducted; acceptable results were found in prior testing.

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Table 3. Test Results Summary (Continued)

Test	Units	Cd	Vendor 1 Zn-Ni	Vendor 2 Zn-NI	Dalistick Zn-Ni (Traditional Plated)	Dalistick Zn-Ni (Dalistick Station)
Wear (500 cycles) (ASTM G 115) (ASTM F 133)	COF[1]	0.32 ± 0.06	0.20 ± 0.03	0.23 ± 0.12	Not tested	0.3 ± 0.14
	Severity Ranking	3	2	2	Not tested	3
Wear (5,000 cycles) (ASTM G 115) (ASTM F 133)	COF	0.44 ± 0.02	0.43 ± 0.07	0.45 ± 0.21	Not tested	0.7 ± 0.35
	Severity Ranking	5	3	3	Not tested	4
Salt Fog Corrosion (ASTM B 117)	Scribed[2]	9	9	8	10	10
	Unscribed[3]	8	7	7	10	10
Electrochemical Properties (ASTM G 1, 3, 5, & 61)	OCP (mV)	-680 ± 3	-1,032 ± 2	-955 ± 93	-1,020 ± 9	-979 ± 1
Whisker Growth (After 3,000 hours) (JEDEC[4] Standard JESD22-A121A)	N/A	No Whiskers	No Whiskers	No Whiskers	Not tested	No Whiskers

* Electrical Contact Impedance performed by Matco Services.

** Electrical Contact Impedance performed by CTC, after equipment was transferred.

[1] COF = Coefficient of friction; measurements are dimensionless.

[2] Represents the average rating at the scribed area (average coating thickness for tested panels in parentheses).

[3] Represents the average rating at the unscribed area on panels that were not scribed (average coating thickness for tested panels in parentheses).

[4] JEDEC = Joint Electron Devices Engineering Council, which is the semiconductor engineering standardization body of the Electronics Industries Alliance (EIA)

2.3 Advantages and Limitations of the Technology

The primary goal of this program is to eliminate the use of Cd and reduce operator exposure to hazardous chemicals in general. Implementation of the Zinidal coating, as applied by the Dalistick Station, will offer immediate and long-term regulatory and EHS benefits including the following:

- Avoidance of Cd compliance issues in military repair operations
- Environmental and operational impacts
  - Ability to perform selective electrochemical treatments and plating using a single system
  - Minimal electrolyte/hazardous chemical solution leakage during processing
  - Ability to treat curved, horizontal, vertical surfaces, and edges either in the field or in the ALCs/Depots
- Reduction of solid waste that is generated from using absorbents
- Reduction of worker exposure to any hazardous material (including residual brush plating solution)
- Reduction of monitoring, use of personal protective equipment, permitting, and record Keeping

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The limitations of this technology/process lie in the following:

- The capital cost of the equipment is significantly higher for the Dalistick Station (at about $125,000) than a conventional brush plating system (at about $15,000).
- Having a single source provider is usually not desirable due to potential impact if the provider closes, reduces inventory, or increases prices due to a captured market.
- Importing a foreign chemical, especially from Europe where regulatory burdens are escalating, even on chemicals that are considered to be far less of an environmental and safety concern than Cd (e.g., Zn and Ni), could result in difficulty in obtaining the Zinidal chemistry in the future.
    - There is one US distributor of the system and supplies which may reduce this burden.

However, when performing a sustainability analysis which includes a number of factors such as hazardous waste disposal costs as well environmental and occupational health and safety costs the 15 year life cycle cost of the system is comparable to a traditional Cd brush plating process.

The concern about a sole source provider of the technology remains however due to the ability to configure the machine, it is expected that other approved brush plating chemistries could be used with the Dalistick Station with testing.

3.0 PERFORMANCE OBJECTIVES

The following performance objectives are primary criteria that have been established for evaluating the Dalistick Station and associated Zinidal Coating:

3. Demonstrate the usefulness of the Dalistick® D.2020 (Dalic Inc.) commercial-off-the-shelf (COTS) brush plating tool for selective plating for DoD maintenance, repair and overhaul operations.
4. Test and evaluate the Zinidal™ Aero Zn-Ni brush-plated coating (by Dalic Inc.) COTS material as a Cd replacement on mild and high-strength steels for repair applications on weapon system parts.

The success of item 1 will be determined by gathering both quantitative and qualitative information during the technology demonstration. Item 2 follows the criteria set by the JTP. These requirements are detailed further in Table 7.

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Table 45. Engineering, Performance and Testing Requirements

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Quantitative Performance Objectives		
Appearance Uniformity	AMS-QQ-P-416 USAF DWG 201027457 MIL-STD-870 BAC 5637 BAC 5664	Visual inspection of all specimens shows that coating is continuous, smooth, adherent, uniform in appearance, free from blisters, pits, nodules, burning, contaminants, excessive powder, and other apparent defects
Thickness &Alloy Composition Uniformity	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 ASTM B 530 ASTM B 568	Average coating thickness on flat areas of the specimen, measured in a minimum of three areas of each specimen is within 0.0004 to 0.0007 inch); Consistent alloy composition is obtained along the fixture cavity when tested using XRF method
Bend Adhesion	USAF DWG 201027457 AMS-QQ-P-416 ASTM B 571 BAC 5637 BSS 7235	There is no separation (flaking, peeling, or blistering) of coating from the basis metal

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Table 4. Engineering, Performance and Testing Requirements (Continued)

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Wet/Dry Tape Paint Adhesion	USAF DWG 201027457 ASTM D 3359 MIL-PRF-23377 MIL-PRF-85582 MIL-PRF-32239A (draft)	Plated specimens are coated with MIL-PRF-85582 or MIL-PRF-23377 and cured for 14 days at room temperature (RT). Specimens are either tested at RT (dry) or immersed for 24 hours (h) in DI water at 73°F then tested (wet) – an adhesion rating of 4B or better (less than 5% area removed), per ASTM D 3359
Corrosion Resistance – Salt Spray Resistance	AMS-QQ-P-416 USAF DWG 201027457 BAC 5637 SAE AMS 2451/9 ASTM B 117 ASTM D 1654	After 96 h exposure, there is no evidence of white corrosion; Up to 500 h exposure, there is no appearance of red rust or comparable to controls (10 per coating scenario)
Corrosion Resistance - SO_2 Resistance	ASTM G 85	Must meet 168 h exposure before appearance of red rust or comparable to controls
Corrosion Resistance -Galvanic Corrosion Resistance	GMW 14872 MIL-PRF-32239A (draft) Section 4.5	Galvanic couple of Zn-Ni and Cd plated steel specimens with Cd plated screws and stainless steel screws (all dry installed). Specimens will be exposed to GMW 14872 corrosion cycle. Red rust corrosion will be comparable to control
Hydrogen Embrittlement	AMS-QQ-P-416 USAF DWG 201027457 SAE AMS 2451/9 ASTM F 519 MIL-STD-870 BAC 5637	No fracture for plated specimens within 200 h after sustained 75% notched fracture strength (NFS) load testing. Type 1a.1 notched bar and Type 1d notched C-ring specimens. All 4 specimens must pass; if one fails, remaining 3 are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture. (3 out of 4 with no fracture = pass) (2 with fracture = fail) Success conclusions will also be drawn from a hydrogen embrittlement study performed by Boeing Research and Technologies and IBECA Technologies particularly in regards to surface treatment effects on hydrogen embrittlement

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Table 4. Engineering, Performance and Testing Requirements (Continued)

Performance Objective	Data Requirements	Success Criteria (meet or exceed)
Service Chemical Hydrogen Embrittlement	USAF DWG 201027457 ASTM F 519	--Four (4) specimens Type 1a.1 notched bar per coating scenario or chemical exposure condition --Four (4) specimens Type 1d notched C-ring per coating scenario; Set 1: specimens immersed service chemical (cleaning compound per MIL-PRF-29602) at elevated temperature for 30 min; specimen removed, air-dried, and tested for 200 h at 75% NFS (all 4 pass); Set 2: specimens immersed in service chemical (cleaning compound per MIL-PRF-29602) at room temperature while tested for 150 h at 45% NFS (all 4 pass) If one fails in Set 1 or Set 2, the remaining 3 for that Set are step-loaded every 2 h in 5% increments to 90% of NFS and held for 2 h with no additional specimen fracture (3 out of 4 pass)
Outdoor Exposure Testing	ASTM D1014-9	Two year outdoor exposure at Kennedy Space Center and Tyndall AFB. Corrosion comparable to controls
Waste Generation	Feedback from Operators during demonstration on waste generated from Dalistick Station and Zinidal Aero Zn-Ni as compared to traditional brush plating	Less hazardous waste generated then traditional brush plating
Qualitative Performance Objectives		
Strippability	USAF DWG 201027456 USAF DWG 201027457	Zn-Ni coating stripped using NH_4NO_3 solution (16 ounces per gallon in water; pH maintained 8.0–9.0 with NaOH). Stripping times less than 60 min at 21–27°C (4 replicates per coating scenario)
Ease of Use	Feedback from Operators during demonstration on usability of Dalistick Station and Zinidal Aero Zn-Ni as compared to traditional brush plating	As good or better usability then controls. Data will be collected on the areas or components where the system is most applicable and has the most promise to be implemented
Ergonomics	Feedback from Operators during demonstration on ergonomics of Dalistick Station and Zinidal Aero Zn-Ni as compared to traditional brush plating	As good or better ergonomics then traditional brush plating

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4.0 SITES/PLATFORM DESCRIPTION

4.1 Test Platforms/Facilities

The Dalistick D.2020 Station was shipped and set up at Corrdesa LLC in Tyrone GA, however once on-site it was agreed upon by all stakeholders to use an updated D.2020 station which was already set up at Corrdesa. This updated station had updated software and a computer controlled activator pump. This station was chosen to more realistically mimic any new systems bought from Dalic. Representatives from FRCSE and AFLCMC were present to provide feedback on the feasibility of the station and Zinidal Aero Zn-Ni for brush plating repair operations.

Although the demonstration was only conducted at Cordessa LLC with FRCSE and AFLCMC representatives present, the demonstration and testing executed under this program targets not only the weapons systems of the US Navy (as listed in Table 4 below), but also those of the USAF, also shown in Table 4. The parts listed therein have Cd plating on the surfaces either from an OEM or deposited during refurbishment, and, thus, have been selected as potential candidates for demonstration.

Table 46. Weapon Systems and Candidate Parts for Cd-free Brush Plating Repair Operations

DoD Organization	Weapon Platform	Candidate Parts
USAF: WR-ALC OC-ALC	C-5, C-17, C-130, F-15, KC-135, E-3	Splice areas, terminal assembly, center chord lugs, MLG door (pins and bushings), mounting bolts, rudder link, torque box, horizontal fin, vertical fin, ruddervators
US Navy: FRCs	UH-1Y/ AH-1Z P-3, FA-18 EA6B	Main Rotor Gearbox Mast Assembly, Tail Rotor Gearbox Mast Assembly, Tail Rotor Gearbox, Torque Arm Bushings, Speed Brake Bushings

4.2 Present Operations

Currently, FRCSE conducts Cd brush plating operations. Essentially, the following process is followed (see Figure 4):

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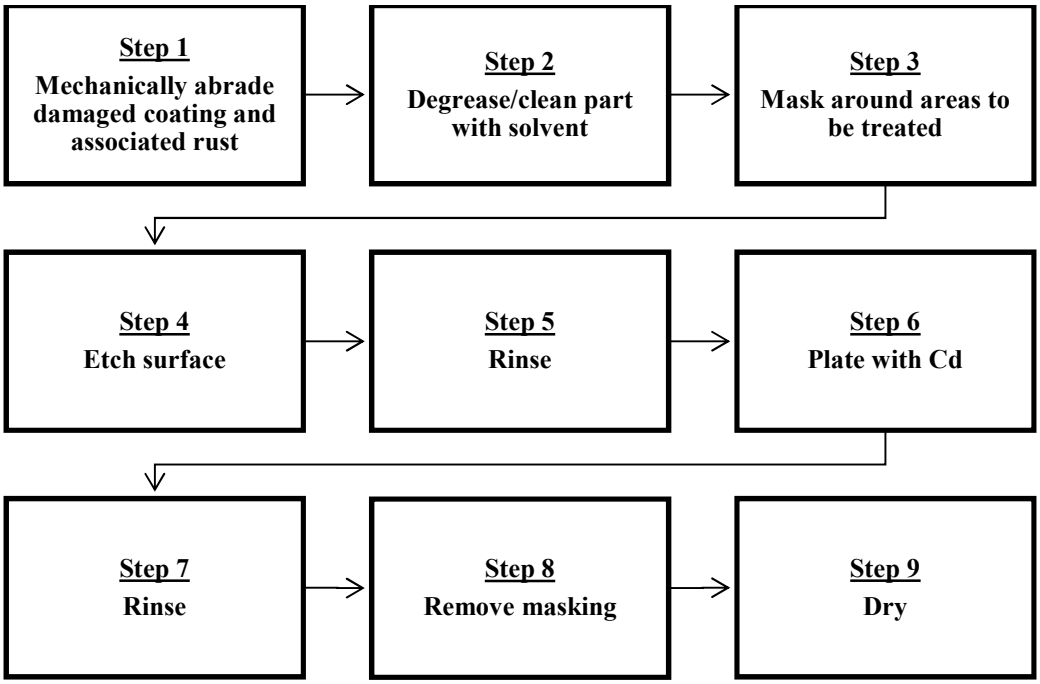

Figure 91. Conventional Cd Brush Plating process

In general, during etching and Cd plating, FRCSE operators dip the conventional brush plating tool into the solution and apply it to the part to be repaired per MIL-STD-865D. The conventional brush plating tool is used for Steps 4 and 6 in Figure 4 above.

In this demonstration, the Dalistick tool was used in Steps 4 and 6, but also could be used in Step 1 to remove light surface rust on the substrate and can also be used to remove damaged Cd coating, as shown in Figure 5.

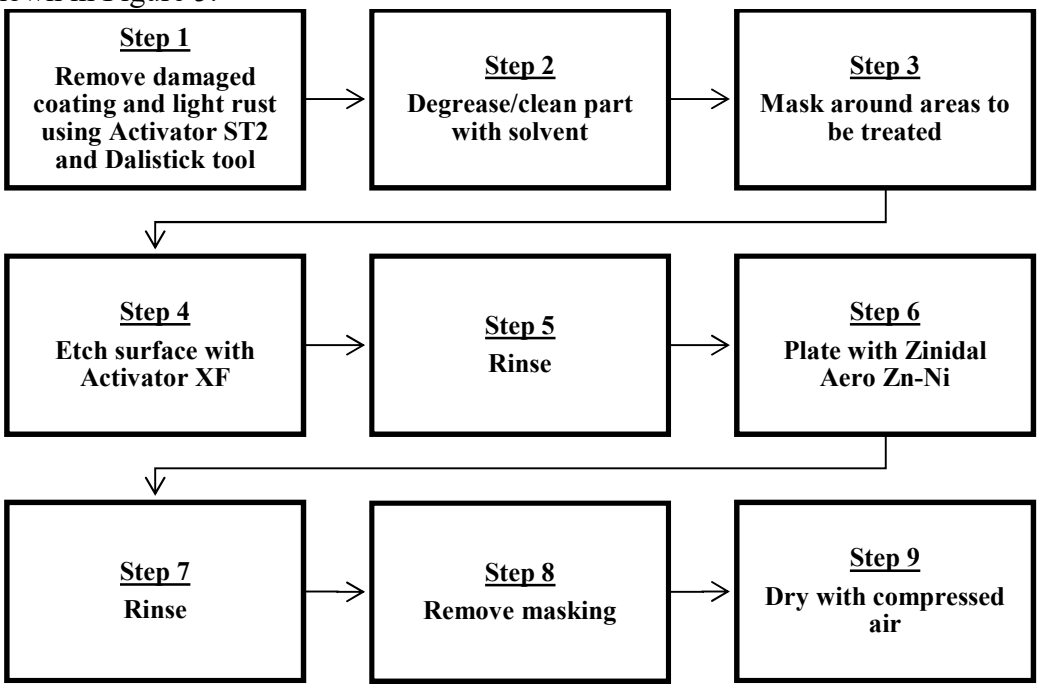

Figure 92. Dalistick Station Zinidal process

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During the demonstration, the Dalistick Station was used to apply the Type II, Class 2 Zinidal coating coatings requirements per AMS QQ-P-416, AMS 2451/9, BAC 5637. A trivalent chromium conversion coating was applied to all Zn-Ni repairs. This was done manually by using a dropper to saturate the surface and rinsing after 30 sec.

All preventative maintenance was adhered to as follows per the manufacturers guidelines:

- Rinse all parts contacting solutions with water at the completion of the operation.
- Clean system parts that contact the activator solutions at least at the end of the day.
- Clean system parts that contact Zinidal Aero Zn-Ni solutions at least once per week with tap water[41] and Zinc Nickel Cleaner.
- Change peristaltic pump tubing after every 12 hours of operation.
- Conduct calibration of the rectifier, unit cooling Dalistick unit, temperature regulation unit (UCDK), flowmeter, Dalistick tool, input/output (I/O) module, and Dalipump annually per the instruction manual.

4.3 Site-Related Permits and Regulations

The Dalistick Station and associated chemicals for use with it are more environmentally friendly than conventional brush plating operations/solutions. This project, with the use of the Zinidal solution and the Dalistick Station, eliminates the use of toxic/carcinogenic Cd material, dramatically reduces solid waste associated with adsorbents used to contain solution leakage attributed with traditional brush plating repair processes, and significantly reduces the use of plating solutions, which are recycled for reuse by the Dalistick Station. Furthermore, emissions monitoring from Zn-Ni coating application, as well as Cd plating and chromic acid anodizing, have been conducted previously by APAVE, The French Authority. They had found that all emissions, as measured at the operator level (see Figure 6), were well below the established PEL and EU regulations, as shown in Table 6. Table 6 also denotes OSHA PELs 8 hr TWA for the United States. As can be seen, the exposure is also well below OSHA PELs.

[41] Note that the manufacturer does recommend the use of distilled water for rinsing out the equipment.

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Figure 93. Operator Monitoring by APAVE[42]

Table 47. Emissions Data for Dalistick Station

Process	Substance	Measured (mg/m^3)	EU authorized max (mg/m^3)	OSHA PEL (mg/m^3)
Cd Plating	Cd	0.0001	0.05	0.005
Chromic Acid Anodizing	Chromic Acid	0.0005	0.05	0.005
Zn-Ni Plating	Nickel Sulfate	0.0008	0.1	0.05[43]

No additional permitting was required to perform the demonstration in Corrdesa's plating lab. Localized ventilation was utilized as a precautionary measure during all plating. Although previous testing shows no additional permitting or PPE required, this determination should be made by local bioenvironmental offices.

5.0 TEST DESIGN

5.1 Demonstration Design

The demonstration took place at Corrdesa LLC in Tyrone GA. Representatives from FRCSE, AFLCMC/EZP, UDRI, and Corrdesa were present during the demonstration. shows the decommissioned high strength steel parts provided by FRCSE. The F-18 pivot assembly is coated in IVD aluminum, while the T-45 launch bar and T-45 pivot assembly are tank plated with Zn-Ni. Multiple locations on each part were stripped of their coatings to simulate repair areas and plated using the Dalistick D.2020 station. These areas can be seen in Figure 84, Figure 85 and Figure 86. The areas chosen were selected to determine the functional limits of areas where the station and tools could reliably plate.

[42] Image provided by Dalic SAS.
[43] For soluble compounds – nickel sulfate is soluble in water.

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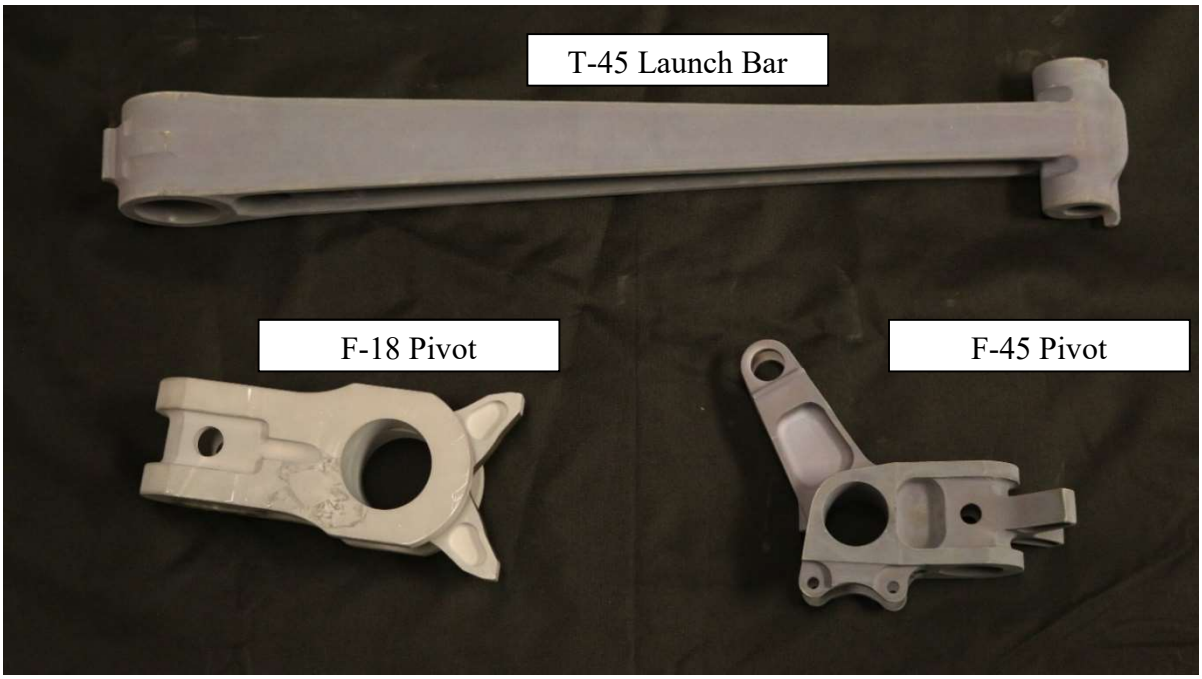

Figure 94. Demonstration Parts

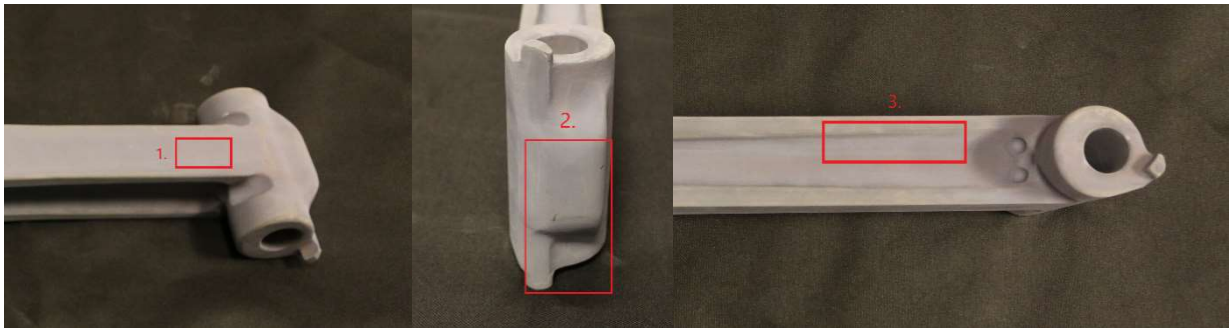

Figure 95. T-45 Launch Bar Repair Locations

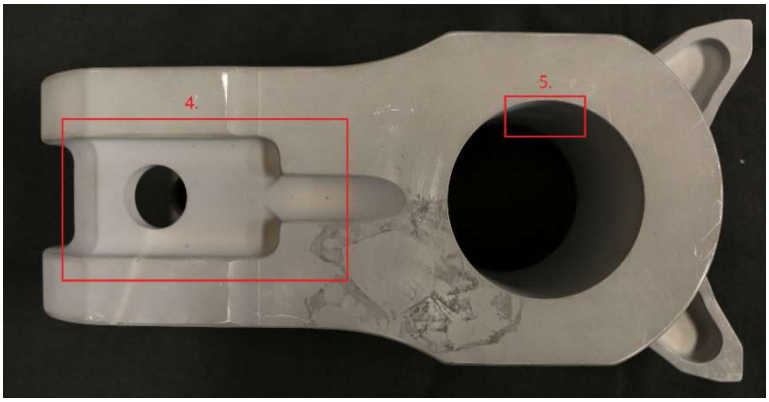

Figure 96. F-18 Pivot Assembly Repair Locations

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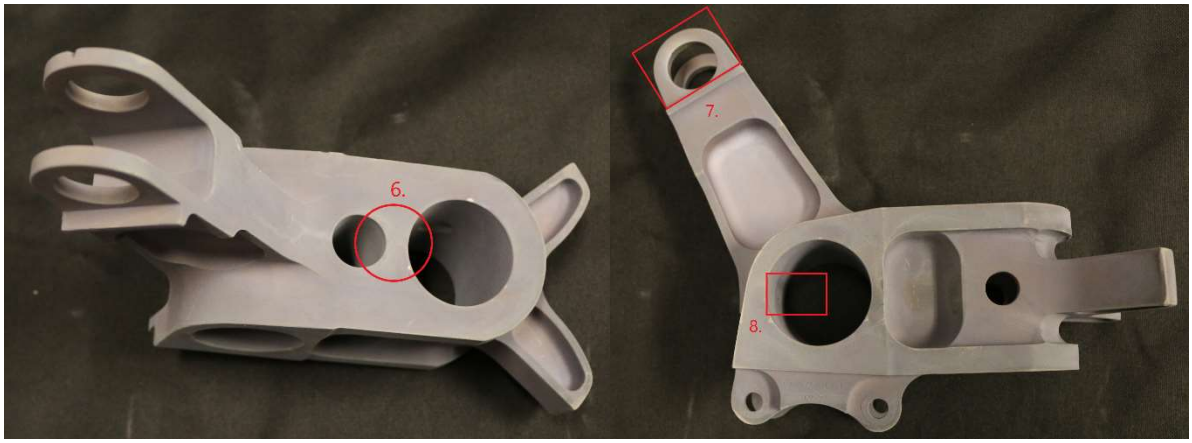

Figure 97. T-45 Pivot Assembly Repair Locations

All plating was performed UDRI and checked by representatives from FRCSE and AFLCMC/EZP.

Plating quality was checked by performing tape adhesion testing. Plating thickness was not confirmed in curved areas, or areas where a coating thickness gauge could not reach (areas 3, 5, 7, and 8).

5.2 Pre-Demonstration Testing and Analysis

Initial screening testing including appearance, thickness, bend adhesion, composition, and salt spray testing was performed with passing results. The process study also yielded results indicating the Zinidal Aero Zn-Ni applied with the Dalistick 2020 station provides better thickness and process controls then traditional brush plating. Further studies were performed to demonstrate the Zinidal Zn-Ni coating could be plated in a repair scenario over Cd, and Zn-Ni brush and tank plantings. Full qualification testing is complete and indicated the technology was ready to be demonstrated on decommissioned components.

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5.3 Design and Layout of Technology Components

The Dalistick D2020 station's major components are shown in detail in **Figure 98** and described in

Figure 83.

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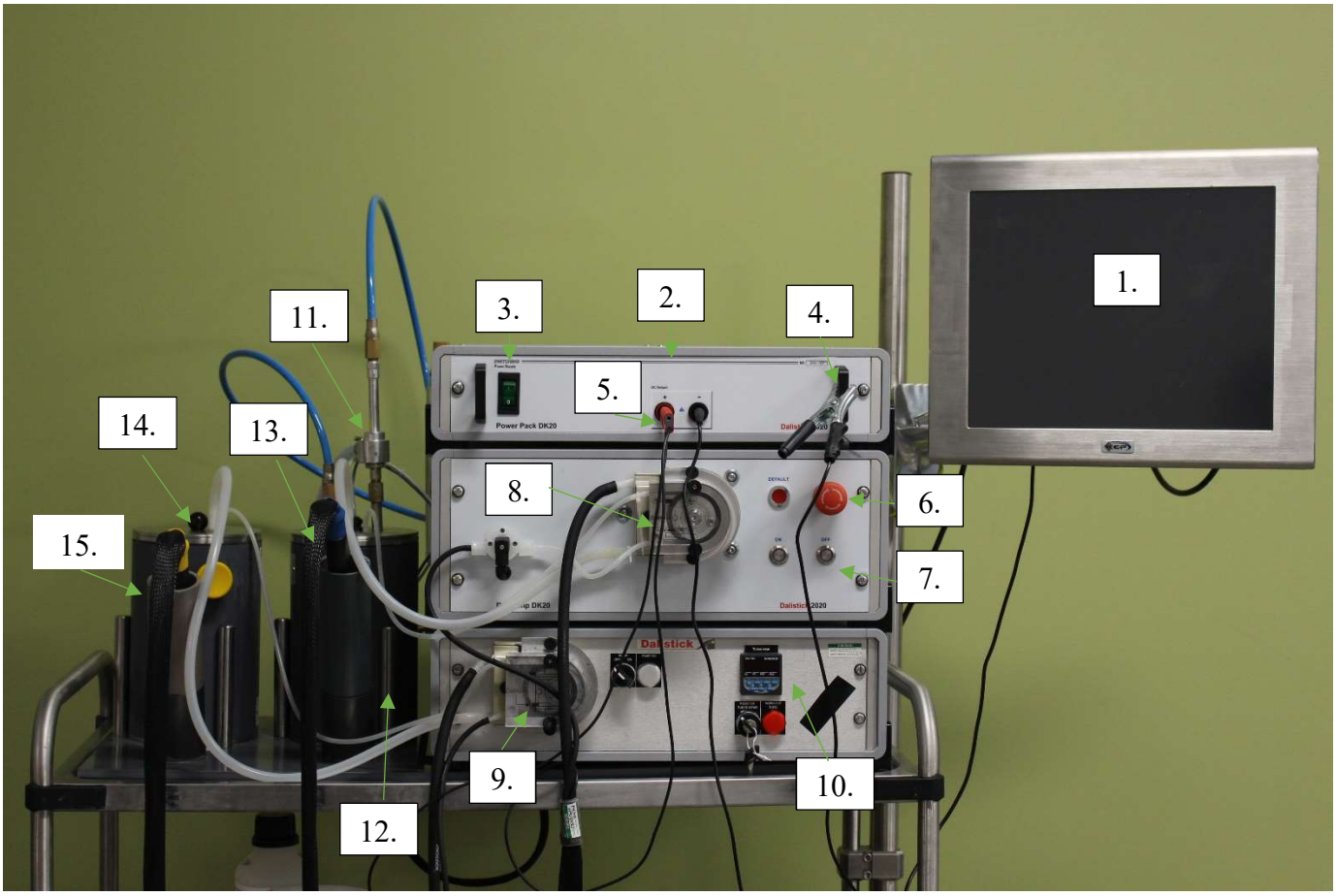

Figure 98: Dalistick D2020 Layout and Technology Components

Table 48: Dalistick D2020 Component Descriptions

Label	Component	Description
1.	Computer	User interface and station controller
2.	Rectifier	Controls plating voltage and amperage
3.	Rectifier Power Switch	Turns on and off power to rectifier
4.	Ground Clamp	Ground connection for part
5.	Tool Electrical Connection	Electrical connection for wands
6.	Emergency Stop	Emergency stop for Zn-Ni pump
7.	Zn-Ni Pump On/Off Switch	Turns on and off power to the Zn-Ni pump
8.	Zn-Ni Peristaltic Pump	Zn-Ni supply and vacuum pump
9.	Activator Peristaltic Pump	Activator supply and vacuum pump
10.	Tube Wear Counter	Counter displaying the tube wear in minutes
11.	Compressed Air Vortex Chiller	Cools the compressed air used to chill the Zn-Ni tank
12	Temperature Controlled Zn-Ni Tank	Tank to hold 1L of Zn-Ni solution
13.	Zn-Ni Wand	Wand for Zn-Ni plating
14.	Activator Tank	Tank to hold 1L of activator solution
15.	Activator Wand	Wand for activator pre-treatment

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5.4 Facility Requirements

No site preparations were required prior to installing the equipment for demonstration, the following sections are guidelines for the facility operational environment and required personal protective equipment.

5.4.1 Space Requirements

The Dalistick D.2020 Station and associated cart occupy a volume of 24" x 36" x 63" (600 x 900 x 1600 mm). Additional space must be allocated for movement of the operator around the cart and associated part being treated. The manufacturer recommends a workspace of 9.84ft x 9.84 ft (3m x 3m) minimum, or approximately 100 ft^2.

5.4.2 Electrical Requirements

The Dalistick D.2020 Station provided for the demonstration requires single phase, 110V alternating current (AC), 50 or 60 Hz, and typically pulls 5A of power (maximum of 11.3A).

The station is outfitted with a power converter which converts the 110V to 230V single phase power for the station. This is because the system is designed and fabricated in Europe so this converter is needed. A UL listed power converter was sourced for this demonstration.

5.4.3 Compressed Air

The Dalistick D.2020 Station uses 87 psi up to 145 psi maximum (7 bar up to 10 bar) at consumption rate of 6.65 cubic feet per minute (25 m^3/hr). The compressed air must be dry and oil free therefore an oil/water separator is required. This requirement was met for the demonstration.

5.4.4 Water

Water is not needed to be hooked to the machine for plating operations. Water is needed to rinse components during the plating process and approximately 4 liters of water is needed to complete the cleaning operations on the machine. The user manual states distilled water should be used, however the manufacturer confirmed treated tap water is sufficient and was used for this demonstration.

5.4.5 Environmental Conditions

Table 3: Dalistick D.2020 Operating Conditionscontains the manufactures recommended operating conditions for the Dalistick D.2020.

Table 49. Dalistick D.2020 Operating Conditions

Condition	Minimum	Maximum
Temperature[44]	53.6 °F (12 °C)	122 °F (50 °C)

[44] The minimum temperature recommendation from the manufacture is due to potential adhesion concerns with the plating. The maximum temperature limitation is due to the electrical component limitations on the station.

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Humidity[45]	45%	65%

The manufacturer also recommends that the unit not be used in sandy/dusty environments or workshops with airborne oil particulates, primarily because the various particulates can have an adverse effect on adhesion of the depositing coating. All environmental conditions were met for the demonstration.

5.5 Safety and Occupational Health Considerations

5.5.1 Noise

When measuring noise in the operator position, including use of the cooling system and pump, noise was measured at 60 to 65 decibels (dBA) when the cooling system is operating. This is below the NIOSH recommended level of 85 dBA over 8 hr. exposure or the 90 dBA permissible exposure limit set forth by OSHA. No hearing protection was used during this demonstration. Ultimately the base safety officer will be responsible for determining if hearing protection is required in specific applications.

5.5.2 Ventilation

Although there are emissions from this operation, measured exposure to hazardous materials, such as Cd, using this Dalistick Station are below the established PEL and EU regulations. APAVE, The French Authority, has conducted air monitoring measurements of the following operations, as performed with the Dalistick Station, to confirm that all air emissions are well below the maximum authorized limit for the EU. Table 50 also denotes OSHA PELs 8 hr. time weighted average (TWA) for the United States.

Table 50. Emissions Data for Dalistick Station

Process	Substance	Measured (mg/m^3)	EU authorized max (mg/m^3)	OSHA PEL (mg/m^3)
Cd Plating	Cd	0.0001	0.05	0.005
Chromic Acid Anodizing	Chromic Acid	0.0005	0.05	0.005
Zn-Ni Plating	Nickel Sulfate	0.0008	0.1	0.059

Monitoring was conducted without any air extraction system over the Dalistick Station and sensors were placed at the shoulders of the operators. In spite of these measurements a localized vent placed over the parts during plating.
Ultimately the base safety officer will be responsible for determining if ventilation/respiratory protection is required.

[45] The humidity range recommendation from the manufacture is due to potential adhesion concerns with the plating.

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5.5.3 Recommended Personal Protective Equipment

Dalic recommends the use of the following general personal protective equipment (PPE) while using the Dalistick D.2020 Station. The final determination will be made by the responsible base safety officer.

- Coveralls or long pants and shirt
- Chemical aprons - when handling concentrated chemicals, such as brush plating solutions, and cleaning solutions, etc.
- Steel toed boots
- Eye protection – safety goggles or a face shield
- Gloves – neoprene, latex, PVC, nitrile or other appropriate type

5.6 Safe Handling of Manufacturer Solutions

The following table denotes required PPE when handling the solutions for this process. Note that the substances of concern within solutions are listed in Section 2.2. For full information on any chemical in this process, including substances of concern that are contained within each Chemical provided in Table 51, please refer to the "Dalic Zinidal Aero Solution Industrial Health Risk Assessment"

Table 51: Safe Handling of Manufacturer Solutions

Chemical	Use	Storage	Handling	Health Hazards	Regulations
IPA	Cleaning	Tightly closed container in a dry, well-ventilated area	Avoid inhalation skin/eye contact, ignition sources; prevent electrostatic charge build up	Central nervous system (CNS) depression; prolonged exp. – nausea, headache, vomiting, narcosis, drowsiness; overexposure – mild, reversible liver effects; aspiration – can lead to lung edema or pneumonia	Superfunds Amendments Reauthorization Act (SARA) Title III[46]
Act. XF	Surface Preparation	Original polyethylene containers/lids only – tightly closed – in spill-containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; avoid contact with strong alkaline products or oxidizing agents and temperatures > 150-170 °F	Do not wear contact lenses; eye irritant if not rinsed immediately; slight irritant to respiratory system without proper ventilation	Follows REACH[14]

[46] Not subject to SARA Title III Section 302, but is subject to Section 313 reporting in select states.

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Table 51: Safe Handling of Manufacturer Solutions (Continued)

Chemical	Use	Storage	Handling	Health Hazards	Regulations
Zinidal Aero	Zn-Ni plating	Original polyethylene containers/lids only – tightly closed – in spill-containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; keep away from strong acids, powerful mineral or oxidizing agents, strong bases, and products reactive with NH_4^+ gas (e.g., salts of Au, Ag, Hg, Cd, and halogen derivatives); avoid temperatures > 104 °F (40 °C); dispose spent solutions and rinse waters as hazardous waste according to facility guidelines for pH value and metal content; contaminated packaging disposed as solid hazardous waste per facility rules. Firefighting – use dry ice (for metal fires) NOT water; Accidental release of vapors/sprays – use respiratory mask with K2P3 cartridge and wash contaminated items with water and dispose properly; release of solutions – wash area with slightly acidic or slightly alkaline produce to remove zinc hydroxide and prevent corrosion product formation – collect rinse water and dispose properly	Do not wear contact lenses or eat, drink or smoke near work station; eye, skin, and respiratory irritant; potential eczema due to allergens; carcinogenic with prolonged exposure[47]; asthma or asthmatic dyspnea[48]; ingestion concerns include headache, nausea, asthenia (abnormal physical weakness), digestive disorders, vomiting, diarrhea, tachycardia; eye contact - rinse immediately with water; skin contact – remove clothing and shoes, wash immediately with plenty of soap/water or shower; inhalation – take victim to well-ventilated area and seek medical attention/advice; minor ingestion – give water, call doctor for pain, nausea, vomiting; major ingestion – do not give anything to drink or induce vomiting – seek immediate medical attention.	Follow REACH regulations[49]

[47] Cancer risk depends on length and exposure level.

[48] Nickel salts may cause sensitization by inhalation, but may disappear immediately or after several hours of exposure.

[49] Product labeling has been established for the Zinidal Aero solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. Restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles (annex XVII of REACH up to commission regulation EC No. 474/2014 of May 8, 2014 (OJ L136 dated 09.05.2014) include the following.

- Nickel shall not be used in articles intended to come into direct and prolonged contact with the skin if the rate of nickel release from them is greater than 0.5 micrograms per square centimeter per week (μg/cm^2/week). It can be allowed if it is covered with an efficient coating permitting to be below this limit for a period of at least 2 years of normal use of the article. The rate of nickel release is lowered to 0.2 μg/cm^2/week in the case of articles inserted into the human body.
- Products classified as carcinogen, mutagen, or toxic to reproduction of categories 1 or 2 (substances or mixtures) shall not be supplied to the general public. The packaging should be marked "Restricted to Professional Users."

It is noted that a chemical safety assessment and a chemical safety report (per the EU REACH) have not been performed for this mixture because the solution is not produced at a quantity greater than 10 tons per year nor used at a quantity greater than 1 ton per year.

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Table 51: Required Personal Protective Equipment (Continued)

Chemical	Use	Storage	Handling	Health Hazards	Regulations
Passivator No. 7	Conversion Coating	Original polyethylene containers/lids only – tightly closed – in spill-containing vat between 41-86 °F (5-30 °C); 3 yr shelf life maximum.	Keep away from direct sunlight; keep away from alkaline, reducing, or combustible products; Avoid temperatures > 200 °C.	Do not wear contact lenses; observe strict cutaneous hygiene; change clothing after work – especially before eating; eye, skin, and respiratory irritant; carcinogen (1st category); mutagen (2nd category); reproductive toxin (3rd category)	Follow REACH regulations[50]

Overall, although the Zinidal Aero does have some more serious health concerns, they are dramatically reduced when compared to the concerns of Cd. Please refer to the "Dalic Zinidal Aero Solution Industrial Health Risk Assessment" for details of the comparison.

5.7 Preventative Maintenance

Table 3 contains the preventative maintenance items for the Dalistick D.2020 station.

Table 52. Dalistick D.2020 Preventative Maintenance

Item	Frequency
Tool Bonnet Replacement	As Needed
Activator Tank Cleaning	Daily
Zinidal Aero Zn-Ni Cleaning	Weekly
Pump Tube Replacement	Every 12 hours of Operation

5.8 Furnished Equipment and Supplies

The following equipment and supplies were provided for the demonstration.

- Demonstration Parts - FRCSE
- Dalistick D.2020 Station on mobile cart – Corrdesa LLC.
- Activator XF solution - UDRI
- Zinidal Aero Zn-Ni solution - UDRI
- Passivator N°7 conversion coating – Corrdesa LLC.
- Zinidal Aero Zn-Ni Cleaning Solution - UDRI

[50] Product labeling has been established for the Passivator No. 3 solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. Chromium trioxide is subject to authorization per annex XIV of REACH 31, and ECHA's consolidated list of 16.06.2014, 155 substances, and has restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles (annex XVII of REACH up to commission regulation EC No. 474/2014 of May 8, 2014 (OJ L136 dated 09.05.2014):

- Products classified as carcinogen, mutagen, or toxic to reproduction of categories 1 or 2 (substances or mixtures) shall not be supplied to the general public. The packaging should be marked "Restricted to Professional Users."

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- Power Converter – Corrdesa LLC.
- Regular Dalistick Tools (2) – Corrdesa LLC.
- Flat Dalistick Tools (2) - UDRI
- Dalistick Tool Bonnets - UDRI
- Rinsing Bottle – Corrdesa LLC.
- Pump Tubing - UDRI
- Vinyl Tape - UDRI
- Aluminum Tape – UDRI
- Adhesive Masking – Corrdesa LLC.
- Adhesion Test Tape - UDRI
- Turning Head - UDRI
- Training Manuals – Corrdesa LLC.
- Solution Data Sheets – Corrdesa LLC.

5.9 Training

Plating was performed by experienced personnel from UDRI and no training was needed. Representatives from UDRI and Corrdesa LLC were on-site to answer any questions which arose from the plating process.

5.10 Performance Assessment Plan

The objective of this demonstration is as follows:

1. Demonstrate the usefulness of the Dalistick® D.2020 (Dalic Inc.) commercial-off-the-shelf (COTS) brush plating tool for selective plating for DoD maintenance, repair and overhaul operations.
2. Qualitatively evaluate the Zinidal™ Aero Zn-Ni brush-plated coating (by Dalic Inc.) COTS material as a Cd replacement on high-strength steels for repair applications on weapon system parts.

The repairs were logged in order to provide insight into the usefulness of the station to DoD brush plating repair operations. The log contained the following information.

- Operator
- Repair description
- Ease of repair
- Quality of repair
- Ergonomics
- Consumables used
- Issues/errors

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6.0 Demonstration Results

6.1 Testing Matrix

The operator, components, repair descriptions, wand used, and masking types can be found in the matrix in Table 53. Different wands were used to enable plating inside holes and to test the limits of where the existing wands can plate. Pictures of the wands can be seen in Figure 89. The head size of each wand is the same (approximately 1 in^2) Dalic Inc. recommends using both aluminum and vinyl tape during plating. Observations from the course of this project and observations from Corrdesa LLC have shown that other masking types can be used. Using only vinyl tape or adhesive electrochemical masking is easier to use on complex surfaces and reduce masking waste. Three masking combinations were tested throughout the demonstration.

Table 53. Testing Matrix

Operator	Part Type / Area	Repair Description	Wand Type	Consumables Used
CV	T-45 Launch Bar Area 1	Top, Flat	Standard Wand	Aluminum and Vinyl Tape
CV	T-45 Launch Bar Area 2	Front Lobe, Curved	Standard Wand	Vinyl Tape
CV	T-45 Launch Bar Area 3	Side, Highly Curved	Flat Wand	Aluminum and Vinyl Tape
CV	F-18 Pivot Assembly Area 4	Forward Cross Bolt Area, Curved with Medium Through Hole	Flat Wand	Vinyl Tape
CV	F-18 Pivot Assembly Area 5	Aft Sleeve Bushing Area, Curved with Large Through Hole	Flat Wand	Vinyl Tape
CV	T-45 Pivot Assembly Area 6	Top, Flat with Two Large Holes	Standard Wand	Electrochemical Masking
CV	T-45 Pivot Assembly Area 7	Flange, Flat with Large Hole	Standard Wand	Aluminum and Vinyl Tape
CV	T-45 Pivot Assembly Area 8	Forward Bushing Area, Curved with Small Through Hole	Flat Wand	Electrochemical Masking

6.2 *Visual Inspections and Coating Thickness*

Each repair was inspected visually by all representatives. Visually all repairs looked good in the areas where the wands could reach. Figure 99. T-45 Launch Bar Repair Area 1 and 2 shows the T-45 launch bar repair area one. The repair visually looks good, however there evidence of the solutions flowing underneath the masking in places. Aluminum and vinyl tape were used in this repair. This was likely caused by the operator not fully adhering the masking to the part.

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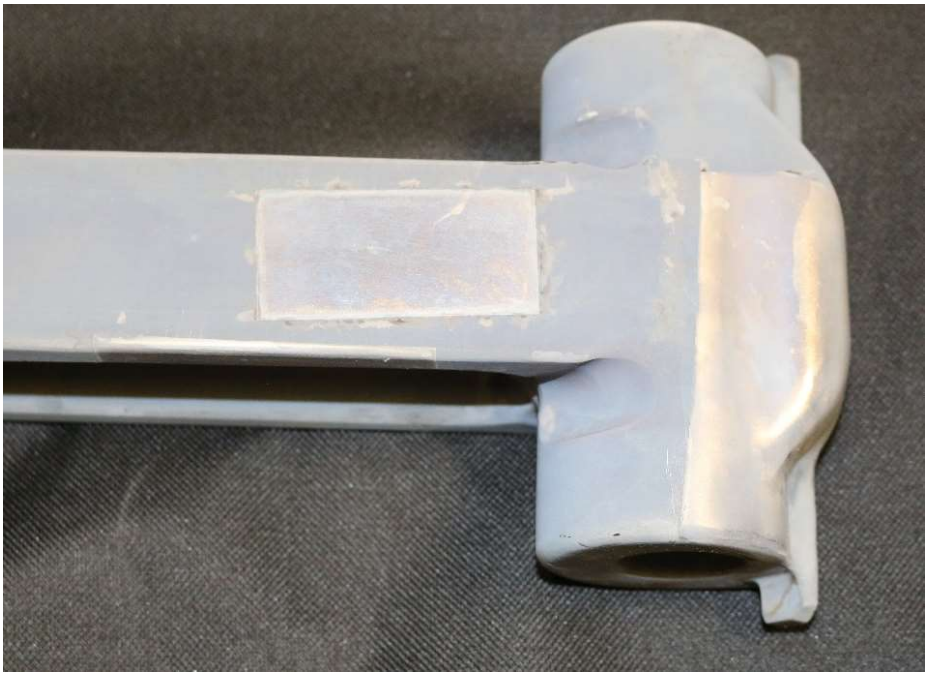

Figure 99. T-45 Launch Bar Repair Area 1 and 2

Figure 100. T-45 Launch Bar Repair Area 2shows the 2nd repair area on the T-45 launch bar. This area shows a very good visual repair with very little solution going underneath the masking. Only vinyl tape was used to mask this area which allowed for much better control around the complex area.

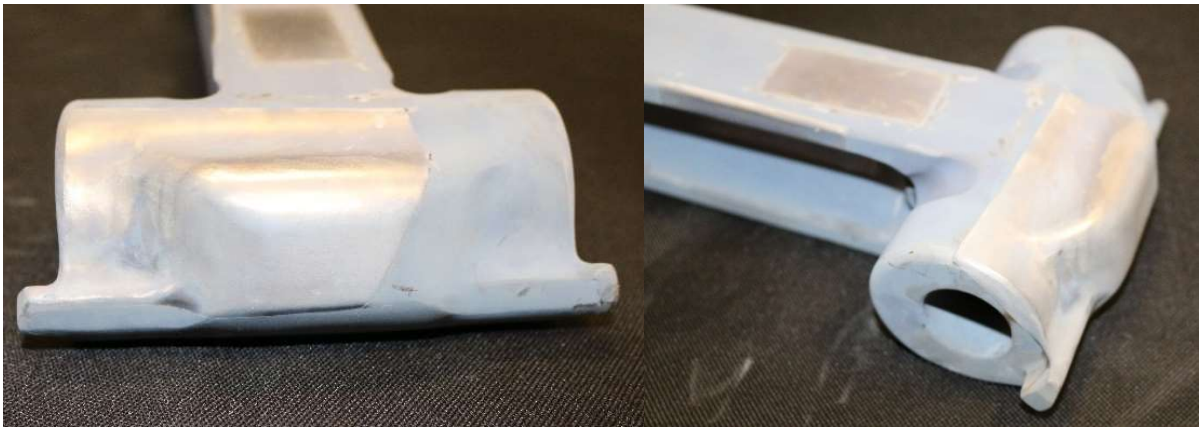

Figure 100. T-45 Launch Bar Repair Area 2

Repair area three is shown in Figure 101. The repair looks visually good. This repair was masked with aluminum and vinyl tape.

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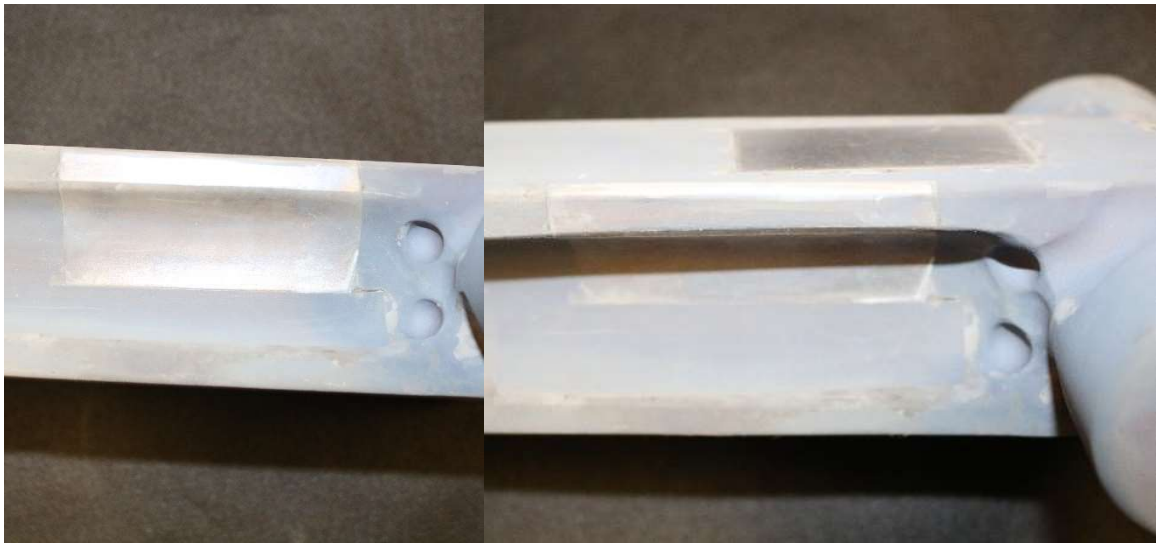

Figure 101. T-45 Launch Bar Repair Area 3

The F-18 pivot assembly repair area four is shown in Figure 102. The repair appears adequate. The tight radius areas were difficult to plate with the standard tools without flooding the area. These repair areas are likely thin, however cross sections were not performed, and measurements could not be accurately taken with the coating thickness gauge.

Figure 102. F-18 Pivot Assembly Repair Area 4

Repair area five of the F-18 pivot assembly was in the aft sleeve bushing area over a large through hole. This repair utilized the flat wand which fit into the bore. Vinyl tape was used to

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mask the area. It can be seen in Figure 103 that the masking was not quite placed in the correct location and bare steel can be seen at the bottom of the repair. Some plating can be seen in the hole which was only masked on the backside. Overall the repair looks visually acceptable where masked properly.

Figure 103. F-18 Pivot Assembly Repair Area 5

Repair area six on the T-45 pivot assembly can be seen in Figure 104. This repair utilized an electrochemical mask which performed very well. The plating on the flat area was easy to perform and left a good repair.

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Figure 104. T-45 Pivot Assembly Repair Area 6

The repair on the 7th area of the T-45 pivot assembly can be seen in Figure 105. It can be seen that the plating was not able to get into the 90° corner of the flange. This was caused by the shape and size of the tool being used. The rest of the repair passes visually.

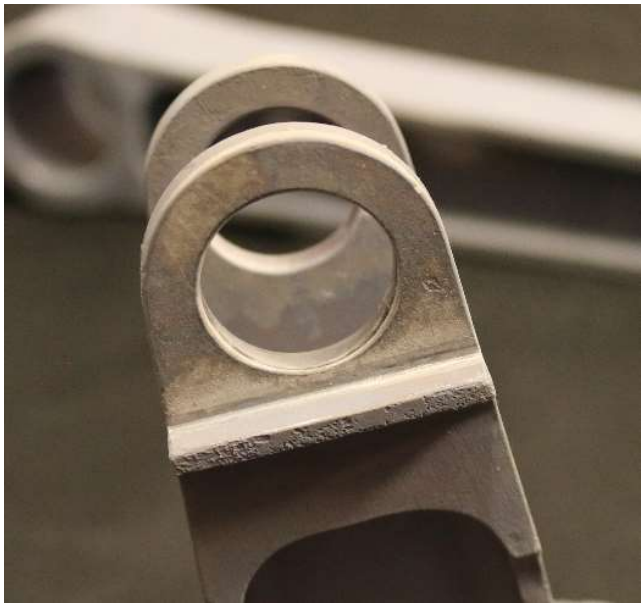

Figure 105. T-45 Pivot Assembly Repair Area 7

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The bore repair on the T-45 pivot assembly can be seen in Figure 106. This repair was also masked with the electrochemical masking. Some plating can be seen on the outside of the bore which was caused by a poor seal on the corner masking. The pitting in the repair was present before the repair and can be seen through the plating. This was not considered detrimental to the visual inspection since it was not caused by the plating itself.

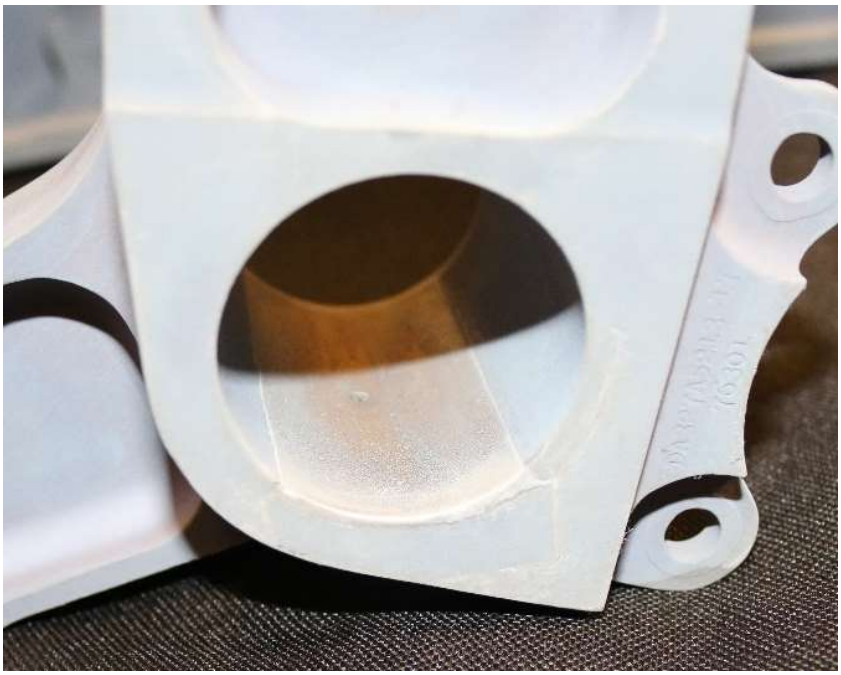

Figure 106. T-45 Pivot Assembly Repair Area 8

Overall all platings visually passed in the areas that were able to be successfully plated. There was no major difference in the masking types used. Operator preparation, especially at overlap regions, was the main contributor to solution seeping under the masking.
The coating thickness could not be measured on curved surfaces using the standard eddy current thickness gauge. Curved repair areas were assumed to be the correct thickness based on observations and cross-sections of cured test specimens during qualification testing. It was also observed that although the machine will calculate the correct quantity of current to plate the calculation only allows for simple shapes. The areas were all estimated too large which caused the thickness on several surfaces that could be measured to be higher than the anticipated station range, but still above the minimum required thickness.

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Table 54. Thickness Results

Part Type / Area	Repair Description	Thickness (mils)	Result
T-45 Launch Bar Area 1	Top, Flat	Not Recorded	N/A
T-45 Launch Bar Area 2	Front Lobe, Curved	0.74	Pass
T-45 Launch Bar Area 3	Side, Highly Curved	1.00	Pass
F-18 Pivot Assembly Area 4	Forward Cross Bolt Area, Curved with Medium Through Hole	Could Not Measure	N/A
F-18 Pivot Assembly Area 5	Aft Sleeve Bushing Area, Curved with Large Through Hole	Could Not Measure	N/A
T-45 Pivot Assembly Area 6	Top, Flat with Two Large Holes	1.16	Pass
T-45 Pivot Assembly Area 7	Flange, Flat with Large Hole	1.08	Pass
T-45 Pivot Assembly Area 8	Forward Bushing Area, Curved with Small Through Hole	Could Not Measure	N/A

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6.3 Ease of Repair and Ergonomics

Each repair was graded on a scale of one to five to rank how easy each area was to plate. Observations on any issues were also documented. Table 55 shows the grades of each repair as well as documented notes.

Table 55. Ease of Repairs

Part Type / Number	Repair Description	Consumables Used	Ease of Use 1 2 3 4 5 Easy Hard	Issues/Errors	Comment on Ergonomics	Other Notes
T-45 Launch Bar Area 1	Top, Flat	Aluminum and Vinyl Tape	1	Masking was Poor	Good Ergonomics	None
T-45 Launch Bar Area 2	Front Lobe, Curved	Vinyl Tape	2	None	Good Ergonomics	Difficult to Passivate without Additional Masking
T-45 Launch Bar Area 3	Side, Highly Curved	Aluminum and Vinyl Tape	3	None	Curved Side was Difficult to Plate	None
F-18 Pivot Assembly Area 4	Forward Cross Bolt Area, Curved with Medium Through Hole	Vinyl Tape	5	Difficult to Plate in Curves without Flooding Solution	Ergonomics were OK	Some Dripping Through Holes
F-18 Pivot Assembly Area 5	Aft Sleeve Bushing Area, Curved with Large Through Hole	Vinyl Tape	2	Minor Drips through Hole	Good Ergonomics	Masked Hole after Activator to Prevent Drips, Masking Covered up Corner of Stripped Area
T-45 Pivot Assembly Area 6	Top, Flat with Two Large Holes	Electrochemical Masking	2	Minor Drips from Holes	Good Ergonomics	None
T-45 Pivot Assembly Area 7	Flange, Flat with Large Hole	Aluminum and Vinyl Tape	3	Hole masked, no drips but solution would pool in hole. Bonnet Fell Out During Plating	Good Ergonomics	Pooled Solution was Easily Vacuumed by Wand, Some Plating on Flange and in Hole Occurred but not Completely in Corner of Flange
T-45 Pivot Assembly Area 8	Forward Bushing Area, Curved with Small Through Hole	Electrochemical Masking	2	Hole not masked, large amount of solution would flow through hole	Good Ergonomics	None

A few limitations of the machine and wands were found during the demonstration. The first was difficulty plating on highly curved or tight inside corners as shown in Figure 107. This was expected due to the size and shape of the tool. The station performed well on flat and more

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slightly curved surfaces. Complex shapes such as area two of the T-45 launch bar could be plated as long as the tool could make contact with the surface. In some tight concave curved surfaces the wand was able to plate successfully, but the area had to be flooded with solution which then could be quickly vacuumed up by the tool. This issue could be easily overcome as different sized and shaped tools are designed.

Figure 107. Inside Corner of Repair Area 7

Another limitation was found if holes were present in the repair area. If holes were not masked the tools were unable to vacuum up the solutions. This caused them to leak out of the holes, or fill up the holes if they were only masked on the back sides. For holes that could be masked, any pooled solution which pooled could be easily vacuumed by the tool periodically without causing any dripping. Some residual solution is observed during the process, but as advertised is mostly dripless on simple geometries. This residual solution can be seen in Figure 108.

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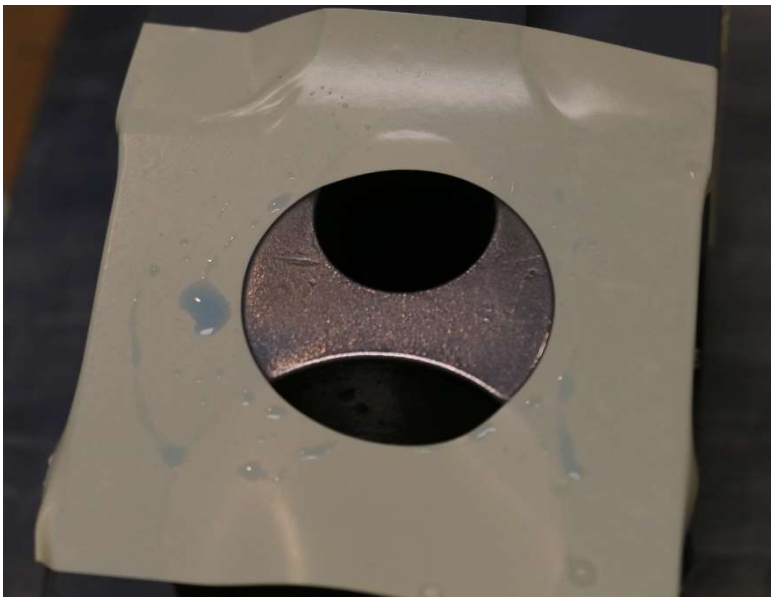

Figure 108. Typical Residual Solution From Plating Process

Another limitation of the process is inherent in the passivation process which typically involves fully saturating a surface for 30 sec as seen in Figure 109. This process worked well for the off aircraft components, however it is anticipated that on larger or more vertical surfaces this may present a hazardous waste issue. This is not any different then the typical process, but it does not make the process truly dripless.

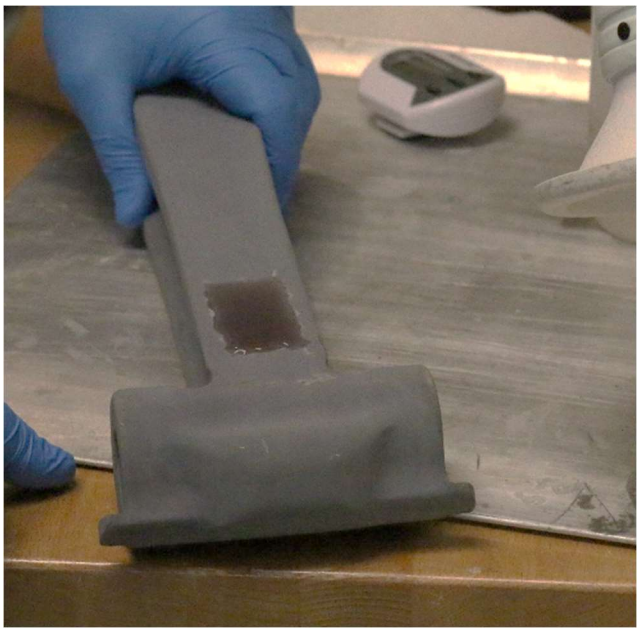

Figure 109. Passivation Process

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6.4 Repair Size and Total Process Time

The new Dalistick D.2020 software provides a few valuable improvements. The first translated the measurement system to the imperial system. The second major improvement allowed for the operator to bypass redundant steps when performing back to back repairs. This was a major improvement in overall station functionality. It also provided some improvements to total process time. As can be seen in Table 56 the process times varied greatly as well as the plating time per square inch of repair area. This was expected based on the range repair areas, range of repair complexity, and inconsistent repair area calculation as previously described. None of the process times were deemed to be excessive or a limiting factor for station deployment.

Table 56. Repair Area Size and Total Process Time

Part Type / Area	Repair Area (in^2)	Total Process Time (min)	in^2/min
T-45 Launch Bar Area 1	2.39	19	0.05
T-45 Launch Bar Area 2	6.00	11	0.54
T-45 Launch Bar Area 3	5.00	18	0.28
F-18 Pivot Assembly Area 4	6.75	16	0.42
F-18 Pivot Assembly Area 5	2.63	23	0.11
T-45 Pivot Assembly Area 6	1.58	16	0.10
T-45 Pivot Assembly Area 7	1.13	9	0.13
T-45 Pivot Assembly Area 8	4.13	20	0.21

6.5 Tape Adhesion

A tape test was performed on all repairs after plating and before passivation as per the standard Dalistick process. All areas passed the tape adhesion testing.

6.6 Conclusions

Zinidal Aero Zn-Ni plating using the Dalistick D.2020 station proved to be capable of plating quality small area repairs on both IVD aluminum and Zn-Ni tank plated high strength steel components. The demonstration was designed to push the limits of the existing tools and station due to the complexity of repairs chosen. Overall the station and tools performed well on all but the smallest radii and inside corners. Tool size and shape was the limiting factor on being able to reach these difficult areas. During plating some dripping of solutions was observed, especially in areas with through holes which were not masked. This limitation can likely be overcome through better masking strategies.

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7.0 COST ASSESSMENT

The Sustainability Analysis performed by NOBLIS contains all of the Life Cycle Inventory and cost data. The sustainability analysis was not updated after the demonstration as the results were not expected to change. This analysis can be utilized for evaluating specific processes as needed.

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Appendix E: Sustainability Analysis

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Sustainability Analysis (SA) for Dalistick Station/Zinidal Aero versus Traditional Cadmium (Cd) Brush Plating

Subcontract Number: RSC15086
Prime Contract Number: GS05T13BMD0001, TO 09

Final Version 1.0

28 July 2016

3150 Fairview Park Drive South
Falls Church, Virginia 22042-4519

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Executive Summary

The U.S. Air Force is working to eliminate cadmium (Cd) used in brush plating repair operations. As part of this effort, the Air Force is evaluating the commercial off-the-shelf (COTS) Dalistick® Station for selective plating the COTS Zinidal Aero zinc-nickel (Zn-Ni) coating on high strength steels (HSS) weapon systems components. The Dalistick® Station is a mobile, electroplating system that performs selective electrochemical treatment. It employs a non-drip stylus and continuously recirculates electrolyte from the holding tank through the head. This closed-loop process results in little or no electrolyte losses, e.g., from leakage, drips, splashes, and fumes.

The Air Force has demonstrated and evaluated Dalistick Zn-Ni plating. As part of this effort, a cost benefit analysis (CBA) was performed to compare Dalistick Zn-Ni plating to Cd brush plating. The CBA found the net present value (NPV) of Dalistick Zn-Ni plating to be $1.8 million higher than Cd brush plating, assuming a 15-year study period and value in 2014 U.S. dollars (USD). The CBA included costs associated with equipment, labor, materials, utilities, and maintenance. The CBA estimated that Dalistick Zn-Ni plating would result in 669 pounds (lbs) less liquid hazardous waste and 141 lbs less solid hazardous waste then Cd brush plating, the cost associated with managing waste was not included in the analysis. The CBA did not assess the environmental or occupational health and safety costs associated with either process.

The Defense Acquisition Guidebook (DAG) requires program managers to consider sustainability in acquisition and select more sustainable systems, i.e., systems that meet performance requirements; have fewer negative impacts on resource availability, climate change, human health, and ecosystem quality; and has a lower total ownership costs (TOC). The Office of the Deputy Under Secretary of Defense for Installations & Environment (DUSD (I&E)) has developed a framework and draft guidance document for performing a Sustainability Analysis, which integrates life cycle cost (LCC) estimating and life cycle assessment (LCA). The LCC estimate quantifies the financial internal cost to DoD. LCA quantifies natural resource requirements and environmental releases through each life cycle stage of a system and evaluates the following resulting impacts:

- **Resource Availability:** Evaluates the potential impact of natural resource use (e.g., land, water, mineral, and fossil resources) on resource quality and availability.
- **Climate Change**: Evaluates the contribution of greenhouse gas (GHG) emissions to global warming and the associated potential impacts, including changes in net agricultural productivity, human health, flood risk, and ecosystem services.
- **Human Health**: Evaluates the potential impact of environmental releases (other than GHG emissions), water use, and noise emissions on human health and productivity.
- **Ecosystem Quality**: Evaluates the potential impact of environmental releases (other than GHG emissions), land use, and water use on biodiversity and ecosystem services.

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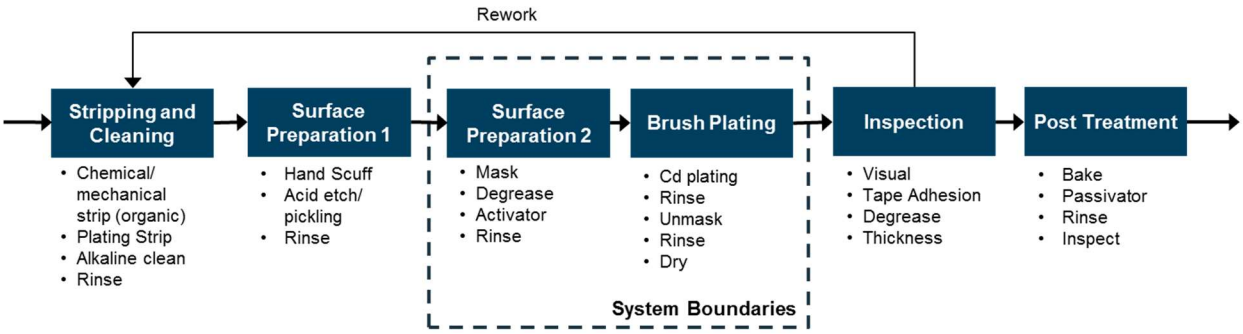
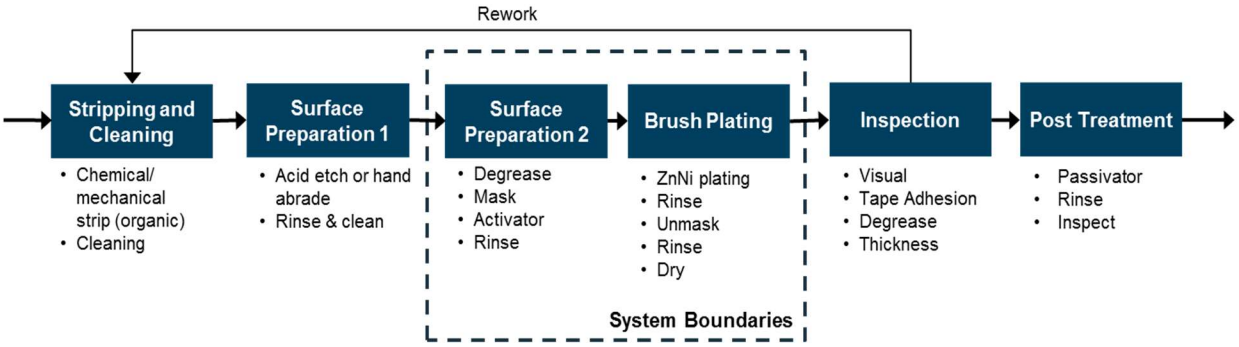
These impacts are monetized to estimate the external cost to society. At this time, the DoD Sustainability Analysis framework does not consider impacts from occupational illnesses, injuries, and fatalities.

This Sustainability Analysis is based on the selective electroplating throughput at Warner Robins Air Logistics Complex (WR-ALC). Part and throughput information obtained from Warner Robins Air Logistic Complex (WR-ALC) Commodities Maintenance Group (CMXG) plating technicians for the previous CBA was used to define two representative parts for this analysis.

Part Type	Surface Area (in^2)	Surface Area (cm^2)	Thickness (µm)	Annual Throughput	% Plated in Plating Shop	% Plated In The Field
Small	15.5	100	13	144	100%	0%
Large	31.0	200	13	828	7%	93%

The figures below show the steps associated with performing Cd brush plating and Dalistick ZnNi plating. For each alternative, cost, input, and output data were collected or estimated for the steps included in the system boundaries.





The study assumed a 15-year life and that WR-ALC would either replace the Cd brush plating equipment or purchase the Dalistick station at the start of the study period. All costs are evaluated in 2014 USD. A 1.1% real discount rate was used to account for the time value of money for all internal costs. A 3% social discount rate was used to account for revealed time preferences and opportunity costs (i.e., placing more value on benefits or costs incurred now than those incurred in the future).

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A life cycle inventory (LCI) of all inputs, outputs, and associated costs was created for both Cd brush plating and Dalistick Zn-Ni plating. Inputs include equipment, labor, procured goods (e.g., chemicals, materials, and supplies), and utilities (e.g., energy and water), used to perform Cd brush or Dalistick Zn-Ni plating. Outputs include plated components, hazardous waste, solid waste, wastewater, and environmental releases. For Cd brush plating, the previous CBA served as the primary data source. For Dalistick Zn-Ni plating data collected by the University of Dayton Research Institute (UDRI) for this study served as the primary data source. Engineering estimates and supplemental research were performed to fill any data gaps. Incomplete output data were provided for both Cd brush plating and Dalistick Zn-Ni. As is common practice in LCA, a mass balance was performed to account for the mass entering and leaving the system. A mass balance assumes that the system is in steady state and mass is conserved. It was used here to identify and estimate flows that might have been unknown or difficult to measure by other means and to more completely accounts for spills, waste, air emissions, and other environmental releases.

In developing the LCI, several sources of uncertainty in the data became apparent. To account for this, two scenarios were developed for both Cd brush and Dalistick Zn-Ni plating. For the Cd brush plating scenarios, all input and output assumptions from the previous CBA were used, air emissions were estimated using a variety of emission estimating techniques, and a mass balance was performed to estimate liquid waste not captured in the previous CBA. Based on this information, the following Cd brush plating scenarios were developed.

- Scenario 1: Assumed all liquid inputs not accounted for in the outputs would be disposed of as liquid hazardous waste.
- Scenario 2: Assumed all liquid inputs not accounted for in the outputs would be disposed of as wastewater, and updated the electricity estimate from the CBA. Electricity for electroplating was estimated using Faraday's Law of Electrolysis and an engineering estimate was performed to estimate compressed air and electricity consumption.

The following table summarizes the inputs, outputs and costs for the Cd brush plating scenarios.

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Description	Scenario 1		Scenario 2	
	Quantity	Cost (2014 USD)	Quantity	Cost (2014 USD)
INITIAL COST				
SIFCO Process Power Pack 20V/30A Rectifier	3 units	$14,142	3 units	$14,142
Total		**$14,142**		**$14,142**
ANNUAL COST				
Labor (production)	900 hours	$133,794	900 hours	$133,794
Labor (transportation)	770 hours	$114,474	770 hours	$114,474
Labor (training)	187 hours	$27,799	187 hours	$27,799
Isopropyl alcohol (IPA)	4,860 mL	$183	4,860 mL	$183
Red Scotch Brite Pad	243 items	$73	243 items	$73
SIFCO ID 13P Polyester Jacket (sock)	972 items	$7,970	972 items	$7,970
Blue paper towels	11,664 items	$397	11,664 items	$397
Neoprene gloves	100 items	$1,000	100 items	$1,000
SIFCO Positive Rectifier Lead	8 items	$1,875	8 items	$1,875
SIFCO Negative Rectifier Lead	8 items	$1,875	8 items	$1,875
Water (cleaning electrolyte)	250 gallons	$0.67	250 gallons	$0.67
Water (rinsing parts)	492 gallons	$1.05	492 gallons	$1.05
Electricity (electroplating)	972 kWh	$69.01	15 kWh	$1.10
Electricity (compressed air)	-	-	45 kWh	$3.17
Cadmium emissions to air	0.006 lbs	N/A	0.006 lbs	N/A
Ethylenediamine emissions to air	0.313 lbs	N/A	0.313 lbs	N/A
Isopropyl alcohol emissions to air	0.017 lbs	N/A	0.017 lbs	N/A
Solid hazardous waste	574 lbs	$1,148	574 lbs	$1,148
Sold waste	4.2 lbs	$0.01	4.2 lbs	$0.01
Liquid hazardous waste	6,087 lbs	$12,775	602 lbs	$1,807
Wastewater	0 gallons	$0	657 gallons	$3
Total		**$310,815**		**$299,785**

For the Dalistick Zn-Ni plating scenarios, values were derived from the UDRI data provided for this study as well as from the CBA. Simple linear regressions were derived from time study data to estimate labor requirements, input and outputs for onsite deionized (DI) water production were obtained from the ecoinvent life cycle inventory dataset, air emissions were estimated using a variety of emission estimating techniques, and a mass balance was performed to estimate liquid waste not captured in the CBA. UDRI's usage rates for the Activator XF solution, Zinidal Aero solution, and bonnets were significantly higher than those used in the CBA. To account for this uncertainty in material usage, two scenarios were evaluated.

- Scenario 1:.Used UDRI's estimated usage rates for Activator XF solution, Zinidal Aero solution, and bonnets.
- Scenario 2: Used the usage rates form the previous CBA for for Activator XF solution, Zinidal Aero solution, and bonnets

The following table summarizes the inputs, outputs and costs for the Dalistick Zn-Ni plating scenarios.

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Description	Scenario 1		Scenario 2	
	Quantity	Cost (2014 USD)	Quantity	Cost (2014 USD)
INITIAL COST				
Dalistick® Workstation D-2020	1 item	$111,100	1 item	$111,100
T Regulation Tank UCDK XF	1 item	$5,352	1 item	$5,352
Dalipump DKPL XF + Dalistick® Tool	1 item	$9,658	1 item	$9,658
Plating Tool Ax (Pkt of 4)	1 item	$190	1 item	$190
Variable Autotransformer (Power converter)	1 item	$365	1 item	$365
Packing & CIF US Intl Airport	1 item	$1,331	1 item	$1,331
Anode T4 (Pkt of 20)	1 item	$153	1 item	$153
Anode X13 (Pkt of 10)	1 item	$127	1 item	$127
Training	5 days	$8,305	5 days	$8,305
Labor (initial training)	200 hours	$29,732	200 hours	$29,732
Total		**$166,311**		**$166,311**
ANNUAL COST				
Labor (production)	1,027 hours	152,605	1,027 hours	152,605
Labor (transportation)	770 hours	$114,474	770 hours	$114,474
Labor (maintenance)	25 hours	$3,717	25 hours	$3,717
Labor (training)	155 hours	$23,042	155 hours	$23,042
Maintenance	1 item	$5,885	1 item	$5,885
Nitrile Gloves	1,944 items	$486	250 items	$513
Dalic Activator Bonnet (Scotch Brite pad)	359 items	$735	1 liter	$29
Activator XF solution	112 liters	$3,712	11 liters	$356
Dalic Zinidal Bonnet	382 items	$784	500 items	$1,025
Zinidal Aero solution	122 liters	$17,792	11 liters	$1,577
Solvent wipe	3,888 items	$194	3,888 items	$194
Lead AX	8 items	$182	8 items	$182
Lead NG	8 items	$242	8 items	$242
Tank Cleaner, Code 10131	5 liters	$148	5 liters	$148
Exacanal Pipe	4,167 cm	$87	4,167 cm	$87
Electricity (DI water)	0.01 kWh	$0.01	0.01 kWh	$0.01
Electricity (compressed air)	140 kWh	$10	140 kWh	$10
Electricity (activation)	29 kWh	$2	29 kWh	$2
Electricity (electroplating)	19 kWh	$1	19 kWh	$1
Water (DI water)	57 gal	$0.15	57 gal	$0.15
Hydrochloric acid, 30% in H2O (DI water)	0.1 lbs	$16	0.1 lbs	$16
Sodium hydroxide, 50% in H2O (DI water)	0.05 lbs	$15	0.05 lbs	$15
Sodium, ion releases to water (DI water)	0.03 lbs	N/A	0.03 lbs	N/A
Carbon dioxide emissions to air (DI water)	0.10 lbs	N/A	0.10 lbs	N/A
Heat waste to air (DI water)	0.69 MJ	N/A	0.69 MJ	N/A
Chloride emissions to air (DI water)	0.10 lbs	N/A	0.10 lbs	N/A
Acetone emissions to air	5.4E-05 lbs	N/A	5.4E-05 lbs	N/A
Hydrochorlic acid emissions to air	1.5E-04 lbs	N/A	0 lbs	N/A
Zinc emissions to air	5.9E-03 lbs	N/A	0 lbs	N/A

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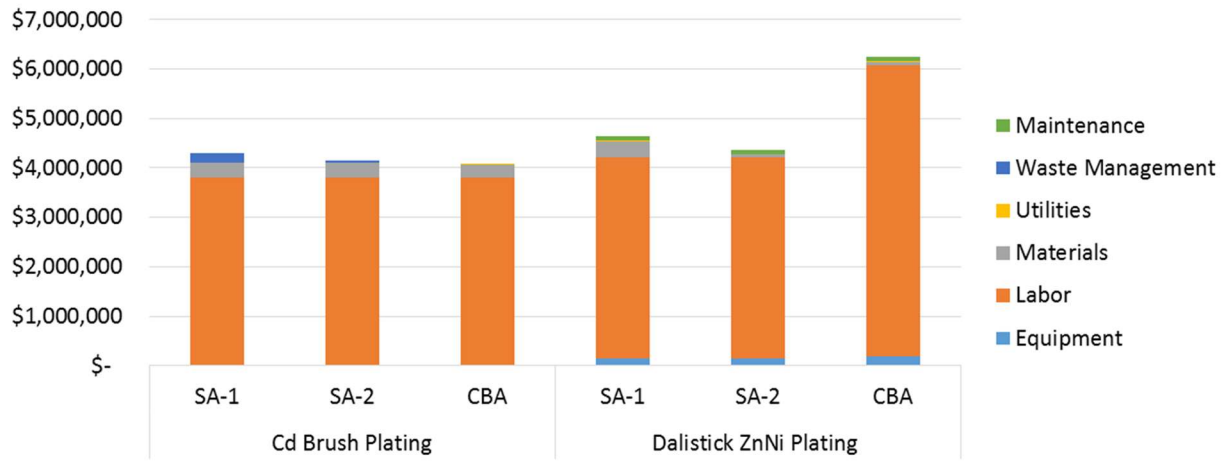
Nickel emissions to air	1.0E-03 lbs	N/A	0 lbs	N/A
Sulfamic acid emissions to air	2.3E-05 lbs	N/A	2.3E-05 lbs	N/A
Solid hazardous waste	21 lbs	$43	24 lbs	$48
Solid waste	90 lbs	$0.27	88 lbs	$0.26
Liquid hazardous waste	481 lbs	$1,443	174 lbs	$521
Wastewater	69 gallons	$0.36	42 gallons	$0.22
Total		**$325,616**		**$305,146**

The following figure compares the net present value (NPV) of the internal cost for the four scenarios evaluated here and from the CBA. The 15-year NPV estimates for Cd brush plating range from $4.1 to $4.3 million USD2014, and from $4.4 to $6.2 million USD2014 for Dalistick Zn-Ni plating. For Cd brush plating the NPV is higher here because this Sustainability Analysis includes costs associated with waste management. The NPV estimates for Dalistick Zn-Ni plating are lower due to significantly lower labor costs. While the NPV estimate for Dalistick Zn-Ni plating is higher than NPV estimate for Cd brush plating in this analysis, the difference between the two is much smaller than in the previous CBA.



Life cycle impact assessment was used to evaluate the potential impacts of resource use and environmental releases both at WR-ALC during the plating process as well as across the supply chain for purchased goods and services. The life cycle impact assessment was performed using scoring factors derived from the Defense Input Output (DIO) dataset. Each input and output identified above was multiplied by the appropriate scoring factor to estimate potential impact and external cost. Endpoint impacts represent the potential damage caused to resource availability, climate change, human health, and ecosystem quality. The following figure compares the relative endpoint impacts across the four scenarios evaluated here. For each endpoint category, the worst performing alternative is assigned a value of 1. All other alternatives are assigned a score equal to the ratio of its potential impact to that of the worst performing alternative. For all endpoint categories, the Dalistck Zn-Ni plating Scenario 1 is the worst performer. However, the material usage rates for this Scenario are most likely too high. For all endpoint categories, the Dalistick Zn-Ni plating Scenario 2 is the best performer.

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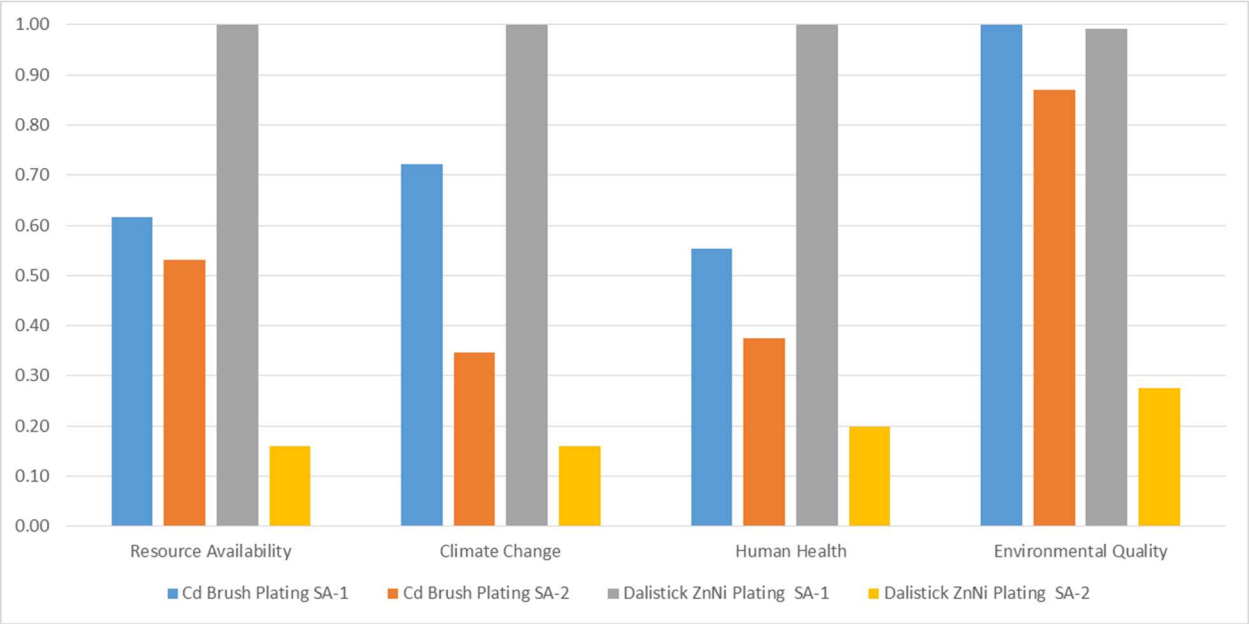

Figure 110. Relative Endpoint Impact Results

External cost (or externalities) represent the tangible and intangible costs borne by non-DoD government agencies or society at large from the impacts identified above. The following table and figure provide the internal and external cost estimates for all scenarios. As discussed above, the internal cost (NPV) of the Cd brush plating alternative was found to be lower than that of the Dalistick Zn-Ni plating. As with the impact results shown above, Dalistck Zn-Ni plating Scenario 1 has the highest external cost estimate and Dalistck Zn-Ni plating scenario 2 has the lowest external cost estimate.

Table 57. Internal and External Costs

	Cd Brush Plating SA-1	Cd Brush Plating SA-2	Dalistick Zn-Ni Plating SA-1	Dalistick Zn-Ni Plating SA-2
Internal Cost (USD2014)	$4,290,449	$4,138,695	$4,646,250	$4,364,626
External Cost (USD2014)	$59,718	$37,608	$95,276	$19,396

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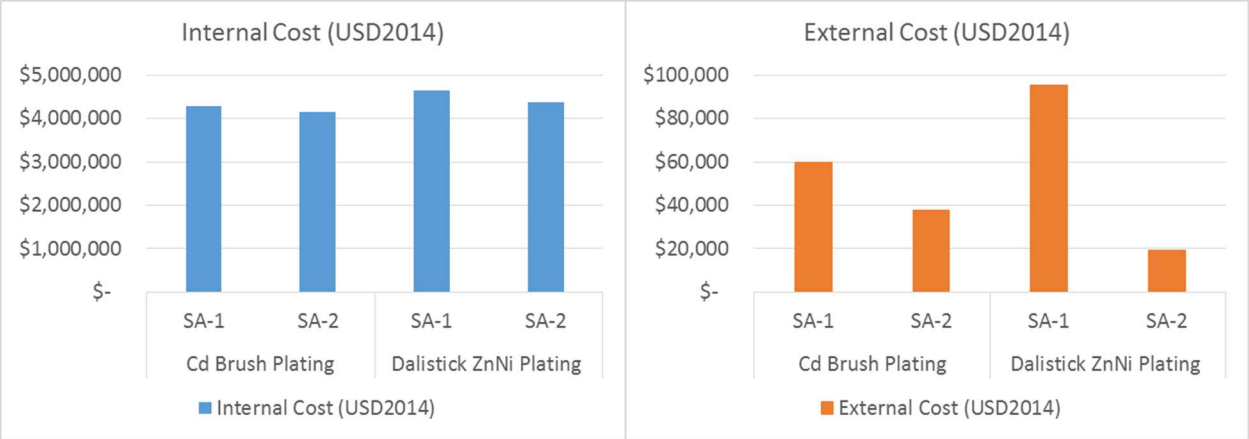

Figure 111. Internal and External Costs

For Cd brush plating, Scenario 1 likely overestimates the amount of liquid hazardous waste generated. For Dalistick Zn-Ni plating, Scenario 1 likely overestimates the amount of Activator XF solution, Zinidal Aero solution, and bonnets used, as well as the associated waste and emissions. For the purpose of comparing the alternatives, it can be assumed that Scenario 2 for both alternatives provides a more robust estimate of internal costs, impacts, and external cost. However, the internal cost estimate for Dalistick Zn-Ni plating should be used cautiously, since the previous CBA found the labor costs to be significantly higher than those estimated in this Sustainability Analysis.

The spider diagram below compares the internal cost, endpoint impacts, and external costs for the two alternatives (i.e., Cd brush plating Scenario 2 and Dalistick Zn-Ni plating Scenario 2). A spoke is provided for each of the results evaluated (i.e., internal cost or 15-year NPV, potential impacts on resource quality and availability, potential impacts related to climate change, impacts on human health and productivity, impacts on biodiversity and ecosystem services, and the external cost to society from these impacts). As with the column charts provided above, the worst performing alternative for each category is assigned a value of 1. The other alternative is assigned a score equal to the ratio of its performance to that of the worst performing alternative. While there is substantial uncertainty in many of the parameter estimates used in this Sustainability Analysis, the results indicate that transitioning from Cd brush plating to Dalistick Zn-Ni plating will slightly increase the internal costs to the Air Force, but significantly reduce the external costs borne by society. With regards to the spills and releases, the results here represent potential impact to humans and ecosystems from releases to the environment. They are based on environmental fate and transport modeling, not workplace modeling. Any occupational hazards associated with exposure to the materials used during Cd brush plating are not captured here.

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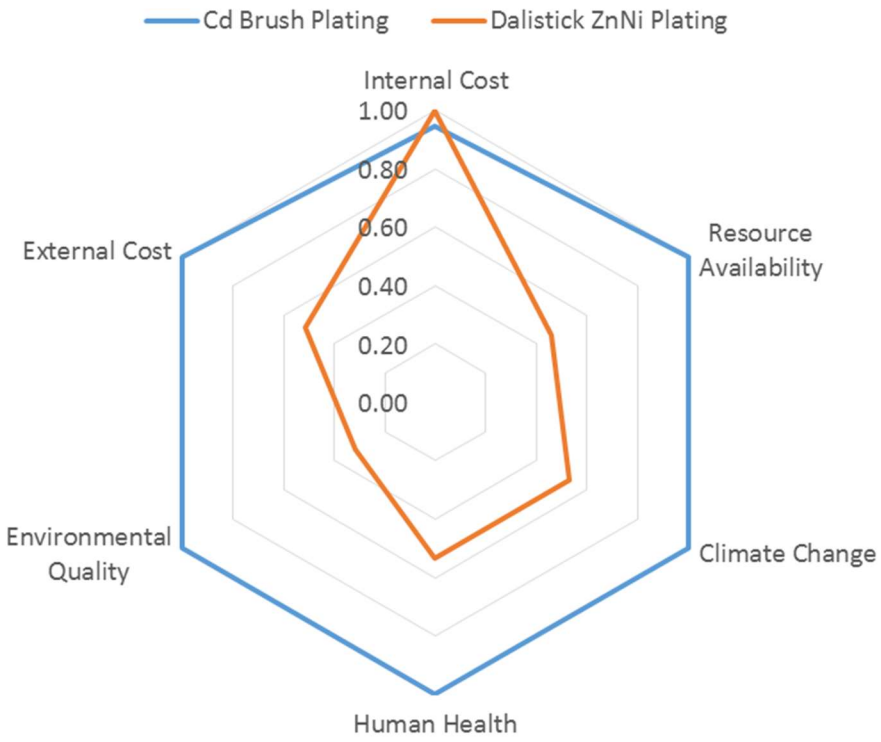

Figure 112. Spider Diagram Comparing the Costs and Impacts of Each Alternative

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List of Acronyms

AFB	Air Force Base
CBA	cost benefit analysis
Cd	Cadmium
CMXG	Commodities Maintenance Group
COTS	Commercial off-the-shelf
DENIX	Defense Environmental Network and Information Exchange
DIO	Defense Input Output
DoD	Department of Defense
ESOH	Environment, safety, and occupational health
ESTCP	Environmental Security Technology Certification Program
HSS	high strength steel
LCA	Life cycle assessment
LCC	Life cycle cost
MSDS	material safety data sheet
NPV	Net present value
NSN	National stock number
OASD (EI&E)	Office of the Assistant Secretary of Defense for Energy, Installations & Environment
OC-ALC	Oklahoma City Air Logistics Complex
OO-ALC	Ogden Air Logistics Complex
PFD	Process flow diagram
SERDP	Strategic Environmental Research and Development Program
TOC	Total ownership cost
UDRI	University of Dayton Research Institute
USMC	United States Marine Corps
WR-ALC	Warner Robins Air Logistic Complex
Zn-Ni	zinc-nickel

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1 Introduction

The Defense Acquisition Guidebook (DAG) requires program managers to consider sustainability in acquisition and select more sustainable systems, i.e., systems that meet performance requirements; have fewer negative impacts on resource availability, climate change, human health, and ecosystem quality; and has a lower total ownership costs (TOC). The Office of the Assistant Secretary of Defense for Energy, Installations & Environment (OASD (EI&E)) developed a framework and draft guidance document for performing a Sustainability Analysis that evaluates the financial cost, environmental impacts, and external costs of a system over its useful life. Noblis conducted a Sustainability Analysis to more fully understand the sustainability of Dalistck Zn-Ni plating as compared to Cd brush plating. While this Sustainability Analysis does assess the environmental impacts and costs associated with both alternatives, it does not assess the occupational health and safety impacts or costs.

1.1 Background

The U.S. Air Force is leading ongoing efforts focused on the elimination of cadmium (Cd) for brush plating repair operations and reduction of solid waste associated with absorbents used to contain solution leakage attributed to traditional brush plating repair processes. The following technical objectives were defined:

1. Demonstrating the commercial off-the-shelf (COTS) Dalistick® Station for selective plating, ensuring its safety and cost-effectiveness for U.S. Department of Defense (DoD) maintenance, repair, and overhaul operations.

2. Testing and evaluating the COTS Zinidal Aero (code 11040) zinc-nickel (Zn-Ni) brush-plated coating as a Cd replacement on high strength steels (HSS) for repair applications on weapon systems parts and components (e.g., landing gear, terminal assemblies, landing gear doors, bushings,).

The Dalistick® Station is a mobile, electroplating system that enables selective electrochemical treatments without generating any leakage of electrolytes during the plating process. The Dalistick Station recovers residual brush plating solution and recycles it for reuse in a closed-loop process at the point of contact with the part. It is designed to perform plating and surface finishing operations on steels or light alloys on site, at depots, or in the field. It performs these treatments on curved, horizontal, and vertical surfaces and edges without any leakage of electrolyte or generation of solid waste (e.g., absorbents materials or pads).

The Zinidal Aero coating is a promising candidate to replace traditional Cd plating. The Zinidal Aero Zn-Ni solution deposits a coating with 10–20% weight Ni and 80–90% weight Zn at varying thicknesses. The coating provides sacrificial corrosion protection to steels, and the process does not require the hydrogen embrittlement relief baking when plated on HSS.

In support of objective 1 above, a cost benefit analysis (CBA) was performed to compare Dalistick Zn-Ni plating to Cd brush plating. The CBA found the net present value (NPV) of Dalistick Zn-Ni plating to be $1.8 million USD2014 higher than Cd brush plating, assuming a 15-year study period. The CBA included costs associated with equipment, labor, materials, utilities, and maintenance. The CBA estimated that Dalistick Zn-Ni plating would result in 669

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pounds (lbs) less liquid hazardous waste and 141 lbs less solid hazardous waste then Cd brush plating, however, the reduction in cost associated with managing less waste was not included in the analysis. In addition, the CBA did not assess the environmental or occupational health and safety costs associated with either process.

1.2 Technical Approach

Sustainability Analysis (Figure 113) integrates life cycle cost (LCC) estimating with life cycle assessment (LCA) to compare two or more systems, components, or processes that meet the same performance requirements. LCC estimating quantifies the financial costs incurred by DoD over a system's lifetime. LCA quantifies natural resource requirements and environmental releases through each life cycle stage of a military system, and estimates the following impacts, as well as the associated external cost to society.

- **Resource Availability:** Includes natural resource use (e.g., land, water, mineral, and fossil resources), potential impacts on resource quality and availability, and the associated marginal cost increases.
- **Climate Change**: Includes greenhouse gas emissions, their contribution to global warming, and the associated impacts, including changes in net agricultural productivity, human health, property damages from increased flood risk, and ecosystem services.
- **Human Health**: Includes environmental releases, water use, and noise emissions, and the associated impacts on human health and productivity.
- **Ecosystem Quality**: Includes environmental releases, land use, and water use, and the associated impacts on biodiversity and ecosystem services.

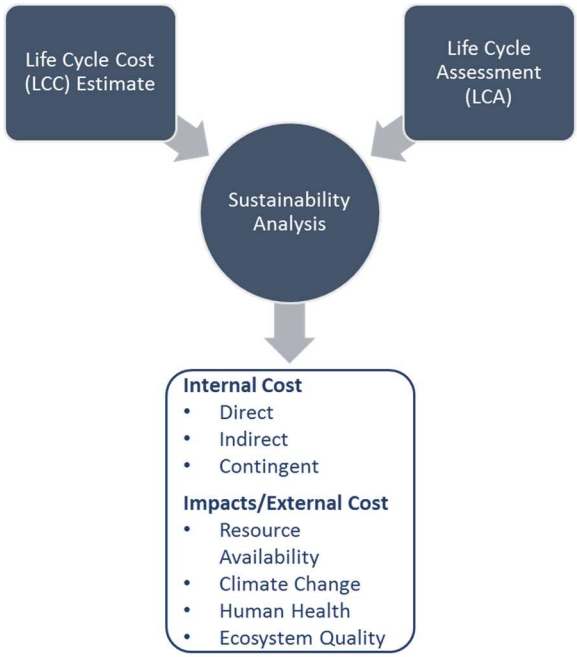

Figure 113. Sustainability Analysis

Integrating LCC estimating and LCA identifies important sustainability impacts, estimates the associated internal and external costs, and relates impacts and costs to the activities that cause them. At this time, the DoD Sustainability Analysis framework does not consider impacts from occupational illnesses, injuries, and fatalities.

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2 Scope

The first step of a Sustainability Analysis is to clearly define the scope of the study.

2.1 Description

A Sustainability Analysis includes the life cycle activities of a weapon system related to the scope of the analysis. Figure 114 shows the life cycle stages for the activities considered in this Sustainability Analysis. The focus is on weapon system sustainment only, and in particular on the activities necessary to perform electroplating to repair damaged plating, in particular components currently repaired via Cd brush plating. Cd brush plating can be used to touch up tank Cd plating (e.g., where electrical contact had to be made) or repair damaged cadmium plating on any weapon system components (e.g., landing gear, actuators). Components can be repaired on-system (e.g., on-aircraft), or the component can be removed and repaired in a plating shop.

As shown in Figure 2, upstream (supply chain) activities include the extraction of resources and production of goods (e.g., chemicals, materials, supplies, electricity) and services (e.g., waste management) procured by the Air Force to perform Cd electroplating. Downstream activities include the activities an Air Force depot undertakes to perform Cd electroplating. The impacts associated with upstream activities (i.e., procured goods and services) and downstream flows (i.e., natural resource usage and environmental releases at Warner Robins Air Logistics Complex (WR-ALC) were estimated using the Defense Input-Output (DIO) dataset (formerly known as the DoD EnvIO dataset), described in the draft Sustainability Analysis guidance document and provided on the Defense Environmental Network and Information Exchange (DENIX) ESOH in Acquisition website.

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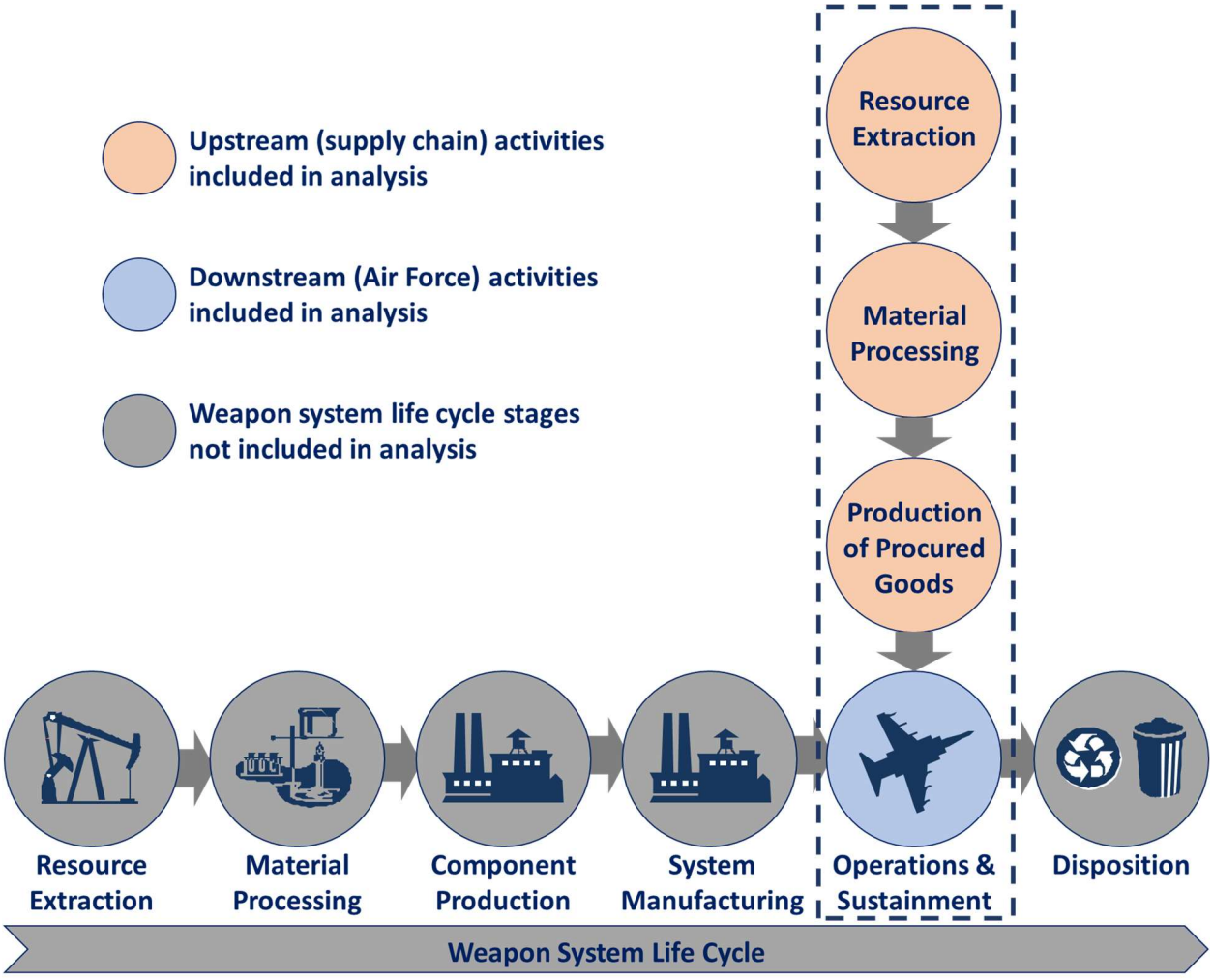

Figure 114. Aspects of Weapon System Life Cycle Included in the Sustainability Analysis

2.2 Function

The function of the traditional Cd brush plating and Dalistick processes are to perform selective electroplating on high strength steels (HSS) for repair applications on weapon systems parts and components (e.g., landing gear, terminal assemblies, landing gear doors, bushings) in in accordance with MIL-STD-865D, Department of Defense Standard Practice: Selective, Brush Plating, Electrodeposition.

2.3 Functional Unit

The functional unit defines the identified functions (performance characteristics) of the system being studied and provides a reference for which the Sustainability Analysis will be performed. The results of a Sustainability Analysis are estimated relative to the functional unit for all alternatives, thereby ensuring comparability of results across alternatives

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Initially, a broader functional unit that included annual throughput at WR-ALC, Oklahoma City Air Logistics Complex (OC-ALC), and Ogden Air Logistics Complex (OO-ALC) was considered. Information provided by the depots about their Cd brush plating activities, a recent study on DoD's use of Cd in weapon system components, and Cd species usage estimates for Cd brush plating from a Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) special study were evaluated. This analysis showed that many components could potentially be Cd brush plated across the Air Force and that WR-ALC usage significantly less Cd for brush plating than OC-ALC and OO-ALC. However, insufficient information was available for characterizing the types of repairs and throughput for each ALC. More information about the findings are included in Appendix A.

The functional unit selected for this Sustainability Analysis is annual selective electroplating throughput at Warner Robins Air Logistics Complex (WR-ALC). It was defined based on part information and throughput estimates defined in the previous CBA, as provided by Warner Robins Air Logistic Complex (WR-ALC) Commodities Maintenance Group (CMXG) plating technicians. The parts, surface area, processing time, and estimated throughput are summarized in Table 58. The report also identified additional parts that may be Cd brush plated at WR-ALC but were not included in the analysis. These included C-130 barrel, C-17 landing gear sprockets, and helicopter parts for the United States Marine Corps (USMC).

Table 58. Estimated Cd Brush Plating Throughput at WR-ALC

Part Type	Weapon System(s)	Plating Location	Number of parts/month	Estimated parts/month	Estimated parts/year
Bushings	C-5, C-17, C-130, and F-15	Selective plating room	Varies between 1 and 24 per month	12	144
Wheel well	C-17	In-field	16 per aircraft; 2-3 aircraft per month	40	480
Strut	C-5	Plating shop	Varies between 2-8 per month	5	60
Engine mounts	C-5	In-field	6 per engine; 4 engines per month	24	288
			Total:	81	972

Table 59 provides more detailed part information and process parameters from the CBA. CMXG plating technicians described the geometry of a representative C-17 bushing to be a cylinder, with a height of approximately 0.5 in and a diameter of 3.8 inches (in), which correlates to a total plated surface area of 28.6 square inches (in^2). The Cd brush plating time for this representative part was estimated to be 5 minutes with plating parameters at approximately 8 volts (V) and between 1 amperes (A) and of 8 A. It was also stated that the bushings are the smallest parts and require than 5 minutes of plating time using traditional Cd brush plating, and the C-17 wheel wells and the C-5 struts are the largest parts and take 20 to 30 minutes to plate using traditional Cd brush plating. While acknowledging that the area to and thickness of the plating varies, the

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CBA estimated that the total average processing time for a plating technician to perform traditional Cd brush plating to a 13-18 micrometer (µm) thickness per MIL-STD-856D is 60 minutes, which includes set-up, masking, addressing personal protective equipment (PPE) requirements, plating operations, record keeping, and clean-up. Throughout the analysis, the CBA assumed 13 µm as a representative thickness for all parts, and estimated a total processing time of 60 minutes for all parts expect the bushings. It should be noted that the CBA did not use part information, processing parameters, or information about solution losses to estimate the amount of Cd solution or processing time required for Cd brush plating. Nor was a time study conducted. Instead, processing times were estimated by plating technicians, and were assumed to be the same for all parts except the bushings.

Table 59. Information about Parts Processed at WR-ALC using Cd Brush Plating

Part Type	Weapon System	Surface Area (in2)	Thickness (µm)	Voltage (V)	Current (amps)	Plating Time (min)	Process Time (min)	Travel Time (min)
Bushings	C-5, C-130, and F-15	Smallest parts	13-18	N/P	N/P	5	30	0
Bushing	C-17	28.6	13-18	8	1-8	5	30	0
Wheel well	C-17	Largest parts	13-18	N/P	N/P	20-30	60	60
Strut	C-5	Largest parts	13-18	N/P	N/P	20-30	60	0
Engine mounts	C-5	N/P	13-18	N/P	N/P	N/P	60	60

N/P = not provided

Since the previous CBA appeared to apply the same assumptions for all of the small parts (i.e., the bushings) and all of the large parts (i.e., the wheel well, strut, and engine mounts), these two part groupings were assumed in this analysis. The specific assumptions used in this analysis are described in Table 60. The amount of surface area repaired for each part type is a key parameter for calculating inputs and outputs for electroplating. The previous CBA did not provide surface area for each part type. Instead, it assumed a total throughput of 18 m^2 (27,900 in^2). Since the process time for a small part was estimated to be half that of a large part for Cd brush plating, here it was assumed that the repair area of a small part is half the size of that of a large part. The required thickness was assumed to be 13 µm for both small and large parts. Annually, 144 small parts and 828 large parts are processed. None of the small parts and 93% of the large parts are repaired in the field. The rest are removed from the weapon system and repaired in the plating shop.

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Table 60. Representative Part Information Assumed for this Analysis

Part Type	Surface Area (in^2)	Surface Area (cm^2)	Thickness (µm)	Annual Throughput	% Plated in Plating Shop	% Plated In The Field
Small	15.5	100	13	144	100%	0%
Large	31.0	200	13	828	7%	93%

Table 60 provides a more refined functional unit – it defines precisely which and how many parts would be repaired by each alternative. All aspects of the Sustainability Analysis are related to this functional unit – 144 small parts and 828 parts repaired annually at WR-ALC for 15 years.

2.4 Reference Flow

The reference flow specifies the amount of each alterative required to fulfil the function defined by the functional unit. Reference flows ensure comparability of sustainability analysis results for each alternative analyzed. From a system perspective, the reference flow for each alternative could be set as the number of small and large parts processed, which was specified above as the functional unit and is the same for both Cd brush plating and the Dalistick station. However, the specific inputs and outputs required to perform Cd brush plating and Dalistick Zn-Ni plating will vary. For example, the amount of solution used to coat a part depends primarily on four parameters: the surface area that must be repaired, the required thickness of the coating, the density of the material, and solution losses. These values are determined on a component-by-component basis (e.g., based on the complexity and geometry of a component) and a case-by-case basis (e.g., based on the amount of coating that is damaged). For this Sustainability Analysis, the amount of Cd and Zn-Ni required for the two plating alternatives is estimated as the primary reference flow for the two alternatives. Table 61 estimates the amount of Cd plating that would be applied to small and large parts annually at WR-ALC using Cd brush plating, and Table 62 estimates the amount of Zn and Ni that would be required using Dalistick Zn-Ni plating. While Table 61 and Table 62 show the estimated about of Cd, Zn, and Ni deposited on components for this Sustainability Analysis, it does not show the total amount of Cd, Zn, or Ni species used. These amounts are determined in the analyses based on solution usage rates.

Table 61. Estimated Mass of Cd Applied to Parts Annually Using Cd Brush Plating

Part Type	Volume of Cd Plating (cm3/part)	Density of Cd (g/cm3)	Mass of Cd Plating (kg/year)	Mass of Cd Plating (lbs/year)
Small	0.13	8.65	0.2	0.4
Large	0.26	8.65	1.9	4.1
Total			**2.0**	**4.5**

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Table 62. Estimated Mass of Zn and Ni Applied to Parts Annually Using Cd Brush Plating

Part Type	Volume of Zn-Ni Plating (cm3)	%wt Zn	Density of Zn (g/cm3)	% wt Ni	Density of Ni (g/cm3)	Mass of Zn Plating (kg)	Mass of Ni Plating (kg)	Total Plating Mass (kg)	Total Plating Mass (lbs)
Small	0.1	85%	7.14	15%	8.91	0.1	0.0	0.1	0.3
Large	0.3	85%	7.14	15%	8.911	1.3	0.2	1.6	3.5
Total						**1.5**	**0.3**	**1.7**	**3.8**

2.5 System Boundaries

System boundaries clearly define what life cycle stages and associated activities are included in the analysis. A process flow diagrams (PFD) provides a visual representations of the system boundaries. High-level, overarching PFDs were first generated to outline the process of the baseline traditional Cd brush plating (traditional stylus) and the alternative Dalistick Zn-Ni plating.

Figure 115 shows the steps associated with traditional Cd brush plating. Stripping and cleaning activities remove soils and corrosion from plated surfaces. Surface preparation activities activate the substrate and undamaged Cd. Brush plating activities selectivity coat the activated area. During this step, a sacrificial Cd anode is wrapped in an absorbent sleeve; the sleeve is kept wet with plating solution; a steady, uniform anode motion is applied on the part; and a constant voltage is used until the target ampere hour (Ah) is reached. The Cd plating quality is inspected. If rework is required, the previous steps are repeated. Upon passing inspection, post treatment is performed if applicable. The system boundaries include steps for which data was available. A more complete analysis would all of the steps shown in Figure 115.

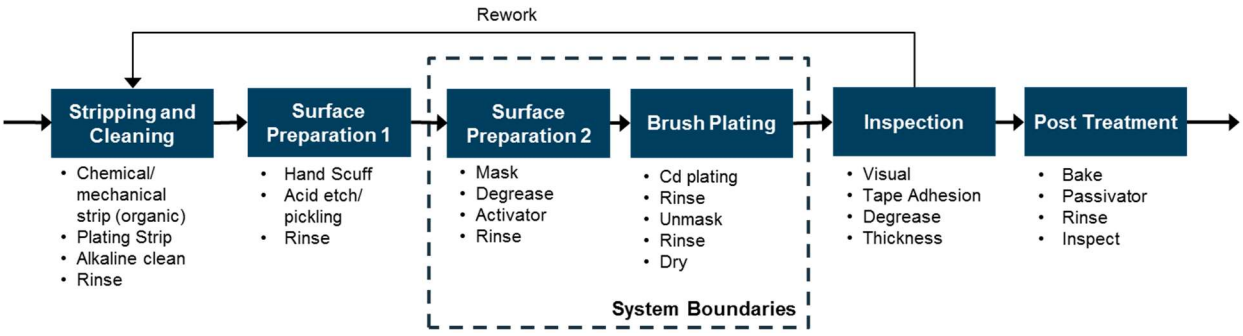

Figure 115. System Boundaries for Traditional Cadmium Brush Plating

Figure 116 shows the steps associated with Dalistick brush plating with Zinidal solution. Stripping and cleaning activities remove soils and corrosion from plated surfaces. Surface

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preparation activities include a limited amount of masking and activate the substrate. Brush Plating activities are completed using the mobile Dalistick workstation. The station minimizes leakage of the electrolyte. The Dalipump and Dalistick tool are used in conjunction to more efficiently brush plate and minimize spillage of the Zinidal Aero solution. The Zn-Ni plating quality is inspected. If rework is required, the previous steps are repeated. Upon passing inspection, post treatment is performed if applicable. The original intent of the study was to include all of the steps shown in Figure 116 in the analysis. However, to ensure an equivalent comparison with traditional Cd brush plating, only the steps included in the system boundary are included in the analysis

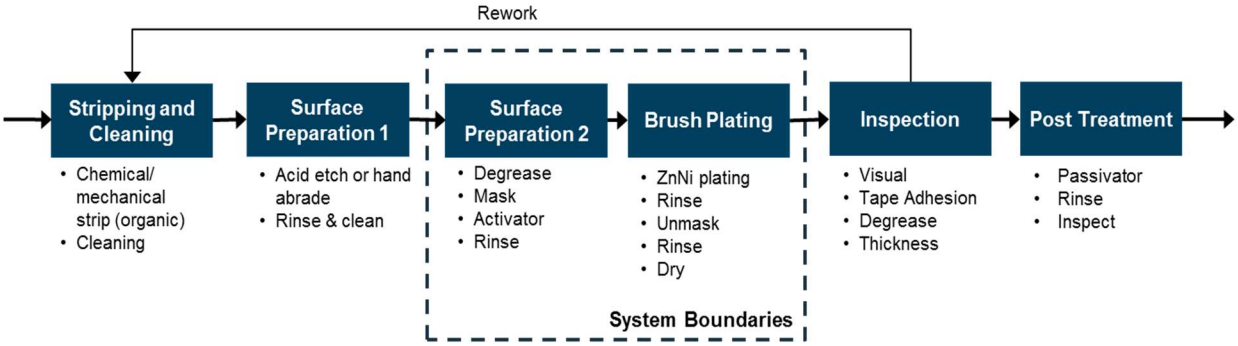

Figure 116. System Boundaries for Dalistick Zn-Ni Plating

Appendix B provides detailed process flow diagrams for each step included in the system boundaries.

2.6 Study Parameters

Table 63 summarizes parameters used to make economic comparisons between the two plating alternatives.

Table 63. Study Parameters

Parameter	Description	Value
Reference year	The year to which all costs are normalized.	2014
Study period	The number of years the Sustainability Analysis is based on.	15 years
Inflation rates	A continuing rate of change in the general price level.	Not used, all values assumed to be in USD2014
Real discount rate	Rate used to convert future monetary values into present value to account for the time value of money.	1.1%[a]
Social discount rate	Rate used to convert the value of future damages (externalities) to the present value of those damages.	3.0%[b]

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a: The real discount rate for a 15-year study period was established according to OMB Circular A-94 (accessed on June 20, 2016)
b: A social discount rate of 3.0% is commonly used in regularity impact assessments that account for the social cost of carbon

2.7 Workbook

The parameters, calculations, and results of the Sustainability Analysis are presented in detail in the remaining sections. The calculations have been provided in a Microsoft Excel workbook, which is provided in Appendix C. It was formatted to allow the analysis to be updated as more detailed information about parts and throughput for WR-ALC, OO-ALC, or OC-ALC are obtained.

3 Life Cycle Inventory (Inputs and Outputs)

A life cycle inventory (LCI) includes all relevant system inputs (e.g., resources, procured, items, and services) and outputs (e.g., products, environmental releases) that fall within the scope of the study. Inventory elements include, but are not limited to, the amount of energy, chemical, material, water, land, and procured goods and services used; the products produced; noise emissions, and release of hazardous materials to air, water, and soil. The LCI will serve as the basis of calculation of life cycle impacts and costs. This section will provide an overview of all inputs and outputs associated with each step included in the system boundaries for both Cd brush plating and Dalistick Zn-Ni plating alternatives. For each procured good and service, an assumed North American Industry Classification System (NAICS) code is provided. The DIO dataset provides average impact and external cost factors for industry sectors, which are classified by NAICS codes.

3.1 Utility, Service, and Labor Rates

Table 64 provides the utility and service rates assumed for the Sustainability Analysis. These rates were assumed for both Cd brush plating and Dalistick Zn-Ni.

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Table 64. Assumed Utility and Service Rates

Utility Type	Price (USD2014)	Data Source(s)	Basis
Labor	$148.66 / hour	CBA	Fully burdened hourly labor rate for plating technicians derived by CMXG Corrosion Control and Prevention Manager
Electricity	$0.071 / kWh	CBA	Average price of electricity to customers per the US Energy Information Administration
Tap Water	$2.00 / CCF	Macon Water Authority	Non - residential consumption (volumetric) rates
Liquid Hazardous Waste Disposal	$3.00 / lb	Estimated	Hazardous waste disposal rates found online
Solid Hazardous Waste Disposal	$2.00 / lb	Estimated	Hazardous waste disposal rates found on line
Wastewater Utility Rate	$0.005 / gal	Black & Veatch	Average sewage rate for industrial uses from "50 Largest Cities Water/Wastewater Rate Survey"
Solid Waste Management	$6.00 / ton	Estimated	Solid waste disposal rates found online

3.2 Alternative 1 - Cd Brush Plating

Cadmium brush plating is the baseline process used at WR-ALC. Input, output, and cost estimates for Cd brush plating were obtained from the CBA unless otherwise noted. The original data can be obtained from the CBA report and files embedded as appendices. Two scenarios were developed to address important uncertainties:

- **Scenario 1:** Assumed all liquid inputs not accounted for in the outputs would be disposed of as liquid hazardous waste. Used the electricity estimate from the previous CBA.

- **Scenario 2**: Assumed all liquid inputs not accounted for in the outputs would be disposed of as wastewater. Estimated electricity requirement based on equipment setting.

The following sections provide the inputs and outputs associated with each cost category. For cost categories where the inputs and outputs differ between the two scenarios, two sets of inputs and outputs are provided.

3.2.1 Initial Investment

WR-ALC currently uses a SIFCO process power pack with a 20V/30A rectifier. While WR-ALC currently has this equipment, the CBA assumed they have a 15 year life and assumed WR-ALC would either replace this equipment or purchase equipment required for Dalistick Zn-Ni plating. Table 65 show shows the estimated cost to replace the equipment currently used at WR-ALC for Cd brush plating.

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Table 65. Initial Investments Assumed for Cd Brush Plating

Description	Quantity	Unit Cost	Total Cost	NAICS
SIFCO Process Power Pack 20V/30A Rectifier	3	$4,714	$14,142	Other general purpose machinery manufacturing (33399A)

3.2.2 Labor

Labor estimates were taken directly from the CBA and are summarized in Table 66. They include transportation time for in the field repairs, production time, and training. Production includes surface preparation and brush plating.

Table 66. Annual Labor Estimate for Cd Brush Plating

Description	Labor	Units	Annual Labor (hours)	Annual Labor Cost ($)
Production - Small parts	0.5	hours/part	72	$10,704
Production - Large parts	1	hours/part	828	$123,090
Transportation - Small parts	1	hours/part plated in-the-field	0	$-
Transportation - Large parts	1	hours/part plated in-the-field	770	$114,474
Training - Initial Cd brush plating training	32	hours/year	32	$4,757
Training - Annual Cd brush plating training	22.5	hours/year	23	$3,345
Training - Annual respirator training	7.5	hours/year	8	$1,115
Training - Weekly PPE training	125	hours/year	125	$18,583
Total			**1,857**	**$276,068**

3.2.3 Materials

The CBA estimated most material inputs on a per part basis. It is likely that the amount of materials used will vary for different parts. Since no additional information was provided about the materials used, the same material usage assumptions were used for this analysis. The prices used in the CBA are also used here. The cost of neoprene gloves, which were not included in the CBA, were estimated based on the price of chemical resistant gloves found online.

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Table 67. Annual Material Estimates for Cd Brush Plating

Description	Usage	Cost	Units	Total Cost	NAICS
SIFCO 2023	6 L/month	$102.50	$/L	$7,380	Coating, engraving, heat treating and allied activities (332800)
Isopropyl alcohol (IPA)	5 mL/small part	$0.04	$/mL	$27	Other basic organic chemical manufacturing (325190)
Isopropyl alcohol (IPA)	5 mL/large part	$0.04	$/mL	$156	Other basic organic chemical manufacturing (325190)
Red Scotch Brite Pad	0.25 pads/small part	$0.30	$/pad	$11	Other fabricated metal manufacturing (33299B)
Red Scotch Brite Pad	0.25 pads/large part	$0.30	$/pad	$62	Other fabricated metal manufacturing (33299B)
SIFCO ID 13P Polyester Jacket (sock)	1 socks/small part	$8.20	$/sock	$1,181	Synthetic rubber and artificial and synthetic fibers and filaments manufacturing (3252A0)
SIFCO ID 13P Polyester Jacket (sock)	1 socks/large part	$8.20	$/sock	$6,790	Synthetic rubber and artificial and synthetic fibers and filaments manufacturing (3252A0)
Blue paper towels	12 towels/small part	$0.03	$/towel	$59	Paper mills (322120)
Blue paper towels	12 towels/large part	$0.03	$/towel	$338	Paper mills (322120)
Neoprene gloves	2 gloves/day	$20.00	$/glove	$2,000	Surgical appliance and supplies manufacturing (339113)
SIFCO Positive Rectifier Lead	0.17 leads/week	$131.00	$/lead	$1,092	Wiring device manufacturing (335930)
SIFCO Negative Rectifier Lead	leads/week	$94.00	$/lead	$783	Wiring device manufacturing (335930)
Total				**$19,878**	

3.2.4 Water

The CBA estimated water inputs per part and per unit time. It is likely that the amount of water used will vary for different parts. Since no additional information was provided about water usage rates, the same water usage assumptions were used for this analysis. Since WR-ALC is near Macon, Georgia, the Macon Water Authority's published rate of $2.00/per CCF for 2014 was used.

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Table 68. Annual Water Estimates for Cd Brush Plating

Description	Usage	Annual Usage (gal)	Annual Water Cost (USD2014)	NAICS
Tap water for cleaning electrolyte	1 gal/day	250	$0.67	221310 Water Supply and Irrigation System
Tap water for rinsing parts - small parts	1 gal/part	144	$0.38	221310 Water Supply and Irrigation System
Tap water for rinsing parts - large parts	1 gal/part	348	$0.93	221310 Water Supply and Irrigation System
Total		**742**	**$2**	

3.2.5 Electricity

The CBA identified two activities that require electricity: (1) use of the SIFCO Process Power Pack to plate components; and (2) used of compressed air to dry components after they are degreased. The CBA estimated 972 kWh of electricity for the 972 production hours, rather than calculating electricity used for each step. Scenario 1 assumes that 972 kWh are used for all processes, as shown in Table 69.

Table 69. Electricity Requirements Assumed for Cd Brush Plating (Scenario 1)

Description	Annual Electricity Requirement (kWh)	Annual Electricity Cost (USD2014)	DOI Activity
Electricity for activation and plating	972	$69	Electricity use, average generation mix - Georgia, U.S.
Total	**972**	**$69**	

For the second scenario, several calculations were used to estimate electricity associated with performing brush plating and using compressed air.

According to the CBA, CMXG plating technicians estimated that a C-17 bushing would plated for 5 minutes with the power pack set to approximately 8 V and between 1 A and 8 A as obtained from CMXG plating shop. Faraday's Law of Electrolysis was used to calculate the electrical current required to deposit 13 µm of Cd on the components.

$$I = (W \cdot n \cdot F)/(t \cdot A)$$

where:

I = current in coulombs per second (Amperes)

W = weight of plated Cd in grams

N = the valence number for the dissolved Cd in solution, which is 2 equivalents/mole

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F = Faraday's constant, which is 96,485.309 coulombs/equivalent.

t = amount of time plating is performed in seconds

A = atomic weight of Cd, is 112.411 g/mole

At 8V, approximately 6.5 A of current would be required to deposit 13 µm of Cd on a surface of 100 cm^2 in 5 minutes. At the same equipment settings, it would take approximately 10 minutes to plate a larger part. This would result in an energy requirement of 4.3 Wh per small part and 8.6 Wh per large part, and a total energy requirement of 8 kWh/year for the 972 parts. In addition, the SIFCO power pack would also be used for applying the activator. It was assumed that the same amount of energy required for plating the part would be required for applying the activator.

The CBA estimated that dried, compressed air is used for approximately 1 minute per part at an unknown pressure or consumption rate, but did not estimate the amount of energy required. For the Sustainability Analysis, an air consumption rate of 10 cfm was assumed. The electricity requirement was estimated using the econinvent life cycle inventory database. The average electricity rate per volume of air for 5 average performing compressors was used, resulting in an estimate of 45 kWh/year for compressed air.

The electricity estimates resulting from the above calculations are provided Table 70, and were used in Scenario 2. The calculated electricity requirement is significantly lower than the estimate used in the previous CBA.

Table 70. Electricity Requirements Assumed for Cd Brush Plating (Scenario 2)

Description	Annual Electricity Requirement (kWh)	Annual Electricity Cost (USD2014)	DOI Activity
Electricity for drying with compressed air	45	$3.17	Electricity use, average generation mix - Georgia, U.S.
Electricity for activation and plating	15	$1.10	Electricity use, average generation mix - Georgia, U.S.
Total	**60**	**$4.27**	

3.2.6 Air Emissions

Air emissions data were not provided in the CBA. Air emissions were estimated for two material inputs: (1) spray isopropyl alcohol (IPA) used to degrease the area to be plated; and (2) the SIFCO Cd (No bake) Code 2023 Cd electrolyte, hereafter referred to as SIFCO 2023. The estimates are provided in Table 71 and described below.

Scope 1 air emissions associated with using IPA were calculated using a method for calculating air emissions factors for cleaning products that is based on Henry's law (Card 2007). With knowledge of isopropyl alcohol's Sanders reference value, $K°_H$ (130 $mole/m^3$), and temperature slope value, α (7500), one can solve for air emission factor, H (gas per liquid).

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$$H = \frac{1}{K_H^O 1{,}000RTexp[\alpha\left(\frac{1}{T} - \frac{1}{T^O}\right)]}$$

The universal gas constant, R, is $8.2057x10^{-5}$ –atm per gmole-K and T^O is equivalent to 298.l5 K. Standard room temperature was used for the calculation (323.15 K). The gas/liquid partition coefficient was found to be 0.002031 mg/l gas per mg/l liquid of isopropyl alcohol. Based on the amount of IPA used, this results in an IPA air emission estimate of 0.008 kg/year (0.017 lbs/year).

The air emissions from SIFCO 2023 were derived based on its assumed composition, provided in **Error! Reference source not found.**, the assumed usage rates, and identified emission factors. No Cd emission factor was provided or found for selective electroplating. As a proxy, the EPA's AP-42 candidate emission factor for Cadmium-Cyanide Electropalting (bath) with no air pollution control of 2.6 mg/A-hr was used. This results in a Cd air emissions estimate of 0.003 kg/year (0.006 lbs/year).

Scope 1 air emissions for ethylenediamine were calculated using a method based on Henry's law. The air-water partitioning coefficient was calculated using the value for a Henry's Law Constant for Henry Volatility (H).

$$H=P/X$$

The Henry's Law Constant for Henry Volatility is determined by dividing the partial pressure (P) by the aqueous-phase concentration (X). The air-watering partitioning coefficient is assumed to be equivalent to the Dimensionless Henry's Law Constant (H').

$$H'=H/(RT)$$

The universal gas constant, R, is 8.2057x10-5 –atm per gmole-K. Standard room temperature was used for the calculation (323.15 K). The Dimensionless Henry's Law Constant was calculated for butyl acetate using the Henry's Law Constant for Henry Volatility, 32.4 (Pa · m3)/mol (Staples, C. A. (2001). A review of the environmental fate and aquatic effects of a series of C4 and C8 oxo-process chemicals.[51] The gas-water partitioning coefficient of ethylenediamine was assumed to be directly proportional to the relationship of relative evaporation rates of ethylenediamine (0.91) and butyl acetate (1). The gas-water partitioning coefficient was found to be 1.10 x 10-2 mg/l gas per mg/l liquid of ethylenediamine. Based on the amount of ethylenediamine used, this results in an ethylenediamine air emission estimate of 0.142kg/year (0.313 lbs/year).

[51] Staples, C.A. (2001) A review of the environmental fate and aquatic effects of a series of C4 and C8 oxo-process chemicals, *Chemosphere*, 45(3), 339-346.

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Table 71. Estimated Air Emissions for Cd Brush Plating

Description	Annual Emissions (kg)	Annual Emissions (lbs)
Cadmium	0.003	0.006
Ethylenediamine	0.142	0.313
Isopropyl alcohol	0.008	0.017

3.2.7 Solid Hazardous Waste

As with the previous CBA, it was assumed red Scotch Brite pads, SIFCO ID 13P polyester jackets (socks), blue paper towels, and neoprene gloves would be disposed of as solid hazardous waste. The previous CBA didn't consider liquid which would be absorbed by and disposed of with some of these material input as solid hazardous waste. Here, it was absorbed that the Scotch Brite pads, SIFCO polyester jackets, and blue paper towels would absorb 100% of their weight, which would then be disposed of as solid hazardous waste as well. The resulting solid hazardous waste estimates are provided in Table 72. The cost to dispose of solid hazardous waste was estimated to be $2.00/lb based on rates found online.

Table 72. Solid Hazardous Waste Estimate for Cd Brush Plating

Description	Relative Weight of Liquid Absorbed	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
Solid hazardous waste from Red Scotch Brite Pad	100%	6	12	$24	Waste management and remediation services (562000)
Solid hazardous waste from SIFCO ID 13P Polyester Jacket (sock)	100%	165	365	$729	Waste management and remediation services (562000)
Solid hazardous waste from Blue paper towels	100%	88	195	$390	Waste management and remediation services (562000)
Solid hazardous waste from Neoprene gloves	0%	1.	3	$5	Waste management and remediation services (562000)
Total		**260**	**574**	**$1,148**	

3.2.8 Solid Waste

The previous CBA did not consider solid waste. The solid waste estimates used in this study are provided in Table 73. The cost to dispose of solid waste was estimated to be $6.00/ton based on rates found online.

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Table 73. Solid Waste Estimate for Cd Brush Plating

$	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
SIFCO rectifier leads	1.9	4.2	$0.01	Waste management and remediation services (562000)
Total	1.9	4.2	$0.01	

3.2.9 Liquid Hazardous Waste

The CBA estimated that 8 oz of liquid hazardous waste were generated per part produced and no wastewater was generated. As part of an LCA it is necessary to perform a mass balance to ensure that all inputs to and outputs from the system are accounted for. A significant amount of liquid inputs were not accounted for in the outputs. Here, two bounding scenarios were developed. The first assumed that all remaining liquid was disposed of as liquid hazardous waste. The second assumed that it was disposed of as wastewater. Remaining liquid was calculated as liquid-based inputs (i.e., SIFCO, IPA, and tap water) minus outputs related to these inputs that are already accounted for (i.e., 8 oz/part liquid hazardous waste, liquid captured by absorbents materials or pads and disposed of as solid hazardous waste or solid waste, Cd deposited on the component, and air emissions). Liquid hazardous waste estimates for the first scenario is provided in Table 74and for the second scenario in Table 75. The cost to dispose of liquid hazardous waste was estimated to be $3.00/lbs based on rates found online.

Table 74. Liquid Hazardous Waste Estimate for Cd Brush Plating (Scenario 1)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
8 oz per part	273	602	$1,807	Waste management and remediation services (562000)
Liquid inputs not accounted for in mass balance	2,488	5,484	$10,969	Waste management and remediation services (562000)
Total	2,761	6,087	$12,775	

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Table 75. Liquid Hazardous Waste Estimate for Cd Brush Plating (Scenario 2)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
8 oz per part	273	602	$1,807	Waste management and remediation services (562000).
Liquid inputs not accounted for in mass balance	0	0	0	Waste management and remediation services (562000).
Total	**273**	**602**	**$1,807**	

3.2.10 Wastewater

As discussed above, no wastewater was identified in the CBA. The scenarios described above were used to estimate the amount of wastewater generated. The estimate for the first scenario (i.e., all remaining liquids disposed of as liquid hazardous waste) is provided in Table 76. The estimate for the second scenario (i.e., all remaining liquids disposed of as wastewater) is provided in Table 77. The average rate charged for wastewater from a 2012/2013 Black & Veatch report title: "50 Largest Cities Water/Wastewater Rate Survey" was used (i.e., $52,521 for treating 10,000,000 gallons of water).

Table 76. Wastewater Estimate for Cd Brush Plating (Scenario 1)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Amount Generated per Year (gal)	Annual Cost (USD2014)	NAICS
Liquid inputs not accounted for in mass balance	0	0	0	0	Water, sewage and other systems (221300)
Total	**0**	**0**	**0**	**0**	

Table 77. Wastewater Estimate for Cd Brush Plating (Scenario 2)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Amount Generated per Year (gal)	Annual Cost (USD2014)	NAICS
Liquid inputs not accounted for in mass balance	2,488	5484	657	$3	Water, sewage and other systems (221300)
Total	2,488	5484	657	$3	

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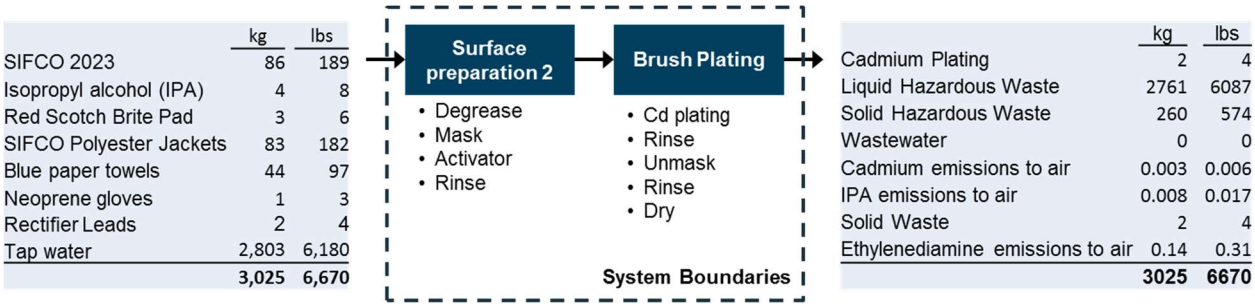
3.2.11 Mass Balance

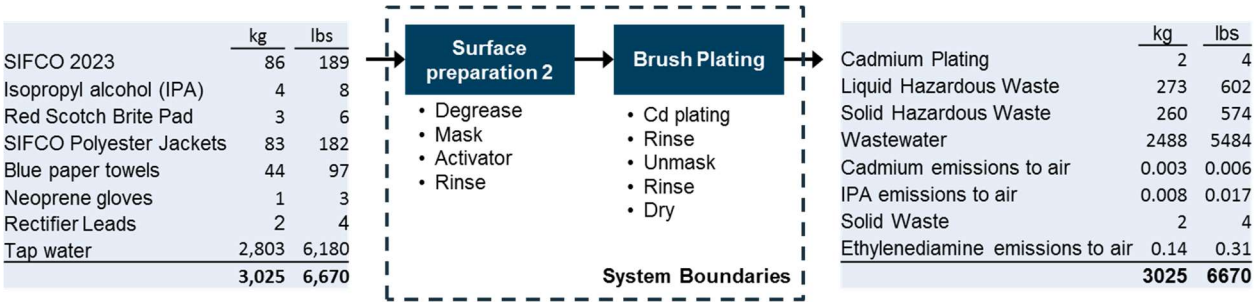
Here a mass balance approach was used to account for all mass entering and leaving the system. Assuming the conservation of mass and energy and that the system is in steady state, mass flows can be identified that might have been unknown or difficult to measure by other means. For example, a higher amount of mass into the system than mass out of the system suggests that assumptions used waste generation or environmental releases might be off. By performing a mass balance, the Sustainability Analysis more accurately accounts for spills, waste, air emissions, and other environmental releases, as well as the associated environmental impacts and external costs. Figure 117 provides the mass balance for the first scenario and Figure 118 provides the mass balance for the second scenario. The first scenario uses the higher electricity consumption estimates from the previous CBA and assumes that all liquid inputs not originally accounted for in the outputs are disposed of as liquid hazardous waste. The second scenario uses the lower electricity



	kg	lbs
SIFCO 2023	86	189
Isopropyl alcohol (IPA)	4	8
Red Scotch Brite Pad	3	6
SIFCO Polyester Jackets	83	182
Blue paper towels	44	97
Neoprene gloves	1	3
Rectifier Leads	2	4
Tap water	2,803	6,180
	3,025	**6,670**

	kg	lbs
Cadmium Plating	2	4
Liquid Hazardous Waste	2761	6087
Solid Hazardous Waste	260	574
Wastewater	0	0
Cadmium emissions to air	0.003	0.006
IPA emissions to air	0.008	0.017
Solid Waste	2	4
Ethylenediamine emissions to air	0.14	0.31
	3025	**6670**

Figure 117. Mass Balance for Cadmium Brush Plating (Scenario 1)



	kg	lbs
SIFCO 2023	86	189
Isopropyl alcohol (IPA)	4	8
Red Scotch Brite Pad	3	6
SIFCO Polyester Jackets	83	182
Blue paper towels	44	97
Neoprene gloves	1	3
Rectifier Leads	2	4
Tap water	2,803	6,180
	3,025	**6,670**

	kg	lbs
Cadmium Plating	2	4
Liquid Hazardous Waste	273	602
Solid Hazardous Waste	260	574
Wastewater	2488	5484
Cadmium emissions to air	0.003	0.006
IPA emissions to air	0.008	0.017
Solid Waste	2	4
Ethylenediamine emissions to air	0.14	0.31
	3025	**6670**

Figure 118. Mass Balance for Cadmium Brush Plating (Scenario 2)

3.3 Alternative 2 – Dalistick Zn-Ni Plating

All inputs and outputs for Dalistick Zn-Ni plating were estimated based on data provided by the University of Dayton Research Institute (UDRI) and from the CBA. Two scenarios were developed to address important uncertainties:

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- **Scenario 1:**.Used UDRI's estimated usage rates for Activator XF solution, Zinidal Aero solution, and bonnets.

- **Scenario 2**: Used the usage rates form the previous CBA for for Activator XF solution, Zinidal Aero solution, and bonnets.

3.3.1 Initial Investments

Initial investment data was obtained from a quote provided by Dalic and used in the previous CBA. In those calculations, the equipment and consumables included in the quote were included as initial capital investments. Here, there were separated out, with one-time equipment and component costs separated from consumables used over time to plate the parts. Table 78 provides initial procurement costs estimates and Table 79 provides initial labor costs estimates required to establish Dalistick Zn-Ni plating capabilities at WR-ALC.

Table 78. Initial Procurement Cost Estimates for Dalistick Zn-Ni Plating

Description	Quantity	Unit Cost	Total Cost	NAICS
Dalistick® Workstation D-2020	1	$111,100.00	$111,100	Metal cutting and forming machine tool manufacturing (33351A)
T Regulation Tank UCDK XF	1	$5,351.50	$5,352	Other electronic component manufacturing (33441A)
Dalipump DKPL XF + Dalistick® Tool	1	$9,658.00	$9,658	Pump and pumping equipment manufacturing (33391A)
Plating Tool Ax (Pkt of 4)	1	$189.53	$190	Cutlery and handtool manufacturing (332200)
Variable Autotransformer (Power converter)	1	$364.55	$365	Power, distribution, and specialty transformer manufacturing (335311)
Packing & CIF US Intl Airport	1	$1,331.00	$1,331	Scenic and sightseeing transportation and support activities for transportation (48A000)
Anode T4 (Pkt of 20)	1	$153.12	$153	Carbon and graphite product manufacturing (335991)
Anode X13 (Pkt of 10)	1	$126.50	$127	Carbon and graphite product manufacturing (335991)
Training 5 days	1	$8,305.00	$8,305	
Total			**$136,579**	

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Table 79. Initial Labor Estimate for Dalistick Zn-Ni Plating

Description	Labor (hours)	Annual Labor Cost ($)
Labor for Initial Dalistick Training	200	$29,732
Total		**$29,732**

3.3.2 Labor

UDRI provided the time study data included in Table 80. Average time estimates were provided for four operations for three parts, with surface area of 3 in^2, 8 in^2, and 19.25 in^2. Table 81 shows the number of minutes required per unit surface area. Surface area was the only independent variable provided for each part. The labor hours required per unit surface area decrease as the amount of surface area increases for these three part sizes. The small number of data points and independent variables limits the extent to which regression analysis can be used to accurately estimate the time required for parts of different shapes and sizes. To develop an estimate for this study, a linear regression was fit to each set of data points. The resulting equations, provided in Figure 119, are used here to estimate the amount of labor time required per unit surface area for each of the four labor steps. Additional data would enable consideration of additional regression models. As a reference, the previous CBA used an estimate of 0.75 hours production time per 5000 mm^2 (or 5.81 min/in^2) for Dalistick Zn-Ni plating. This value is higher than the total average production time provided by UDRI (provided in the last column of Table 81.

Table 80. Time Study Data Provided for Dalistick Zn-Ni Plating

Panel Plating Area (in^2)	Set up Time (min/part)	Average Masking Time (min/part)	Average Activator Step Time (min/part)	Average Zinidal Plating Time (min/part)	Total Average Production Time (min/part)
3.00	4.60	3.30	3.00	2.63	13.53
8.00	3.80	5.33	7.72	7.47	24.32
19.25	7.58	6.48	15.07	15.87	45.00

Table 81. Time Required per Unit Surface Area for Dalistick Zn-Ni Plating

Panel Plating Area (in^2)	Average Set up Time (min/in^2)	Average Masking Time (min/in^2)	Average Activator Step Time (min/in^2)	Average Zinidal Plating Time (min/in^2)	Total Average Production Time (min/in^2)
3.00	1.53	1.10	1.00	0.88	4.51
8.00	0.48	0.67	0.96	0.93	3.04
19.25	0.39	0.34	0.78	0.82	2.34

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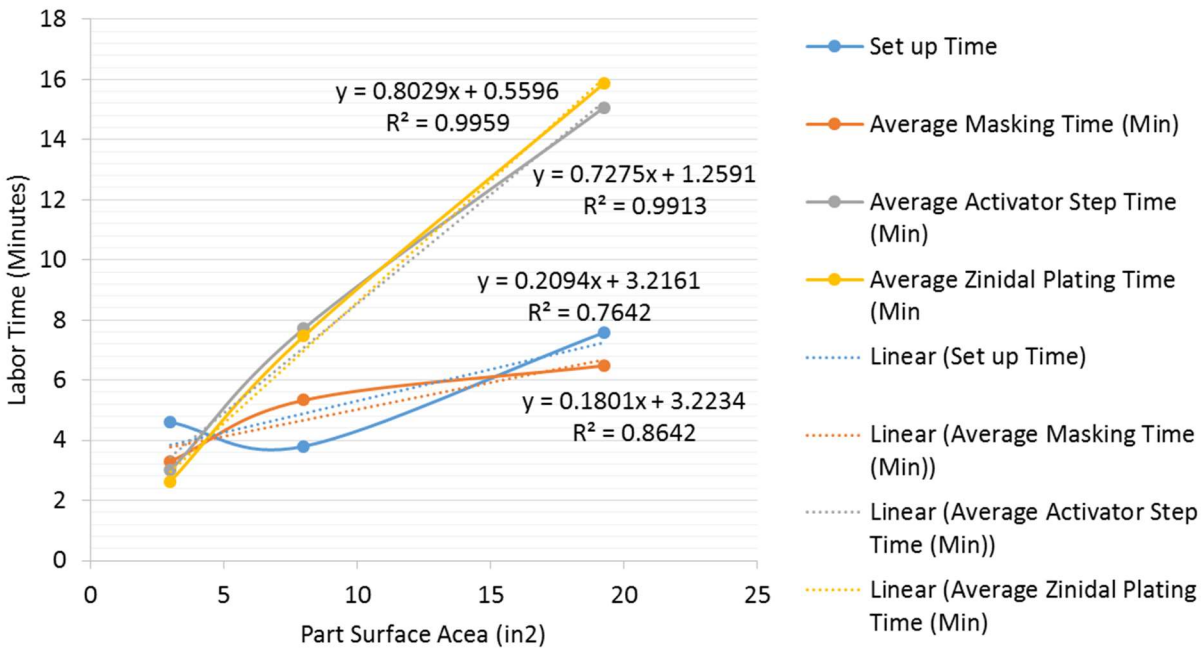

Figure 119. Linear Regression between Part Surface Area and Labor Time for Dalistick Zn-Ni Plating

The CBA did not appear to include transportation labor for parts repaired in the field. Here, it is assumed that Dalistick Zn-Ni plating would require the same amount of transportation time for in-the-field repairs as Cd brush plating.

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Table 82. Annual Labor Estimate for Dalistick Zn-Ni Plating (Scenarios 1 and 2)

Description	Labor	Units	Annual Labor (hours)	Annual Labor Cost (USD2014)
Transportation - small parts	1.0	hours/part plated in the field	0	$-
Transportation - large parts	1.0	hours/part plated in the field	770	$114,474
Labor for Set up - small parts	6.5	mins/part	16	$2,305
Labor for Set up - large parts	9.7	mins/part	134	$19,915
Labor for Masking - small parts	6.0	mins/part	14	$2,146
Labor for Masking - large parts	8.8	mins/part	122	$18,067
Labor for Activator Step - small parts	12.5	mins/part	30	$4,472
Labor for Activator Step - large parts	23.8	mins/part	329	$48,850
Labor for Zinidal Plating - small parts	13.0	mins/part	31	$4,640
Labor for Zinidal Plating - large parts	25.4	mins/part	351	$52,210
Labor for Weekly Equipment Cleaning	30.0	mins/week	25	$3,717
Labor for tri-annual Dalistick Zinidal Zn-Ni process training	22.5	hours/year	23	$3,345
Labor for annual respirator training	7.5	hours/year	8	$1,115
Labor for weekly PPE training	125.0	hours/year	125	$18,583
Total			**1,977**	**$293,838**

3.3.3 Materials

Material input information was obtained primarily form UDRI, and supplemented as needed with information from the CBA. UDRI's usage rates for the Activator XF solution, Zinidal Aero solution, and bonnets were significantly higher than those used in the CBA. Both the UDRI and CBA usage rates are based on the amount of surface area plated. To account for this uncertainty in material usage, two scenarios were evaluated. Table 83 provides material inputs for Scenario 1, which is based on UDRI's usage rates for the Activator XF solution, Zinidal Aero solution, and bonnets. Table 84 provides material inputs for Scenario 2, which is based on Activator XF solution, Zinidal Aero solution, and bonnet usage rates used in the CBA.

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Table 83. Annual Material Estimates for Dalistick Zn-Ni Plating (Scenario 1)

Description	Usage	Cost	Total Cost	NAICS
Nitrile Gloves	2 gloves / part	$0.25 / glove	$486	Surgical appliance and supplies manufacturing (339113)
Dalic Activator Bonnet (Scotch Brite pad) - small parts	0.0002 bonnet / mAh	$2.05 / bonnet	$62	Other general purpose machinery manufacturing (33399A)
Dalic Activator Bonnet (scotch brite pad) - large parts	0.0002 bonnet / mAh	$2.05 / bonnet	$674	Other general purpose machinery manufacturing (33399A)
Activator XF solution - small parts	0.059 L / Ah	$33.00 / L	$303	Other basic organic chemical manufacturing (325190)
Activator XF solution - large parts	0.059 L / Ah	$33.00 / L	$3,409	Other basic organic chemical manufacturing (325190)
Dalic Zinidal Bonnet - small parts	0.0002 bonnet / mAh	$2.05 / bonnet	$64	Other general purpose machinery manufacturing (33399A)
Dalic Zinidal Bonnet - large parts	0.0002 bonnet / mAh	$2.05 / bonnet	$720	Other general purpose machinery manufacturing (33399A)
Zinidal Aero solution – small parts	0.1 L / Ah	$146.00 / L	$1,423	Fertilizer manufacturing (325310)
Zinidal Aero solution – large parts	0.1 L / Ah	$146.00 / L	$16,368	Fertilizer manufacturing (325310)
Solvent wipe	4 wipes / part	$0.05 / wipe	$194	All other chemical product and preparation manufacturing (3259A0)
Lead AX	0.167 leads / week	$21.89 / lead	$182	Wiring device manufacturing (335930)
Lead NG	0.167 leads / week	$29.04 / lead	$242	Wiring device manufacturing (335930)
Tank Cleaner, Code 10131	0.1 L / week	$29.50 / L	$148	Other basic inorganic chemical manufacturing (325180)
Exacanal Pipe	16.7 cm/day	$0.02 / cm	$87	Other rubber product manufacturing (326290)
Total			**$24,362**	

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Table 84. Annual Material Estimates for Dalistick Zn-Ni Plating (Scenario 2)

Description	Usage	Cost	Total Cost	NAICS
Nitrile Gloves	2 gloves / part	$0.25 / glove	$486	Surgical appliance and supplies manufacturing (339113)
Dalic Activator Bonnet (Scotch Brite pad)	1 bonnet / day	$2.05 / bonnet	$513	Other general purpose machinery manufacturing (33399A)
Activator XF solution - small parts	0.0006 mL / mm^2	$33.00 / L	$29	Other basic organic chemical manufacturing (325190)
Activator XF solution - large parts	0.0006 mL / mm^2	$33.00 / L	$328	Other basic organic chemical manufacturing (325190)
Dalic Zinidal Bonnet	2 bonnets / day	$2.05 / bonnet	$1,025	Other general purpose machinery manufacturing (33399A)
Zinidal Aero solution	0.0006 mL / mm^2	$146.00 / L	$126	Fertilizer manufacturing (325310)
Zinidal Aero solution	0.0006 mL / mm^2	$146.00 / L	$1,451	Fertilizer manufacturing (325310)
Solvent wipe	4 wipes / part	$0.05 / wipe	$194	All other chemical product and preparation manufacturing (3259A0)
Lead AX	0.167 leads / week	$21.89 / lead	$182	Wiring device manufacturing (335930)
Lead NG	0.167 leads / week	$29.04 / lead	$242	Wiring device manufacturing (335930)
Tank Cleaner, Code 10131	0.1 L / week	$29.50 / L	$148	Other basic inorganic chemical manufacturing (325180)
Exacanal Pipe	16.7 cm/day	$0.02 / cm	$87	Other rubber product manufacturing (326290)
Total			**$4,810**	

3.3.4 Deionized Water

According to UDRI, deionized (DI) water is used during multiple steps to rinse the repair area with a squeeze bottle. In the largest area evaluated (19.25 in^2), an ounce or two of DI water was used. Assuming an ounce or two of DI water was used in the largest area, a usage rate of 1.5 oz/in^2 was calculated.

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Table 85. Annual Deionized Water Estimates for Dalistick Zn-Ni Plating

Description	Annual DI Water (gal)	Annual DI Water (kg)	Annual DI Water (lbs)
DI water (activator rinse) - small parts	1	5	11
DI water (activator rinse) - large parts	16	59	130
DI water (Zinidal aero rinse) - small parts	1	5	11
DI water (Zinidal aero rinse) - large parts	16	59	130
DI water (masking residuals rinse) - small parts	1	5	11
DI water (masking residuals rinse) - large parts	16	59	130
Total	51	193	425

It was assumed that the DI water is produced onsite. The inputs and outputs associated with producing DI water were obtained from the ecoinvent life cycle inventory database. Data was obtained from a process that includes a strong cation exchanger a degasser and a strong anion exchanger, is operated with counterflow regeneration, and does not include lime decarbonation pre-treatment.

Table 86. Estimated Inputs for DI Water Used in Dalistick Zn-Ni Plating

Description	Usage per kg DI water	Amount per year	Cost	Annual Cost (USD2014)	NAICS / DIO Activity
Electricity	0.00045 kWh	0.01 kWh	$0.071 / kWh	$0.01	Electricity use, average generation mix - Georgia, U.S.
Hydrochloric acid, 30% in H2O	0.00024 kg	0.1 lbs	$157.25 / lb	$16	Other basic inorganic chemical manufacturing (325180)
Sodium hydroxide, 50% in H2O	0.00012 kg	0.05 lbs	$ 33 / lb	$15	Other basic inorganic chemical manufacturing (325180)
Tap water	1.11 kg	57 gal	$0.003 / gal	$0.15	Water, sewage and other systems (221300)

Table 87. Estimated Outputs for DI Water Used in Dalistick Zn-Ni Plating

Description	Generated per kg DI water	Amount per year	NAICS
Sodium, ion to water	7.00E-05 kg	0.014 kg	N/A
Carbon dioxide, biogenic to air	0.00023 kg	0.044 kg	N/A
Heat, waste to air	0.00162 MJ	0.312 MJ	N/A
Chloride to air	2.30E-04 kg	0.044 kg	N/A
Wastewater	0.11 kg	21 kg	Water, sewage and other systems (221300)

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3.3.5 Electricity

Electricity for applying the activator was estimated based on the equipment setting provided by UDRI and the activator processing time as derived from UDRI's time study. The electricity for electroplating was estimated using Faraday's Law of Electrolysis. The electricity for compressed air was estimated using the same approach described above for Cd brush plating.

Table 88. Electricity Requirements Assumed for Dalistick Zn-Ni Plating

Description	Annual Electricity Requirement (kWh)	Annual Electricity Cost (USD2014)	DOI Activity
Electricity for drying with compressed air	140	$10	Electricity use, average generation mix - Georgia, U.S.
Electricity for activation	29	$2	Electricity use, average generation mix - Georgia, U.S.
Electricity for electroplating	19	$1	Electricity use, average generation mix - Georgia, U.S.
Total	189	$13	

3.3.6 Air Emissions

One of the primary benefits of Dalistick plating is that it employs a non-drip stylus, which continuously recirculates electrolyte from the holding tank through the head. Dalic claims that this eliminates drips, splashes, and fumes. However, no test data confirming this claim was found. For this analysis, two scenarios were developed. Scenario 1 includes emissions estimates for Activater XB and Zinidal Aero. Scenario 2 does not.

An MSDS was not provided for Activater XB. MSDSs for several Dalic activators were located. These activators contained hydrochoric acid and water, except one, which contained sulphuric acid and water. Here it is assumed that the activator is 15 %wt HCl. As a proxy, the AP-42 for hydrochoric acid production facilities was used. The smallest emission factor, for a plant with a caustic scrubber, was 0.004 kg per Mg produced. An emission factor of 0.004kg/Mg was assumed for hydrochloric acid.

The MSDS for specified that it contains 1-5% nickel dichloride and <10% ammonium hydroxide solution. The source of zinc was not specified, but it may be zinc chloride. EPA's AP-42 provides a candidate emission factor for Nickel Electropalting (bath) with an unspecified wet scrubber. Rather than use the candidate emission factor, the lowest recorded emission factor was used (4.5 mg/A-hr). While the AP-42 provides information on zinc-nickel plating, it does not provide emission factors for zinc. The emission factor was applied to Zn and Ni on a wt% basis (i.e., that 85% of the emissions are Zn and 15% are Ni). While there could potentially be additional emissions from the electroplating step, they were assumed to be negligible for both scenarios.

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The CBA assumed that acetone and paper towels would be used for degreasing. UDRI, however, assumed that solvent wipes were used. Here, it is assumed that acetone-based wipes are used, and 1/2 of the weight of the wipes are acetone. A gas/liquid partition coefficient of 0.0015 (mg/l gas)/(mg/l liquid) was assumed.

Per the MSDS, the tank cleaner is < 20% Sulphamidic acid. The same emission factor used for to estimate hydrochloric acid emissions from the activator was used (i.e, 0.004kg/Mg used).

Table 89 provides estimated air emissions for Scenario 1 and Table 90 provides estimated air emissions for Scenario 2.

Table 89. Estimated Air Emissions for Dalistick Zn-Ni Plating (Scenario 1)

Description	Annual Emissions (kg)	Annual Emissions (lbs)
Acetone	2.4E-05	5.4E-05
Hydrochorlic acid (from activator)	6.8E-05	1.5E-04
Zinc (from Zinidal Aero solution)	2.7E-03	5.9E-03
Nickel (from Zinidal Aero solution)	4.8E-04	1.0E-03
Sulfamic acid (Tank Cleaner, Code 10131)	1.0E-05	2.3E-05

Table 90. Estimated Air Emissions for Dalistick Zn-Ni Plating (Scenario 2)

Description	Annual Emissions (kg)	Annual Emissions (lbs)
Acetone	2.4E-05	5.4E-05
Sulfamic acid (Tank Cleaner, Code 10131)	1.0E-05	2.3E-05

3.3.7 Solid Hazardous Waste

It was assumed that the nitrile gloves and Dalic Zinidal bonnets would be disposed of as solid hazardous waste, with the Zinidal bonnets absorbing 100% of their weight, which would then be disposed of as solid hazardous waste as well. The amount of solid hazardous waste is different for the two scenarios. Table 91 provides the solid hazardous waste estimates for Scenario 1 (which uses UDRI's bonnet usage rates) and Table 92 provides the solid hazardous waste estimates for Scenario 2 (which uses bonnet usage rates from the previous CBA). The cost to dispose of solid hazardous waste was estimated to be $2.00/lb based on rates found online.

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Table 91. Solid Hazardous Waste Estimate for Dalistick Zn-Ni Plating (Scenario 1)

Description	Relative Weight of Liquid Absorbed	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
Nitrile Gloves	0%	6	13	$26	Waste management and remediation services (562000)
Dalic Zinidal Bonnets	100%	4	8	$16	Waste management and remediation services (562000)
Total		10	21	$43	

Table 92. Solid Hazardous Waste Estimate for Dalistick Zn-Ni Plating (Scenario 2)

Description	Relative Weight of Liquid Absorbed	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
Nitrile Gloves	0%	6	13	$26	Waste management and remediation services (562000)
Dalic Zinidal Bonnets	100%	5	11	$22	Waste management and remediation services (562000)
Total		11	24	$48	

3.3.8 Solid Waste

Per UDRI, the activator is a mild acid and the Scotch Brite pads that absorb activator could likely be disposed of as solid waste. Here it is assumed that the solvent wipes are also disposed of as solid waste. However, UDRI indicated that they could potentially be recycled depending on the solvent used. The amount of solid hazardous waste is different for the two scenarios. Table 93 provides the solid hazardous waste estimates for Scenario 1 (which uses UDRI's bonnet usage rates) and Table 94 provides the solid hazardous waste estimates for Scenario 2 (which uses bonnet usage rates from the CBA). The cost to dispose of solid waste was estimated to be $6.00/ton based on rates found online.

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Table 93. Solid Waste Estimate for Dalistick Zn-Ni Plating (Scenario 1)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
Dalic Activator Bonnet (scotch brite pads)	4	8	$0.02	Waste management and remediation services (562000)
Solvent wipes	32	72	$0.22	Waste management and remediation services (562000)
Lead AX & NG	2	4	$0.01	Waste management and remediation services (562000)
Exacanal Pipe	3	6	$0.02	Waste management and remediation services (562000)
Total	**41**	**90**	**$0.27**	

Table 94. Solid Waste Estimate for Dalistick Zn-Ni Plating (Scenario 2)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
Dalic Activator Bonnet (scotch brite pads)	2	5	$0.02	Waste management and remediation services (562000)
Solvent wipes	32	72	$0.22	Waste management and remediation services (562000)
Lead AX & NG	2	4	$0.01	Waste management and remediation services (562000)
Exacanal Pipe	3	6	$0.02	Waste management and remediation services (562000)
Total	**40**	**88**	**$0.26**	

3.3.9 Liquid Hazardous Waste

The liquid hazardous waste estimates for Dalistick Zn-Ni plating are provided in Table 95 for Scenario 1 (UDRI's usage rates for Zinidal Aero) and Table 96 for Scenario 2 (usage rates from previous CBA for Zinidal Aero). In each of the scenarios, the liquid waste estimate for remaining Zinidal solution was calculated as amount of Zinidal used minus the amount of Zn and Ni deposited on components and released to air. The cost to dispose of liquid hazardous waste was estimated to be $3.00/lbs based on rates found online.

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Table 95. Liquid Hazardous Waste Estimate for Dalistick Zn-Ni Plating (Scenario 1)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
DI water used for plating	64	142	$425	Waste management and remediation services (562000)
Remaining Zinidal solution	149	328	$984	Waste management and remediation services (562000)
Tank Cleaner, Code 10131	5	11	$34	Waste management and remediation services (562000)
Total	**218**	**481**	**$1,443**	

Table 96. Liquid Hazardous Waste Estimate for Dalistick Zn-Ni Plating (Scenario 2)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Annual Cost (USD2014)	NAICS
DI water used for plating	64	142	$425	Waste management and remediation services (562000)
Remaining Zinidal solution	9	21	$62	Waste management and remediation services (562000)
Tank Cleaner, Code 10131	5	11	$34	Waste management and remediation services (562000)
Total	**79**	**174**	**$521**	

3.3.10 Wastewater

The wastewater estimates for Dalistick Zn-Ni plating are provided in Table 97 for Scenario 1 (UDRI's usage rates for the activator) and Table 98 for Scenario 2 (activator usage rates from previous CBA). The remaining activator solution was calculated as the amount of activator used minus activator absorbed in the activator bonnet and hydrochloric acid form the activator released to air. The average rate charged for wastewater from a 2012/2013 Black & Veatch report title: "50 Largest Cities Water/Wastewater Rate Survey" was used (i.e., $52,521 for treating 10,000,000 gallons of water).

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Table 97. Wastewater Estimate for Dalistick Zn-Ni Plating (Scenario 1)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Amount Generated per Year (gal)	Annual Cost (USD2014)	NAICS
DI Water used for activator rinse	64	142	17	$0.09	Water, sewage and other systems (221300)
Remaining Activator XF solution	112	248	30	$0.16	Water, sewage and other systems (221300)
Unaccounted outputs from DI water	21.2	47	6	$0.03	Water, sewage and other systems (221300)
DI water for masking residuals rinse	64.3	142	17	$0.09	Water, sewage and other systems (221300)
Total	**262**	**578**	**69**	**$0.36**	

Table 98. Wastewater Estimate for Dalistick Zn-Ni Plating (Scenario 2)

Description	Amount Generated per Year (kg)	Amount Generated per Year (lbs)	Amount Generated per Year (gal)	Annual Cost (USD2014)	NAICS
DI Water used for activator rinse	64	142	17	$0.09	Water, sewage and other systems (221300)
Remaining Activator XF solution	10	21	3	$0.01	Water, sewage and other systems (221300)
Unaccounted outputs from DI water	21.2	47	6	$0.03	Water, sewage and other systems (221300)
DI water for masking residuals rinse	64.3	142	17	$0.09	Water, sewage and other systems (221300)
Total	**160**	**352**	**42**	**$0.22**	

3.3.11 Mass Balance

Figure 117 provides the mass balance for the Scenario 1 and Figure 118 provides the mass balance for Scenario 2. Scenario 1 uses UDRI's higher activator, zinidal, and bonnet usage rates. Scenario 2 uses the lower activator, Zinidal, and bonnet usage rates from the previous CBA.

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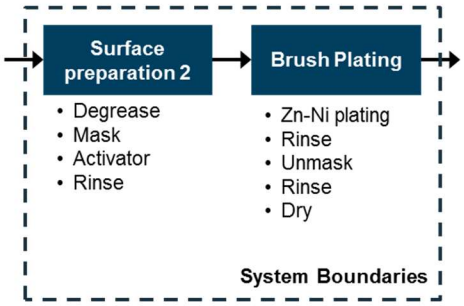
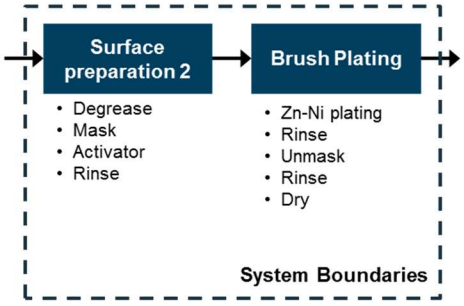
	kg	lbs
Nitrile Gloves	6	13
Dalic Activator Bonnet	2	4
Activator XF solution	114	252
Dalic Zinidal Bonnet	2	4
Zinidal Aero solution	152	336
Solvent wipe	33	72
Lead AX & NG	2	4
Tank Cleaner, Code 10131	5	11
Exacanal Pipe	3	6
HCl, 30% in H2O	0.06	0.12
NaOH, 50% in H2O	0.04	0.08
Tap water	214	471
	532	**1,173**



	kg	lbs
Zinc Plating	1.5	3.2
Nickel Plating	0.3	0.6
Liquid Hazardous Waste	218	481
Solid Hazardous Waste	10	21
Solid Waste	41	90
Wastewater	262	578
Zinc emissions to air	0.0027	0.0059
Nickel emissions to air	0.0005	0.0010
HCl emissions to air	0.0001	0.0002
Sulfamic acid to air	0.00001	0.00002
Acetone emissions to air	0.00002	0.00005
Sodium, ion to water	0.01	0.03
Carbon dioxide, biogenic to air	0.04	0.10
Chloride to air	0.04	0.10
	533	**1,174**

Figure 120. Mass Balance for Dalistick Zn-Ni Brush Plating (Scenario 1)

	kg	lbs
Nitrile Gloves	6	13
Dalic Activator Bonnet	1	3
Activator XF solution	11	24
Dalic Zinidal Bonnet	2	5
Zinidal Aero solution	14	30
Solvent wipe	33	72
Lead AX & NG	2	4
Tank Cleaner, Code 10131	5	11
Exacanal Pipe	3	6
HCl, 30% in H2O	0.1	0.1
NaOH, 50% in H2O	0.04	0.08
Tap water	214	471
	290	**640**



	kg	lbs
Zinc Plating	1.5	3.2
Nickel Plating	0.3	0.6
Liquid Hazardous Waste	79	174
Solid Hazardous Waste	11	24
Solid Waste	40	88
Wastewater	160	352
Zinc emissions to air	0	0
Nickel emissions to air	0	0
HCl emissions to air	0	0
Sulfamic acid to air	0.00001	0.00002
Acetone emissions to air	0.00002	0.00005
Sodium, ion to water	0.01	0.03
Carbon dioxide, biogenic to air	0.04	0.10
Chloride to air	0.04	0.10
	291	**641**

Figure 121. Mass Balance for Dalistick Zn-Ni Brush Plating (Scenario 2)

4 Life Cycle Cost Estimate and Impact Assessment

4.1 Internal Costs

Figure 122 compares the internal cost of the scenarios described above for Cd brush plating and Dalistick Zn-Ni plating as well as from the CBA. The 15-year NPV estimates for Cd brush plating range from $4.1 to $4.3 million USD2014, and from $4.4 to $6.2 million USD2014 for Dalistick Zn-Ni plating. The 15-year NPV estimates from this Sustainability Analysis are higher than the estimate from the CBA for Cd brush plating, which is expected because the costs associated with waste management have been added to the internal cost calculation. These estimates are still comparable as most of the data for Cd brush plating came directly from the CBA. In contrast, the 15-year NPV estimates from this Sustainability Analysis are lower than the estimate from the CBA or Dalistick Zn-Ni plating primarily due to the lower annual labor cost

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estimates. While the NPV estimate for Dalistick Zn-Ni plating is higher than NPV estimate for Cd brush plating, the difference between the two is much smaller than in the CBA.

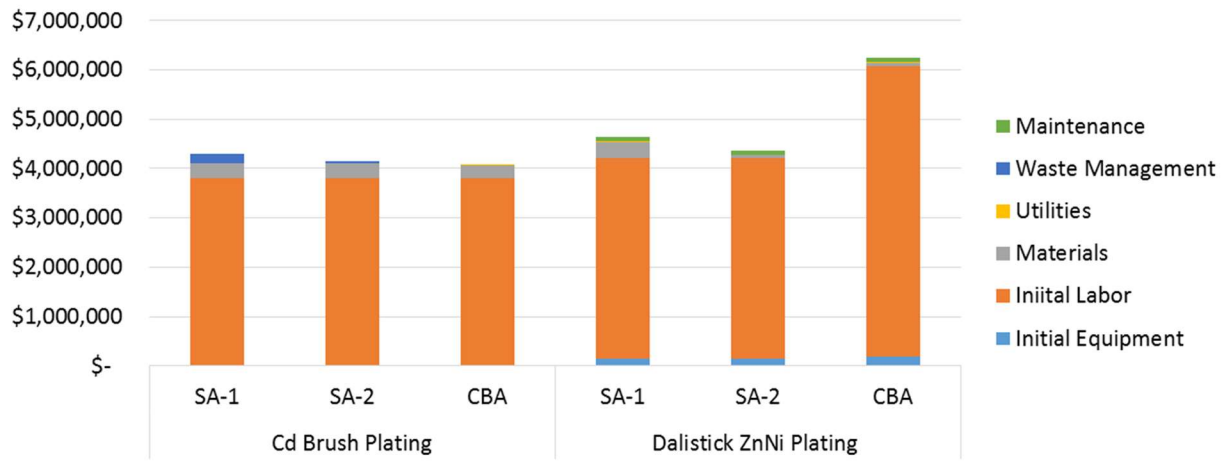

Figure 122. Net Present Value of Internal Costs by Cost Category

Figure 123 compares the labor costs estimates from this Sustainability Analysis to those from the CBA. The annual labor estimate is $276 thousand for Cd brush plating and ranges from $294 to $428 thousand for Dalistick Zn-Ni plating, with the labor estimate from the CBA 46% higher than the estimate from this Sustainability Analysis. For Cd brush plating, the transportation and processing time estimates were estimated by plating technicians; these values were used in both the CBA and this Sustainability Analysis. For Dalistick Zn-Ni plating, the CBA conducted a time trial with two different technicians from UDRI. However, very little detailed was available about the time trial. A total processing labor estimate was provided. (0.75 hours per 5000 mm^2). Therefore, it was not possible to determine which processing steps are included (e.g., it's not clear if transportation for in the field repairs is included), and it is not possible to determine what is driving the differences in labor estimates between the CBA and this Sustainability Analysis.

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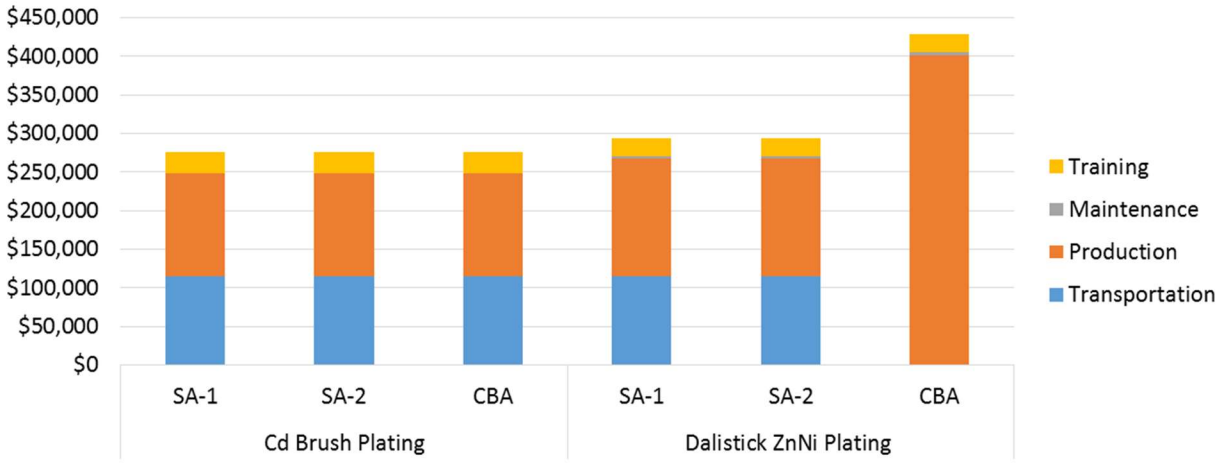

Figure 123. Annual Labor Costs

Figure 124 compares the material cost estimates from this Sustainability Analysis and the CBA. The material cost estimate for Cd brush plating in this Sustainability Analysis is slightly higher than that from the CBA as this Sustainability Analysis includes the cost of neoprene gloves. For Dalistick Zn-Ni plating, the material cost estimate for Scenario 1 is significantly higher than the estimate from the CBA. The primary driver is the difference in usage rate estimates provided by UDRI and the CBA for Activator XF solution, Zinidal Aero solution, and bonnet. The UDRI estimated usage rates are significantly higher than those in the CBA.

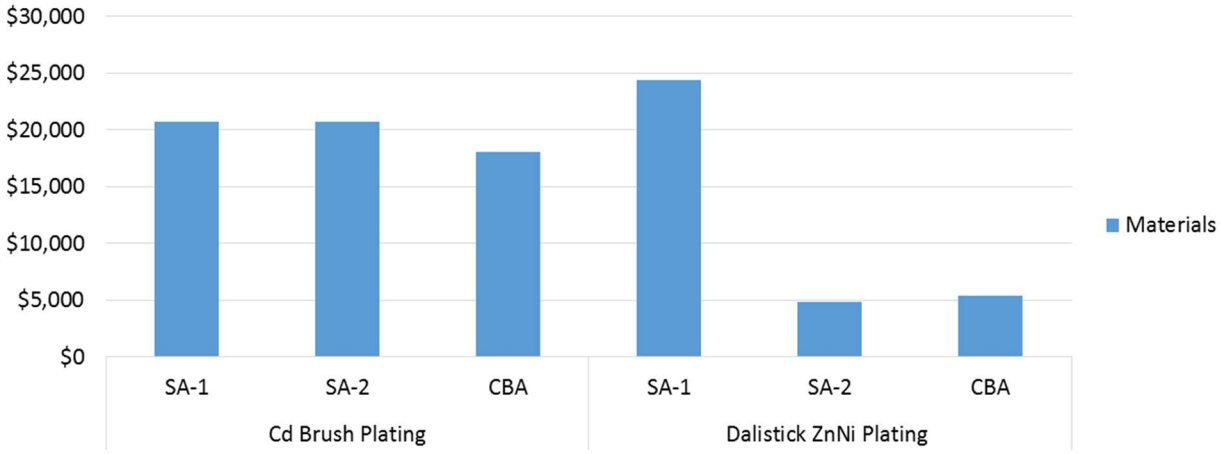

Figure 124. Annual Material Costs

Material efficiency rates were calculated based on the solution usage rates, chemical composition of the solutions, as obtained from the material safety data sheets (MSDSs), and calculated mass

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of coating. Material efficiency is measured as the amount of material in the product (e.g., Cd deposited on the components) divided by the amount of material used (i.e., Cd contained in the solution used). Table 99 shows Cd usage information, which is the same for both Cd brush plating scenarios and results in a material efficiency of 21%. It should be noted that a Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) special study titled "Advanced Coatings 5-year Strategy and Roadmap" (October 2015) estimated that 5.66 lbs of Cd species were used at WR-ALC for Cd brush plating from June 17, 2014 through June 16, 2015. It isn't clear if the SERDP-ESTCP study is based on the amount of Cd deposited on parts or the amount contained in the plating solution. If the former, actual throughput at WR-ALC might be about 20% higher than estimated in this analysis. If the latter, the throughput at WR-ALC or the solution usage rate might be lower than assumed here. Reconciling the differences between the SERDP-ESTCP and CBA estimates would provide for a more accurate analysis.

Table 99. Comparison of Annual Cd Species Usage for WR-ALC

Material	Sustainability Analysis Cd deposited on parts (lbs/year)	Sustainability Analysis Cd contained in SIFCO (lbs/year)
Cd	4.5	21.4
Efficiency		**21%**

Table 100 compares the amount of Zn and Ni required based on estimates used in this analysis to Zn and Ni that would be used assuming both the usage rates obtained from UDRI and the usage rates obtained from the CBA. The UDRI usage rates result in a 7% material efficiency whereas the usage rates from the CBA result in an 82% material efficiency. Considering that Dalistick plating is expected to experience relatively low material losses (due to the non-drip stylus and continuously recirculation of electrolyte), it is expected to be a more material efficient process than Cd brush plating. The solution usage rate provided by UDRI and used in Scenario 1 seems unrealistically high. It is probably safe to assume that the solution usage rate from the CBA and used in Scenario 2 is likely to be more accurate..

Table 100. Comparison of Zn and Ni Usage Estimates

Material	Mass Required for Reparing Components (lbs/year)	Mas Consumed Based on UDRI Zinidal Aero Usage Rate (lbs/year)	Mass Consumed Based on Zinidal Aero Usage Rate from Previous CBA (lbs/year)
Zn	3.2	43.5	3.9
NI	0.6	8.4	0.7
Total	**3.8**	**52.0**	**4.6**
Efficiency		**7%**	**82%**

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Figure 125 compares the waste management cost estimates from this Sustainability Analysis. The CBA estimated the amount of liquid and solid hazardous waste, but did not estimate the associated cost. For both Cd brush plating and Dalistick Zn-Ni plating, liquid inputs that were not accounted for in the outputs were assumed to have resulted in either liquid hazardous waste or wastewater. For Cd brush plating, there were two scenarios. In Scenario 1, all of the unaccounted inputs were assumed to result in liquid hazardous waste. In Scenario 2, they were all assumed to result in wastewater. For Dalistick Zn-Ni plating, all unaccounted for liquids were assumed to result in wastewater. The reason for the difference in waste management costs between the Dalistick Zn-Ni plating scenarios is that the material usage rates, and therefore the eventual waste generation rates, are significantly lower in Scenario 2. The costs associated with waste management are driven by hazardous waste (since the cost to dispose of a unit of hazardous waste are significantly higher than the costs to dispose of solid waste or wastewater). Figure 126 shows the amount of liquid and solid hazardous waste estimated for each scenario in this Sustainability Analysis as well as in the previous CBA. The use of mass balance to account for all inputs was the primary driver for the difference in estimates between the Sustainability Analysis and CBA.

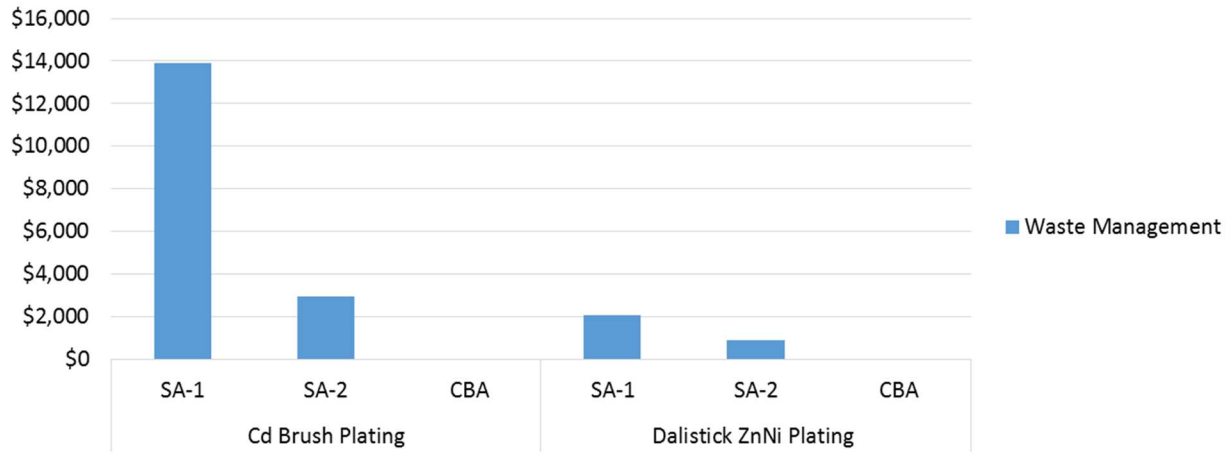

Figure 125. Comparison of Waste Management Cost Estimates

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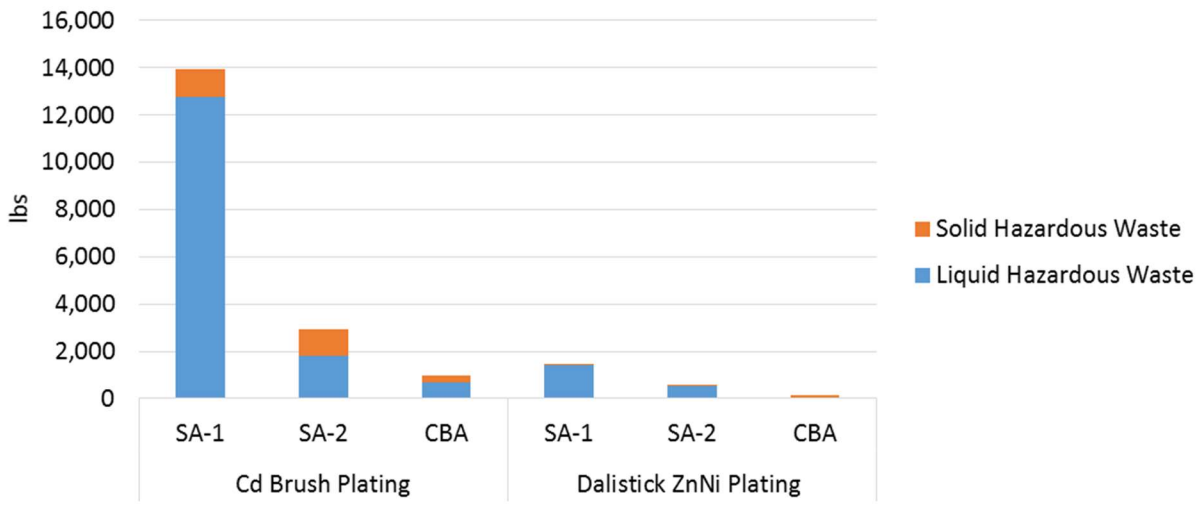

Figure 126. Comparison of Hazardous Waste Estimates

4.2 Impacts

Life cycle impact assessment was used to evaluate the potential human health and environmental impacts of resource use and environmental releases both at WR-ALC during the plating process as well as across the supply chain for purchased goods and services.

4.2.1 Midpoint Impacts

Midpoint impacts are indicators of potential impact at some point along the cause-effect chain. They provide an indicator of the relative potency, in terms of physical units, of each system's aggregated resource consumption and environmental releases. Table 101 provides the results obtained from using the Defense Input Output (DIO) dataset to estimate the upstream (supply chain) impacts from procured goods and services as well as the downstream (onsite) impacts form natural resource usage and environmental releases. These values represent a negative impact, so higher numbers represent worse performance.

Table 101. Results of the Midpoint Impact Assessment

	Units	Cd Brush Plating SA-1	Cd Brush Plating SA-2	Dalistick Zn-Ni Plating SA-1	Dalistick Zn-Ni Plating SA-2
Climate change	kg CO2-eq	802,141	385,924	1,112,670	177,014
Respiratory inorganics	kg PM2-5-eq	131	87	262	46
Respiratory organics	kg NMVOC-eq	1,929	1,391	2,587	484
Carcinogens, unspecified	CTUh	8.2E-04	5.9E-04	3.6E-03	5.4E-04
Carcinogens, indoor	CTUh	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Carcinogens, pesticide	CTUh	3.2E-07	2.8E-07	4.5E-07	1.17E-07

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Non-carcinogens, unspecified	CTUh	1.9E-02	1.3E-02	1.8E-02	6.3E-03
Non-carcinogens, indoor	CTUh	0.0E+00	0.0E+00	2.0E-11	2.0E-11
Non-carcinogens, pesticide	CTUh	2.0E-06	1.7E-06	2.8E-06	6.4E-07
Water deprivation	m3 deprived	1,154	1,026	1,790	386
Fossil energy use	kg oil-eq	38,854	33,407	62,993	9,991
Land use	m2-yr arable-eq	74,440	64,692	73,816	20,580
Mineral use	kg iron-eq	21,545	17,952	30,915	14,388
Aquatic ecotoxicity	CTUe	62	54	65	18

Figure 127 compares the relative midpoint impacts across the four scenarios evaluated here. For each midpoint category, the worst performing alternative is assigned a value of 1. All other alternatives are assigned a score equal to the ratio of its potential impact to the that of the worst performing alternative. For all but two impact categories, the Dalistck Zn-Ni plating Scenario 1 is the worst performer. However, it was clearly shown above that the material usage rates for this Scenario are too high. For all but one impact category, the Dalistick Zn-Ni plating Scenario 2 is the best performer.

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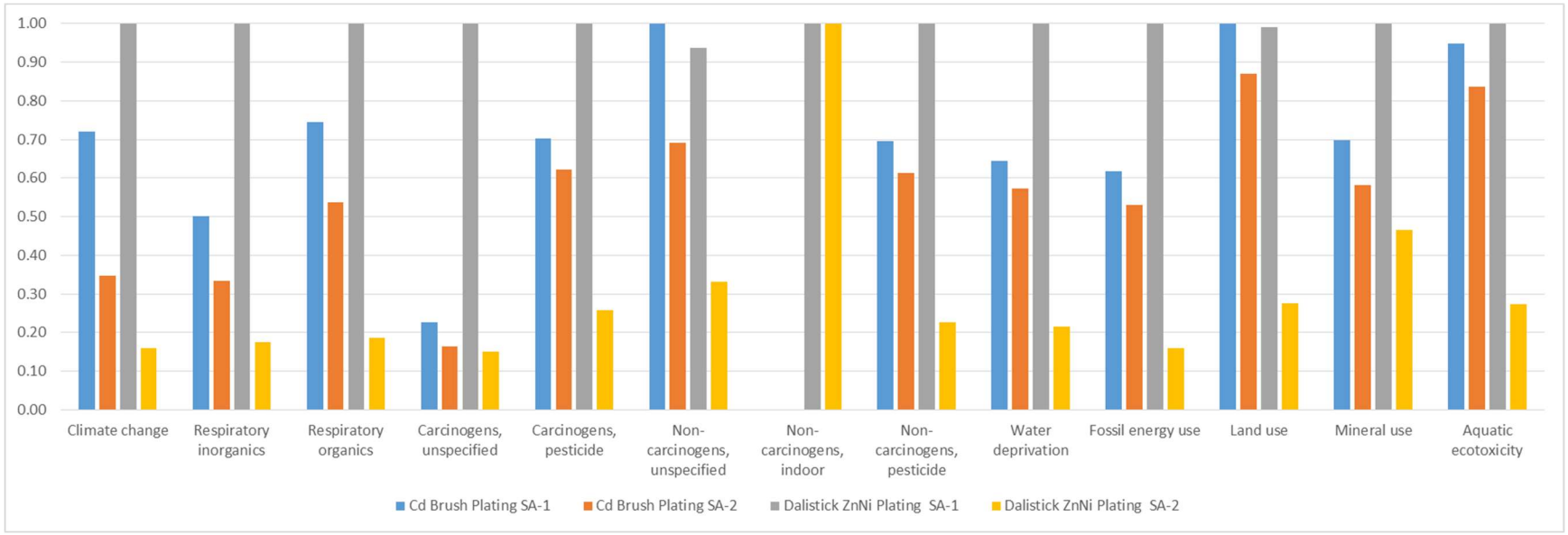

Figure 127. Relative Midpoint Impact Results

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4.2.2 Endpoint Impacts

Endpoint impacts represent the potential damage caused to resource availability, climate change, human health, and ecosystem quality. Because endpoint impacts are expressed in units of damage, the results for the subcategories can be aggregated. This makes it easier to understand the relative importance of different impacts and makes comparisons between alternatives possible. Table 102 provides the results obtained from using the Defense Input Output (DIO) dataset to estimate the upstream (supply chain) impacts from procured goods and services as well as the downstream (onsite) impacts form natural resource usage and environmental releases. These values represent a negative impact, so higher numbers represent worse performance. Figure 128 compares the relative endpoint impacts across the four scenarios evaluated here. For all endpoint categories, the Dalistck Zn-Ni plating Scenario 1 is the worst performer. However, it was clearly shown above that the material usage rates for this Scenario are too high. For all endpoint categories, the Dalistick Zn-Ni plating Scenario 2 is the best performer.

Table 102. Results of the Endpoint Impact Assessment

	Units	Cd Brush Plating SA-1	Cd Brush Plating SA-2	Dalistick Zn-Ni Plating SA-1	Dalistick Zn-Ni Plating SA-2
Resource Availability	MJ extra	1,631,679	1,402,962	2,644,785	420,322
Climate Change	kg CO2-eq	802,141	385,924	1,112,670	177,014
Human Health	DALY	2.E-01	1.E-01	3.E-01	6.E-02
Ecosystem Quality	PDF*m2*yr	44,759	38,899	44,407	12,376

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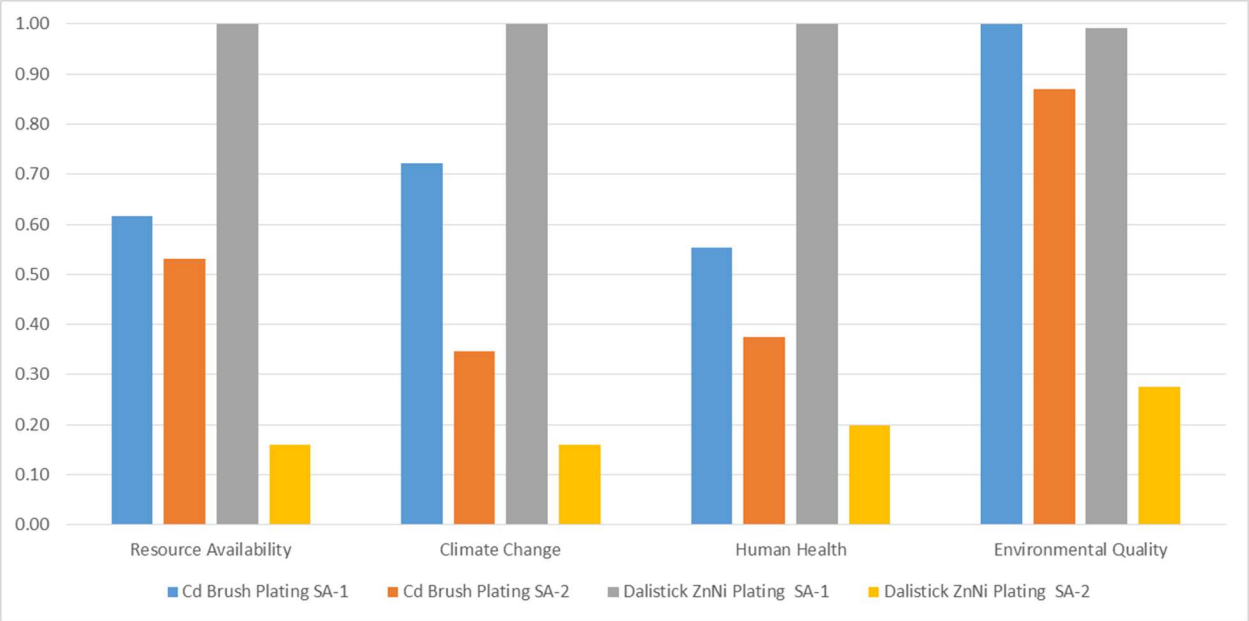

Figure 128. Relative Endpoint Impact Results

4.2.3 External Cost

External cost (or externalities) represent the tangible and intangible costs borne by non-DoD government agencies or society at large from the impacts identified above. Table 103 and Figure 129 provide the internal and external cost estimates for all scenarios. As discussed at the beginning of this section, the internal cost (NPV) of the Cd brush plating alternative was found to be lower than that of the Dalistick Zn-Ni plating. As with the impact results, Dalistck Zn-Ni plating Scenario 1 has the highest external cost estimate and Dalistck Zn-Ni plating scenario 2 has the lowest external cost estimate.

Table 103. Internal and External Costs

	Cd Brush Plating SA-1	Cd Brush Plating SA-2	Dalistick Zn-Ni Plating SA-1	Dalistick Zn-Ni Plating SA-2
Internal Cost (USD2014)	$4,290,449	$4,138,695	$4,646,250	$4,364,626
External Cost (USD2014)	$59,718	$37,608	$95,276	$19,396

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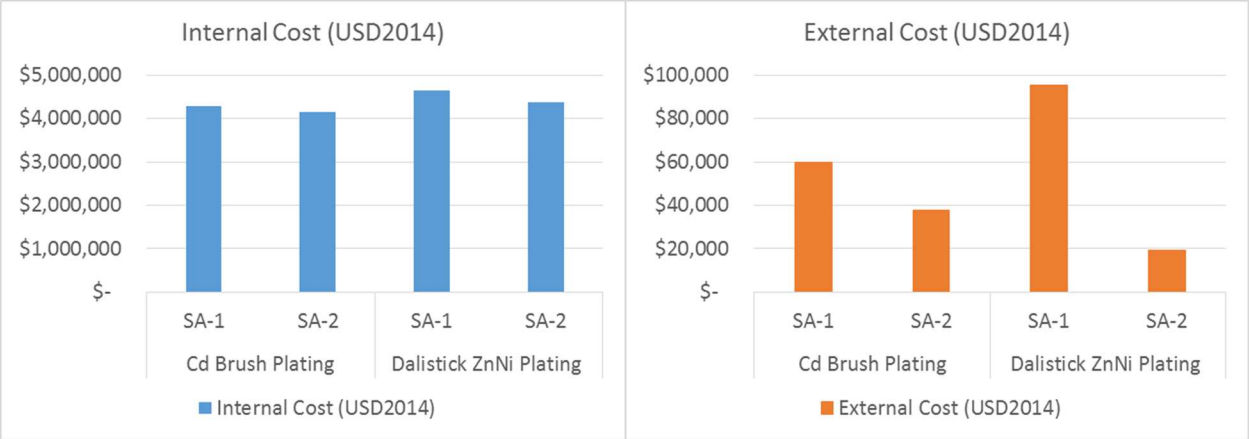

Figure 129. Internal and External Costs

5 Synthesis of Results

For Cd brush plating, Scenario 1 likely overestimates the amount of liquid hazardous waste generated. For Dalistick Zn-Ni plating, Scenario 1 likely overestimates the amount of Activator XF solution, Zinidal Aero solution, and bonnets used, as well as the associated waste and emissions. For the purpose of comparing the alternatives, it can be assumed that Scenario 2 for both alternatives provides a more robust estimate of internal costs, impacts, and external cost. However, the internal cost estimate for Dalistick Zn-Ni plating should be used cautiously, since the previous CBA found the labor costs to be significantly higher than those estimated in this Sustainability Analysis.

The spider diagram in Figure 130 compares the internal cost, endpoint impacts, and external costs for the two alternatives (i.e., Cd brush plating Scenario 2 and Dalistick Zn-Ni plating Scenario 2). A spoke is provided for each of the results evaluated (i.e., internal cost or 15-year NPV, potential impacts on resource quality and availability, potential impacts related to climate change, impacts on human health and productivity, impacts on biodiversity and ecosystem services, and the external cost to society from these impacts). As with the column charts provided above, the worst performing alternative for each category is assigned a value of 1. The other alternative is assigned a score equal to the ratio of its performance to that of the worst performing alternative. While there is substantial uncertainty in many of the parameter estimates used in this Sustainability Analysis, the results indicate that transitioning from Cd brush plating to Dalistick Zn-Ni plating will increase the internal costs to the Air Force, but reduce the external costs borne by society.

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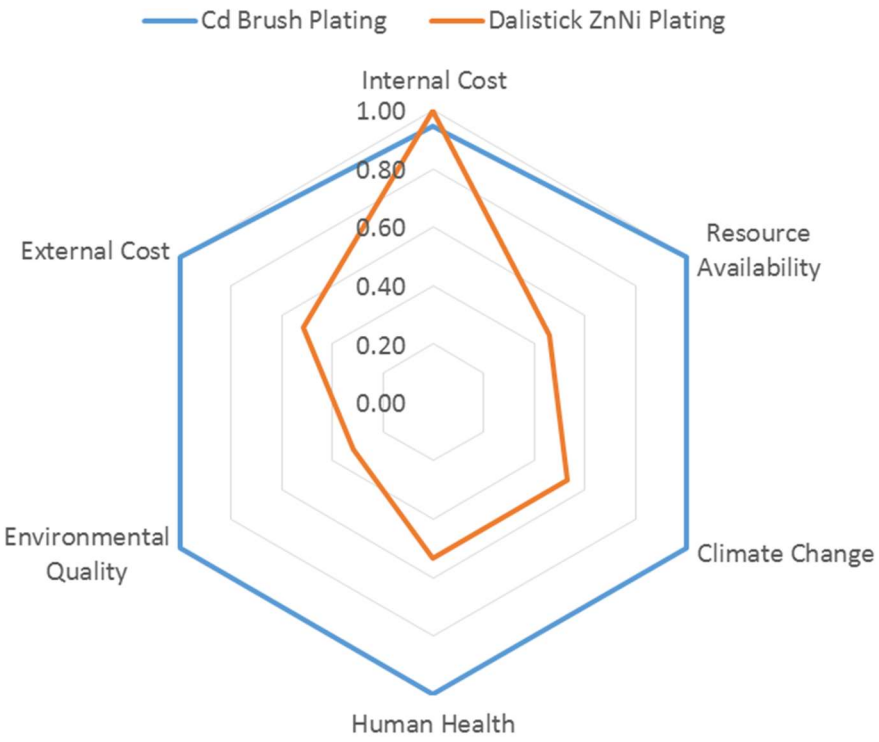

Figure 130. Spider Diagram Comparing the Costs and Impacts of Each Alternative

For each input and output in the Cd brush plating Scenario 2 alternative, Table 104 shows the percentage of endpoint impact and external cost that it is responsible for. Polyester jackets production, SIFCO 2023 production, hazardous waste management, and rectifier lead production drive most of the impacts and external cost. It should be recalled that Scenario 2 assumes that all of the unaccounted for liquid outputs results in wastewater, whereas Scenario 1 assumes that it results in liquid hazardous waste. Therefore, hazardous waste management would be an even more important driver of impact and external cost in Scenario 1. In both scenarios, 21.4 lbs of Cd were estimated to be contained in the SIFCO 2023, while only 4.5 lbs of Cd was estimated to be deposited on components. This results in a material efficiency of 21%. If the actual process efficiency is higher, less SIFCO 2023 would be used, thereby reducing its relative importance in overall in impact and external cost. With regards to the spills and releases, the results here represent potential impact to humans and ecosystems from releases to the environment. They are based on environmental fate and transport modeling, not workplace modeling. Any occupational hazards associated with exposure to the materials used during Cd brush plating are not captured here.

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Table 104. Drivers of Impact and External Cost for Cd Brush Plating

Sector/Activity	Resource Availability Endpoint	Climate Change Endpoint	Human Health Endpoint	Ecosystem Quality Endpoint	External Cost
Initial Equipment	1%	2%	2%	3%	3%
SIFCO 2023	16%	22%	29%	13%	25%
Isopropyl alcohol (IPA)	2%	1%	1%	3%	1%
Scotch Brite Pad	0%	0%	0%	0%	0%
Polyester Jackets	69%	38%	36%	49%	41%
Paper Towels	1%	2%	4%	19%	3%
Neoprene gloves	1%	1%	1%	3%	1%
Rectifier Leads	5%	6%	10%	5%	9%
Water	0%	0%	0%	0%	0%
Electricity Use	0%	0%	0%	0%	0%
Hazardous Waste Management	4%	29%	12%	4%	15%
Solid Waste Management	0%	0%	0%	0%	0%
Wastewater	0%	0%	0%	0%	0%
Cadmium Emissions to Air	0%	0%	4%	0%	2%
Ethylenediamine Emissions to Air	0%	0%	0%	0%	0%
Isopropyl Alcohol Emissions to Air	0%	0%	0%	0%	0%

For each input and output in the Dalistick Zn-Ni Scenario 2 alternative, Table 105 shows the percentage of endpoint impact and external cost that it is responsible for. Initial equipment production, Zinidal Aero production, and bonnet production drive most of the impacts and external cost. While occupational impacts are not captured here, they are not expected to be significant due to the nature of the Dalistick Zn-Ni work station, which is expected to result in very few drips, spills, and releases, as well as

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Table 105. Drivers of Impact and External Cost from Dalistick Zn-Ni Plating

Sector/Activity	Resource Availability Endpoint	Climate Change Endpoint	Human Health Endpoint	Ecosystem Quality Endpoint	External Cost
Initial Equipment & Components	27%	26%	39%	38%	42%
Nitrile Gloves	2%	1%	1%	4%	1%
Bonnets	7%	6%	7%	16%	7%
Activator XF solution	12%	4%	3%	21%	4%
Zinidal Aero solution	40%	46%	36%	6%	33%
Solvent Wipes	3%	1%	1%	2%	1%
Leads	2%	1%	2%	2%	2%
Tank Cleaner	2%	1%	3%	1%	2%
Exacanal Pipe	1%	0%	0%	8%	1%
Electricity	0%	1%	1%	0%	1%
Hydrochloric acid for DI Water	0%	0%	0%	0%	0%
Sodium hydroxide for DI Water	0%	0%	0%	0%	0%
Water	0%	0%	0%	0%	0%
Hazardous Waste Management	3%	12%	4%	2%	6%
Solid Waste Managemnt	0%	0%	0%	0%	0%
Wastewater	0%	0%	0%	0%	0%
Zinc Emissions to Air	0%	0%	0%	0%	0%
Nickel Emissions to Air	0%	0%	0%	0%	0%
Acetone Emissions to Air	0%	0%	0%	0%	0%
Hydrochloric Acid Emissions to Air	0%	0%	0%	0%	0%
Sulfamic Acid Emissions to Air	0%	0%	0%	0%	0%

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Appendix A – Air Force Use of Cadmium for Brush Plating

Initially, a broader functional unit that included annual throughput at WR-ALC, Oklahoma City Air Logistics Complex (OC-ALC), and Ogden Air Logistics Complex (OO-ALC) was considered. Initial efforts focused on collecting throughput data to enable a bottom-up Sustainability Analysis. This approach would have generated the most accurate results. However, it would require detailed information about the specific components repaired at each depot on an annual basis. However, there is no known mechanism for tracking this information. Even if repairs are tracked by depot plating shops, components coated on-aircraft may not be recorded. Table 106 summarizes information provided by the depots about their Cd brush plating activities. This information is insufficient for conducting a bottom-up analysis across the depots.

Table 106. Information about Cd Brush Plating Provided by the Depots

WR-ALC	OC-ALC	Travis AFB

• C5 Engine Mounts
• C17 Landing Gear Bushing
  ○ One occurrence every few months
  ○ Repair made on aircraft
• Use approximately 2 gal of Cd solution each year
	• TF33 and F100 Engine Parts
	  ○ Purchased with Cd. These parts are tank stripped at OC-ALC.
	• Possibly Cd Coated Bolts
	• Small amount of Brush plating, unknown components
		• Minor Touchups
		• Use in-house facility a few times a year
		• Mostly bushings and landing gear

Next, data from a recent study conducted by Noblis on DoD's use of Cd and chromium (Cr) was reviewed to see if sufficient information could be gleaned for a bottom-up analysis. Data werecollected from the Defense Logistics Agency (DLA) Pin Point tool, which collates part information from many data sources, and the Weapons Systems Impact Tool (WSIT), which provides information about the relationships between parts, weapon systems and specifications and standards. The analysis focused on processes that used Cd and Cr, and then attempted to link weapon systems and individual components that were maintained using these processes. Table 107 shows the high number of Air Force weapon systems with national stock numbers (NSNs) that reference Cd coatings, as well as the total number of NSNs referencing Cd coatings. A depot could perform Cd brush plating on essentially any part that the Air Force cadmium plates or that comes in from the original equipment manufacturer (OEM) Cd plated. While this analysis shows that many components could potentially be Cd brush plated, it does little to characterize actual throughput at the depots. The only way to get a list of components and throughput, would be to obtain it from each depot.

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Table 107. References to Cadmium Coatings in Air Force Systems

Weapon System Type	Number of Weapon Systems with NSNs that Reference Cadmium Coatings	Number of NSNs that Reference Cadmium Coatings
Aircraft	153	111,283
Engines	28	6802
Land	19	1,604
Missiles	15	7,071
Other	15	3,689

As a reference point, Table 108 provides Cd species usage estimates from usage for Cd brush plating from June 17, 2014 through June 16, 2015 from a Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) special study titled "Advanced Coatings 5-year Strategy and Roadmap" (October 2015). This table indicates that WR-ALC performs significantly less Cd brush plating than OC-ALC and OO-ALC.

Table 108. Cadmium Used for Cadmium Brush Plating (17June 2014 to 16 June 2015)

Air Force (lbs Cd species)	OC-ALC (lbs Cd species)	OO-ALC (lbs Cd species)	WR-ALC (lbs Cd species)
130.58	33.4	72.61	5.66

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Appendix B – Detailed Process Flow Diagrams (PFD)

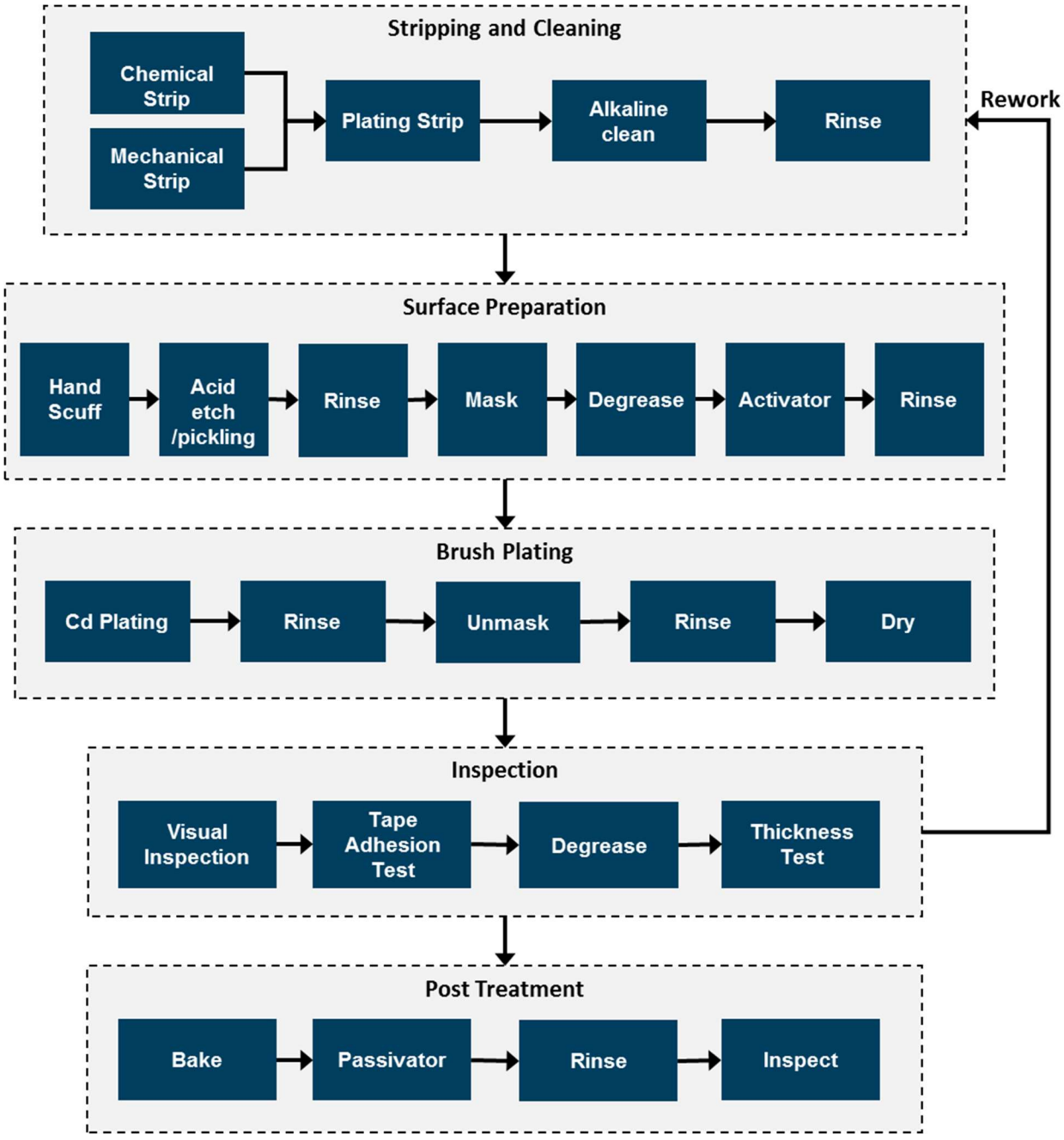

Figure 131. Detailed Process Flow Diagram for Cd Brush Plating

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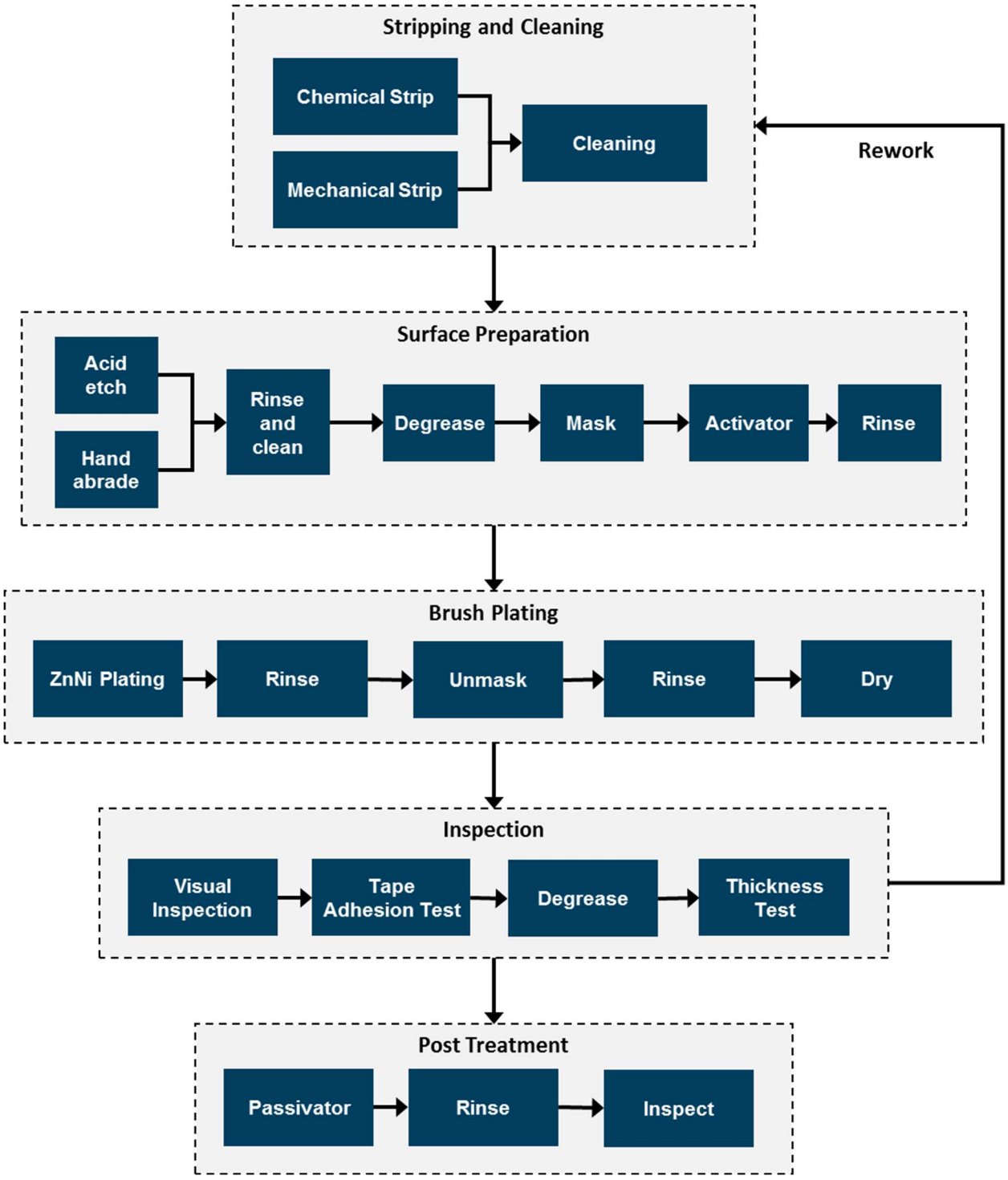

Figure 132. Detailed Process Flow Diagram for Dalistick Zn-Ni Plating

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Appendix C – Life Cycle Inventory (LCI) Data

SA for Cd Brush vs
Dalistick ZnNi Platin

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Appendix F : Industrial Health Risk Assessment

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Dalic Zinidal Aero Solution Industrial Health Risk Assessment

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Acronyms, Abbreviations, and Nomenclature

°C	degree(s) Celsius
µg/cm^2/week	microgram per square centimeter per week
µm	micrometer
A	Ampere(s)
ACGIH	American Conference of Governmental Industrial Hygienists
Ag	silver
Al	aluminum
ALC	Air Logistics Complex
ATE	Acute Toxicity Estimate
Au	gold
CAS	Chemical Abstract Service
CBA	Cost Benefit Analysis
Cd	cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Classification, Labeling, and Packaging
cm	centimeter
CMXG	Commodities Maintenance Group
CNS	central nervous system
COTS	commercial off the shelf
Cr^{3+}	trivalent chromium
Cr^{6+}	hexavalent chromium
DOT	Department of Transportation
DPS	Douglas Process Standard
EC	European Commission
EH&S	Environmental, Health, and Safety
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EO	European Union
EU	Executive Order
FAR	Federal Acquisition Regulation
FFP-3	filtering facepiece-3
g/L	gram(s) per liter
GHS	Globally Harmonized System
HCS	Hazard Communications Standard
HSS	high strength steel
IARC	International Agency for Research on Cancer
IAW	in accordance with
IHRA	Industrial Health Risk Assessment
in	inch(es)
IPA	isopropyl alcohol

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LEL	lower explosive limit
LHE	low hydrogen embrittlement
LV	limit value
m/s	meter(s) per second
MEK	methyl ethyl ketone
mg/kg	milligram per kilogram
mg/L	milligram per liter
mg/m^3	milligram per cubic meter
mg Ni/L	milligram(s) nickel per liter
mm^2	square millimeter(s)
MRO	maintenance, repair, and overhaul
NaCl	sodium chloride
NH_3	ammonia
Ni	nickel
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
PMEL	precision maintenance equipment laboratory
PPE	personal protective equipment
ppm	part(s) per million
PVC	polyvinyl chloride
REACH	Registration, Evaluation, Authorization, and Restriction of Chemicals
SARA	Superfund Amendments and Reauthorization Act
SDS	safety data sheet
Sn	tin
STEL	short term exposure limit
STOT SE	single target organ toxicity single exposure
STOT RE	single target organ toxicity repeated exposure
TDS	technical data sheet
TLV	threshold limit value
TO	Technical Order
TWA	time weighted average
U.S.	United States
USAF	United States Air Force
V	volt(s)
VAC	volts alternating current
WR-ALC	Warner Robins Air Logistics Complex
Xi	irritant
Zn-Ni	zinc nickel

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Executive Summary

Cadmium (Cd) was one of the 17 chemicals selected for reduction by the United States (U.S.) Environmental Protection Agency (EPA) per EPA 700-F-92-003, dated November 1992, which calls for voluntary industry reduction of 17 toxic chemicals. Directive-Type Memorandum (DTM) 12-003, "Control and Management of Surface Accumulations from Lead, Hexavalent Chromium, and Cadmium Operations," dated 18 April 2012, requires the DoD to employ a systems engineering approach to establish, document, and integrated refined procedures to ensure surfaces are maintained as free as practicable of accumulations of lead, hexavalent chromium (Cr^{6+}), and cadmium[52]. Further, Executive Order (EO) 13693, "Planning for Federal Sustainability in the Next Decade," dated 19 March 2015, requires the reduction or minimizing the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of in support of advancing waste prevention and pollution prevention[53]. The replacement of Cd electroplating, otherwise known as plating, promotes the reduction of toxic and hazardous chemicals and materials. Cd is classified as a carcinogen, and long-term exposure has been linked to lung cancer and kidney disease. Today, Cd (Chemical Abstract Service [CAS] No. 7440-43-9) is extensively used in plating operations to enhance corrosion and cathodic protection on United States Air Force (USAF) weapon systems. In efforts to reduce the use of Cd throughout USAF operations, various potential alternative processes have been under review, of which one is a novel brush plating tool named the Dalistick® Station, here-after referred to as the "Dalistick." The Dalistick is a commercial-off-the-shelf (COTS) tool that can be used to apply Zinidal Aero (Code 11040) zinc-nickel (Zn-Ni) coating using an electrodeposition process (i.e. brush plating). During a recent evaluation sponsored by the USAF, the Dalistick-applied Zinidal Zn-Ni coating was evaluated for use on high strength steels (HSS). The objective of this industrial health risk assessment (IHRA) document is to compare the solutions used in the baseline Cd traditional brush plating process and the alternative Dalistick-applied Zinidal Aero Zn-Ni process in terms of work environment requirements and environmental, health, and safety (EH&S) regulations.

Within this IHRA document, the solution properties, EH&S considerations, deposited alloy properties, and assessment of individual components of the baseline and alternative plating solutions are discussed. Because many of the Dalistick Zinidal process solutions are manufactured by Dalic, which is a French-based company, both European Union (EU) and U.S. environmental regulations were considered. Baseline solutions included degreasing solvent isopropyl alcohol (IPA) and Cd brush plating solution SIFCO Cd (No bake) Code 2023 Electrolyte. Alternative solutions included degreasing solvent acetone and Dalic solutions Activator ST2, Activator XF, Zinidal Zero, and Passivator No. 3 (for Type II coatings, per Technical Order [TO] 42C2-1-7,

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[52] *"Directive-Type Memorandum (DTM) 12-003, 'Control and Management of Surface Accumulations from Lead, Hexavalent Chromium, and Cadmium Operations'."* https://acc.dau.mil/adl/en-US/513451/file/64297/DTM-12-003%20-%20surface%20accumulation%20of%20Lead%20Hexavalent%20Chromium%20Cadmium.pdf. Accessed 27 October 2015.

[53] *"Executive Order – Planning for Federal Sustainability in the Next Decade."* The White House. https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade. Accessed 27 October 2015.

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Metal Treatments: Electrodeposition of Metals and Metal Surface Treatments to Meet Air Force Maintenance Requirements.). Each solution was analyzed in terms solution components, properties, control parameters, and EH&S considerations. SIFCO 2023 and Zinidal Aero were also analyzed in terms of deposited alloy properties and an IHRA of hazardous solution components.

SIFCO 2023 contains cadmium sulfate, which is considered a carcinogen, as determined by the International Agency for Research on Cancer (IARC), the American Conference of Governmental Industrial Hygienists (ACGIH), the National Toxicology Program (NTP), and the Occupational Safety and Health Administration (OSHA), and chronic exposure may cause lung and prostate cancer, as well as kidney disease.

Nickel dichloride is the only component in the Zinidal Aero solution that presents a risk as a carcinogen as determined by the National Institute of Occupational Safety and Health (NIOSH). The risk of cancer depends on the length and level of exposure. Nickel chloride is also a known mutagen and a reproductive toxin, as soluble Ni can cross the placenta barrier. The only hazard presented by zinc chloride and ammonia (NH_3) is potential for irritation to the skin, eyes, and respiratory system. Nickel chloride is also an irritant to the skin, eyes, and respiratory system.

During transfer of the chemical from the solution container to the Dalistick station, potential exposure routes are relevant. Operators should always wear proper personal protective equipment (PPE), including gloves, safety glasses, and laboratory clothing, such as overalls or laboratory coats and safety shoes. While possible, the EH&S risks during transfer are also considered low and offer a better situation than that of Cd.

No key issues were determined in terms of ecotoxicity or toxicity of the solution or the solution components for Zinidal Aero. United Nations proper shipping labels include the use of "toxic liquid" and "inorganic." The Zinidal Aero solution is recommended to be labeled as hazardous waste and disposed of according to facility guidelines.

With the use of proper PPE and the closed-loop Dalistick, the Zinidal Aero solution is a less hazardous alternative to Cd brush plating. The Zinidal Aero solution should be accompanied by an updated safety data sheet (SDS) at all times to ensure chemical updates are assessed for changes to safe operating procedures for the solution.

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1.0 INTRODUCTION

Cadmium (Cd) was one of the 17 chemicals selected for reduction by the United States (U.S.) Environmental Protection Agency (EPA) per EPA 700-F-92-003, dated November 1992, which calls for voluntary industry reduction of 17 toxic chemicals. Directive-Type Memorandum (DTM) 12-003, "Control and Management of Surface Accumulations from Lead, Hexavalent Chromium, and Cadmium Operations," dated 18 April 2012, requires the DoD to employ a systems engineering approach to establish, document, and integrated refined procedures to ensure surfaces are maintained as free as practicable of accumulations of lead, hexavalent chromium (Cr^{6+}), and cadmium[54]. Further, Executive Order (EO) 13693, "Planning for Federal Sustainability in the Next Decade," dated 19 March 2015, requires the reduction or minimizing the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of in support of advancing waste prevention and pollution prevention[55]. The replacement of Cd electroplating, otherwise known as plating, promotes the reduction of toxic and hazardous chemicals and materials. In efforts to reduce the use of Cd throughout USAF operations, various potential alternative processes have been under review, of which one is a novel brush plating tool named the Dalistick® Station, here-after referred to as the "Dalistick." Currently, Cd is applied is used for a variety of applications, including in-the-field, brush plate repair. Maintenance, repair, and overhaul (MRO) operations are required to address Cd coatings for field plating repairs. The Dalistick is a commercial-off-the-shelf (COTS) tool that can be used to apply Zinidal Aero (Code 11040) zinc-nickel (Zn-Ni) coating using an electrodeposition process (i.e. brush plating). During a recent evaluation sponsored by the USAF, the Dalistick-applied Zinidal Zn-Ni coating was evaluated for use on high strength steels (HSS). The objective of this industrial risk health assessment (IHRA) document is to compare the solutions used in the baseline Cd traditional brush plating process and the alternative Dalistick-applied Zinidal Aero Zn-Ni process in terms of work environment requirements and environmental, health, and safety (EH&S) regulations. It is noted that performance and financial aspects associated with the Dalistick operation are not discussed within this document. For such information, please contact the USAF point of contact (POC) as stated within the cover sheet of this report.

1.1 Background

The baseline and alternative processes are discussed briefly. A separate document, *Dalistick Cost Benefit Analysis (CBA),* dated 30 October 2015, describes the baseline and alternative processes and associated costs in greater detail.

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[54] *"Directive-Type Memorandum (DTM) 12-003, 'Control and Management of Surface Accumulations from Lead, Hexavalent Chromium, and Cadmium Operations'."* https://acc.dau.mil/adl/en-US/513451/file/64297/DTM-12-003%20-%20surface%20accumulation%20of%20Lead%20Hexavalent%20Chromium%20Cadmium.pdf. Accessed 27 October 2015.

[55] *"Executive Order – Planning for Federal Sustainability in the Next Decade."* The White House. https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade. Accessed 27 October 2015.

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1.1.1 Baseline Process Background

The baseline process for this IHRA is the Cd traditional brush plating, low hydrogen embrittlement (LHE) conducted in accordance with (IAW) MIL-STD-865D, *Department of Defense Standard Practice: Selective, Brush Plating, Electrodeposition* and per Douglas Process Specification (DPS) 9.89, *Cadmium, Brush*, performed by the Commodities Maintenance Group (CMXG) at Warner Robins Air Logistics Complex (WR-ALC). The baseline process is also IAW Technical Order (TO) 42C2-1-7, *Metal Treatments: Electrodeposition of Metals and Metal Surface Treatments to Meet Air Force Maintenance Requirements, Chapter 27: Stylus (Brush) Plating*. The CMXG also only has chemicals for this process detailed in these specifications.

The equipment utilized for the Cd traditional brush plating process is a SIFCO Process Power Pack 20 volts (V)/30 Amperes (A) rectifier. The CMXG has three rectifiers for use on the Brush Plating Cart in the Selective Plating Room at WR-ALC plating shop. The rectifiers required 110 volts alternating current (VAC) and are calibrated annually by the Precision Maintenance Equipment Laboratory (PMEL). An electrolyte trough pan (sized 5 inches [in] x 8 in) is stored on the bottom on the Brush Plating Cart. Stainless steel plating wands are used for the Cd traditional brush plating process.

The major process steps and associated labor hours for baseline Cd traditional brush-plating are described in Figure 1. Two chemical solutions are utilized during this process, including isopropyl alcohol (IPA) and SIFCO Cd (No bake) Code 2023 Electrolyte, here-after referred to as SIFCO 2023.

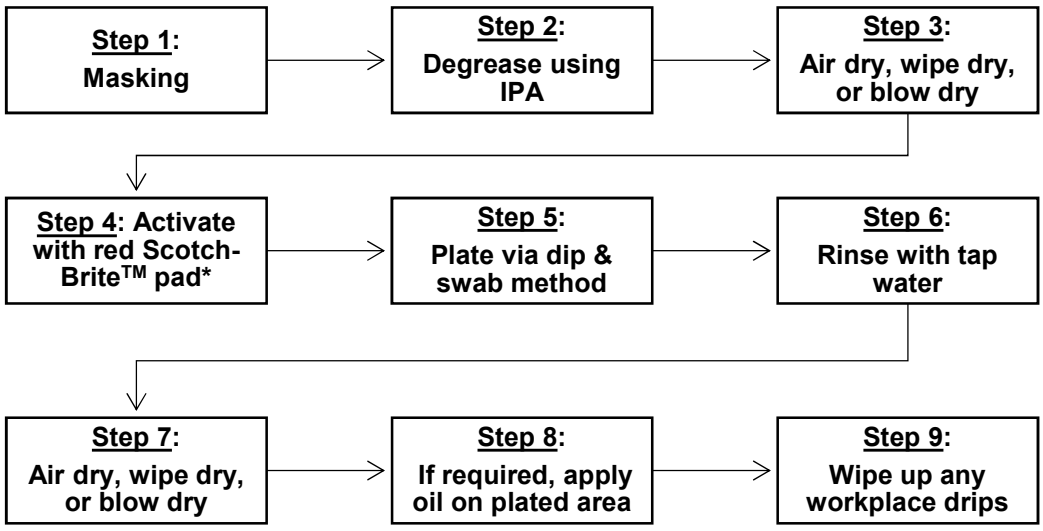

Figure 133. Process Steps for Baseline Cd Traditional Brush Plating

The process steps in Figure 1 are summarized steps from MIL-STD-865D and TO 42C2-1-7, as described by the plating technicians at WR-ALC known as "metalizers." The time required for masking is dependent upon the part type. The degreasing step uses spray IPA to clear debris in

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the area to be plated. The drying step is approximately 30 seconds per part, and blow drying uses dried, compressed air. The activation step may require reverse current activation with the plating rectifier for approximately 1 minute[56]. Plating parameters are pre-set in the plating rectifier. Plating time varies between 5 minutes and 30 minutes. Metalizers use a thickness gauge to confirm coating thickness if the customer (i.e. USAF weapon system) requires a specific thickness. The weapon systems requiring this repair process are the C-5, C-17, C-130, and F-15 at WR-ALC.

The total average time for one metalizer to perform traditional Cd brush plating on a single part plated to a 13-18 micrometer (μm) [per MIL-STD-856D] thickness is 1 hour, which includes set-up, masking, personal protective equipment (PPE) requirements, plating operations, record keeping, and clean-up.

In terms of required PPE, Cd traditional brush plating metalizers are required to wear hearing protection, neoprene gloves, aprons, laboratory coats, safety glasses or goggles (operator's choice), and steel-toed shoes. Operators must use respirators when working in closed spaces such as the C-17 wheel well. Metalizers use respirators approximately four times per year. Parts plated in the Selective Plating Room are plated utilizing fume hood ventilation.

Training required for the Cd traditional brush plating metalizers is 1.5 hours tri-annually for five metalizers per year. Initial training for metalizers for the Cd traditional brush plating process is a total of 32 hours. Annual respirator training is 1.5 hours. Metalizers are required to complete five minutes of general PPE training per day.

1.1.2 Alternative Process Background

The Dalistick is manufactured by Dalic, Inc (Vitre, France) and distributed by Corrdesa LLC (Newnan, Georgia, U.S.) [Dalistick® North American agent]. The Dalistick® Station 2020 is the chosen alternative technology and equipment. The brush plating coating systems for application with the Dalistick over bare 4130 steel include:

- Zinidal Aero Zn-Ni Solution Product 11040 (Dalic, Inc.)
- Zinidal Aero Zn-Ni Solution Product 11040 with Cr^{+6} conversion coating (SIFCO 5030)

The Dalistick can be used to repair the following tank-applied coatings:

- Cd per QQ-P-416
- Tank applied LHE Zn-Ni

The Dalistick is a mobile plating workstation unit combining a Dalistick tool, a rectifier, a temperature regulating unit, a circulation unit with a Dalipump, and a trolley. The Dalistick enables selective electrochemical treatment without generating any leakage of electrolyte with the flow control by the double-headed pump. The Dalistick is designed to achieve on-site, on-plane,

[56] The metalizers at WR-ALC could not specify the condition that differentiates and requires reverse current activation was required.

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or in-workshop, thin metallic layers and surface finishing on steel substrates or light alloys. Treatments can be performed with a limited amount of pre-masking and with simplified surface preparation. Treatments can be achieved in any position – on curved, horizontal, or vertical surfaces and edges. The Dalistick permits the use of small volumes of electrolytes which are used and also recycled in a closed system without leakage. This system provides practical, environmentally-friendly and safe plating or anodizing.

The Dalistick has several applications detailed below:

- Anti-corrosion coatings on light aluminum (Al) alloys (chromic or sulfuric anodizing), Zn, LHE Zn-Ni, LHE Cd
- Surface preparation for bonding or soldering (phosphoric anodizing)
- Increasing electrical conductivity with gold (Au) or silver (Ag)
- Anti-fretting corrosion coatings with tin (Sn) alloys

The Dalistick includes a 17-in shielded touch screen, printer, remote control, database with technical parameters of each plating job, Microsoft software for technician guidance, and set-up of process parameters. The capital costs of the Dalistick also include a case, cleaning kit, rectifier, equipment trolley, regulation unit, Dalipump and kit, and a consumables kit. The capital costs of the Dalistick include several major components, including a control pack (1), thermal control unit (2), power pack (3), and Dalipump (4). The Dalistick is featured in Figure 2.

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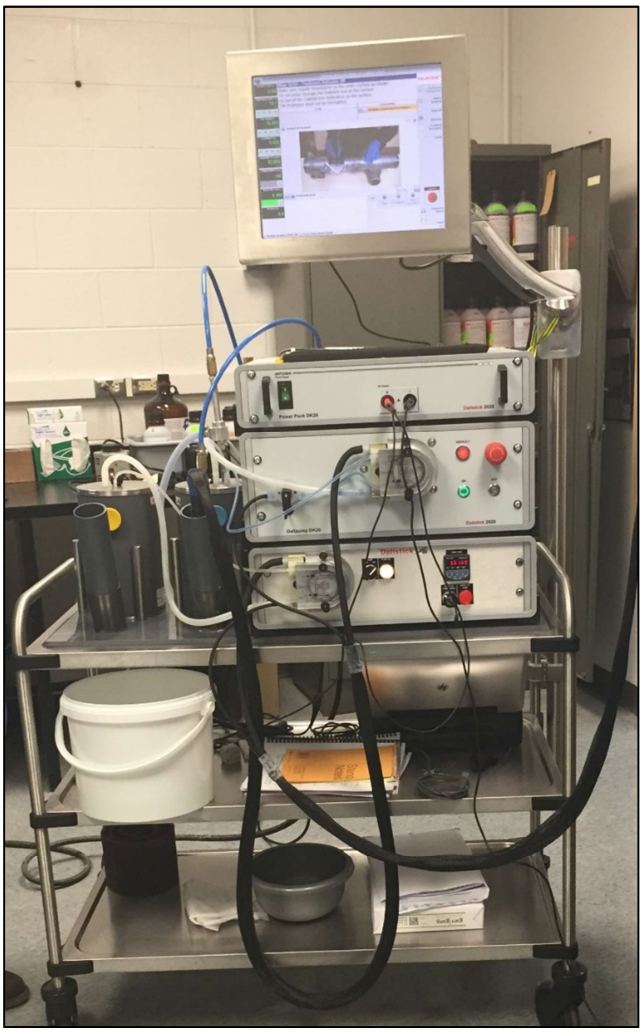

Figure 134. Dalistick Station

The Dalistick process, coupled with the Zinidal Aero solution, to plate Zn-Ni has been found to be a promising candidate to replace traditional Cd brush plating. The COTS Zinidal Aero solution provides a coating with a 10-20% weight nickel (Ni) and 80-90% weight Zn at varying thicknesses. The coating provides sacrificial corrosion protection for steels, and the process does not require hydrogen embrittlement relief when plated on HSS. Characteristics of the Dalistick process (using the Zinidal solution) are almost complete absence of hydrogen embrittlement caused by cathodic polarization. This is due to many factors. They include the specific amount of the electrolyte being significantly less than of the area of the part to be coated (a reduction in size in the order of one-sixth to one-third) permitting open air plant without the use of the fume hood, continuous friction between the bonnette and the plated surface to evacuate the hydrogen, and the use of electrolytes with a specially researched formulation to provide a non-embrittling coating.

The major process steps and associated labor hours for alternative Dalistick Zinidal Zn-Ni coating process are described in Figure 3. Four chemical solutions are utilized during this process, including acetone and Dalic solutions Activator XF, Zinidal Aero Zn-Ni, and Passivator No. 3.

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The alternative process includes options for both Type I and Type II coatings. Type I is defined as plated without supplementary treatment, and Type II is defined as plated with supplementary chromium conversion coating, which is the Dalic-supplied Passivator No. 3 solution.

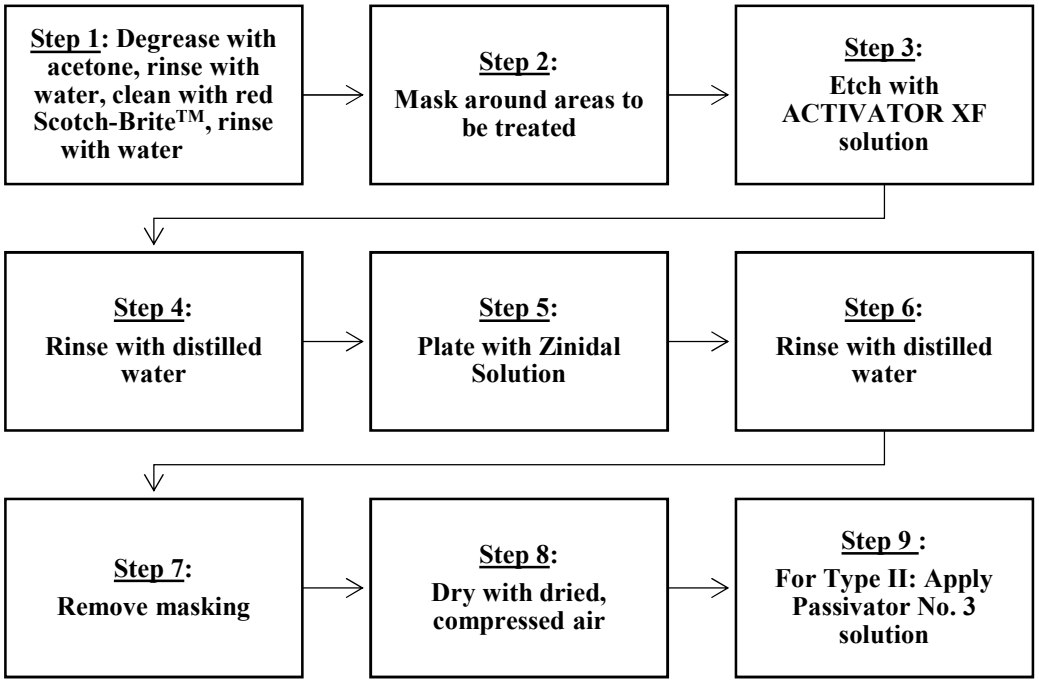

Figure 135. Dalistick Station Process Steps

The total time for one technician to plate a surface area of 5000 square millimeter (mm^2) [approximately 7.8 in^2] plated to a 13-18 μm thickness is 0.75 hours[57]. For Type II per TO 42C2-1-7 coatings, the technician applies the Passivator No. 3 with a cotton swab on top of the Zinidal Zn-Ni coating, and the coating is dried for 24 hours. Weekly cleaning of the station, including replacing the Zinidal Aero Zn-Ni plating solution every 7 days, has an associated labor time of 30 minutes.

In terms of PPE, Dalistick technicians are required to wear gloves, laboratory coats, goggles, and steel-toed shoes. The system does not require a fume hood for operation. Safety rules detailed in the instruction manual suggest referencing electrolyte safety data sheets (SDSs) and following general laboratory practices. The training required for new Dalistick technicians is 5 days (i.e. 40 hours).

Activator ST2 removes corrosion and Cd (consumption of electrolyte may depend from actual state of surface – e.g. heavier corrosion or thicker Cd deposits to be removed from the area to be refurbished would require more electrolyte usage) from the part surface. Activator XF etches the

[57] This time was confirmed with trials for two different technicians by University of Dayton Research Institute (UDRI) in May 2015.

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surface before application of the Zinidal Aero. For Type II coatings, Passivator No. 3 solution is applied to the surface with a cotton swab and is a post plating treatment.

1.2 Objective

The primary objective of this industrial health risk assessment (IHRA) is to is to compare the solutions used in the baseline Cd traditional brush plating process and the alternative Dalistick-applied Zinidal Zn-Ni coating process in terms of work environment requirements and EH&S regulations for use at USAF Air Logistics Complexes (ALCs).

2.0 APPROACH

The USAF requested that this IHRA be completed to evaluate the solutions used in the baseline Cd traditional brush plating process and the alternative Dalistick-applied Zinidal Zn-Ni coating process. This assessment was performed to evaluate the solutions in terms of working environment requirements and EH&S regulations. As noted previously, the IHRA did not consider or focus on performance, economics, or general use interests.

3.0 BASELINE PROCESS SOLUTIONS

The solutions used in the baseline Cd traditional brush plating process are listed in Table 1.

Table 109. Baseline Cd Traditional Brush Plating Process Solutions

Solution	Annual Usage
IPA	4.86 L
SIFCO 2023	72 L

The annual usage for the solutions listed in Table 1 was determined during a site visit to CMXG at WR-ALC in August 2015. The chemicals are described in detail in the following sections.

3.1 IPA Technical data

This section describes the EH&S data for the IPA solution.

3.1.1 IPA Components, Properties, and Control Parameters

IPA, CAS No. 67-63-0 and also known as 2-propanol, was assessed in terms of health effects and hazard regulations. Table 2 details the hazardous components according to the Globally Harmonized System (GHS) Hazard statements, hereafter referred to as "H-Statements" for Classification and Labeling of Chemicals. Definitions of the H-Statements in Table 2 and throughout this document are included in Appendix AA.

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Table 110. IPA Hazards Classifications

Component	CAS Number	Hazardous Classifications According to GHS Classifications
IPA (2-propanol)	67-63-0	Flammable Liquid: 2, H225 Eye Irritant: 2A, H319 STOT SE: 3, H336

STOT SE = Specific Target Organ Toxicity Single Exposure

The GHS is a "worldwide initiative to promote standard criteria for classifying chemicals according to their health, physical, and environmental hazards.[58]" The U.S. EPA and Occupational Safety and Health Administration (OSHA) have adopted their regulations to align with the GHS[59].

Table 3 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS.

Table 111. IPA Hazardous Solution Components According to GHS Classifications

Component & Concentration Range in the Mixture	CAS Number	GHS Classifications IAW with 29 CFR 1910 (OSHA HCS)	
IPA (2-propanol) 100%	67-63-0	Flammable Liquid: 2 Eye Irritant: 2A STOT SE: 3 CNS	H225 H319 H336

CLP = Classification, Labeling, and Packaging
HCS = Hazard Communication Standard
CNS = Central Nervous System

No additional substances are present in the IPA solution that are lower than the minimal level of danger, as noted on the SDS.

Table 4 details the chemical properties of the IPA solution per the SDS.

[58] ***"Globally Harmonized System for Classification and Labeling of Chemicals."*** United States Environmental Protection Agency. <http://www.epa.gov/oppfead1/international/globalharmon.htm>. Accessed 27 May 2015.
[59] ***"Modification of the Hazard Communication Standard (HCS) to conform with the United Nations' (UN) Globally Harmonized System of Classification and Labeling of Chemicals."*** United States Department of Labor. <https://www.osha.gov/dsg/hazcom/hazcom-faq.html>. Accessed 27 May 2015.

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Table 112. IPA Solution Properties

Property	Value
Appearance	Colorless liquid
Odor	Alcohol-like
Melting Point/Freezing Point	-89.49°C
Initial Boiling Point and Boiling Range	81.0-83.0°C
Flash Point	12°C (closed cup)
Upper/lower flammability or explosive limits	UEL: 12.7% (Vapor) LEL: 2% (Vapor)
Relative Density	0.78 g/mL
Water Solubility	Completely soluble
Auto-ignition temperature	425.0°C

°C = Degrees Celsius
UEL = upper explosive limit
LEL = lower explosive limit
g/L = gram(s) per liter

Table 5 includes control parameters for the IPA solution components per OSHA, the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Institute for Occupational Safety and Health (NIOSH).

Table 113. IPA Control Parameter Limits of Solution Components

Component	CAS Number	OSHA PEL TWA	ACGIH TLV TWA	ACGIH TLV STEL	NIOSH TWA	NIOSH STEL
IPA (2-propanol)	67-63-0	400 ppm 980 mg/m^3	200 ppm	400 ppm	400 ppm 980 mg/m^3	500 ppm 1,225 mg/m^3

PEL = Permissible Exposure Level
TWA = Time Weighted Average
TLV = Threshold Limit Value
STEL = Short Term Exposure Level
ppm = part(s) per million
mg/m^3 = milligram(s) per cubic meter

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3.1.2 IPA EH&S Considerations

EH&S considerations are detailed in this section per the details on the IPA solution SDS. EH&S processes are detailed in terms of personal protective equipment (PPE), handling and storage, stability and reactivity, toxicological information, ecological information, regulatory information.

PPE

The PPE recommendations per IPA SDS include the following guidelines:

- Eye/face protection: Face shield and safety glasses.
- Skin protection: Gloves.
- Body protection: Impervious clothing, flame retardant, antistatic protective clothing.
- Respiratory protection: Where risk assessment demonstrates appropriate, full-face respirator with multi-purpose respirator cartridges or type ABEK (EN 14387) respirator cartridges as back-up to engineering controls.
- Control of environment exposure: prevent further leakage or spillage if safe to do so. Do not let product enter drains.

Handling and Storage

Precautions for safe handling of IPA include avoiding contact with skin and eye, avoiding inhalation of vapor or mist, using explosion-proof equipment, keeping away from sources of ignition, and taking measures to prevent build-up of electrostatic charge. IPA should be kept in a tightly closed container in a dry and well-ventilated place. Open containers should be resealed and kept upright to prevent leakage.

Stability and Reactivity

The solution is stable at room temperature under recommended storage conditions. There is a possibility of hazardous reactions from vapors forming explosive mixture with air. Exposure to heat, flames, and sparks should be avoided. Materials that are incompatible with IPA include oxidizing agents, acid anhydrides, Al, halogenated compounds, and acids.

Toxicological Information

IPA presents acute toxicity detailed in Table 6, as detailed in the SDS. It is noted that no specific toxicology information for the mixture was available for respiratory or skin sensitization, germ cell mutagenicity, reproductive toxicity, specific target organ toxicity repeated exposure (STOT RE), aspiration hazard. STOT SE may cause drowsiness or dizziness.

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Table 114. Toxicity of IPA

Toxic Component	Toxicity		
	LD50 Oral (rat)	LC50 Inhalation (rat, 8 hour)	LD50 Dermal Rabbit
IPA	5,045 mg/kg	16,000 ppm	12,800 mg/kg

mg/kg = milligram(s) per kilogram

IPA is not classified as a known carcinogen. CNS depression, prolonged or repeated exposure can cause nausea, headache, vomiting, narcosis, and drowsiness. Overexposure may cause mild, reversible liver effects. Aspiration may lead to lung edema or pneumonia.

Ecological Information

Ecotoxicity of IPA includes:

- LC50 Pimephales promelas fish (96 hours): 9,6400.00 milligrams per liter (mg/L)
- EC50 Daphnia magna (24 hours): 5,102.00 mg/L

Toxicity to algae of IPA for EC50 green algae (72 hours) is > 2,000.00 mg/L and EC50 algae (24 hours) is > 1,000.00 mg/L.

Regulatory Information

IPA is not subject to reporting requirements per the Superfund Amendments and Reauthorization Act (SARA) Title III, Section 302; however, IPA is subject to reporting in select states per SARA Title III, Section 313, as noted on the product SDS.

3.2 SIFCO 2023 TECHNICAL DATA

This section describes the EH&S data for the SIFCO 2023 solution. This section describes technical information for the SIFCO 2023 solution in terms of plating specifications, physical properties, and microhardness information obtained from the manufacturer's website.

3.2.1 SIFCO 2023 Solution Properties

SIFCO 2023 was assessed in terms of health effects and hazard regulations. Table 7 details the hazardous components according to the GHS H-Statements for Classification and Labeling of Chemicals.

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Table 115. SIFCO 2023 Hazards Classifications

Component	CAS Number	Hazardous Classifications According to EC Regulation & Label Elements
SIFCO 2023	N/A (Solution Mixture)	Acute Toxicity 4, H302/H312/H332 Skin Irritant 2, H315 Eye Irritant 2A, H319 Respiratory Sensitivity 1, H334 Skin Sensitivity 1, H317 Mutagen 1B, H340 Carcinogen 1B, H350 Reproduction 1B, H360FD STOT RE 1, H372 Aquatic Chronic 2, H411

Table 8 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS. The SIFCO 2023 solution is an aqueous solution containing cadmium sulfate and ethylenediamine.

Table 116. SIFCO 2023 Hazardous Solution Components According to GHS Classifications

Component & Concentration Range in the Mixture	CAS Number	Hazardous Classifications According to GHS Classifications
Cadmium Sulfate 10-30%	10124-36-1	Acute Toxicity. 3, H301 Acute Toxicity. 2, H330 Mutagen 1B, H340 Carcinogen 1B, H350 Reproductive 1B, H360FD STOT RE 1, H372 Aquatic Acute 1, H400 Aquatic Chronic 1, H410
Ethylenediamine 10-30%	107-15-3	Flammable Liquid 3, H226 Acute Toxicity 4, H302 Acute Toxicity 4, H312 Skin Corrosivity 1B, H314 Eye Damage 1, H318 Respiratory Sensitivity 1, H334 Skin Sensitivity 1, H317

Table 9 details the chemical properties of the SIFCO 2023 solution per the SDS.

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Table 117. SIFCO 2023 Solution Properties

Property	Value
Appearance	Clear liquid
Odor	No characteristic odor
pH	10.7-11.3
Relative Density	1.160-1.170

Table 10 includes control parameters for the SIFCO 2023 solution components per OSHA, the ACGIH, and the NIOSH.

Table 118. SIFCO 2023 Control Parameter Limits of Solution Components

Component	CAS Number	OSHA PEL TWA	ACGIH TWA
Cadmium Sulfate 10.0-30.0%	10124-36-1	0.005 mg/m^3	0.002 mg/m^3
Ethylenediamine 10.0-30.0%	107-15-3	10 ppm	10 ppm

3.2.2 SIFCO 2023 EH&S Considerations

EH&S considerations are detailed in this section per the details on the SIFCO 2023 solution SDS. EH&S processes are detailed in terms of PPE, handling and storage, stability and reactivity, toxicological information, ecological information, regulatory information.

PPE

The PPE recommendations per the SIFCO 2023 SDS include the following guidelines:

- Appropriate engineering controls including process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure below any statutory or recommended limits, if use generates dust, fumes, gas, vapor, or mist.
- Eye/face protection: Tight-fitting safety glasses.
- Skin protection: Chemical-resistant, impervious gloves. Nitrile rubber gloves are recommended.
- Body protection: Appropriate footwear and additional protective clothing complying with an approved standard.

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- Wash at the end of each work shift and before eating, smoking, and using the toilet.
- If ventilation is inadequate, suitable respiratory protection must be worn. Respiratory protection must be used if the airborne contamination exceeds the recommended occupational exposure limit.

Handling and Storage

Precautions for safe handling of SIFCO 2023 include to avoid spilling, contact with skin and eye, avoid inhalation of vapor or mist, and provide adequate general and local exhaust ventilation. SIFCO 2023 should be kept in a tightly closed, original container in a cool, dry and well-ventilated place protected from freezing and direct sunlight. Storage classifications are toxic and corrosive.

Stability and Reactivity

The solution is stable at room temperature under recommended storage conditions and has no known reactivity hazards. Avoid exposure to heat for prolonged periods of time. Avoid exposure to acids and oxidizing agents.

Toxicological Information

SIFCO 2023 presents acute toxicity detailed in Table 11 as detailed in the SDS. The acute toxicities of SIFCO 2023 solution components are also detailed in Table 11.

Table 119. Toxicity of SIFCO 2023

Toxic Component	Toxicity		
	ATE Oral	ATE Dermal	ATE Inhalation
SIFCO 2023	1,831.5 mg/kg	1,100.00 mg/kg	1.5 mg/L
Cadmium sulfate	500.0 mg/kg	1,100.0 mg/kg	Gases: 4,500.0 ppm Vapors: 11.0 ppm Dusts/Mists: 1.5 mg/L
Ethylenediamine	LD50 1,200.0 mg/kg	LD50 560.0 mg/kg	LC50 Dust/Mist 14.7 mg/L

ATE = Acute Toxicity Estimate

Vapors of SIFCO 2023 may irritate the respiratory system and may cause coughing and difficulties in breathing. SIFCO 2023 is toxic if swallowed and causes severe burns in mouth esophagus, and stomach. Skin contact with SIFCO 2023 may cause serious chemical burns to the skin. Eye contact with SIFCO 2023 may cause serious eye damage and immediate first aid is imperative.

Ecological Information

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SIFCO 2023 is considered dangerous for the environment and may cause long-term adverse effects in the aquatic environment. Ecotoxicity for cadmium sulfate demonstrates acute aquatic toxicity $LE(C)_{50}$ $0.1 < L(E)C_{50} \leq 1$. The acute ecotoxicity for ethylenediamine includes:

- Fish (96 hours): 115.7 mg/L
- Daphnia magna (48 hour): 3mg/L
- Aquatic plants (Pseudokirchneriella subcapitata) 996 hours): 151 mg/L

Regulatory Information

Ethylenediamine is subject to reporting requirements per:

- SARA Title III, Section 302 Extremely Hazardous Substances Tier II Threshold Planning Quantities at 10,000 pounds (lb),
- Per Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Superfund, Hazardous Substances Reportable Quantities (per EPA) at final CERCLA RQ 5,000 lb,
- SARA Extremely Hazardous Substances Emergency Planning and Community Right-to-Know Act (EPCRA) Reportable Quantities at 5,000 lb,
- Per SARA 313 Emission Reporting, and
- CAA Accidental Release Prevention at a threshold quantity of 20,000 lbs.

3.2.3 SIFCO 2023 Deposited Alloy Properties

SIFCO 2023 deposits a Cd coating for sacrificial corrosion protection of iron, steel, and cast iron[60]. The deposited Cd coating has a desired appearance of medium-gray and matte finish. The microporous deposit should demonstrate fair ductility. The maximum one-layer thickness of the coating deposit is 125 µm (0.005 in)[6].

4.0 ALTERNATIVE PROCESS SOLUTIONS

The solutions used in the alternative Dalistick Zinidal Zn-Ni coating process are listed in Table 12.

[60] ***"Item # 80202320, Cadmium No Bake®."*** SIFCO ASC. http://plating.sifcoasc.com/item/preparatory-and-plating-solutions/plating-solutions-2/80202320. Accessed 27 August 2015.

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Table 120. Alternative Dalistick Zinidal Zn-Ni Coating Process Solutions

Solution	Projected Annual Usage
Acetone	27 L
Activator ST2	7.2 L
Activator XF	10.8 L
Zinidal Aero Zn-Ni	10.8 L
Passivator No.3	3.6 L

The projected annual usage for the solutions listed in Table 12 was determined in the Dalistick CBA. The chemicals are described in detail in the following sections.

4.1 Acetone Technical Data

This section describes the EH&S data for acetone.

4.1.1 Acetone Components, Properties, and Control Parameters

Acetone, CAS No. 67-64-1 was assessed in terms of health effects and hazard regulations. Table 13 details the hazardous components according to the GHS H-Statements for Classification and Labeling of Chemicals.

Table 121. Acetone Hazards Classifications

Component	CAS Number	Hazardous Classifications According to GHS Classifications
Acetone	67-64-1	Flammable Liquid: 2, H225 Eye Irritant: 2A, H319 STOT SE: 3, H336

Table 14 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS.

Table 122. Acetone Hazardous Solution Components According to GHS Classifications

Component & Concentration Range in the Mixture	CAS Number	GHS Classifications IAW with 29 CFR 1910 (OSHA HCS)	
Acetone 100%	67-64-1	Flammable Liquid: 2 Eye Irritant: 2A STOT SE: 3 CNS	H225 H319 H336

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No additional substances are present in the acetone that are lower than the minimal level of danger, as noted on the SDS.

Table 15 details the chemical properties of the acetone per the SDS.

Table 123. Acetone Solution Properties

Property	Value
Appearance	Colorless liquid
Melting Point/Freezing Point	-94°C
Initial Boiling Point and Boiling Range	56°C
Flash Point	-16.99°C (closed cup)
Upper/lower flammability or explosive limits	UEL: 13% (Vapor) LEL: 2% (Vapor)
Relative Density	0.791 g/mL
Water Solubility	Completely miscible

Table 16 includes control parameters for the acetone solution components per OSHA, the ACGIH, and the NIOSH.

Table 124. Acetone Control Parameter Limits of Solution Components

Component	CAS Number	OSHA PEL TWA	ACGIH TLV TWA	ACGIH TLV STEL	NIOSH TWA
Acetone	67-64-1	1,000 ppm 2,400 mg/m^3	500 ppm	750 ppm	250 ppm 590 mg/m^3

4.1.2 Acetone EH&S Considerations

EH&S considerations are detailed in this section per the details on the acetone SDS. EH&S processes are detailed in terms of PPE, handling and storage, stability and reactivity, toxicological information, ecological information, regulatory information.

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PPE

The PPE recommendations per MEK SDS include the following guidelines:

- Eye/face protection: Face shield and safety glasses.
- Skin protection: Gloves.
- Body protection: Impervious clothing, flame retardant, antistatic protective clothing.
- Respiratory protection: Where risk assessment demonstrates appropriate, full-face respirator with multi-purpose respirator cartridges or type ABEK (EN 14387) respirator cartridges as back-up to engineering controls.
- Control of environment exposure: prevent further leakage or spillage if safe to do so. Do not let product enter drains.

Handling and Storage

Precautions for safe handling of acetone include avoiding contact with skin and eye, avoiding inhalation of vapor or mist, using explosion-proof equipment, keeping away from sources of ignition, and taking measures to prevent build-up of electrostatic charge. Acetone should be stored in a tightly closed container in a dry and well-ventilated place. Open containers should be resealed and kept upright to prevent leakage.

Stability and Reactivity

The solution is stable at room temperature under recommended storage conditions. There is a possibility of hazardous reactions from vapors forming explosive mixture with air. Exposure to moisture, heat, flames, and sparks should be avoided. Materials that are incompatible with acetone include bases, oxidizing agents, reducing agents, and phosphorous oxychloride.

Toxicological Information

Acetone presents acute toxicity, which is detailed in Table 17 as detailed in the SDS. Skin corrosion/irritation toxicity for rabbit resulted in mild skin irritation (24 hours).

Table 125. Toxicity of Acetone

Toxic Component	Toxicity		
	LD50 Oral (rat)	LC50 Inhalation (rat, 8 hour)	LD50 Dermal Guinea Pig
Acetone	5,800mg/kg	32,000 mg/m^3	7,426 mg/kg

Additional toxicity of acetone as noted on the SDS includes:

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- Skin corrosion/irritation (rabbit, 24 hour) resulted in mild skin irritation
- Serious eye damage/eye irritation (rabbit, 24 hour) resulted in eye irritation
- Respiratory or skin sensitization (guinea pig) resulted in not causing skin sensitization.

No data related to germ cell mutagenicity is available. Acetone is not classified as a known carcinogen.

Ecological Information

Ecotoxicity of acetone includes:

- LC50 Oncorhynchus mykiss (rainbow trout) (96 hours): 5,540 mg/L
- LC50 Daphnia magna (48 hours): 8,800 mg/L

Regulatory Information

Acetone is not subject to reporting requirements per SARA Title III, Section 302 nor does it exceed the threshold reporting levels established by SARA Title III, Section 313.;

4.2 Activator ST2 Technical Data

This section describes the EH&S data for the Dalic Activator ST2 solution.

4.2.1 Activator ST2 Components, Properties, and Control Parameters

Activator ST2 was assessed in terms of health effects and hazard regulations. Table 18 details the hazardous components according to the GHS H-Statements for Classification and Labeling of Chemicals.

Table 126. Activator ST2 Hazards Classifications

Solution	CAS Number	Hazardous Classifications According to EC Regulation & Label Elements
Activator ST2	N/A (Solution Mixture)	Irritant (Xi) R36/38 irritating to eyes and skin S26: in case of contact with eyes, rinse immediately with plenty of water and seek medical advice S37/39: wear suitable gloves and eye/face protection

EC = European Commission

Table 19 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS.

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Table 127. Activator ST2 Hazardous Solution Components According to GHS Classifications

Component & Concentration Range in the Mixture	CAS Number	Hazardous Classifications According to 67/548/EEC (updated by CLP adaptations)		Hazardous Classifications According to Regulation EC No. 1272/2009 & 2008 (CLP and adaptations)	
		Classification	Labeling		
Sulfuric Acid <5%	7664-93-9	C R35	C R35; S(1/2) 2-20-45	Skin Corrosivity 1A	H314

No additional substances are present in the Activator ST2 solution that are lower than the minimal level of danger, as noted on the SDS.

Table 20 details the chemical properties of the Activator ST2 solution per the SDS.

Table 128. Activator ST2 Solution Properties

Property	Value
Appearance	Colorless to pale yellow liquid
pH	<1
Crystallization/Melting Point	-2-/-4°C
Boiling Point	100°C
Flammability	No
Oxidizing Properties	No
Risk of Explosion and Fire	No, but potentially dangerous reaction with strong oxidizers if product is accidentally concentrated or dehydrated
Relative Density	1.06 g/mL
Water Solubility	Miscible in water in all proportions

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Table 21 includes control parameters for the Activator ST2 solution components per OSHA, the ACGIH, and the NIOSH.

Table 129. Activator ST2 Control Parameter Limits of Solution Components

Component	CAS Number	OSHA PEL (TWA)	NIOSH TWA
Sulfuric Acid <5%	7664-93-9	1 mg/m^3	1 mg/m^3

4.2.2 Activator ST2 EH&S Considerations

EH&S considerations are detailed in this section per the details on the Activator ST2 solution SDS. EH&S processes are detailed in terms of PPE, handling and storage, stability and reactivity, toxicological information, ecological information, regulatory information.

PPE

The PPE recommendations per Activator ST2 SDS include the following guidelines:

- Provide an effective laboratory ventilation system to inhale sprays/vapors when created and extracted from the premises. Otherwise, or if insufficient, work in a ventilated room and wear a protective breathing mask with an A2B2P3 cartridge (EN405:2902 standard) or a filtering facepiece-3 (FFP3) mask (EN 149:2009 standard).
- Provide gloves to be worn by operator(s).
- Provide safety goggles with lateral protection or a facial screen to be worn by operator(s). Operator(s) should not wear contact lenses while operating system.
- Provide overalls and safety shoes to be worn by operator(s)
- Provide an eye basin near the workstation.
- Provide a shower, powerful tap, and sink unit near workstation.

Handling and Storage

The Activator ST2 solution should be used as it is supplied. The solution should be stored in original containers constructed of polyethylene. Per manufacturer directions, solution containers should be closed tightly after use with the original cap. Solution containers should not be re-used to store other solutions.

Solution containers should be stored on a spill-containing vat in a laboratory setting and maintained in an area between 5° and 30°C as well as away from direct sunlight. The solution should be kept away from strong alkaline products and powerful oxidizing agents. The maximum recommended shelf life is three years from the manufacturer's date under normal storage conditions.

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Stability and Reactivity

The Activator ST2 solution is stable at ambient temperature, as water evaporation is the only storage risk. The manufacturer suggests temperatures above 150-170°C be avoided. Strong bases and powerful oxidizing agents (such as nitrates or chlorates) should also be avoided in preparation that the solution was accidentally dehydrated or concentrated. Possibly hazardous thermal decomposition products include carbon oxides and sulfur oxides.

Toxicological Information

Sulfuric acid presents acute toxicity, which is detailed in Table 22, as is detailed in the SDS for Activator ST2.

Table 130. Toxicity of Activator ST2 Toxic Components

Toxic Component	Toxicity	
	LD50 Oral (rat)	LC50 Inhalation (rat, 2 hour)
Sulfuric Acid	2,140 mg/kg	510 mg/m^3

Sulfuric acid is weakly carcinogenic for animals and has demonstrated mutagenic results on animals. Sulfuric acid is non-toxic for reproduction with present knowledge.

It is noted that no specific toxicology information for the mixture Activator ST2 was available from the manufacturer.

The health hazards linked to the Activator ST2 solution were evaluated based on applicable regulations and bibliographic data from the SDS. The mixture is a weak irritant to skin and eyes and a slight irritant to the respiratory system.

Ecological Information

Ecotoxicity of sulfuric acid at concentrations of 94% to 96% include:

- LC50 Gambusia affinis fish (96 hours): 42 mg/L
- EC50 Daphnia magna (24 hours): 29 mg/L
- EC 50 Crangon crangon shrimp (48 hours): 70-80 mg/L
- LC50 crustaceans (48 hours): 42.5 mg/L
- EC50120 activated sludge bacteria (120 hours): 58 mg/L.

According to available data, the compounds in the Activator ST2 mixture are easily biodegradable and do not bioaccumulate.

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Regulatory Information

Product labeling has been established for the Activator ST2 solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. No substances are subject to authorization per annex XIV of Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), and no restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles are currently in place. The solution does not contain substances that deplete the ozone layer, are persistent organic pollutants.

4.3 Activator XF Technical Data

This section describes the EH&S data for the Dalic Activator XF solution.

4.3.1 Activator XF Components, Properties, and Control Parameters

Activator XF was assessed in terms of health effects and hazard regulations. Table 23 details the hazardous components according to the GHS H-Statements for Classification and Labeling of Chemicals.

Table 131. Activator XF Hazards Classifications

Solution	CAS Number	Hazardous Classifications According to EC Regulation & Label Elements
Activator XF	N/A (Solution Mixture)	Not Regulated S37/39: wear suitable gloves and eye/face protection

Table 23 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS.

Activator XF is noted as a weakly acidic aqueous solution and contains no hazardous components according to EC regulations. No additional substances are present in the Activator XF solution that are lower than the minimal level of danger, as noted on the SDS.

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Table 24 details the chemical properties of the Activator XF solution per the SDS.

Table 132. Activator XF Solution Properties

Property	Value
Appearance	Colorless to pale yellow liquid
pH	4.4
Crystallization/Melting Point	0°C
Boiling Point	Approximately 100°C
Flammability	No
Oxidizing Properties	No
Risk of Explosion and Fire	No, but potentially dangerous reaction with strong oxidizers if product is accidentally concentrated or dehydrated
Relative Density	1.13 g/mL
Water Solubility	Miscible in water in all proportions

No exposure limits in air were noted on the solution SDS for Activator XF.

4.3.2 Activator XF EH&S Considerations

EH&S considerations are detailed in this section per the details on the Activator XF solution SDS. EH&S processes are detailed in terms of PPE, handling and storage, stability and reactivity, toxicological information, ecological information, regulatory information.

PPE

The PPE recommendations per Activator XF SDS include the following guidelines:

- Provide an effective laboratory ventilation system to inhale sprays/vapors when created and extraction out of the premises. Otherwise or if insufficient, work in a ventilated room and wear a protective breathing mask with an A2B2P3 cartridge (EN405:2902 standard) or a filtering FFP3 mask (EN 149:2009 standard).
- Provide gloves (nitrile or latex) to be worn by operator(s)
- Provide safety glasses with lateral protection or a facial screen to be worn by operator(s). Operator(s) should not wear contact lenses while operating system.
- Provide overalls and safety shoes to be worn by operator(s)
- Provide an eye basin near the workstation.
- Provide a shower, powerful tap, and sink unit near workstation.

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Handling and Storage

The Activator XF solution should be used as it is supplied. The solution should be stored in original containers constructed of polyethylene. Per manufacturer directions, solution containers should be closed tightly after use with the original cap. Solution containers should not be re-used to store other solutions.

Solution containers should be stored on a spill-containing vat in a laboratory setting and maintained in an area between 5° and 30°C as well as away from direct sunlight. The solution should be kept away from strong alkaline products and powerful oxidizing agents. The maximum recommended shelf life is three years from the manufacturer's date under normal storage conditions.

Stability and Reactivity

The Activator XF solution is stable at ambient temperature, as water evaporation is the only storage risk. The manufacturer suggests temperatures above 150-170°C be avoided. Strong bases and powerful oxidizing agents (such as nitrates or chlorates) should also be avoided in preparation that the solution was accidentally dehydrated or concentrated. Possibly hazardous thermal decomposition products include carbon oxides, sulfur oxides, nitrogen oxides, and sodium oxide before 250°C. Decomposition of the most stable constituents from 900°C with release of sulfur oxides and sodium oxide.

Toxicological Information

No solution components demonstrate toxicity.

It is noted that no specific toxicology information for the mixture Activator XF was available from the manufacturer.

The health hazards linked to the Activator XF solution were evaluated based on applicable regulations and bibliographic data from the SDS. The mixture can become irritating to the eyes in case of contact if water rinsing is not immediately realized, and the mixture is slightly irritating to the respiratory system without proper workplace ventilation.

Ecological Information

According to the available data, Activator XF is not considered dangerous for the aquatic environment. According to available data, the compounds in the Activator XF mixture are easily biodegradable and do not bioaccumulate.

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Regulatory Information

Product labeling has been established for the Activator XF solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. No substances are subject to authorization per annex XIV of REACH, and no restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles are currently in place. The solution does not contain substances that deplete the ozone layer, are persistent organic pollutants.

4.4 Zinidal Aero Technical data

This section describes the technical data for the Zinidal Aero solution. In addition to describing the solution, the SDS describes the main electrolysis parameters of Zinidal Aero plating using Dalistick and treatment with the Dalistick, application processes on steel, an example application process on Al, and reworking processes on Zn-Ni and on Cd.

4.4.1 Zinidal Aero Solution Components, Properties, and Control Parameters

The components of the Zinidal Aero solution were assessed in terms of health effects and hazard regulations. Table 25 details the hazardous solution components according to the GHS H-Statements for Classification and Labeling of Chemicals. Additional SDSs for zinc chloride, nickel dichloride, and NH_4^+ were utilized for this analysis and are included in Appendices I, J, and K.

Table 133. Zinidal Aero Hazards Classifications

Solution	CAS Number	Hazardous Classifications According to EC Regulation & Label Elements
Zinidal Aero	N/A (Solution mixture)	Carcinogen 1 R49 Mutagen 3 R68 Reproductive 2 R51 T R48/23 Xi R36/37/38 R42/43 N R51-53 S23, S26, S28, S 36/37/38, S38, S53, S45, S60, S61

Table 26 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS.

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Table 134. Zinidal Aero Hazardous Solution Components According to GHS Classifications

Component & Concentration Range in the Mixture	CAS Number	Hazardous Classifications According to 67/548/EEC (updated by CLP adaptations)		Hazardous Classifications According to Regulation EC No. 1272/2009 & 2008 (CLP and adaptations)	
Zinc Chloride	7646-85-7	No data	Xn; R22 C; R34 N; R50-53	Acute Toxicity 4 Skin Corrosivity 1B Eye Irritant 2 STOT SE 3 Aquatic Acute 1 Aquatic Chronic 1	H302 H314 H319 H335 H400 H410
Nickel Dichloride 1-5%	7718-54-9	Carcinogen 1 R49 Mutagen 2 R68 Reproductive 2 R61 T R23/25-48/23 Xi R38 R42/43 N R50-53	T, N T49-61-23/25-38-42/43-48/23-68-50/53; S53-45-60-61	Carcinogen 1A Mutagen 2 Reproductive. 1B Acute Toxicity 3* Acute Toxicity 3* STOT RE 1 Skin Irritant 2 Respiratory Sensitivity 1 Skin Sensitivity. 1 Aquatic Acute 1 Aquatic Chronic 1	H350i H341 H360D*** H331 H301 H372** H315 H334 H317 H400 H410
NH_3…% <10%	1336-21-6	C R34 N R50	C,N R34-50; S(1/2-) 26-36/37/39-45-61	Skin Corrosivity. 1B Aquatic Acute 1	H314 H400

Additional substances are present in the Zinidal Aero solution that are lower than the minimal level of danger, as noted on the SDS. This further demonstrates the less toxic nature of the solution and potential areas of concern.

Table 27 details the chemical properties of the Zinidal Aero solution per the SDS that was provided by the manufacturer.

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Table 135. Zinidal Aero Solution Properties

Property	Value
Appearance	Blue liquid
Odor	NH_3
Relative Density	1.25
Solubility	Limited in water; precipitates metal hydroxides
Boiling Point	Approximately 100°C
Crystallization/Melting Point	Less than -10°C
Flammability	None
Oxidizing Properties	None
Zn-Ni content	100 g/L (for non-used solution)
pH	8.6 -9.0

Table 28 includes control parameters for the solution components per OSHA, the ACGIH, and NIOSH.

Table 136. Zinidal Aero Control Parameter Limits of Solution Components

Component	CAS Number	OSHA PEL (TWA)	ACGIH TWA	ACGIH STEL	NIOSH TWA
Zinc chloride	7646-85-7	1 mg/m^3	1 mg/m^3	2 mg/m^3	-
Nickel dichloride	7718-54-9	1.0 mg/m^3	0.1 mg/m^3 TLV	-	0.015 mg/m^3
NH_3	1336-21-6	18 mg/m^3 (25 ppm)	18 mg/m^3 TLV (25 ppm)	35 ppm	18 mg/m^3

Zinidal Aero (Code 11040) solution components are detailed in Table 29 in terms of NIOSH and OSHA hazard classifications per the product's SDS. Classifications marked with a dash are not defined on the SDS, as these compounds do not present significant hazards in terms of these limits.

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Due to the closed-loop process of the Dalistick, promotion of air contaminants is low during use, with the exception of manual cleaning and changing electrolytes from tanks. Ideally, an exhaust pipe would be placed approximately 30 centimeters (cm) from the treated area with an inside speed of 7 to 10 meters per second (m/s) of air to provide acceptable air contaminant levels (correlating to 0.5 to 1.0 m/s of air at the surface area). This preventive methodology normalizes any risk of exceeding air contaminant limits for the operator during plating.

Table 137. Zinidal Aero Solution Component Hazard Analysis per NIOSH and OSHA Exposure Limits in Air

Component	NIOSH		OSHA	
	LV 8 hour (mg/m^3)	LV 15 min (mg/m^3)	LV 8 hour (mg/m^3)	LV 15 min (mg/m^3)
Zinc Chloride[61]	1	2	1	-
Zinc Inorganic Compounds	-	-	-	-
Nickel Inorganic Compounds (Water Soluble)	0.015	-	35	-
Ammonia (NH_3)	18	27	1	-

LV = limit value

4.4.2 EH&S Considerations

EH&S considerations are detailed in this section per the details on the Zinidal Aero solution manufacturer's SDS. EH&S processes are detailed in terms of PPE, handling and storage, stability and reactivity, toxicological information, ecological information, disposal considerations, transport information, regulatory information, first aid measures, firefighting measures, and accidental release measures.

PPE

The PPE recommendations per the Zinidal Aero solution SDS include the following guidelines:

- Provide an effective laboratory ventilation system[62].
- Provide gloves to be worn by operator(s)[63].
- Provide safety goggles with lateral protection or a facial screen to be worn by operator(s). Operator(s) should not wear contact lenses while operating system.
- Provide overalls and safety shoes to be worn by operator(s).

[61] EH&S hazards are detailed for this components as fume respirable dust.
[62] A fume hood is not necessary for the closed-loop brush plating process. If ventilation system in work room is insufficient, the operator can wear a filtering FFP3 mask (EN 149; 2009 standard).
[63] Glove material can be neoprene, latex, or polyvinyl chloride (PVC).

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- Provide an eye basin near the workstation.
- Provide a shower, powerful tap, and sink unit near workstation.
- In the case of large quantities, provide breathing mask for emergency interventions.

Handling and Storage

The Zinidal Aero solution should be used as it is supplied. The solution should be stored in original containers constructed of polyethylene. Per manufacturer directions, solution containers should be closed tightly after use with the original cap. Solution containers should not be re-used to store other solutions. Operators should not drink, eat, or smoke near the workstation or solution.

Solution containers should be stored on a spill-containing vat in a laboratory setting and maintained in an area between 5° and 30°C as well as away from direct sunlight. The solution should be kept away from strong acids, powerful mineral or oxidizing agents, strong bases, and products reactive with NH_3 gas (i.e. salts of Au and Ag, mercury, calcium, and halogen derivatives). The maximum recommended shelf life is three years from the manufacturer's date under normal storage conditions.

Stability and Reactivity

The solution is stable at room temperature. Minimal evaporation of water and NH_3 occurs above 30°C. The manufacturer suggests temperatures above 40°C be avoided. Strong acids and bases should also be avoided due to neutralization and emission of NH_3 gas, respectively. Possibly hazardous thermal decomposition products include emission of NH_3, nitrogen oxides, sulfur oxides, zinc oxide, and nickel oxides.

Toxicological Information

The solution components nickel chloride and NH_3 present acute toxicity concerns, as detailed in Table 30. It is noted that no specific toxicology information for the mixture was available from the manufacturer; however, concerns are low due the low levels associated with the individual components.

Table 138. Toxicity of Zinidal Aero

Toxic Component	Toxicity	
	LD50 Oral (rat)	LC50 Inhalation (rat, 2 hour)
Nickel Chloride	105-680 mg/kg	-
NH_3	350 mg/kg	7600 mg/m^3

The health hazards linked to the Zinidal Aero solution were evaluated based on applicable regulations and bibliographic data from the product SDS. The mixture is known to be an irritant to skin, eyes, and the respiratory system. Nickel salts and quarternary ammonium salts are

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allergens and may cause the appearance of recurring eczema in some occurrences of exposure. In the case of eye exposure, immediate decontamination with water should be realized to prevent serious damage. These compounds are toxic in the case of prolonged exposure via inhalation and can cause cancer. The risk of cancer depends on the length and level of exposure. The nickel salts present in the solution may cause sensitization by inhalation such as asthma or asthmatic dyspnea. Issues may appear immediately or after several hours of exposure and usually disappear quickly in the absence of exposure. Symptoms of ingestions include headache, asthenia (abnormal physical weakness), nausea, digestive system disorders with vomiting and diarrhea, and tachycardia, and immediate medical attention should be obtained.

Ecological Information

Currently, no ecological data on the solution mixture exists; however, the concentrations of various substances in solution are sufficient to classify the solution mixture as "N – Dangerous for the Environment" with the EU R51-53 label. The Zinidal Aero solution SDS recommends that it be prevented from entering drains, waterways, or soil. Bibliographic data for NH_3 compounds, zinc salts, and nickel chloride are described in this section to represent the compounds of the mixture. Ecotoxicity of NH_3 and its solutions include:

- LC50 fish (96 hours): 0.16-4.6 mg/L
- EC50 Daphnia Magna (anhydrous, 48 hours): 24-101 mg/L

Toxicity of ammonium ions is much lower. NH_3 has a low bioaccumulation potential and is soluble in water. Soil adsorbs the NH_3 compound and microorganisms quickly oxidize NH_3 to form the nitrate ion. In water, NH_3 can be nitrified by microorganisms or adsorbed by sediments and colloids. Ecotoxicity of zinc compounds presents little to no information; however, available data on other zinc compounds indicate that such compounds should be considered highly toxic for aquatic environments. Nickel chloride is considered to be acute and chronic ecotoxicity. Ecotoxicity values for nickel chloride include:

- C50 fish (96 hours): 3.1-350 mg/L (with a median of 20.9 mg/L across 44 studies)
- LC50 crustaceans (48 hours): 0.013-160 mg/L (with a median of 6.89 mg/L across 30 studies)
- EC50 crustaceans (48 hours): 6.56 mg/L
- EC50 algae: 0.66 mg/L.
-

No observed effect concentrations (NOECs) for fish (specifically, rainbow trout) is 0.06-0.24 milligrams of Ni per liter (mg Ni/L) and Daphnia Magna is 0.01-0.22 mg Ni/L. Bioconcentration of Ni is small in the different tested aquatic species and would not apparently bio-intensify along the trophic chain. In acidic soils, soluble nickel compounds should be classified as toxic to plants. This toxicity depends on the bioavailability of nickel ions, which is low in soils having a pH higher than 5.5.

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Disposal Considerations

According to the manufacturer's SDS, the Zinidal Aero solution and any water used for rinsing should not be disposed of in sinks or drains due to pH and metal content. The solution and respective rinse water should be disposed of as hazardous waste according to facility guidelines for pH value and metal content. Additionally, contaminated solution packaging if not re-used with the same product should be considered as solid hazardous waste to be disposed of according to facility guidelines.

Transport Information

Proper shipping labels for the solution per United Nations regulations include "toxic liquid" and "inorganic." Transport hazard classes include 6.1 subsidiary risk – not applicable, marine pollutant. Environmental hazards include toxic to aquatic life with long lasting effects. Shipping information should include special precautions in case of accident (including wearing eye protection, gloves, protective clothing, and a protective breathing mask (K2P3 cartridge) for emergency interventions in case of emission of gas/fumes/vapor/spray. It is recommended that transport should be in small quantities only.

Regulatory Information

Product labeling has been established for the Zinidal Aero solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. Restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles (annex XVII of REACH up to commission regulation EC No. 474/2014 of May 8, 2014 (OJ L136 dated 09.05.2014) include the following.

- Nickel shall not be used in articles intended to come into direct and prolonged contact with the skin if the rate of nickel release from them is greater than 0.5 micrograms per square centimeter per week (μg/cm^2/week). It can be allowed if it is covered with an efficient coating permitting to be below this limit for a period of at least 2 years of normal use of the article. The rate of nickel release is lowered to 0.2 μg/cm^2/week in the case of articles inserted into the human body.
- Products classified as carcinogen, mutagen, or toxic to reproduction of categories 1 or 2 (substances or mixtures) shall not be supplied to the general public. The packaging should be marked "Restricted to Professional Users."

It is noted that a chemical safety assessment and a chemical safety report (per the EU REACH) have not been performed for this mixture because the solution is not produced at a quantity greater than 10 tons per year nor used at a quantity greater than 1 ton per year.

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First Aid Measures

Recommended first aid measures from the manufacturer of the Zinidal Aero solution are included in Table 31. Additionally, first aid responders should wear gloves and goggles, as well as protective clothing/shoes according to the situation.

Table 139. First Aid Measures According to Contact/Exposure Route

Contact/ Exposure Route	First Aid Measure
Skin	Take off contaminated clothing and shoes. Wash immediately with plenty of water and soap. Take shower if needed.
Eyes	Rinse **immediately** with plenty of water for approximately 15 minutes. Call an ophthalmologist.
Inhalation	Under abnormal conditions of use causing considerable inhalation, remove the casualty from the contaminated area, let him take a rest in a well-ventilated room and seek medical advice. Transfer to hospital for a medical supervision and start of a symptomatic treatment.
Ingestion	In case of a little absorption only, give water to drink. See a doctor for pain, nausea or vomiting. In case of a significant ingestion, do not give anything to drink and do not attempt to induce vomiting. Call the medical service for an immediate transfer to hospital.

Firefighting Measures

Suitable extinguishing media is dry ice for metal fires. Water should be avoided for extinguishing media. Containers exposed near the first should be cooled with water.

Accidental Release Measures

Potential exposure in non-emergency and emergency situations should be avoided by wearing the proper PPE at all times when working with the Zinidal Aero solution. In the case of vapors or sprays, a protective respiratory mask with a K2P3 cartridge should be worn. All contaminated items should be washed with water and disposed of properly.

To clean up non-recoverable solution, the recommended process includ es washing the area with a slightly acidic or slightly alkaline product to remove zinc hydroxide and prevent any development of white corrosion products. Collect any recoverable rinsing water for proper disposal through sites waste system.

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4.4.3 Deposited Alloy Properties

When coupled with a Cr^{6+} passivation[64], the deposited alloy provides sacrificial corrosion and high protection of steels with an average coating thickness of 8 µm. The protection of the 8 µm thick deposited Zn-Ni coating is approximately 20% greater than that of Zn[65].

In a neutral salt spray environment, unpassivated Zn-Ni alloy coating provides approximately 1½ to 2 times greater protection than Zn at the same thickness. Protection time increases with increased thickness. With 8-µm thickness, the first rust pit appears between 100 to 200 hours depending on the part substrate and geometry. Specifically, with 1018 steel and a 12-13-µm deposited Zn-Ni coating, the first rust pit appears after 500 hours.

An 8-µm-thick deposited coating on mild steel passivated with Cr^{6+} No. 3 solution by dipping for 6 to 8 seconds realizes traces of white, oxidized corrosion compounds in the first hours subjected to a neutral salt spray. No increased corrosion is observed after 200 to 300 hours of exposure. First rust pits appear beyond 1000 hours with; however, a thermal treatment at 120°C for 1 hour before the salt spray test causes corrosion products to develop after 1000 hours.

4.5 Passivator No.3 Technical Data

This section describes the EH&S data for the Dalic Passivator No. 3 solution.

4.5.1 Passivator No. 3 Components, Properties, and Control Parameters

Passivator No.3 was assessed in terms of health effects and hazard regulations. Table 32 details the hazardous components according to the GHS H-Statements for Classification and Labeling of Chemicals.

[64] According to corrosion requirements, 4 µm to 6 µm thick coating may be sufficient.
[65] 50 g/L in sodium chloride (NaCl).

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Table 140. Passivator No.3 Hazards Classifications

Component	CAS Number	Hazardous Classifications According to EC Regulation & Label Elements
Passivator No.3	N/A (Solution Mixture)	Carcinogen Category 1, R45 Mutagen Category 2, R46 T R23 Xn 48/20-42 Xi R36/37/38 R52/23

Table 33 details components or impurities contributing to hazards according to the GHS Classifications as detailed on the SDS.

Table 141. Passivator No. 3 Hazardous Solution Components According to GHS Classifications

Component & Concentration Range in the Mixture	CAS Number	Hazardous Classifications According to 67/548/EEC (updated by CLP adaptations)		Hazardous Classifications According to Regulation EC No. 1272/2009 & 2008 (CLP and adaptations)	
		Classification	Labeling		
Chromium (VI) trioxide <2.5%	1333-82-0	O R9 Carcinogen R45 Mutagen 2 R46 Reproductive 3 R62 T+ R26 T R24/25-48/23 C R35 R42/43 N R50-53	O,T+,N R45-46-9-24/25-26-35-42/43-48/23-62-50/53; S53-45-60-61	Ox. Sol. 1 Carcinogen 1A Mutagen 1B Reproductive 2 Acute Toxicity 2 Acute Toxicity 3 STOT RE 1 Skin Corrosivity 1A Respiratory Sensitivity 1 Skin Sensitivity 1 Aquatic Acute 1 Aquatic Chronic 1	H271 H350 H340 H361 H330 H311 H301 H372 H314 H334 H317 H400 H410

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No additional substances are present in the Passivator No. 3 solution that are lower than the minimal level of danger, as noted on the SDS. The Passivator No. 3 solution does contain not regulated salts.

Table 34 details the chemical properties of the Passivator No.3 solution per the SDS.

Table 142. Passivator No. 3 Solution Properties

Property	Value
Appearance	Orange red liquid
Odor	Odorless
pH	<1
Crystallization/Melting Point	-8°C
Boiling Point	Approximately 100°C
Flammability	No
Oxidizing Properties	No
Risk of Explosion and Fire	Risk in case of contact with easily oxidizable materials if the preparation has been accidently dehydrated
Relative Density	1.14 g/L
Water Solubility	Miscible in water in all proportions

Table 35 includes control parameters for the Passivator No. 3 solution components per OSHA, the ACGIH, and the NIOSH.

Table 143. Passivator No. 3 Control Parameter Limits of Solution Components

Component	CAS Number	OSHA PEL (TWA)	NIOSH TWA
Chromium (VI) trioxide <2.5%	1333-82-0	0.05 mg/m^3	0.001 mg/m^3

4.5.2 Passivator No. 3 EH&S Considerations

EH&S considerations are detailed in this section per the details on the Passivator No.3 solution SDS. EH&S processes are detailed in terms of PPE, handling and storage, stability and reactivity, toxicological information, ecological information, regulatory information.

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PPE

The PPE recommendations per Passivator No.3 SDS include the following guidelines:

- Provide a ventilated place; more protection is not mandatory if the product is applied with cotton or by soaking in a small volume of solution.
- Provide gloves to be worn by operator(s), preferably of PVC, neoprene, and possibly nitrile or latex).
- Provide safety goggles with lateral protection or a facial screen to be worn by operator(s). Operator(s) should not wear contact lenses while operating system.
- Provide overalls and safety shoes to be worn by operator(s)
- Provide an eye basin near the workstation.
- Provide a shower, powerful tap, and sink unit near workstation.

Handling and Storage

The Passivator No. 3 solution should be used as it is supplied. The solution should be stored in original containers constructed of polyethylene. Per manufacturer directions, solution containers should be closed tightly after use with the original cap. Solution containers should not be re-used to store other solutions. Observe a very strict cutaneous hygiene and change clothes after work, especially before eating.

Solution containers should be stored on a spill-containing vat in a laboratory setting and maintained in an area between 5° and 30°C as well as away from direct sunlight. The solution should be kept away from alkaline, reducing, or combustible products. The maximum recommended shelf life is three years from the manufacturer's date under normal storage conditions.

Stability and Reactivity

The Passivator No. 3 solution is stable at ambient temperature, as water evaporation is the only storage risk. The manufacturer suggests temperatures above 200°C be avoided. Contact with alkaline, reducing, or combustible products should also be avoided. Possible hazardous thermal decomposition products include chromium oxides and oxygen above 200°C.

Toxicological Information

Chromium trioxide presents acute toxicity detailed in Table 36 as detailed in the SDS for Passivator No. 3.

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Table 144. Toxicity of Passivator No. 3

Toxic Component	Toxicity			
	LD50 Oral (rat)	LC50 Oral (mouse)	LD50 Inhalation (rat, 4 hour)	LD50 Skin (rabbit or guinea pig)
Sulfuric Acid	52-113 mg/kg	135-175 mg/kg	217 mg/m^3	57 mg/kg

No specific toxicology information for the mixture Passivator No. 3 was available from the manufacturer.

Health hazards linked to the Passivator No. 3 solution were evaluated based on applicable regulations and bibliographic data from the SDS. The mixture is irritating to the skin, eyes, and respiratory system (as well as toxic). Soluble Cr^{6+} can enter the body by all routes, primarily respiratory in an industrial environment. Cr^{6+} is distributed mainly in the liver, kidneys, spleen, and lungs. Cr^{6+} is quickly reduced to trivalent chromium (Cr^{3+}) in the cells of all tissues. Excretion is mainly urinary (>80%). Chromium trioxide is classified as a carcinogen of the 1st category (i.e. known to have carcinogenic potential for humans if no protection is provided), as a mutagen of the 2nd category (i.e. presumed to have such effects for humans without protection, classification largely based on animal evidence), and as toxic for reproduction of the 3rd category (i.e. there is some suspicion because of some positive studies on animals).

Ecological Information

Ecotoxicity of chromium trioxide include the following:

- LC50 fish (96 hours): 21 – 60 mg/L
- LC50 crustaceans (48 hours): 0.162 - 100mg/L

Cr^{6+} can be reduced to Cr^{3+} in water by organic matter, and Cr^{3+} will settle in the sediments. Bioaccumulation of Cr^{6+} from soil to above ground parts of plants is unlikely.

Regulatory Information

Product labeling has been established for the Passivator No. 3 solution according to EC regulation No. 1272/2006 of December 16, 2006 (CLP regulation, OJ L353 of 31.12.2008), its adaptations up to commission regulation No. 605/2014 of June 5 2014 (OJ L167 of 0.6.06.2014) and with the 1999/45/EC directive reviewed in January 23, 2006 by the directive 2006/8/EC. Chromium trioxide is subject to authorization per annex XIV of REACH 31, and ECHA's consolidated list of 16.06.2014, 155 substances, and has restrictions on the manufacturing, placing on the market, and use of certain dangerous substances, mixtures, and articles (annex XVII of REACH up to commission regulation EC No. 474/2014 of May 8, 2014 (OJ L136 dated 09.05.2014):

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- Products classified as carcinogen, mutagen, or toxic to reproduction of categories 1 or 2 (substances or mixtures) shall not be supplied to the general public. The packaging should be marked "Restricted to Professional Users."

5.0 IHRA for Baseline and Alternative Plating Solutions

5.1 SIFCO 23023 IHRA for Solution Components

The hazardous solution components detailed of the SIFCO 2023 solution included:

- Cadmium sulfate
- Ethylenediamine

These components will be assessed for the IHRA of the baseline Cd traditional brush plating solution.

5.1.1 Cadmium Sulfate

Cadmium sulfate (CAS No. 10124-36-4) is a known irritant to the eyes, skin, and respiratory system. Cadmium sulfate is considered a carcinogen as determined by International Agency for Research on Cancer (IARC), ACGIH, the National Toxicology Program (NTP), and the OSHA, and chronic exposure may cause lung and prostate cancer[66]. Information for acute toxicity of cadmium sulfate includes: LD50 oral rat: 280 mg/kg. In terms of ecological information, cadmium sulfate demonstrates toxicity to fish at LC50 (90 hours) 0.2 mg/L and toxicity to daphnia and other aquatic invertebrates (48 hours) at 0.15 mg/L.

Cadmium sulfate is an inorganic compound that forms toxic fumes of cadmium oxide when heated[67]. Exposure to cadmium sulfate causes damage to the lungs resulting in shortness of breath, chest pain, and pulmonary edema. Exposure can also cause damage to the kidneys and decreased renal function.

[66] ***"Safety Data Sheet Cadmium Sulphate Solution."*** Sigma Aldrich. <http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=US&language=en&productNumber=318620&brand=FLUKA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3D1336-21-6%26interface%3DCAS%2520No.%26N%3D0%2B%26mode%3Dpartialmax%26lang%3Den%26region%3DUS%26focus%3Dproduct>. Accessed 27 August 2015.

[67] ***"Cadmium Sulfate."*** PubChem. < http://pubchem.ncbi.nlm.nih.gov/compound/Cadmium_sulfate#section=Top>. Accessed 27 August 2015.

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5.1.2 Ethylenediamine

Ethylenediamine (CAS No. 107-15-3) is a known irritant to the eyes, skin, and respiratory system[68]. This component is not considered a carcinogen as determined by IARC, ACGIH, NTP, and OSHA. Information for acute toxicity of ethylenediamine includes: LD50 oral rat: 1,200 mg/kg, LC50 inhalation rat (4 hour) 14.7 mg/L, and LD50 Dermal rabbit 560 mg/kg. In terms of ecological information, ethylenediamine demonstrates toxicity to pimephales promelas fish at LC50 (90 hours) 115.7 mg/L and toxicity to daphnia and other aquatic invertebrates (48 hours) at 3 mg/L.

Ethylenediamine is a common organic solvent that can form toxic nitrogen oxides during combustion. Ethylenediamine demonstrates a danger of cutaneous absorption, i.e. rapid absorption exposure through unbroken skin[14].

5.2 Zinidal Aero IHRA for Solution Components

The hazardous solution components detailed of the Zinidal Aero solution included:

- Zinc Chloride
- Zn Inorganic Compounds
- Ni Inorganic Compounds
- NH_3.

For the purpose of this IHRA, the individual components selected for analysis included zinc, nickel dichloride, inorganic Ni, and NH_3.

5.2.1.1 Zinc

Zinc chloride solution can cause severe skin burns and eye damage and is a known eye and respiratory irritant. It is, however, not classified as a known mutagen, carcinogen, or reproductive toxin. Some tests conducted with animals have indicated potential for embryotoxic activity[69]. Toxic effects described in animals include corrosion of mucosal surfaces, liver effects, and kidney effects[8]. Toxic effects in animals with only inhalation exposure include lower respiratory irritation with pulmonary edema[8].

Acute toxicity of zinc chloride liquid solution[8]:

- ATE oral 500.000 mg/kg body weight
- LD50 Oral Rat: 350 mg/kg.

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[68] ***"Safety Data Sheet Ethylenediamine."*** Sigma Aldrich. < http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=US&language=en&productNumber=E26266&brand=SIAL&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Fsial%2Fe26266%3Flang%3Den>. Accessed 27 August 2015.

[69] ***"Zinc Chloride Solution Safety Data Sheet."*** http://www.zaclon.com/pdf/zinc_chloride_soln_tech_grade_625_msds.pdf. Accessed 28 May 2015.

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In terms of ecological information, no data are available for persistence and degradability or mobility in soil. The bioaccumulation potential in terms of BCF fish 1 is 16000[8]. Transport label for "Corrosive" is required according to the U.S. Department of Transportation (DOT).

In general, Zn is a common element and can enter the body through the digestive tract (via ingestion) or lungs (via inhalation of Zn dust of fumes)[70]. Zn exposure via skin absorption is low[9]. There exists a low risk for zinc chloride fuming to occur because the Zinidal Aero electrolyte solution is not heated during the Dalistick process, and the specifics for this hazard are not presented in this IHRA. High levels of Zn in the human body can have adverse health effects dependent upon the dose, duration, exposure route, personal traits and habits, and the presence of other chemicals. Symptoms may occur such as stomach cramps, skin irritation, vomiting, nausea, anemia and even flu-like symptoms[71]. Extensive exposure to zinc chloride can cause respiratory disorders[10].

5.2.1.2 Nickel

Ni compounds present in the solution are in a soluble state. These compounds are largely eliminated from the solution during the brush plating process as the Ni is plated onto the surface. Solid Ni particles are eliminated after several weeks or years (in the case of machining). Water soluble nickel chloride is classified as a carcinogen by inhalation. Nickel chloride is also a known mutagen and a reproductive toxin as soluble Ni can cross the placenta barrier, as noted in the Zinidal Aero SDS.

Nickel dichloride solution (CAS No. 7718-54-9) is a known irritant to the eyes, skin, and respiratory system[72]. Nickel dichloride is labeled as a carcinogen by the EC per GHS-US classifications via inhalation. The carcinogen 1A classification per GHS-US classifications defines the compound as a known or presumed human carcinogen on the basis of epidemiological and/or animal data. Nickel dichloride is considered a carcinogen because of its potential to cause cancer via inhalation, which indicates that the compound is not a known carcinogen via other pathways, e.g. skin absorption. Operators using the Zinidal Aero solution can protect themselves against this risk by always wearing the proper PPE. NIOSH has concluded that certain nickel compounds are potential occupational carcinogens as defined by the OSHA carcinogen policy[73]. Nickel and certain nickel compounds, including nickel powder, nickel carbonyl, nickel oxide, and nickel carbonate are listed as carcinogens by the NTP and the IARC.

Information for acute toxicity of nickel dichloride liquid solution includes: LD50 oral rat: 681 mg/kg. In terms of ecological information, no data are available for persistence and degradability,

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[70] ***"Toxic Substances Portal – Zinc."*** <http://www.atsdr.cdc.gov/phs/phs.asp?id=300&tid=54>. Accessed 28 May 2015.
[71] ***"Zinc-Zn."*** Lenntech. <http://www.lenntech.com/periodic/elements/zn.htm>. Accessed 28 May 2015.
[72] ***"Material Safety Data Sheet Liquid Nickel Chloride."*** Atotech. <http://www.hillbrothers.com/msds/pdf/n/nickel-chloride-liquid.pdf>. Accessed 28 May 2015.
[73] ***"NIOSH: Nickel metal and other compounds (as Ni)."*** CDC. <http://www.cdc.gov/niosh/idlh/7440020.html>. Accessed 10 June 2015.

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mobility in soil, or bioaccumulation potential[74]. It is noted that this component is not labeled as dangerous goods by the U.S. DOT.

5.2.1.3 Ammonia

NH_3 (CAS No. 1336-21-6) is a known irritant to the eyes, skin, and respiratory system. This component is not considered a carcinogen as determined by IARC, ACGIH, NTP, and OSHA[75]. Information for acute toxicity of NH_3 solution includes[76]: LD50 oral rat: 350 mg/kg. In terms of ecological information, no data is available for persistence and degradability, mobility in soil, or bioaccumulation potential[13]. This component is not labeled as dangerous goods by the U.S. DOT.

NH_3 is a common chemical. Common industrial exposure routes to NH_3 are through inhalation of NH_3 gas or vapor[77]. Exposure to high concentrations of NH_3 can cause immediate burning of the nose, throat, and respiratory tract, which can cause bronchiolar and alveolar edema and airway destruction resulting in respiratory distress of failure.

6.0 CONCLUSIONS

The alternative Zinidal Aero solution demonstrates a low risk from an EH&S perspective, as documented within this IHRA and compared to the baseline Cd traditional brush plating solution. Table 37 compares the hazard information of the baseline and alternative plating solutions.

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[74] ***"Safety Data Sheet Nickel Atomic Spectroscopy Standard Concentrate."*** Sigma Aldrich. <http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=US&language=en&productNumber=03369&brand=FLUKA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3D7718-54-9%26interface%3DCAS%2520No.%26N%3D0%26mode%3Dmatch%2520partialmax%26lang%3Den%26region%3DUS%26focus%3Dproduct>. Accessed 28 May 2015.

[75] ***"Safety Data Sheet Ammonium Hydroxide Solution."*** Sigma Aldrich. <http://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=US&language=en&productNumber=318620&brand=FLUKA&PageToGoToURL=http%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fsearch%3Fterm%3D1336-21-6%26interface%3DCAS%2520No.%26N%3D0%2B%26mode%3Dpartialmax%26lang%3Den%26region%3DUS%26focus%3Dproduct>. Accessed 28 May 2015.

[76] ***"Material Safety Data Sheet Aqua Ammonia."*** Hill Brothers Chemical Company. <http://www.hillbrothers.com/msds/pdf/Aqua-10.pdf>. Accessed 28 May 2015.

[77] ***"The Facts About Ammonia."*** New York State Department of Health. <https://www.health.ny.gov/environmental/emergency/chemical_terrorism/ammonia_tech.htm>. Accessed 28 May 2015.

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Table 145. Hazard Comparison between SIFCO 2023 and Zinidal Aero Solutions

Solution	Hazard Information
SIFCO 2023	Toxic by inhalation or swallowing. Vapors may irritate throat and respiratory system. Ingestion may cause severe internal injury. Skin contact causes burns and sensitization. Eye contact causes burns and poses risk of serious damage to eye. Gas or vapor is harmful from prolonged exposure or in high concentrations. Known carcinogen for humans. Prolonged or repeated exposure may cause damage to skin, eyes, respiratory system, and teeth. May cause severe and delayed health effects such as inflammation of the lungs and chemical bronchitis. May increase possibility of prostate cancer.
Zinidal Aero Solution	Irritant to skin, eyes, and respiratory system. May cause cancer by inhalation. Possible risk of irreversible effects due to mutagenicity. Reproductive toxin; may cause adverse effects to unborn child. Toxic; danger of serious damage to health by prolonged exposure through inhalation Irritating to eyes, respiratory system, and skin. May cause sensitization by inhalation and skin contact.

SIFCO 2023 contains cadmium sulfate, which is considered a carcinogen as determined by IARC, ACGIH, NTP, and OSHA, and, as previously noted, chronic exposure may cause lung and prostate cancer, as well as kidney disease. EO 13693, "Planning for Federal Sustainability in the Next Decade," dated 19 March 2015, requires the reduction or minimizing the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of in support of advancing waste prevention and pollution prevention. The replacement of Cd electroplating, otherwise known as plating, promotes the reduction of toxic and hazardous chemicals and materials.

Nickel dichloride is the only component in the Zinidal Aero solution that presents a risk as a carcinogen as determined by NIOSH. The risk of cancer depends on the length and level of exposure. Nickel chloride is also a known mutagen and a reproductive toxin as soluble Ni can cross the placenta barrier. The only hazard presented by zinc chloride and NH_3 is potential for irritation to the skin, eyes, and respiratory system. Nickel chloride is also an irritant to the skin, eyes, and respiratory system.

During transfer of the chemical from the solution container to the Dalistick, potential exposure routes are relevant. Operators should always wear proper PPE, including gloves, safety glasses, and laboratory clothing, such as overalls or laboratory coats and safety shoes. While possible, the EH&S risks during transfer are also considered low and offer a better situation than that of Cd.

No key issues were determined in terms of ecotoxicity or toxicity of the solution or the solution components for Zinidal Aero. United Nations proper shipping labels include toxic liquid and inorganic. The Zinidal Aero solution is recommended to be labeled as hazardous waste and disposed of according to facility guidelines.

With the use of proper PPE and the closed-loop Dalistick, the Zinidal Aero solution is a less hazardous alternative to Cd brush plating. The Zinidal Aero solution should be accompanied by an updated SDS at all times to ensure chemical updates are assessed for changes to safe operating procedures for the solution.

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Appendix AA
Hazard Abbreviations, Phrase, and Statements Definition

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Phrase	Definition
Xn	Harmful
C	Corrosive
N	Dangerous for the environment
T	Toxic
S	Safety
Xi	Irritant
R22	Harmful if swallowed
R23	Toxic by inhalation
R23/25	Toxic by inhalation and if swallowed
R34	Causes burns
R 36/37/38	Irritating to eyes, respiratory system, and skin.
R38	Irritating to skin
R42/43	May cause sensitization by inhalation and skin contact
R45	May cause cancer
R46	May cause heritable genetic damage
R48/23	Toxic; danger of serious damage to health by prolonged exposure through inhalation
R49	May cause cancer by inhalation
R50	Very toxic to aquatic organisms
R50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment
R68	Possible risk of irreversible effects
R61	May cause harm to the unborn child
S1/2	Keep locked up and out of reach of children
S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice
S36/37/39	Wear suitable protective clothing, gloves, and eye/face protection
S45	In case of accident or if you feel unwell, seek medical advice immediately
S53	Avoid exposure – obtain special instructions before use
S60	This material and its container must be disposed of as hazardous waste
S61	Avoid release to the environment.
H225	Highly flammable liquid and vapor
H226	Flammable liquid and vapor
H271	May cause fire or explosion; strong oxidizer
H301	Toxic if swallowed
H302	Harmful is swallowed
H311	Toxic in contact with skin
H312	Harmful in contact with skin
H314	Causes severe skin burns
H315	Causes skin irritation
H317	May cause an allergic skin reaction
H318	Causes serious eye damage
H319	Causes serious eye irritation
H330	Fatal if inhaled
H331	Toxic if inhaled
H332	Harmful if inhaled
H334	May cause allergy of asthma symptoms or breathing difficulties if inhaled
H335	May cause respiratory irritation
H336	May cause drowsiness or dizziness
H340	May cause genetic defects
H341	Suspected of causing genetic defects
H350i	May cause cancer by inhalation
H360D	May cause damage to unborn child
H360FD	May cause damage to fertility
H361	Suspected of damaging fertility or the unborn child
H372	Causes damage to organs through prolonged or repeated exposure
H400	Very toxic to aquatic life
H410	Very toxic to aquatic life with long lasting effects
H411	Toxic to aquatic life with long lasting effects

Appendix G : Station Validation Results Summary

WP-201412 Cadmium-Free Alternatives to Brush Plating Repair Operations

Chris Venturella: The University of Dayton Research Institute (UDRI)

29-Apr-17

1. Replacement Station Validation

The replacement Dalistick 2020 station operability was validated. The following tests were used to determine if the station was plating specimens properly. Table 4 summarizes the results

- Zinc and nickel composition
- Bend Adhesion
- Thickness
- Appearance

Table 4: Replacement Station Validation Summary

Zinc and nickel composition	The testing was performed after Dalistick station replacement, compositions of the new machine are comparable to the previous machine
Bend Adhesion	No flaking or peeling of the coating was observed, which indicated good adhesion
Thickness	The average coating thickness is approximately 1 micron thinner than the coatings plated with Dalistick 2020 station used for the screening testing. This still meets the thickness required in MIL-STD-865D
Appearance	All plated specimens were free from visual defects that could impact the performance of the coating

1.1. Station Validation Composition Results

Three 1008 steel specimens and three 4130 steel specimens were plated with the Zinidal Aero Zn-Ni plating. The specimens were examined by X-ray Fluorescence (XRF). The iron Kα, nickel Kα, and zinc Kα peaks in the XRF spectra were integrated to compare their relative signal intensities. When the spectra were compared, they found the nickel-to-zinc areas were consistent. These ratios of 0.22 and 0.23 also matched all of the ratios from the earlier screening testing. This indicates the compositions of the new machine are comparable to the previous machine and testing. Table 3 summarizes the spectra data. Figures 11 and 12 show the overlaid spectra for each substrate. It should be noted that Iron (Fe) is seen on the spectra overlays because the XRF beam travels through though coating and detects iron in the underlying steel substrate.

Table 3: Spectra Data for Zinidal Zn-Ni Plating

Designation	Ni Area	Zn Area	Ni/Zn
1008 - 1	468.9	2020.0	0.23
1008 - 2	449.0	2006.5	0.22
1008 - 3	428.5	1926.0	0.22
4130 - 1	414.1	1880.1	0.22
4130 - 2	466.5	2071.8	0.23
4130 - 3	479.2	2085.2	0.23

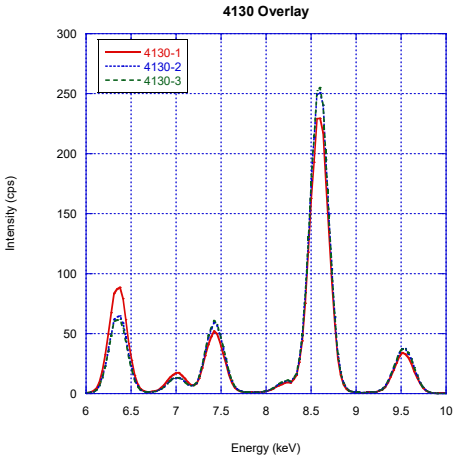

Figure 11: Overlay of 4130 Sample Plated Area XRF Spectra

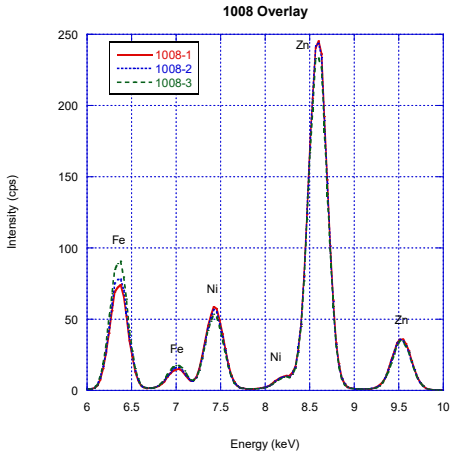

Figure 12: Overlay of 1008 Sample Plated Area XRF Spectra

1.2. Station Validation Bend Adhesion Results

Three 1008 steel specimens and three 4130 steel specimens were plated with the Zinidal Aero Zn-Ni plating. They were bent between 90 degrees and 180 degrees until broken. The plating was then visually inspected to determine if any flaking or peeling was present under 4x magnification. Crazing is considered acceptable. The specimens passed this adhesion test. Figure 13 shows one of the 4130 steel specimens under the 4X magnification. No flaking or peeling of the coating was observed, which indicated good adhesion.

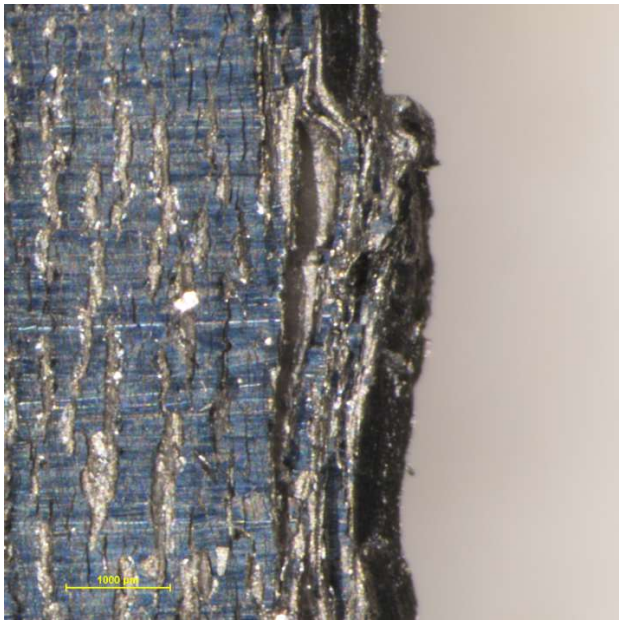

Figure 13: 4130 Bend Adhesion Specimen under 4X Magnification

1.3. Station Validation Thickness and Appearance Testing

All Zinidal Aero Zn-Ni specimens had the thickness measured using a dry film thickness gauge to validate the specimens were of a similar thickness to the specimens plated with the Dalistick 2020 station used for the screening testing. The results of this thickness measurements can be found in Table 4. The average coating thickness is approximately 1 micron thinner than the coatings plated with Dalistick 2020 station used for the screening testing. This still meets the thickness required in MIL-STD-865D. Three additional specimens were plated, and all showed average thicknesses of approximately 12 microns, which matches the average thickness from the screening testing.

Table 4: Thickness Data

Specimen	Thickness 1	Thickness 2	Thickness 3	Thickness 4	Thickness 5	Average
1008-BA-Val-1	10.3	9.2	10.8	10.6	14.5	11.08
1008-BA-Val-2	13.1	8.4	9.3	12.9	10.8	10.9
1008-BA-Val-3	14.3	15.8	9.4	10.6	14.1	12.84
4130-BA-Val 1	9.6	9.3	11.2	10.9	12	10.6
4130-BA-Val 2	14.8	15	10.4	13.8	10.9	12.98
4130-BA-Val 3	12.8	7.8	11	13.9	11.7	11.44
4130-C-Val-1	7.8	12	7.3	11.7	10.5	9.86
4130-C-Val-2	7.3	11.7	9.8	9.7	7.3	9.16
4130-C-Val-3	7.9	7.4	13	10.3	7.9	9.3
1008-C-Val-1	7.13	9.8	10.4	8.1	7.8	8.646
1008-C-Val-2	8.9	8.1	9	7.2	9.4	8.52
1008-C-Val-3	7.9	7.1	12.5	10.9	10.6	9.8

Averge All	Average 1008	Average 4130
10.43	10.30	10.56

The appearance of each specimen was inspected for defects, and none were found. This portion of the validation testing was passed.

2.0 *Conclusion*

The results of the validation tests performed on the replacement Dalistick 2020 station were positive. UDRI resumed plating on 27 Apr 17. All plating information is being recorded and monitored as it was during the screening testing to ensure quality plating throughout the specimen preparation process.

Appendix H : Hydrogen Embrittlement Characterization of No-Bake Brush Plating Zinc-Nickel Processes Report

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FINAL REPORT:

Hydrogen Embrittlement Characterization of No-Bake Brush Plating Zinc-Nickel Processes

For

UDRI – University of Dayton Research Institute

REVISION DATE: 21 October 2019

REVISION LETTER: A

Issue Date: 30 August 2019

Subcontract Number: RSC16119

Prepared By: *Stephen P. Gaydos*

Date: 30 August 2019

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1.0 Executive Summary

Dalistick Zinidal Aero Zinc-Nickel (ZnNi) brush plating material is being qualified to replace Cadmium (Cd) brush plating on high strength steel to be used for touch up repairs on aircraft. This process needs to be non-embrittling because it is performed on high strength steel aircraft parts where hydrogen embrittlement relief baking is also not permitted.

Previous testing performed at AFRL (Air Force Research Laboratory – WPAFB, OH) has shown inconsistent results while testing this zinc-nickel coating for hydrogen embrittlement. The standard ASTM F 519 hydrogen embritlement test is a "Pass" or "Fail" test and does not provide any indication about the failure mechanism. The failure mechanisms due to hydrogen embrittlement needs to be tested for and understood to allow the current Dalistick Zinidal Aero zinc-nickel solution to confidently pass hydrogen embrittlement testing and be optimized. This report describes Phase 1 testing to characterize different brush plate coatings that are currently approved for high strength steel, and compare them with the Zinidal Aero ZnNi to determine why Zinidal Aero inconsistently passes hydrogen embritlement testing. Phase 2 testing was then carried out to execute a Design of Experiment test plan to determine the key factors to optimize the Zinidal Aero ZnNi and make it a non-embrittling process.

For Phase 1, four types of ZnNi brush plate coated specimens were evaluated and compared with brush plate coated cadmium test specimens. The structure and surface morphology of the coated specimens were evaluated by SEM, and other structural analysis techniques, and showed different degrees of crack formation. Cross-sections of the coatings evaluated by transverse cut and FIB (Focused Ion Beam) showed presence of some through thickness cracks, and extensive cracking was observed when using the Zinidal Aero Dalistick process. Using XRD (X-Ray Diffraction), the presence of gamma crystal phase was observed on the ZnNi coatings, and some delta phase was also detected. Hydrogen embrittlement susceptibility tests by ISL (Incremental Step Load) testing had passing results for SIFCO 2023 cadmium and SIFCO 4018 zinc-nickel, while the Zinidal Aero ZnNi coated samples had low or inconsistent passing results. Microstructures of the coatings were observed to be one of the primary reasons for embritlement failure, Cd coatings had some interconnected through thickness micropores while 4018 ZnNi coatings had a large density of inter connected micro pores. The presence of interconnected pores facilitated hydrogen escape paths thereby negating the embrittlement of the steel. Further evidence of this mechanism was provided by electrochemical permeation tests. The confinement of surface cracks within a few micrometers, lack of hydrogen escape pathways, and inhomogeneity in defect distribution contributed to failures of high strength steel coated with the Dalistick Zinidal Aero ZnNi process. Fractographic observation also corroborated the presence of intergranular failure features at the crack initiation regions for Zinidal Aero plated at different voltages.

Phase 2 testing used a Design of Experiment test method to evaluate the effect of using a high voltage strike prior to brush plating, and different surface preparation methods, such as pre-cleaning and surface activation, on the hydrogen embrittlement susceptibility of high strength steel using the Zinidal Aero ZnNi brush plating process. Hydrogen embrittlment properties were evaluated using the ISL (Incremental Step Load) test method, and showed that irrespective of the surface activation step and strike layer, test specimens plated after a surface preparation with Scotch Brite abrasive

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pads were more likely to not be susceptible to hydrogen embrittlement, whereas inconsistent results were obtained when using the grit blast process.

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An optimized process has been developed for the Dalistick Zinidal Aero ZnNi brush plating process, but additional confirmation runs need to be carried out using the ASTM F 519 sustained load test method to qualify the process.

2.0 Introduction

Dalistick Zinidal Aero zinc-nickel brush plating solution is being qualified to replace cadmium brush plating that is currently used for touch up repairs on high strength steel aircraft parts. Because this process is occasionally performed on painted and assembled aircraft parts, hydrogen embrittlement relief baking is not permitted. To ensure the new zinc-nickel brush plating material, and no-bake plating process does not cause hydrogen embritlement, ASTM F 519 embrittlement testing is performed.
However, previous testing performed at Air Force Research Laboratory – WPAFB, OH (AFRL) have shown inconsistent results when testing this Dalic zinc-nickel brush plating material for hydrogen embrittlement. The standard ASTM F 519 test is a “Pass” or “Fail” test and does not help determine the mechanisms of any failures.

The failure mechanisms due to hydrogen embrittlement needed to be tested for, and understood, to allow the current Dalic Zinidal Aero zinc-nickel solution to confidently pass hydrogen embrittlement testing and be optimized. This work consisted of IBECA Technologies Corp. conducting hydrogen embrittlement tests on brush plated test specimens that were provided by Boeing Research & Technology (BR&T) using SIFCO conventional brush plating equipment, and University of Dayton Research Institute (UDRI) using the new dripless Dalistick brush plating equipment.

The testing described in this report consists of two Phases (Phase 1 and 2). During Phase 1, brush plate test specimens were made at BR&T using SIFCO equipment to prepare SIFCO 2023 cadmium, SIFCO 4018 zinc-nickel, and Dalistick Zinidal Aero zinc-nickel test specimens. The Dalistick Aero zinc-nickel test specimens were prepared at 8 and 12 volts DC (Direct Current). The SIFCO 2023 cadmium brush plating material is the current material used for touch-up repairs and the SIFCO 4018 zinc-nickel is the only qualified zinc-nickel brush plating material currently used as an alternative for cadmium brush plating.
Brush plate test specimens were also made at UDRI using Dalistick equipment to prepare Dalistick Zinidal Aero zinc-nickel test specimens. These brush plated test specimens were then sent to IBECA for analysis to compare the hydrogen embritlement characteristics of the different brush plate coatings.

The analysis carried out at IBECA included detailed characterization of the coating materials by means of analytical techniques, including electron microscopy, X-Ray Diffraction, electrochemical and corrosion tests. Hydrogen measurements by means of electrochemical permeation and vacuum thermal desorption were also conducted to evaluate the internal and environmental hydrogen interaction of the coating materials. The characterization work was underscored by mechanical testing, principally by the incremental step loading method to

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quantify the effect of processing and material characteristics in terms of hydrogen embrittlement. The Phase 1 test results provided data driven inputs for improving the hydrogen embrittlement performance of the Dalistick Zinidal Aero zinc-nickel, with the ultimate objective of consistently passing the embrittlement test without baking.

Phase 2 consisted of taking the key processing parameters identified by Phase 1 testing, and developing a Design of Experiment (DoE) to optimize the brush plating process for Dalistick Zinidal Aero and comparing this process when using either the conventional SIFCO brush plating equipment or the new dripless Dalistick equipment.

After successfully completing the Phase 2 DoE tests, confirmations test runs were carried out to verify the performance of the optimized process selected to apply No-Bake Dalistick Zinidal Aero zinc-nickel brush plating to high strength steel and consistently pass the hydrogen embritlement test.

3.0 Phase 1 Test Plan

On August 24, 2017, a kick-off meeting was held at IBECA Technologies Corp., in Montreal, QC, Canada, to discuss the test plan for Phase 1. It was decided to carry out characterization tests during this phase on different brush plate test specimens using the IBECA test procedures described in Attachment No. 1 of this report. The characterization tests carried out were as follows:

- Characterization of Coating Structure
    - Which included SEM (Scanning Electron Microscopy), metallography, XRD (X-ray Diffraction), FIB (Focused Ion Beam) cross-sections, and TEM (Transmission Emission Microscopy) foils to characterize the structure and surface morphology of the different brush plate coatings.
- Electrochemical Permeation (EP)
- Vacuum Thermal Desorption Spectroscopy (TDS)
- Incremental Step Loading (ISL)

The following test specimens were selected for the four tests:

- Characterization of Coating Structure: 1x6x0.040 inch 4130 steel strips
- Electrochemical Permeation (EP): 4x6x0.004 inch 1010 steel shim stock cut into 1x1 inch pieces
- Vacuum Thermal Desorption Spectroscopy (TDS): ASTM F 519, Type 1a.1 test specimens with a 90 degree notch
- Incremental Step Loading (ISL): ASTM F 519, Type 1a.1 test specimens with a 90 degree notch

NOTE: ASTM F 519 allows the use of 60 or 90 degree notches for Type 1a.1 test specimens. The 90 degree notch was chosen for this project because it is easier to brush plate a 90 degree notch rather than a 60 degree notch.

It was also decided at the kick-off meeting to apply the following brush plating materials to these steel test specimens:

- SIFCO 2023 Cadmium (Cd) – this is an approved brush plating material used in the

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aerospace industry

- SIFCO 4018 Zinc-Nickel (ZnNi) – this is an approved brush plating material used in the aerospace industry

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- Dalistick Zinidal Aero ZnNi at 8 and 12 Volts – this material is being qualified as another alternative to cadmium brush plating (8V and 12V was chosen based on previous screening tests conducted at BR&T as acceptable brush plating voltages for this material)

Test specimens were brush plated at BR&T (St. Louis, MO) and UDRI (Dayton, OH). BR&T used SIFCO conventional brush plating equipment and tools to apply all of the brush plating materials, described above, to the steel test specimens. A complete description of the SIFCO brush plating process can be found at www.sifco.com. BR&T used BAC 5854 to apply the SIFCO 2023 cadmium and BAC 5664 to apply the SIFCO 4018 zinc-nickel. The brush plate processes used to apply the Zinidal Aero, using SIFCO equipment, was developed by BR&T from previous internal R&D projects conducted at Boeing.

UDRI used Dalistick equipment to only apply Zinidal Aero to the steel test specimens. UDRI used the brush plate process described in the technical data sheet for Dalistick Zinidal Aero ZnNi (see Attachment No. 3). A complete description of the Dalistick dripless brush plating process can be found at www.dalicworld.com.

The test matrix for applying the different coatings to the various steel test specimens using different brush plating equipment is shown in Table 1.

		Boeing Brush Plate Test Specimens				UDRI Brush Plate Test Specimnens	
Test	**Test Specimen**	**2023 Cd**	**4018 ZnNi**	**Dalic ZnNi 8V**	**Dalic ZnNi 12V**	**Dalisitck ZnNi**	**Totals**
Characterization	4130 steel, 1"x6"x.04"	1	1	1	1	1	5
EP	1010 steel, 4x6x0.004" shim*	1	1	1	1	1	5
TDS	ASTM F 519 1a.1 - Notch at 90°	3	3	3	3	3	15
ISL	ASTM F 519 1a.1 - Notch at 90°	3	3	3	3	3	15
* Cut into 3 ea. 1x1 inch pieces							

Table 1 - Phase 1 Test Matrix

Attachment No. 2 of this report shows all of the brush plate worksheets used to apply SIFCO 2023 Cd, SIFCO 4018 ZnNi and Dalistick Zinidal Aero ZnNi (at 8 and 12 V) using SIFCO brush plating equipment and tools at BR&T. Figures 1 to 7 show the different steps that were followed to go from a bare steel ASTM F 519 Type 1a.1 test specimen to a ZnNi plated test specimen with conversion coating.

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Figure 1 – ASTM F 519 Type 1a.1 Test Specimens As Received

Figure 2 - Type 1a.1 Test Specimens Masked Before Grit Blasting

Figure 3 - Type 1a.1 Test Specimen Masked After Grit Blasting

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Figure 4 - Brush Plate Tool with Zinidal Aero ZnNi Plating Solution

Figure 5 - Type 1a.1 Test Specimen Being Brush Plated with Zinidal Aero ZnNi Brush Plating Solution

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Figure 6 - Type 1a.1 Test Specimen After Brush Plating with Zinidal Aero Brush Plating Solution

Figure 7 - ZnNi Plated Type 1a.1 Test Specimen After Conversion Coating

Attachment No. 3 of this report shows the Technical Data Sheet for Dalistick Zinidal Aero ZnNi brush plating and some of the brush plate worksheets that were used at UDRI to apply Dalistick Zinidal Aero ZnNi using their Dalistick brush plating equipment.

All of the brush plated test specimens shown in Table 1 were sent to IBECA for characterization testing as described in Attachment No. 1.

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4.0 Phase 1 Test Results

Figure 8 shows the surface and cross section of the five different brush plate coatings evaluated.

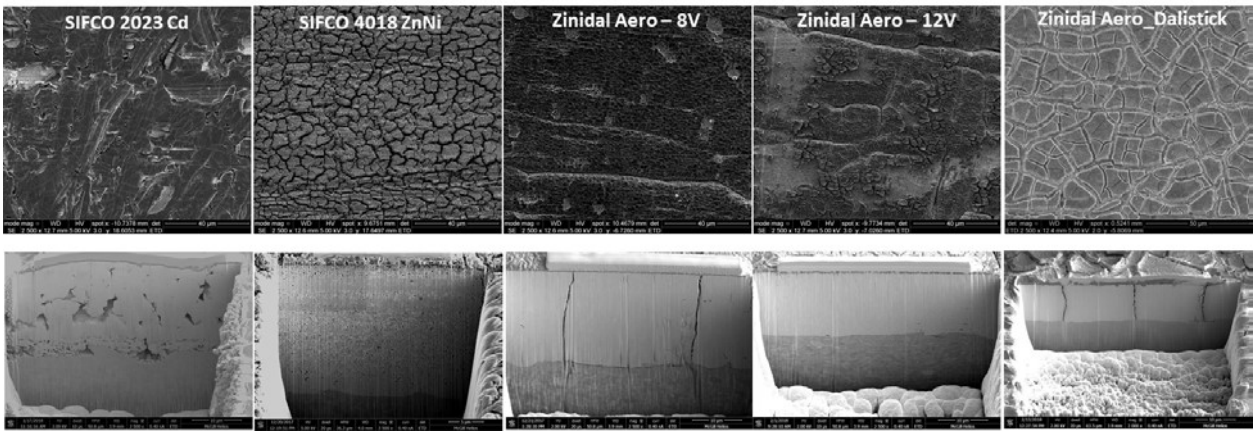

Figure 8 - Photographs Showing the Surface and Cross-Section of the Different Brush Plate Materials Evaluated

Attachment No. 4 shows the test report from IBECA that includes the Phase 1 testing results. The conclusions from the Phase 1 testing were as follows (refer to Attachment No. 4 to see how the conclusions were reached):

- SIFCO 2023 Cd and SIFCO 4018 ZnNi coatings are not susceptible to hydrogen embrittlement as demonstrated by passing the ASTM F 1624 ISL (Incremental Step Load) test and achieving a ≥ 90% NFS hydrogen embritlement threshold.
- Zinidal Aero ZnNi applied at UDRI with Dalistick equipment was non-embrittling and passed by achieving a ≥ 90% NFS hydrogen embritlement threshold, but Zinidal Aero ZnNi applied at BR&T with SIFCO equipment was embrittling and failed by not achieving a ≥ 90% NFS hydrogen embritlement threshold.
- TDS measurements showed higher desorption of hydrogen for SIFCO 4018 ZnNi followed by Zinidal Aero ZnNi applied by the SIFCO 8V, SIFCO 12V and Dalistick processes.
- Permeation measurements showed similar diffusion coefficients for cadmium and all of the ZnNi coatings, and permeation flux was dependent on the coating microstructure (such as the presence of through thickness cracks observed in some of the coatings).
- Presence of dislocations and other crystal defects can influence hydrogen embrittlement of substrate steel, and were observed in the different brush plate coatings, but how these features affect the ability to pass embritlement tests after brush plating was not determined.

A meeting was held at UDRI in Dayton, OH on July 24, 2018 to discuss the Phase 1 test results and make a decision on how to proceed for Phase 2 testing.

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5.0 Phase 2 Test Plan

After discussing the Phase 1 test data during the July 24th meeting at UDRI, it was agreed that nothing could be done to change the formulation of the Zinidal Aero ZnNi to improve the structure or surface morphology to optimize its hydrogen embritlement performance. Therefore, the only choice was to carry out a Design of Experiment (DoE) test plan for Phase 2 in order to optimize the No-Bake Dalistick Zinidal Aero brush plate process, and determine the optimum process to consistently pass the ASTM F 519 embrittlement test. Table 2 shows the proposed DoE with the four brush plate process factors that were evaluated:

Factor Description	# Levels	Values	Comments
Strike	2	Strike or No Strike	Strike = Plate at 16V for 1 minute then finish plating at 12V. No Strike = Plate only at 12V
Surface Prep	2	Scotch Brite or Grit Blast	Use either Scotch Brite or Grit Blast to clean steel before brush plating.
Activation	2	Activation or No Activation	Activate = Apply acid anodic etch at 16V for 1 minute after abrasive cleaning and before brush plating. No Activation = Apply brush plating immediately after abrasive cleaning.
Brush Plating Site	2	BR&T and UDRI	Since brush plating is a manual operation, the test specimens will be brush plated at UDRI and BR&T to insure that results are not affected by brush plating site.

Table 2 - Factors for Design of Experiment to Optimize the Dualistic Zinidal Aero Zinc-Nickel Brush Plating Process

Output for the DoE will be the ISL (Incremental Step Load) test results (0% to 100% NFS) using ASTM F 519, Type 1a.1 test specimens, with a 90 degree notch, that are ISL (Incremental Step Load) tested in accordance with ASTM F 1624 following this step load protocol: 15 steps at 5% NFS per hour followed by 5 steps at 5% NFS per every 2 hours. Test specimens that achieve 90% NFS or greater are considered passing this 25 hour ISL embritlement test. This is a new test method being studied by ASTM subcommittee F07.04 to replace ASTM F 519 because it is faster (25 hours versus 200 hours) and quantifiable (ISL output is %NFS hydrogen embritlement threshold and not just a Pass or Fail result).

BR&T prepared the Phase 2 DoE test plan that was reviewed by UDRI and IBECA. The final DoE test plan was approved on August 7, 2018 and it was decided to do the Phase 2 DoE test plan with 3 replicates to produce 48 test specimens (24 from UDRI and 24 from BR&T). See Attachment No. 5 for the Phase 2 DoE test plan.

The strike voltage was decided to be 16V after BR&T prepared 1x6x0.040" steel test specimens with different ZnNi strikes that were evaluated by IBECA to determine the best strike voltage. The results from IBECA regarding this evaluation of strike voltages can be found in their final report shown in Attachment No. 4.

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BR&T also prepared Master Brush Plate work sheets that were used at BR&T and UDRI for the DoE (see Attachment No. 6). It was also decided, and added to the brush plate work sheets, that only 3 test specimens will be able to be plated and shipped to IBECA for ISL testing, and they shall be tested within 72 hours after plating, if possible. This would require at least 16 weeks to complete the testing of all 48 test specimens in the DoE.

Attachment No. 7 shows all of the brush plate work sheets from BR&T that were used to brush plate the 24 DoE test specimens. Attachment No. 8 shows all of the brush plate work sheets from UDRI that were used to brush plate their 24 test specimens.

All 48 DoE test specimens were sent to IBECA for ISL testing.

6.0 Phase 2 Test Results

Table 3 shows the Phase 2 ISL test results for the 48 brush plated DoE test specimens.

Table 4 also shows the same DoE test results but sorts them by surface prep method (grit blast or Scotch Brite scrub), in order to illustrate the dramatic difference between surface prep methods. Grit blast produces a high amount of embritlement failing results (< 90% NFS) as opposed to the Scotch Brite surface prep method which produced a high amount of embritlement passing results (≥ 90% NFS).

Attachment No. 9 show the DoE test report that analyzed the 48 data points and performed a statistical analysis of the data. The conclusions were as follows:

- The factors seem to work together to produce a particular %NFS value as summarized below:
  - The high voltage strike used before brush plate does not appear to have any effect on passing or failing the embritlement test.
  - Using the Dalistick brush plate equipment at UDRI caused 50% of the test specimens with the grit blast surface preparation to pass the embritlement test, but 75% passed the embritlement test if Scotch Brite was used as the surface prep.
  - Using SIFCO brush plate equipment at BR&T caused 100% of the test specimens with the Scotch Brite surface preparation to pass the embritlement test, but 100% failed the embritlement test if grit blast was used as the surface prep.
  - More confirmatory experiments need to be performed to see which combination(s) are consistently producing %NFS above 90%, and understand the differences when using SIFCO equipment, which controls the voltage, compared with Dalistick equipment, which controls the current.

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Specimen #	Strike	Surface Prep	Activation	Brush Plate Power Supply*	Fracture Load	%NFS
1	Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50
2	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60
3	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60
4	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	34.3	93.7
5	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	33	90.1
6	No Strike	Scotch Brite	Chemical	SIFCO-Volts	35.4	96.8
7	No Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50.1
8	Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50
9	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	18.3	50.1
10	Strike	Grit Blast	Sandpaper	SIFCO-Volts	21	57.4
11	Strike	Grit Blast	Chemical	SIFCO-Volts	22	60.1
12	Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60.2
13	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.3	99.2
14	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100
15	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	34.7	94.9
16	Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60
17	No Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100.1
18	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100.1
19	No Strike	Grit Blast	Chemical	SIFCO-Volts	22	60
20	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	37.6	102.7
21	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100
22	No Strike	Grit Blast	Chemical	SIFCO-Volts	20.1	55
23	No Strike	Scotch Brite	Chemical	SIFCO-Volts	35.6	97.4
24	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.1	98.7
25	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	23.8	65
26	Strike	Scotch Brite	Chemical	Dalicstick-Amps	33.5	91.4
27	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	29.7	81.2
28	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	32.8	89.6
29	Strike	Grit Blast	Chemical	Dalicstick-Amps	22	60
30	Strike	Grit Blast	Chemical	Dalicstick-Amps	23.8	65
31	No Strike	Grit Blast	Chemical	Dalicstick-Amps	19.9	54.4
32	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	35.9	98.1
33	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	36.4	99.5
34	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	33	90.2
35	Strike	Scotch Brite	Chemical	Dalicstick-Amps	35.5	96.9
36	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	34	92.9
37	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	34.8	95
38	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	37.1	101.4
39	No Strike	Grit Blast	Chemical	Dalicstick-Amps	23.8	65
40	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	34.4	94
41	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	23.8	65
42	Strike	Grit Blast	Chemical	Dalicstick-Amps	27.5	75
43	No Strike	Grit Blast	Chemical	Dalicstick-Amps	36.5	99.8
44	Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.6	100
45	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.3	99.2
46	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	36.5	99.8
47	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	35	95.6
48	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	38.2	104.5

* SIFCO brush plate power supply used at BR&T controls the voltage and current varies during plating, and DALICSTICK brush plate power supply used at UDRI controls the current and voltage varies during plating.

Table 3 - Phase 2 DoE ISL Test Results

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Specimen #	Strike	Surface Prep	Activation	Brush Plate Power Supply*	Fracture Load	%NFS
1	Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50
2	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60
3	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60
7	No Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50.1
8	Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50
9	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	18.3	50.1
10	Strike	Grit Blast	Sandpaper	SIFCO-Volts	21	57.4
11	Strike	Grit Blast	Chemical	SIFCO-Volts	22	60.1
12	Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60.2
16	Strike	Grit Blast	Sandpaper	SIFCO-Volts	22	60
19	No Strike	Grit Blast	Chemical	SIFCO-Volts	22	60
22	No Strike	Grit Blast	Chemical	SIFCO-Volts	20.1	55
25	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	23.8	65
29	Strike	Grit Blast	Chemical	Dalicstick-Amps	22	60
30	Strike	Grit Blast	Chemical	Dalicstick-Amps	23.8	65
31	No Strike	Grit Blast	Chemical	Dalicstick-Amps	19.9	54.4
32	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	35.9	98.1
33	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	36.4	99.5
38	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	37.1	101.4
39	No Strike	Grit Blast	Chemical	Dalicstick-Amps	23.8	65
42	Strike	Grit Blast	Chemical	Dalicstick-Amps	27.5	75
43	No Strike	Grit Blast	Chemical	Dalicstick-Amps	36.5	99.8
46	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	36.5	99.8
48	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	38.2	104.5
4	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	34.3	93.7
5	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	33	90.1
6	No Strike	Scotch Brite	Chemical	SIFCO-Volts	35.4	96.8
13	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.3	99.2
14	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100
15	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	34.7	94.9
17	No Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100.1
18	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100.1
20	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	37.6	102.7
21	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100
23	No Strike	Scotch Brite	Chemical	SIFCO-Volts	35.6	97.4
24	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.1	98.7
26	Strike	Scotch Brite	Chemical	Dalicstick-Amps	33.5	91.4
27	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	29.7	81.2
28	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	32.8	89.6
34	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	33	90.2
35	Strike	Scotch Brite	Chemical	Dalicstick-Amps	35.5	96.9
36	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	34	92.9
37	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	34.8	95
40	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	34.4	94
41	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	23.8	65
44	Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.6	100
45	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.3	99.2
47	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	35	95.6
NOTE: Yellow = Failed ISL Embrittlement Test; Green = Passed ISL Embrittlement Test						

Table 4 - Phase 2 DoE ISL Test Results Sorted by Surface Prep

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7.0 DoE Confirmation Run Test Plan

As a result of the DoE testing done in Phase 2, it was decided to carry-out some DoE confirmation run testing to verify if the surface prep using Scotch Brite scrubbing, rather than grit blasting, would produce passing hydrogen embrittlement test results ($\geq$ 90% NFS with ISL testing).

Table 5 shows the DoE confirmation run test matrix. Test specimen numbers 49 to 60 were the confirmation runs using Dalistick Zinidal Aero ZnNi that was applied to Type 1a.1 test specimens using either the SIFCO brush plating equipment at BR&T or the Dalistick equipment at Corrdesa (UDRI sent their Dalistick equipment to this vendor located at Tyrone, GA) and the test specimens were prepared with a Scotch Brite surface prep followed by activation with either chemical (Dalistick Activator XF) or sandpaper, and no strike before plating was used with the Zinidal Aero ZnNi brush plating solution.

Attachment 10 shows all of the brush plating worksheets for test specimens 49 to 60. After brush plating, these test specimens were ISL tested at BR&T rather than IBECA.

Table 5 also shows that ISL embritlement testing was performed on Type 1a.1 test specimens brush plated with SIFCO 4018 ZnNi using the Dalistick equipment. This additional testing was done for information purposes only to determine if Dalistick equipment could also be used to apply SIFCO 4018 and pass the hydrogen embritlement ISL test without an embritlement relief bake. Attachment 10 also includes the brush plating work sheets for the SIFCO 4018 test specimens (numbers 61 to 66).

Test Sample No.	Specimen Lot Number	Solution	Location	Surface Prep	Activate	Strike	Plating Power Supply
49	1.1A	Zinidal Aero	BR&T	Scotch-Brite	Chemical	No	SIFCO - 12V
50	1.1A	Zinidal Aero	BR&T	Scotch-Brite	Chemical	No	SIFCO - 12V
51	1.1A	Zinidal Aero	BR&T	Scotch-Brite	Chemical	No	SIFCO - 12V
52	1.1A	Zinidal Aero	BR&T	Scotch-Brite	Sandpaper	No	SIFCO - 12V
53	1.1A	Zinidal Aero	BR&T	Scotch-Brite	Sandpaper	No	SIFCO - 12V
54	1.1A	Zinidal Aero	BR&T	Scotch-Brite	Sandpaper	No	SIFCO - 12V
55	1.1A	Zinidal Aero	Coredessa	Scotch-Brite	Chemical	No	DALISTICK - 12V
56	1.1A	Zinidal Aero	Coredessa	Scotch-Brite	Chemical	No	DALISTICK - 12V
57	1.1A	Zinidal Aero	Coredessa	Scotch-Brite	Chemical	No	DALISTICK - 12V
58	1.1A	Zinidal Aero	Coredessa	Scotch-Brite	Sandpaper	No	DALISTICK - 12V
59	1.1A	Zinidal Aero	Coredessa	Scotch-Brite	Sandpaper	No	DALISTICK - 12V
60	1.1A	Zinidal Aero	Coredessa	Scotch-Brite	Sandpaper	No	DALISTICK - 12V
61	1.1A	SIFCO 4018	Coredessa	Scotch-Brite	Chemical	No	DALISTICK - 12V
62	1.1A	SIFCO 4018	Coredessa	Scotch-Brite	Chemical	No	DALISTICK - 12V
63	1.1A	SIFCO 4018	Coredessa	Scotch-Brite	Chemical	No	DALISTICK - 12V
64	1.1A	SIFCO 4018	Coredessa	Scotch-Brite	Sandpaper	No	DALISTICK - 12V
65	1.1A	SIFCO 4018	Coredessa	Scotch-Brite	Sandpaper	No	DALISTICK - 12V
66	1.1A	SIFCO 4018	Coredessa	Scotch-Brite	Sandpaper	No	DALISTICK - 12V

Table 5 - DoE Confirmation Run Test Matrix

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8.0 Doe Confirmation Run Test Results

Table 6 shows the DoE confirmation run ISL test results for the 12 Zinidal Aero ZnNi brush plated test specimens (49 to 60). It appears that half of these passed the embritlement test at 90% NFS and the other half barely failed the embritlement test at 85% NFS, the majority of these borderline failures were with the SIFCO brush plating equipment.

Table 6 also shows the results for the SIFCO 4018 ZnNi. The results showed that SIFCO 4018 applied at 6V with Dalistick equipment using Scotch Brite surface prep and chemical activation (Activator XF), could pass the embritlement test by reaching 90% NFS during ISL testing. However, if sandpaper rather than chemical activation is used, the SIFCO 4018 fails the embritlement test by only reaching 65% or 85% NFS.

Test Sample No.	Specimen Lot Number	Solution	Surface Prep	Activate	Strike	Plating Power Supply	Brush Plate Date	Date Received by Boeing for ISL Testing	ISL Test Date	%NFS
49	1.1A	Zinidal Aero	Scotch-Brite	Chemical	No	SIFCO - 12V	7/15/2019	7/15/2019	7/16/2019	85%
50	1.1A	Zinidal Aero	Scotch-Brite	Chemical	No	SIFCO - 12V	7/15/2019	7/15/2019	7/17/2019	85%
51	1.1A	Zinidal Aero	Scotch-Brite	Chemical	No	SIFCO - 12V	7/15/2019	7/15/2019	7/18/2019	85%
52	1.1A	Zinidal Aero	Scotch-Brite	Sandpaper	No	SIFCO - 12V	7/31/2019	7/31/2019	8/1/2019	90%
53	1.1A	Zinidal Aero	Scotch-Brite	Sandpaper	No	SIFCO - 12V	7/31/2019	7/31/2019	8/5/2019	85%
54	1.1A	Zinidal Aero	Scotch-Brite	Sandpaper	No	SIFCO - 12V	8/8/2019	8/8/2019	8/12/2019	85%
55	1.1A	Zinidal Aero	Scotch-Brite	Chemical	No	DALISTICK - 12V	7/8/2019	7/9/2019	7/9/2019	90%
56	1.1A	Zinidal Aero	Scotch-Brite	Chemical	No	DALISTICK - 12V	7/8/2019	7/9/2019	7/10/2019	90%
57	1.1A	Zinidal Aero	Scotch-Brite	Chemical	No	DALISTICK - 12V	7/8/2019	7/9/2019	7/11/2019	85%
58	1.1A	Zinidal Aero	Scotch-Brite	Sandpaper	No	DALISTICK - 12V	7/22/2019	7/23/2019	7/29/2019	90%
59	1.1A	Zinidal Aero	Scotch-Brite	Sandpaper	No	DALISTICK - 12V	7/22/2019	7/23/2019	7/30/2019	90%
60	1.1A	Zinidal Aero	Scotch-Brite	Sandpaper	No	DALISTICK - 12V	7/22/2019	7/23/2019	7/31/2019	90%
61	1.1A	SIFCO 4018	Scotch-Brite	Chemical	No	DALISTICK -6V	8/5/2019	8/6/2019	8/6/2019	90%
62	1.1A	SIFCO 4018	Scotch-Brite	Chemical	No	DALISTICK -6V	8/5/2019	8/6/2019	8/7/2019	90%
63	1.1A	SIFCO 4018	Scotch-Brite	Chemical	No	DALISTICK -6V	8/5/2019	8/6/2019	8/8/2019	90%
64	1.1A	SIFCO 4018	Scotch-Brite	Sandpaper	No	DALISTICK - 6V	8/12/2019	8/13/2019	8/13/2019	65%
65	1.1A	SIFCO 4018	Scotch-Brite	Sandpaper	No	DALISTICK - 6V	8/12/2019	8/13/2019	8/14/2019	65%
66	1.1A	SIFCO 4018	Scotch-Brite	Sandpaper	No	DALISTICK - 6V	8/12/2019	8/13/2019	8/15/2019	85%
Pass = > 90% NFS for ISL										
Fail = < 90% NFS for ISL										

Table 6 - DoE Confirmation Run ISL Test Results

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9.0 Conclusions

9.1 Phase 1

1) SIFCO 2023 Cd and SIFCO 4018 ZnNi coatings brush plated with SIFCO equipment are not susceptible to hydrogen embrittlement. Presence of extensive cracks and micropores observed on these coatings minimized the hydrogen embrittlement susceptibility.

2) Zinidal Aero ZnNi coatings brush plated with Dalistick equipment were able to pass the hydrogen embrittlement test, but Zinidal Aero ZnNi coatings brush plated with SIFCO equipment were not able to pass the hydrogen embrittlement test.

3) TDS measurements shows highest desorption of hydrogen for SIFCO 4018 ZnNi followed by Zinidal Aero ZnNi applied at 8V and 12V with SIFCO equipment, and with Dalistick equipment.

4) After a thorough review of the characterization data, it appeared that structure and surface morphology of the Zinidal Aero ZnNi coatings was different from the SIFCO Cd and SIFCO ZnNi coatings, but there were no major differences that stood out that would suggest what would be required to improve the Zinidal Aero ZnNi to consistently pass the hydrogen embritlement test after brush plating.

9.2 Phase 2 –DoE Tests to Optimize Zinidal Aero ZnNi Process

1) The high voltage strike step, used before brush plating, doesn't modify the hydrogen embrittlement susceptibility for the Zinidal Aero ZnNi coating.

2) The activation step (chemical or sand paper), doesn't modify the hydrogen embrittlement susceptibility for the Zinidal Aero ZnNi coating.

3) The surface preparation step (Scotch Brite or grit blast) used prior to activation, had a significant effect on the hydrogen embritlement susceptibility for the Zinidal Aero ZnNi coating. Use of Scotch Brite doesn't cause hydrogen embritlement, but the grit blasting method used as a pre- cleaning step had higher probability of causing hydrogen embritlement, especially when using the SIFCO equipment.

9.3 DoE Confirmation Runs with Zinidal Aero ZnNi

1) Using Scotch Brite prior to the plating process did not cause hydrogen embritlement in 50% of test specimens and produced a borderline embritlement test result in the other 50%. The results were inconclusive.

2) Activation step (chemical or sand paper) still did not have a significant impact on the hydrogen embritlement results.

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10.0 Recommendations

Embrittlement tests that were performed for this report were done using the "new" Incremental Step Load test method. During the confirmation runs, 50% of the test specimens passed the ISL test with > 90% NFS and the other 50% failed by reaching only 85% NFS during the ISL test, which is only 5% NFS below from passing at 90% NFS.

The ISL test method is still being studied to determine if it can replace the standard ASTM F 519 sustained load (SL) 200 hour test method, and there is a possibility that the ISL test method could be too sensitive when compared with the standard SL test method.

It is recommended to repeat the confirmation run test matrix, shown in Table 5 of this report for specimen numbers 49 to 60, but use the 200 hour standard test method in ASTM F 519 with a 75% NFS sustained load in order to qualify the optimized Dalistick Zinidal Aero ZnNi brush plating process.

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Attachment No. 1 – IBECA Characterization Tests

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Technical Proposal

The University of Dayton Research Institute

HYDROGEN EMBRITTLEMENT CHARACTERIZATION OF NO-BAKE BRUSH PLATING ZINC-NICKEL PROCESSES

This technical proposal is submitted as per the requirements of The University of Dayton Research Institute (UDRI), Request for Proposal No. SC1076, GSA Prime Contract: GS05Q15BMD0001 / TO 06

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BACKGROUND

A Dalic Zinidal Aero zinc-nickel brush plating material is being qualified to replace cadmium brush plating on high strength steel to be used for touch up repairs to aircraft. This process can be performed on aircraft and hydrogen embrittlement relief baking is not permitted. To ensure the new zinc-nickel material and plating process does not cause hydrogen embrittlement, an ASTM F 519 test is usually performed. However, previous testing performed at AFRL (Air Force Research Laboratory – WPAFB, OH) have shown inconsistent results while testing zinc-nickel coatings for hydrogen embrittlement. The standard ASTM F 519 testing is a "Pass" or "Fail" test and does not help determine the mechanisms of any failures. The failure mechanisms due to hydrogen embrittlement need to be tested for and understood to allow the current Dalic Zinidal Aero zinc-nickel solution to confidently pass hydrogen embrittlement testing or be optimized.

PROPOSAL

The objective of this proposal is to evaluate and compare hydrogen embrittlement (HE) characteristics of the two brush process ZnNi electroplating formulas. The analysis comprises detailed characterization of the coating materials by means of analytical techniques, including electron microscopy, X-Ray Diffraction, electrochemical and corrosion behavior. Hydrogen measurements by means of electrochemical permeation and vacuum thermal desorption will be conducted to evaluate the internal and environmental hydrogen interaction of the coating materials. The characterization work will be underscored by mechanical testing, principally be the incremental step loading method to quantify the effect of processing and material characteristics in terms of hydrogen embrittlement. The results will provide data driven inputs for improving the hydrogen embrittlement performance of formula B, with the ultimate objective of consistently passing the HE test without baking.

DESCRIPTION OF METHODOLOGY

The following is a detailed description of each technique that is available for this proposal and the type of information that may be generated by each method. A final methodological approach will be established in consultation with Boeing. Note, Boeing will supply all of the steel test specimens and apply the ZnNi coatings for the evaluation.

Characterization of coatings

- Scanning electron microscopy (SEM) – to characterize coatings in terms of surface and cross sectional morphology, coating thickness, defect distribution, microstructure.
- Focused Ion Beam (FIB) – in situ milling and imaging to characterize the coating cross section for defects without damaging the interface, and also to extract thin foil for examination in a TEM.
- Transmission electron microscopy (TEM) – to characterize the crystallite size and grain boundaries of the coatings and to evaluate the crystal structure using electron diffraction.
- X-Ray Diffraction (XRD) – to evaluate the crystal structure, phase composition and residual stresses in the coatings.

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- Correlate plating parameters with coating characteristics.

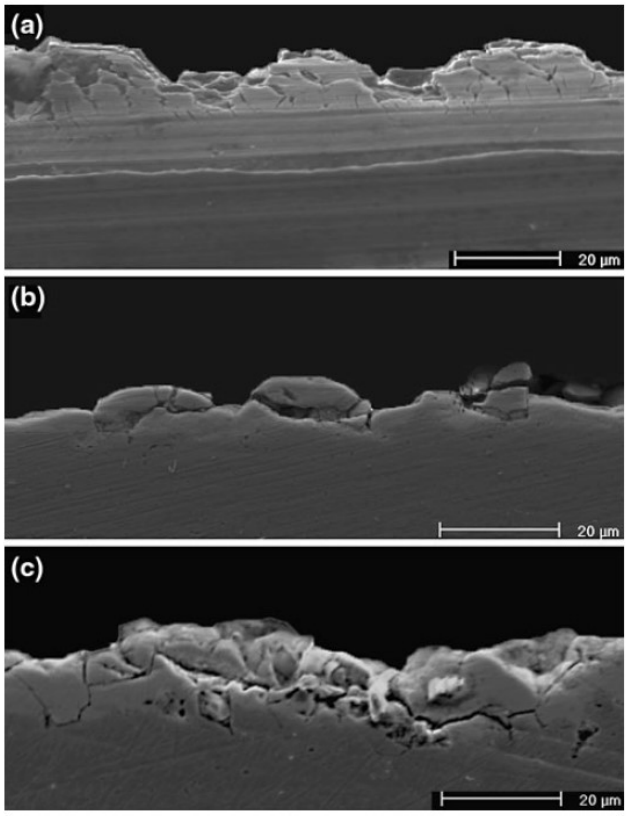

Fig. 1.Example of cross-sectional SEM images of Zn–Ni coatings on low carbon steel shims a uniform defect- free cross section, b as-plated Zn–Ni coatings with discontinuities and microcracks, c Zn–Ni cross section after post-baking heat treatment with microcracks and discontinuities

a. Electrochemical behavior

Open circuit potential (OCP) measurement – to generate relative scale of corrosion potentials of the coatings in alkaline media with respect to a saturated calomel electrode (SCE) for a specific time period.

b. Quantification of Hydrogen Embrittlement Susceptibility Internal and Environmental

Electrochemical permeation (EP)

The permeation cell is made of two adjacent Teflon reservoirs. A 6 volt battery with variable resistance is used as the charging source. In this setup, the specimen acts as the working electrode for both cells. Platinum wire is used as a counter electrode for both cells. A constant current density in the order of 0.1 mA is applied on the charging side. The exit side of the permeation cell is maintained at constant potential such as to minimize the oxidation current, in the order of -300 mV with respect to standard calomel electrode. On this same exit or anodic side of the permeation cell, current generated by hydrogen atoms is monitored with

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respect to time. The data generated will make it possible to calculate the diffusion coefficient and permeation flux for each coating.
Substrates made of steel shim cut to 40 mm x 40 mm, then fine polished. The samples will be coated with Palladium on one side using plasma sputtering technique.

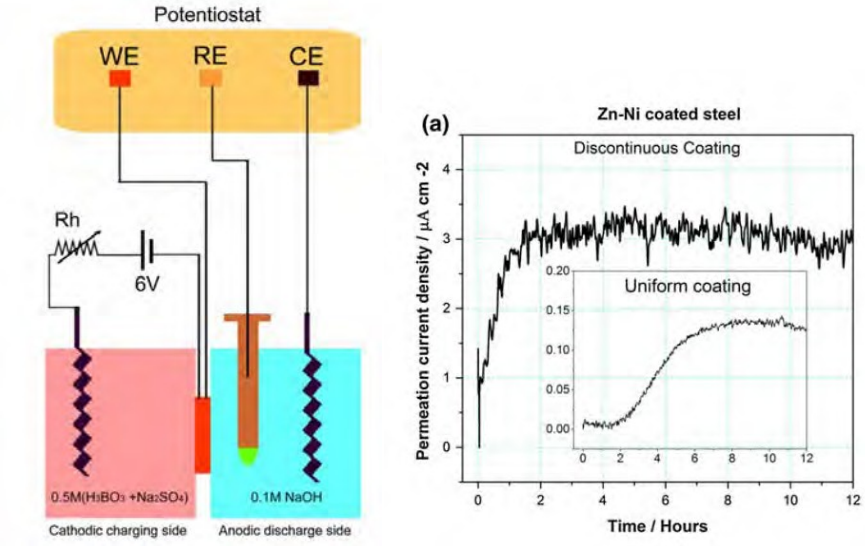

Fig 2. Electrochemical permeation cell schematic (left), Permeation current densities of a uniform and discontinuous Zn–Ni-coated steel (right). Source. Sriraman.

Vacuum thermal desorption spectroscopy (TDS)

Simply described, the thermal desorption apparatus consists of (i) a vacuum chamber, capable of being heated that houses the bulk specimen, (ii) Integrated hydrocarbon free scroll and turbo molecular pumps (TMP) to evacuate and maintain vacuum within the system, (iii) conduits and locking valves, and (iv) a downstream mass spectrometer.

The specimen holding chamber and other conduits in the vacuum thermal desorption apparatus are made of ultrahigh vacuum (UHV) grade 316 stainless steel. The chamber is pumped down by both turbo molecular pumps to a vacuum of less than 5 X 10 -6 mbar. After reaching the required vacuum range, the mass spectrometer is turned on to measure the hydrogen ion intensity at the required temperature. The sample is heated by infrared and the temperature is controlled by means of a thermocouple placed directly on the specimen surface. Measurement of the amount of hydrogen present in the coated sample is preceded by baseline measurements: (i) of residual hydrogen present in the specimen holding chamber, and (ii) of residual hydrogen present in the bare specimen. A quadruple mass spectrometer placed on the exit side of the chamber quantifies the amount of hydrogen desorbed from the specimen by measuring hydrogen ion intensity. TDS can also be utilized to measure the environmental hydrogen embrittlement susceptibility. After immersion tests of the coated steel specimen for a defined time period the amount of hydrogen adsorbed in the steel can be measured by baking immediately in the TDS.

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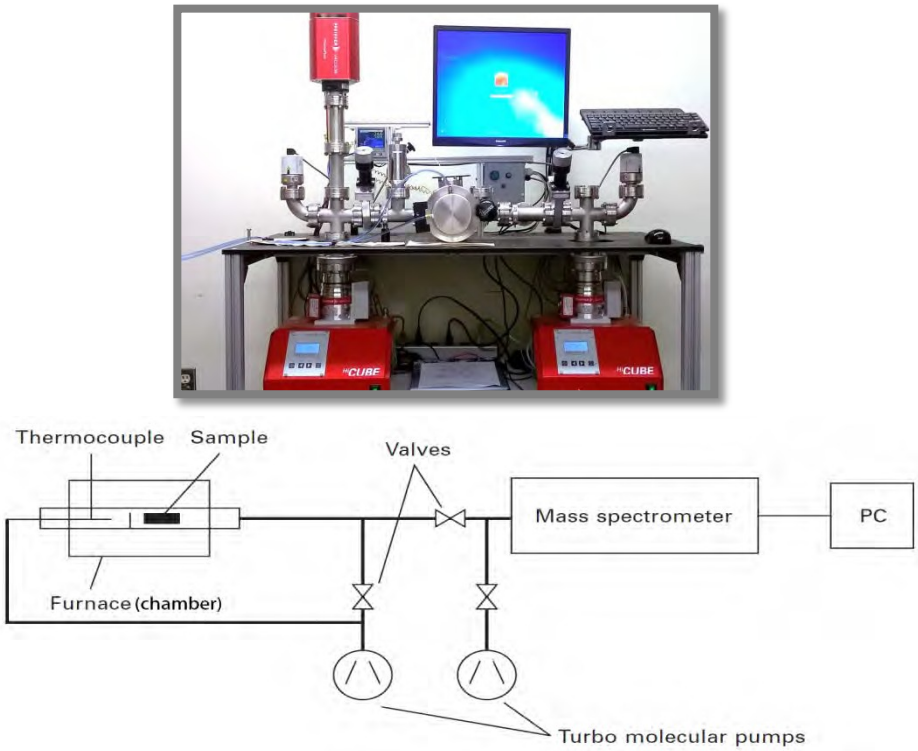

Fig. 3 Thermal desorption spectrometer and schematic

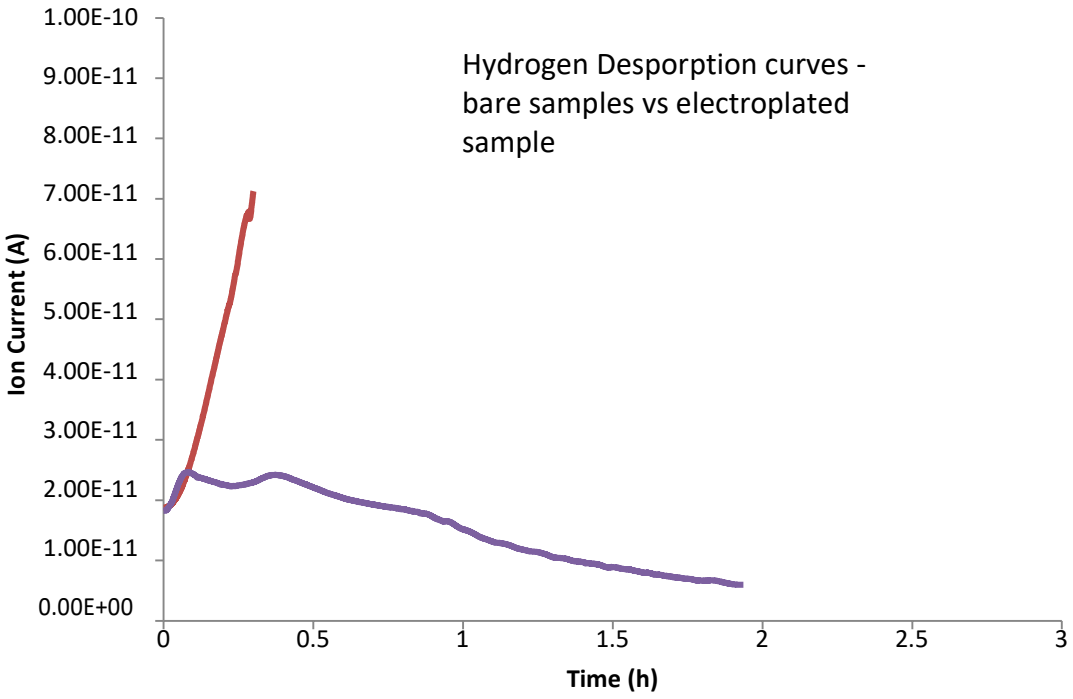

Fig. 4 Examples of thermal desorption spectra for bare and electroplated samples

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c. Mechanical testing – incremental step loading (ISL)

The incremental step load (ISL) apparatus is a computerized four-point bend, displacement control loading frame. It is capable of holding a displacement within ± 0.13 µm and reaching target loads within ± 0.4 lb. Specimens can be tested in air to measure the effect of prior exposure to hydrogen by a coating process. The test subjects the specimen to a bending stress and an increasing load by incremental steps until crack initiation occurs. The duration of a test is dependent upon the degree of embrittlement of the specimen. Under normalized stress intensity conditions, the maximum load at the onset of cracking is defined as the HE threshold. For the purpose of this investigation, the same specimens used in the TDS experiments will be used for ISL testing.

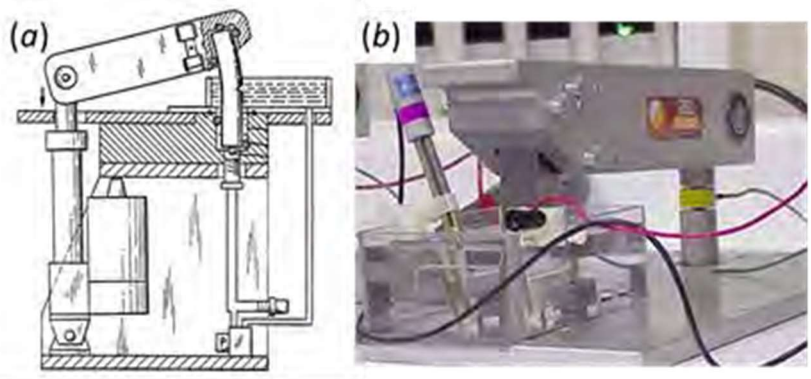

Figure 5: (a) Schematic illustration of the loading frame of an ISL apparatus. (b) A picture of the actual loading frame with the environmental chamber.

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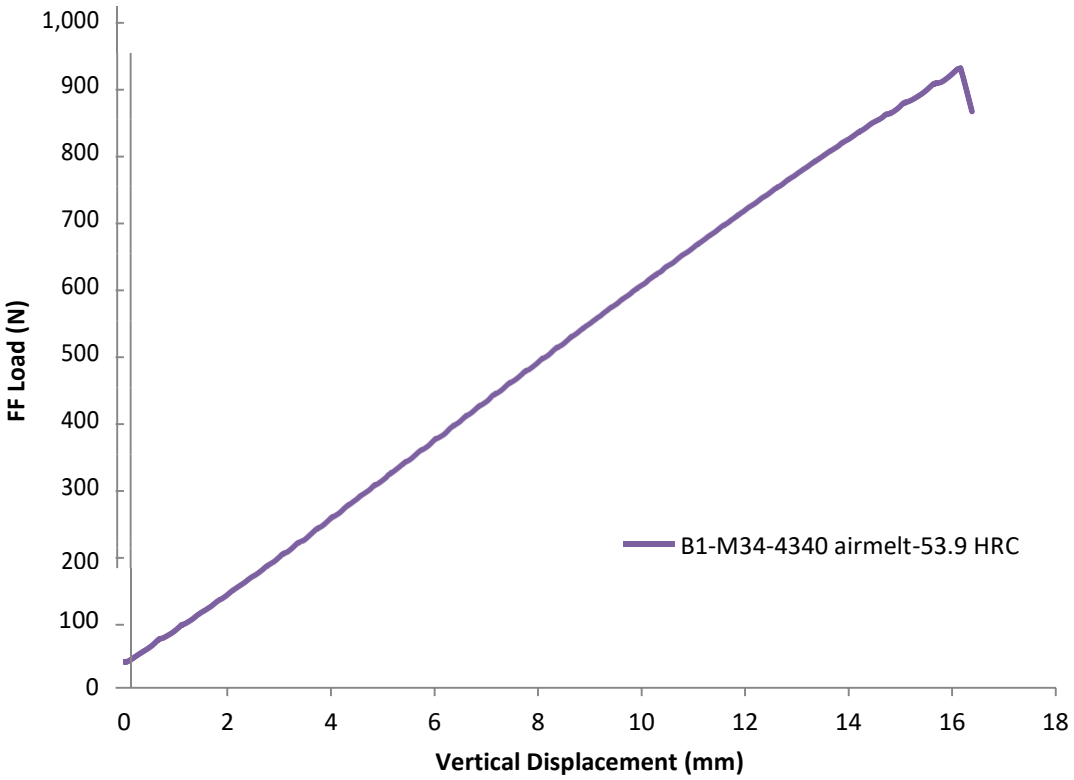

Fig. 6 Example of bending fast fracture test on electroplated notch bar sample

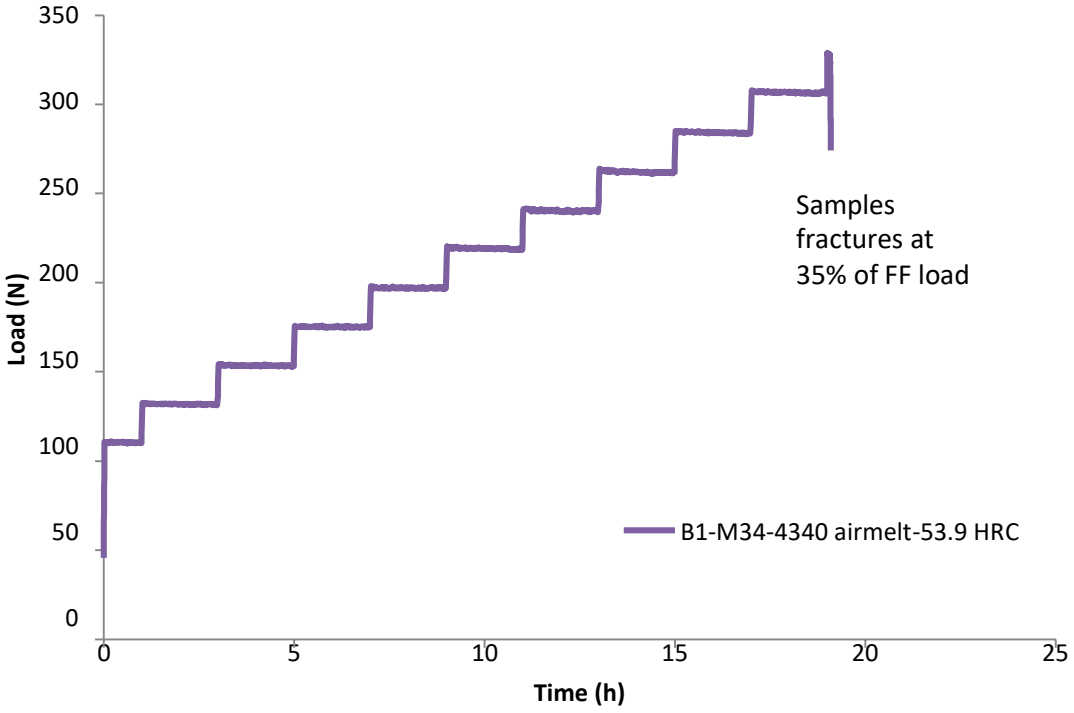

Fig. 7 Example of bending ISL test on electroplated notch bar sample showing time dependent loss of fracture strength

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Attachment No. 2 – BR&T Brush Plate Work Sheets for Phase 1 Test Specimens

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Base Material:	4130 Steel 1x6x0.040 inch	**Area Plated:**	1x2"	**Quantity of Test Specimens: 1**
Deposit Required:	SIFCO 2023 Cd	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-75 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 2023: A-Hr = 70 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 70 * 2 * 0.0008 = 0.11				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 2 sq. in. Brush plate In center of test strip to repair area 1x2 inches.
5	Pre-Wet	SIFCO 2023	0				Prewet with SIFCO 2023.
6	Cd Plate	SIFCO 2023	6 to 20	Fwd	2 to 4 (4 to 8 amps)	0.11	Start at 18-20 volts until a visible layer of cadmium is deposited, then reduce the voltage to 6 to 9 volts to stop burning and continue plating for the number of ampere–hours calculated. Deposit shall be smooth, fine–grained, adherent, and free from blisters, pits, nodules, indications of burning, and other defects. Slight residual discoloration, not attributable to burning, is acceptable.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	SIFCO 3002/5005					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 3002/5005 solution. Swab SIFCO 3002/5005 onto surface for 15 to 60 seconds to form gold to light brown conversion coating.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
3	18 - 8	1.18 mils		1.26	1.02	0.09	
* mils After Plating							

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Base Material:	4130 Steel 1x6x0.040 inch	**Area Plated:**	1x2"	**Quantity of Test Specimens: 1**
Deposit Required:	SIFCO 4018 Zn-Ni	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-75 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	

Notes: Plating Formula for Sifco 4018: A-Hr = 120 * Area (sq.in.) * Thickness (inches)

Amp-Hr = 120 * 2 * 0.0008 = 0.19

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 2 sq. in. Brush plate In center of test strip to repair area 1x2 inches.
5	Pre-Wet	NONE	0				**Do not prewet with SIFCO 4018!**
6	Zn-Ni Plate	SIFCO 4018	6	Fwd	4 to 8 (8 to 16 amps)	0.19	Start at 6 V and stay at 6 V. Avg. current density is 6 amps/sq.in. Deposit should be medium-gray, matte, smooth deposit. Deposit shall not be bright or burnt.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	SIFCO 5030/3004					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 5030/3004 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 3 minutes to develop a dark coating color.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
1	6	1.00 mils		1.06	0.87	0.07	

* mils After Plating

Base Material:	4130 Steel 1x6x0.040 inch	**Area Plated:**	1x2"	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-75 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	

Notes: Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)

Amp-Hr = 105 * 2 * 0.0008 = 0.17

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 2 sq. in. Brush plate In center of test strip to repair area 1x2 inches.
5	Pre-Wet	ZINIDAL Aero 11040	0				Prewet with Zinidal Aero
6	Zn-Ni Plate	ZINIDAL Aero 11040	7.5 to 10	Fwd	10 (20 amps)	0.17	Start at 10 volts then drop in 1 volt increments until 8 - 9 volts. Adjust voltage to maintain an average current density of 10 amps/sq.in. Deposit should be a bright to matte, smooth deposit.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 seconds to develop a dark coating color.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
2	10 - 8	0.93 mils		0.99	0.78	0.08	

* mils After Plating

Base Material:	4130 Steel 1x6x0.040 inch	**Area Plated:**	1x2"	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-75 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	

Notes: Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)

Amp-Hr = 105 * 2 * 0.0008 = 0.17

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 2 sq. in. Brush plate In center of test strip to repair area 1x2 inches.
5	Pre-Wet	ZINIDAL Aero 11040	0				Prewet with Zinidal Aero
6	Zn-Ni Plate	ZINIDAL Aero 11040	12	Fwd	10 (20 amps)	0.17	Start at 12 volts and maintain volatage at 12 V. Deposit should be a dull - not bright and no burning.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 seconds to develop a dark coating color.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
4	12	0.66 mils		0.69	0.61	0.04	

* mils After Plating

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Base Material:	1010 Steel 4x6x0.004 inch	**Area Plated:**	2.5x3.5"	**Quantity of Test Specimens: 1**
Deposit Required:	SIFCO 2023 Cd	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-90 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 2023: A-Hr = 70 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 70 * 8.75 * 0.0008 = 0.49				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 8.75 sq. in. Brush plate In center of test panel to repair area 2.5 x 3.5 inches.
5	Pre-Wet	SIFCO 2023	0				Prewet with SIFCO 2023.
6	Cd Plate	SIFCO 2023	6 to 20	Fwd	2 to 4 (16 to 32 amps)	0.49	Start at 18-20 volts until a visible layer of cadmium is deposited, then reduce the voltage to 6 to 9 volts to stop burning and continue plating for the number of ampere–hours calculated. Deposit shall be smooth, fine–grained, adherent, and free from blisters, pits, nodules, indications of burning, and other defects. Slight residual discoloration, not attributable to burning, is acceptable.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	SIFCO 3002/5005					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 3002/5005 solution. Swab SIFCO 3002/5005 onto surface for 15 to 60 seconds to form gold to light brown conversion coating.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
8	18 - 8	1.33		1.8	0.83	0.35	
* mils After Plating							

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Base Material:	1010 Steel 4x6x0.004 inch	**Area Plated:**	2.5x3.5"	**Quantity of Test Specimens: 1**
Deposit Required:	SIFCO 4018 Zn-Ni	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-90 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 4018: A-Hr = 120 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 120 * 8.75 * 0.0008 = 0.84				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 8.75 sq. in. Brush plate In center of test panel to repair area 2.5 x 3.5 inches.
5	Pre-Wet	NONE	0				**Do not prewet with SIFCO 4018!**
6	Zn-Ni Plate	SIFCO 4018	6	Fwd	4 to 8 (32 to 64 amps)	0.84	Start at 6 V and stay at 6 V. Avg. current density is 6 amps/sq.in. Deposit should be medium-gray, matte, smooth deposit. Deposit shall not be bright or burnt.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	SIFCO 5030/3004					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 5030/3004 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 3 minutes to develop a dark coating color.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
5	6	1.02		1.47	0.58	0.34	
* mils After Plating							

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Base Material:	1010 Steel 4x6x0.004 inch	**Area Plated:**	2.5x3.5"	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-90 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 8.75 * 0.0008 = 0.74				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 8.75 sq. in. Brush plate In center of test panel to repair area 2.5 x 3.5 inches.
5	Pre-Wet	ZINIDAL Aero 11040	0				Prewet with Zinidal Aero
6	Zn-Ni Plate	ZINIDAL Aero 11040	7.5 to 10	Fwd	10 (88 amps)	0.74	Start at 10 volts then drop in 1 volt increments until 8 to 9 volts. Adjust voltage to maintain an average current density of 10 amps/sq.in. Deposit should be a bright to matte, smooth deposit.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 seconds to develop a dark coating color.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
7	8-Oct	1.06		1.41	0.91	0.18	
* mils After Plating							

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Base Material:	1010 Steel 4x6x0.004 inch	**Area Plated:**	2.5x3.5"	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 to 0.8 mil	
Plating Tool:	Graphite FT-90 Flat Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 8.75 * 0.0008 = 0.74				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deoxidize	Al Oxide Sandpaper					Dry sand to remove oxides.
3	Clean	MPK or Desoclean 45					Remove sanding debris.
4	Mask	Vinyl/Teflon Tape					Expose 8.75 sq. in. Brush plate In center of test panel to repair area 2.5 x 3.5 inches.
5	Pre-Wet	ZINIDAL Aero 11040	0				Prewet with Zinidal Aero
6	Zn-Ni Plate	ZINIDAL Aero 11040	12	Fwd	10 (88 amps)	0.74	Start at 12 volts and maintain volatage at 12 V. Deposit should be a dull - not bright and no burning.
7	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
8	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 seconds to develop a dark coating color.
9	Rinse						
10	Dry						

#	Volts	Thickness*	Thickness Range*	max	min	std dev	
6	12	1.2		1.33	1.03	0.1	
* mils After Plating							

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 3**
Deposit Required:	SIFCO 2023 Cd	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 2023: A-Hr = 70 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 70 * 1.25 * 0.0008 = 0.07				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	SIFCO 2023	0				Prewet with SIFCO 2023.
8	Cd Plate	SIFCO 2023	6 to 20	Fwd	2 to 4 (4 to 8 amps)	0.07	Start at 18-20 volts until a visible layer of cadmium is deposited, then reduce the voltage to 6 to 9 volts to stop burning and continue plating for the number of ampere–hours calculated. Deposit shall be smooth, fine–grained, adherent, and free from blisters, pits, nodules, indications of burning, and other defects. Slight residual discoloration, not attributable to burning, is acceptable.
9	Rinse, Demask, Rinse and Air						Rinse again after demasking.
10	Conversion Coat	SIFCO 3002/5005					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 3002/5005 solution. Swab SIFCO 3002/5005 onto surface for 15 to 60 seconds to form gold to light brown conversion coating.
11	Rinse and Dry						

NOTE:

Ship 3 for HE Testing within 72 hours.

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	36	5/8/2018	10:30				
1.1A	34	5/8/2018	11:43				
1.1A	33	5/8/2018	11:55				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 4**
Deposit Required:	SIFCO 4018 ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 4018: A-Hr = 120 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 120 * 1.25 * 0.0008 = 0.12				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	NONE	0				**Do not prewet with SIFCO 4018!**
8	Zn-Ni Plate	SIFCO 4018	6	Fwd	4 to 8	0.12	Start at 6 V and stay at 6 V. Avg. current density is 6 amps/sq.in. Deposit should be medium-gray, matte, smooth deposit. Deposit shall not be bright or burnt.
9	Rinse, Demask, Rinse and Air						Rinse again after demasking.
10	Conversion Coat	SIFCO 5030/3004					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 5030/3004 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse (preferred). Keep surface wet for 30 to 60 seconds to develop a dark coating color.
11	Rinse						
12	Dry						
Ship 4 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	19	5/21/2018	12:55				
1.1A	20	5/21/2018	13:15				
1.1A	32	5/21/2018	14:00				
1.1A	35	5/21/2018	15:25				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 4**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8	Zn-Ni Plate	Zinidal Aero 11040	8 to 9V	Fwd	10	0.105	Start at 10 volts then drop in 1 volt increments until 10 amps/sq.in. (8 to 9 V). Adjust voltage to maintain an average current density of 10 amps/sq.in. Deposit should be a bright to matte, smooth deposit.
9	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
10	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 seconds to develop a dark coating color.
11	Rinse						
12	Dry						
Ship 4 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	37	6/4/2018	8:30				
1.1A	38	6/4/2018	8:45				
1.1A	39	6/4/2018	10:55				
1.1A	40	6/4/2018	11:15				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 4**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.105	Start at 12 volts and maintain volatage at 12 V. Deposit should be a dull - not bright and no burning.
9	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
10	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 - 20 seconds to develop a dark coating color.
11	Rinse						
12	Dry						
Ship 4 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	1	5/29/2018	10:40				
1.1A	2	5/29/2018	10:55				
1.1A	3	5/29/2018	11:10				
1.1A	4	5/29/2018	11:25				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 3**
Deposit Required:	SIFCO 2023 Cd	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	50 FPM	
Solution Supply:	Dip	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 2023: A-Hr = 70 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 70 * 1.25 * 0.0008 = 0.07				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	SIFCO 2023	0				Prewet with SIFCO 2023.
8	Cd Plate	SIFCO 2023	6 to 20	Fwd	2 to 4 (4 to 8 amps)	0.07	Start at 18-20 volts until a visible layer of cadmium is deposited, then reduce the voltage to 6 to 9 volts to stop burning and continue plating for the number of ampere–hours calculated. Deposit shall be smooth, fine–grained, adherent, and free from blisters, pits, nodules, indications of burning, and other defects. Slight residual discoloration, not attributable to burning, is acceptable.
9	Rinse, Demask, Rinse and Air						Rinse again after demasking.
10	Conversion Coat	SIFCO 3002/5005					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 3002/5005 solution. Swab SIFCO 3002/5005 onto surface for 15 to 60 seconds to form gold to light brown conversion coating.
11	Rinse and Dry						
NOTE:							

Ship 3 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated	Date & Time Tested	Pass/Fail	Comments
1.1A	17	12/5/2017 16:30	12/8/2017	PASS	ISL TEST = 92.2% NFS
1.1A	18	12/5/2017 16:30	12/8/2017	PASS	ISL TEST = 93.2% NFS
1.1A	45	12/5/2017 16:30	12/8/2017	PASS	ISL TEST = 90% NFS

Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.

	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 3**
Deposit Required:	SIFCO 4018 ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Sifco 4018: A-Hr = 120 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 120 * 1.25 * 0.0008 = 0.12				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	NONE	0				**Do not prewet with SIFCO 4018!**
8	Zn-Ni Plate	SIFCO 4018	6	Fwd	4 to 8	0.12	Start at 6 V and stay at 6 V. Avg. current density is 6 amps/sq.in. Deposit should be medium-gray, matte, smooth deposit. Deposit shall not be bright or burnt.
9	Rinse, Demask, Rinse and Air						Rinse again after demasking.
10	Conversion Coat	SIFCO 5030/3004					Use Type A brown Scotch-Brite and water to clean surface, rinse thorougly, remove excess water (do not dry) then apply SIFCO 5030/3004 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 30 to 60 seconds to develop a dark coating color.
11	Rinse						
12	Dry						
Ship 3 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	47	1/29/2018	14:00	2/1/2018		Pass	94.18% NFS
1.1A	9	1/29/2018	15:00	2/2/2018		Pass	98% NFS
1.1A	10	1/29/2018	16:00	2/4/2018		Pass	96.91% NFS
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 3**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8	Zn-Ni Plate	Zinidal Aero 11040	7.5 to 10V	Fwd	10	0.105	Start at 10 volts then drop in 1 volt increments until 10 amps/sq.in. Adjust voltage to maintain an average current density of 10 amps/sq.in. Deposit should be a bright to matte, smooth deposit.
9	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
10	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 seconds to develop a dark coating color.
11	Rinse						
12	Dry						
Ship 3 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	12	2/12/2018	14:00	2/15/2018		Fail	8.5V - 60.05% NFS
1.1A	11	2/12/2018	14:45	2/14/2018		Fail	8.5V - 60.05% NFS
1.1A	25	2/12/2018	13:05	2/15/2018		Fail	8.5V - 64.97%
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 3**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2	Deox	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5	Activate	Al Oxide abrasive					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.105	Start at 12 volts and maintain volatage at 12 V. Deposit should be a dull - not bright and no burning.
9	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
10	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle (preferred). Keep surface wet for 10 - 20 seconds to develop a dark coating color.
11	Rinse						
12	Dry						
Ship 3 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	27	2/19/2018	12:50	2/22/2018		Fail	64.97% NFS
1.1A	26	2/19/2018	13:05	2/23/2018		Fail	69.88% NFS
1.1A	28	2/19/2018	13:13	2/24/2018		Fail	69.88% NFS
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Attachment No. 3 – UDRI Brush Plate Work Sheets for Phase 1 Test Specimens and Tech Data Sheet for Dalistick Zinidal Aero Zinc-Nickel Brush Plating

DATA SHEET

Code: FT DA 5

Zinc-Nickel alloy plating using Zinidal Aero solution and DALISTICK

1. FIELD OF APPLICATION

The Zinc-Nickel alloy produced by electrolysis of ZINIDAL AERO solution with the classical brush process or with the DALISTICK tool is particularly designed to protect steel and aluminium from corrosion. This alloy is more suitable than Cadmium or Zinc if a superficial hardness is required or if the treated part is to be occasionally exposed to higher than room temperature. The plating is realized in a very short time.

2. MAIN PROPERTIES OF THE DEPOSIT

- ***Average Vickers hardness***: 250-300 HV (50g)
- ***Nickel content***: 10-14%
- ***Average thickness***: For high protection levels of steel, 8 µm are enough with a Chromium VI passivation. According to the part shape or anticorrosion requirements, 6 or maybe 4 µm might be sufficient.
- ***Galvanic coupling tests***: The bare coating is sacrificial when associated with steel. The protection time of steel plated with 8 µm is about 20 % longer with Zinc-Nickel than with Zinc *(in 50 g/L NaCl)*.
- ***Protection against corrosion in neutral salt spray****: Not passivated deposits on mild steel:*
  - Compared to Zinc at the same thickness, the protection time with the alloy, just before the first rust pits appear, is greater by 1.5 / 2.
  - The protection time increases with the thickness (has been tested up to 30 µm).
  - With 8 µm, the first rust pits appear between 100 to 200 hrs according to the part shape and the base metal. Then corrosion quickly spreads on the surface.
  - 1018 steel coated with 12-13 µm: first rust points after 500 h.

  Zinc-Nickel (8 µm)-coated mild steel passivated with the Cr VI PASSIVATEUR n°3 solution (dipping, 6-8 s):
  - Traces of white oxidized compounds appear in the first hours. They remain rare after 200-300 hrs of exposure.
  - First rust pits appear beyond 1000 hrs. With a thermal treatment for 1 hr at 120°C before the salt spray test, they start appearing right after 1000 hrs.

  Zinc-Nickel (8 µm)-coated 6060 Al passivated with the CrVI PASSIVATEUR n°3 solution (cotton wool, 10 s):
  - The parts are not corroded after an exposure of 800 hrs (white traces).
- ***Corrosion tests on real site***: Our current experience on pieces exposed in natural corrosion since 12 years shows that one micron of Zinc-nickel alloy procures a protection during one year. As an example, for a 10 years protection, we would recommend 10 µm plus a 50 % reserve, i.e. 15 µm.

3. LIST OF EQUIPMENT AND NECESSARY CONSUMABLES

Masking around the area to be treated

Adhesive tapes 3M 5413 and other tapes of PVC or aluminum.

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Removal of an existing deposit (cadmium, zinc or zinc-nickel)

- On steel: by hand abrading or with etchings: ACTIVATOR ST2 solution, code 10076 (for the 3 metals) or CADMIUM & ZINC STRIP, code 10090 (if cadmium) or solution ACTIVATOR XA, code 10005 (if zinc-nickel).
- On aluminum: DEPASSIVATOR 25-2 solution, code 10103.

Surface preparation before plating (on steel, electrochemically)

Acetone
ACTIVATOR XF, code: 10054
Brush electrodes and X13 plating tools or Dalistick (not the same than the one used for plating).

Surface preparation before plating (on steel, by hand abrading)

Pneumatic grinding tool equipped with 3M ROLOC disks:
Brown disk: reference SCDRA MARR, 66L05528 – Blue disk: reference SCDR ATF BL, 66L05523.
220 grit silicon carbide paper
3M red 'Scotch brite' ref: CF-RL type 'A' very
fine. CC115 alumina powder, size F150 or 150
mesh or 88 µm Cotton wool

Surface preparation before plating (on aluminum 2219)

DEGREASER ST solution, code 10006.
220 grit silicon carbide paper and 3M red 'Scotch brite' ref: CF-RL type 'A'
very fine. ACTIVATOR 25 solution, code 10040.

ZINIDAL AERO plating

ZINIDAL AERO solution, code 11040

Passivation

PASSIVATEUR N°3 solution, code
10039. Cotton wool

Equipment for the electrochemical treatment

DALISTICK PA station.

Hot air (hair dryer for example) or oil-free dry compressed air

Inspection and measurement of the layer

Adhesive tape 3M 895 for the adhesion (adhesion on steel: 600 cN/cm).
Magnetic induction equipment for thickness.
Micrographic inspection on micro-sections for structure and thickness

Means of protection

Gloves of nitrile, goggles, protective clothes and shoes.

All equipments and consumables can be sourced from DALIC, France which is manufacturer of the solutions and of the DALISTICK station.

4. MAIN ELECTROLYSIS PARAMETERS of ZINIDAL AERO PLATING using DALISTICK

Maximum voltage	Adjust at **12 V**
Maximum current	Adjust at **5 A**
Polarity	Normal
Quantity of current (q)	**64 mAh** / 1 µm on 1 dm^2
Temperature	Keep at **20°C**
Fabric	Dalistick bonnet of white scotch brite. Change it every about 5 dm^2
DALISTICK electrode	Platinized Titanium
Maximum recommended usage rate	Up to **10 Ah/L**

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Achieving 1 µm of zinc-nickel on 1 dm², lasts about 1,35 min.

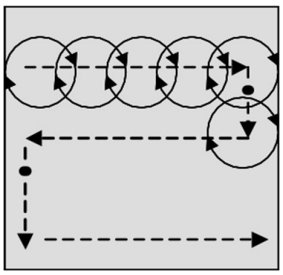
5. TREATMENT WITH THE DALISTICK

Use the following formula to calculate the current quantity (Q):

Q (mAh) = area to be treated (dm²) x required thickness (µm) x q (mAh / µm on 1 dm²)

The processing time can be arrived at by using the formula:

Q (Ah) = I (A) x time (h)



At the beginning, wet the area with the DALISTICK and the solution without power then switch on the power pack and commence the electrolytic process. Move homogeneously all over the surface with small circular movements. If possible, change regularly the application movement of the DALISTICK.

It is not necessary to apply strong pressure between the DALISTICK and the surface being processed.
Do not leave the tool motionless while in contact with the part. The treatment must not be interrupted.
When the treatment is finished, switch off the power pack, replace the tool in its support and switch off the pump.
Strictly observe the usage rate that is recommended for the solution.

6. APPLICATION PROCESSES ON STEEL

Treatment range n°1 – Electrochemically, on bare steel

Not treated 1018 steel, 15CDV6 treated at 1030-1060 MPa and AISI E4340 at 1800 MPa have been tested

1. Degrease with solvent,
2. Mask around the area to be treated. Apply pressure on the tape especially near the angles to avoid infiltration,
3. Etching with ACTIVATOR XF solution: 16V, reverse polarity, 500 mAh/dm², brush plating tool covered with Bonnet having for example a size of the ¼ of that to be treated or Dalistick tool (see FTDA6) - Wipe with wet paper until it becomes clean, without allowing the surface to dry,
4. Rinse with water,
5. Moisten the surface with ZINIDAL AERO solution without current,
6. Do the ZINIDAL AERO treatment with DALISTICK,
7. Rinse with water,
8. Remove the masking,
9. Rinse with water, 10.Dry with paper,
11. Dry with hot or oil-free dry compressed air,.

If the coating has to be passivated: After step 7:

- Dry with hot or oil-free dry compressed air,
- Apply passivation,
- Rinse with water,
- Remove the masking,
- Rinse with water,
- Dry with hot or oil-free dry compressed air.

Treatment range n°2 – By hand abrading on bare steel

1. Degrease with solvent,
2. Mask around the area to be treated. Apply pressure on the tape especially near the angles to avoid infiltration,
3. Grind as close as possible from the masking with a pneumatic grinding tool equipped with a 3M brown ROLOC disk – Clean with wet paper (until it becomes clean),
4. Grind as close as possible from the masking with a pneumatic grinding tool equipped with a 3M blue

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ROLOC disk - Clean with wet paper (until it becomes clean),
5. Abrade with 220 grit paper and water (2 go and back following the 2 part directions) - Clean with wet paper (until it becomes clean),
6. Abrade with red 'scotch brite' and water (2 go and back following the 2 part directions) while insisting close to the tape - Clean with wet paper (until it becomes clean),
7. Clean with CC115 alumina powder on a piece of wet cotton (2 go and back following the 2 part directions) - Clean with wet paper (until it becomes clean),
8. Moisten the surface with the ZINIDAL AERO solution without current,
9. Perform the treatment with the

DALISTICK, 10.Rinse with water,
11.Remove the masking, rinse with
water, 12.Dry with paper,
13.Dry with hot or oil-free dry compressed air.

If the coating has to be passivated:
After step 10, proceed as described above.

Remark: the use of a pneumatic grinding tool may be avoided. For that, follow the above procedure with only the steps 1, 2, 5 (but take 120 grit paper for 5) and then continue with 7 to 13. Check adhesion.

Treatment range n°3 on coated steel (local repair of damaged cadmium, zinc or zinc-nickel platings)

Way 1: apply the sequence of steps n°2 to remove the damaged layer and repair with zinc-nickel.

Way 2: apply the sequence of steps n°1 but replace ACTIVATOR XF in step 3 by an electrochemical treatment
with ACTIVATOR ST2 solution, code 10076, 16 V, reverse polarity (technical data sheet FTDA7 with Dalistick). According to the steel and if the zinc-nickel plating can be realized immediately, continue with the step 4 of the range n°1. Otherwise, recommence at step 3 (XF), possibly with a lower current quantity.

Way 3: cadmium can be dissolved also with CADMIUM & ZINC STRIP solution, code 10090. Apply for a few minutes without current on a piece of cotton wool until to see the substrate (10 min for 15 µm, which is three times longer than with ACTIVATOR ST2). Rinse with water and then continue with the treatment range n°1 or n°2.

Way 4: zinc-nickel can be dissolved also with ACTIVATOR XA solution, code 10005. Apply for about 5 minutes without current on a piece of cotton wool until to see the substrate. Rinse with water and then continue with the treatment range n°1 or n°2.

7. APPLICATION PROCESSES ON ALUMINIUM

Several sequences can be applied following the situation (bare or coated aluminum, type of aluminum alloy).
We are describing below an example: the repair of scratches going thru 2219 aluminum; this is plated with damaged zinc or zinc-nickel, with possibly a sandwiched layer of nickel.

1. Degrease with solvent,
2. Mask around the area to be treated. Apply pressure on the tape especially near the angles to avoid infiltration,
3. Apply DEPASSIVATOR 25-2 solution with a piece of Dalistick bonnet without current for a few seconds (after blackening, the color becomes white).
4. Rinse with water,
5. Degrease with DEGREASER ST solution (normal polarity, 20V, 250 mAh/dm²),
6. Rinse with water,
7. Abrade with red 'scotch brite' and water,
8. Rinse with water,
9. Apply ACTIVATOR 25 solution with a piece of Dalistick bonnet without current for 30 seconds,
10. Rinse with water,
11. Do the ZINIDAL AERO treatment with DALISTICK, 12 µm,
12. Rinse with water, remove the masking, rinse with water,
13. Abrade the repair and all around with red 'scotch brite' and water,

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14. Do the ZINIDAL AERO treatment with DALISTICK on the abraded area, 5-10 µm,
15. Rinse with water,
16. Abrade with P220 paper and then with red 'scotch brite' on the limits of the first treatment to remove any trace,
17. Rinse with water, dry with paper, dry with hot air or compressed de-oiled dry air.

8. REWORKING PROCESSES

To coat zinc-nickel on itself (notably for a thickness over 30 µm): sand down the surface with water and red 'scotch brite'. Rinse with water. Wet with ZINIDAL AERO solution first without current and then with.

To coat zinc-nickel on cadmium: sand down the cadmium with red 'scotch brite' moistened with ZINIDAL AERO solution (no re-use). Rinse with new ZINIDAL AERO solution and apply current.

9. PASSIVATION WITH PASSIVATEUR n°3 SOLUTION

Following the shape and size of the treated area, several methods can be applied at room temperature (15- 25°C), always on dry Zinc-Nickel:

- **Dipping** for 6 to 8 sec.
- **Local application (small areas)**: moisten a piece of cotton wool with solution. Apply on the surface with a soft movement, mildly for 8 s.
- **Application by spraying (large areas)**: spray and let some minutes (30 maximum). In all cases, rinse immediately with tap water. Dry with hot air or compressed de-oiled dry air.

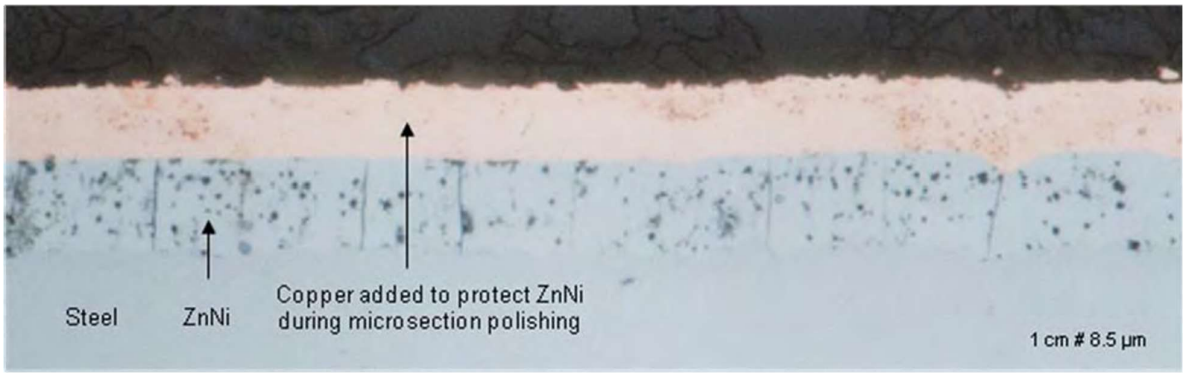
Before setting up the part in operation, it's advisable to wait some hours (12 to 24) before handling it in order to favour the stabilization of the passivation layer, even if this seems to be adherent.

10. QUALITY INSPECTION

Follow the determinations required in the product specification for example:

- **Visual aspect**,
- **Adhesion** with adhesive tape 3M 895 or 3M 250,
- **Thickness measurements**: magnetic measurements performed with equipment calibrated on the bare substrate that has followed the same cleaning range, can give a good estimate of the thickness.

Adhesion and thickness can be also evaluated on micrographic sections:



Sectional view of the coating on steel (treatment ranges n°1 or n°2)

11. TECHNICAL SUPPORT

We are at your service to establish the optimal operating conditions suited to each application, should you so require.

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DALIC®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Characterization Specimen 1
Creation date :	26/09/2017 09:29:53

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Characterization Specimen 1
Part designation	Characterization Specimen 1

Treatment

Surface (dm²)	0,38
Estimated duration	3,79

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002 B24
Beaker	Zinc Nickel unit
Initial volume	1,00
Total current quantity (mA	0,06
Thickness	13,00
Min. allowable thickness	8,00
Max. allowable thickness (	18,00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002 B9	1,00	Dalistick tool for Activators
Passivateur n°3	20150001 B3	0,00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant

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06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : Characterization Specimen 1
Creation date : 26/09/2017 09:29:53

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.38 Quantity of current (mAh) :316.16 Treatment duration (min) :0:03:48	Compliant
26	DKPL pump activation Message Validate	Compliant

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27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

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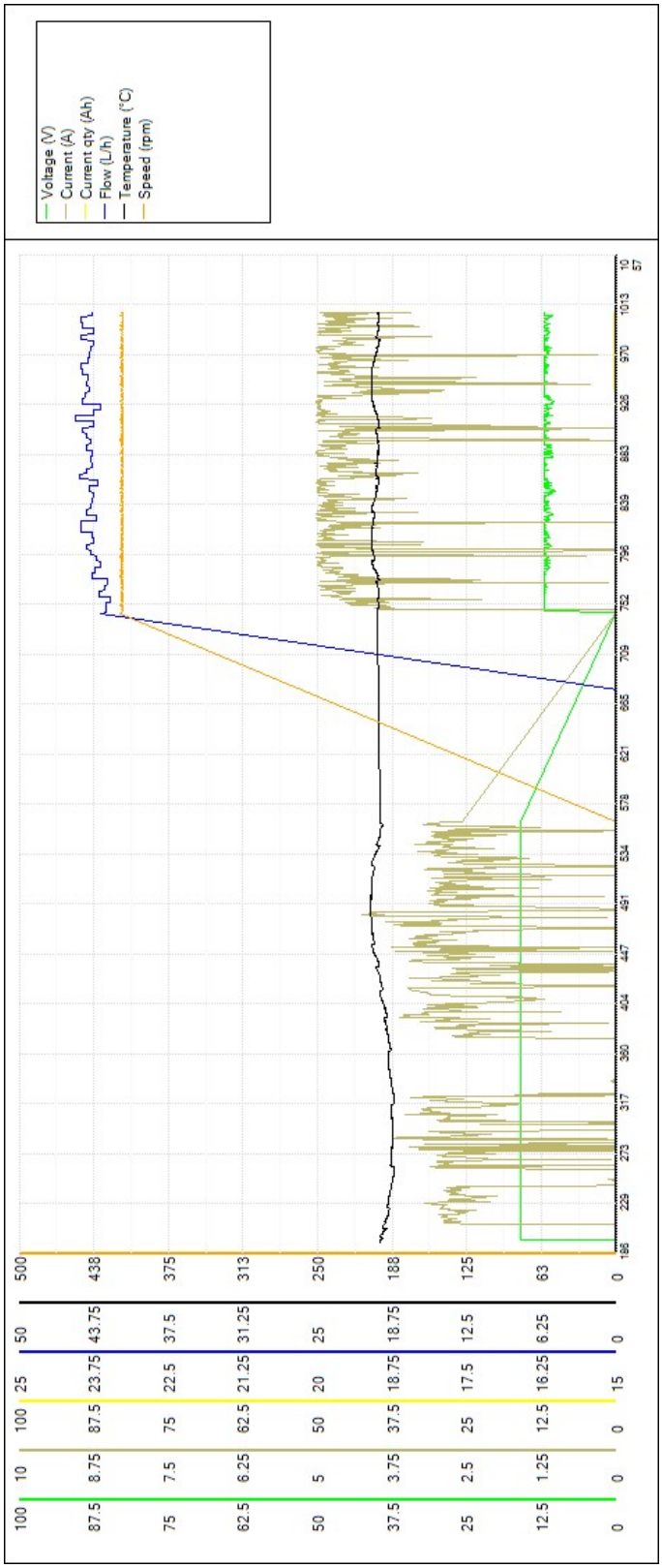
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (20160002 B9 - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002 B24 - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALIC®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Characterization Specimen 1 **Creation date :** 26/09/2017 09:29:53

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 9.1 Maximum (µm) : 15.5 Average (µm) : 12.36 Standard deviation (µm) : 2.03 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Emily Meredith	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)

DALIC®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Characterization Specimen 1
Creation date : 26/09/2017 09:29:53

Events

Date	N°	Type	Completion
10:01:08	66	Step over	
10:01:08	66	Operating mode complete	
10:01:06	66	Step started	Message Validate
10:01:06	65	Step over	
10:01:05	65	Step started	Control Final
10:01:05	64	Step over	
10:01:05	64	Step started	Message Validate
10:01:04	63	Step over	
10:01:03	62	Step over	
10:01:03	63	Step started	Message Validate
10:01:03	62	Step started	Message Validate
10:01:03	61	Step over	
10:01:02	60	Step over	
10:01:02	61	Step started	Message Validate
10:01:01	60	Step started	Message Validate
10:01:01	59	Step over	
10:01:00	59	Step started	Message Validate
10:00:59	58	Step over	
09:53:27	58	Step started	Control Thickness (µm)
09:53:27	57	Step over	
09:53:25	57	Step started	Message Validate
09:53:25	56	Step over	
09:53:22	56	Step started	Control Adhesion
09:53:22	55	Step over	
09:53:20	55	Step started	Control Aspect
09:53:19	54	Step over	
09:53:18	54	Step started	Message Validate
09:53:18	53	Step over	
09:53:16	52	Step over	
09:53:16	53	Step started	Message Validate
09:53:15	51	Step over	
09:53:15	52	Step started	Message Validate
09:53:14	51	Step started	Message Validate
09:53:14	50	Step over	
09:47:04	50	Exception	port:3, slave:1, starting address:0 end:10 System.Exception: Time-out read serial port 3 at DalistickDevices.Rs232.AttendreBytesRS232(Int32 bnBytes) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 698 at DalistickDevices.Rs232.Read(Int32 Bytes2Read) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 713 at DalistickDevices.ClassModbus.AttentRéponseEqt(Byte[]& TableauRéponse, Int32& NbDonnéesDansTrame) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 331 at DalistickDevices.ClassModbus.Lecture(Int16& esclave, Int32& adresse, Int16& nbregistre, Int64[]& TablRéponse, Codefonction Code, Byte LgData, Boolean ignorerErreurs) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 478
09:47:00	50	Communication error	Dalipump
09:47:00	49	Step over	
09:47:00	50	Step started	Message Validate

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09:47:00	49	Communication error	Dalipump

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09:46:59	49	Powering	
09:46:59	49	No compressed air	
09:46:49	48	Step over	
09:46:49	49	Step started	Message Validate
09:46:49	48	Step started	Setting Pumping (Set point: Off)
09:46:49	47	Step over	
09:46:43	46	Step over	
09:46:43	47	Step started	Message Validate
09:46:42	46	Step started	Setting Generation (Set point: Off)
09:46:42	45	Step over	
09:42:20	44	Step over	
09:42:20	45	Step started	Waiting Current quantity (%) (Set point: 100)
09:42:19	43	Step over	
09:42:19	44	Step started	Setting Generation (Set point: On)
09:42:19	43	Step started	Setting Solution (20160002 B24 - Zinidal Aero)
09:42:19	42	Step over	
09:42:19	42	Step started	Setting Polarity (Set point: Plating)
09:42:19	41	Step over	
09:42:18	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
09:42:18	40	Step over	
09:42:18	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
09:42:18	39	Step over	
09:42:18	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
09:42:17	38	Step over	
09:41:57	38	Process defect: flow lower limit reached	
09:41:52	38	Step started	Message Validate
09:41:52	37	Step over	
09:41:48	37	Step started	Message Validate
09:41:48	36	Step over	
09:41:48	36	Process defect: flow lower limit reached	
09:41:47	36	Step started	Setting Pumping (Set point: On)
09:41:47	35	Step over	
09:39:24	35	Step started	Message Validate
09:39:24	34	Step over	
09:39:19	34	Step started	Message Validate
09:39:19	33	Step over	
09:39:18	33	Step started	Setting Generation (Set point: Off)
09:39:18	32	Step over	
09:33:12	31	Step over	
09:33:12	32	Step started	Waiting Current quantity (%) (Set point: 100)
09:33:11	30	Step over	
09:33:11	31	Step started	Setting Generation (Set point: On)
09:33:11	30	Step started	Setting Solution (20160002 B9 - Activator XF)
09:33:11	29	Step over	
09:33:09	29	Step started	Message Validate
09:33:09	28	Step over	
09:32:54	28	Step started	Message Validate
09:32:54	27	Step over	
09:32:40	27	Step started	Message Validate
09:32:40	26	Step over	
09:32:29	26	Step started	Message Validate
09:32:29	25	Step over	
09:31:32	24	Step over	
09:31:32	25	Step started	Setting Surface
09:31:32	24	Step started	Setting Pumping (Set point: Off)
09:31:32	23	Step over	
09:31:29	23	Step started	Message Validate
09:31:29	22	Step over	

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09:31:27	21	Step over	
09:31:27	22	Step started	Message Validate
09:31:27	20	Step over	
09:31:27	21	Step started	Setting Pumping (Set point: On)
09:31:26	19	Step over	
09:31:26	20	Step started	Message Validate
09:31:25	18	Step over	
09:31:25	19	Step started	Message Validate
09:31:25	17	Step over	
09:31:25	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
09:31:23	17	Step started	Message Validate
09:31:23	16	Step over	
09:31:23	15	Step over	
09:31:23	16	Step started	Message Validate
09:31:22	15	Step started	Message Validate
09:31:22	14	Step over	
09:31:22	14	Step started	Message Validate
09:31:21	13	Step over	
09:31:16	13	Step started	Message Validate
09:31:16	12	Step over	
09:30:22	11	Step over	
09:30:22	12	Step started	Message Validate
09:30:22	11	Step started	Message Validate
09:30:22	10	Step over	
09:30:21	10	Step started	Message Validate
09:30:21	09	Step over	
09:30:20	08	Step over	
09:30:20	09	Step started	Message Validate
09:30:19	08	Step started	Message Validate
09:30:19	07	Step over	
09:30:15	07	No compressed air	
09:30:15	07	Powering	
09:30:00	06	Step over	
09:30:00	07	Step started	Message Validate
09:30:00	05	Step over	
09:30:00	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
09:30:00	04	Step over	
09:30:00	05	Step started	Setting Polarity (Set point: Anodizing)
09:30:00	03	Step over	
09:30:00	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
09:30:00	02	Step over	
09:30:00	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
09:29:59	02	Step started	Setting Generation (Set point: Off)
09:29:59	01	Step over	
09:29:58	01	Step started	Setting Pumping (Set point: Off)
09:29:57	01	Operating mode started	Characterization Specimen 1

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DALIC®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Characterization Specimen 2
Creation date :	26/09/2017 10:49:34

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Characterization Specimen 2
Part designation	Characterization Specimen 2

Treatment

Surface (dm²)	0,38
Estimated duration	3,82

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002 B24
Beaker	Zinc Nickel unit
Initial volume	1,00
Total current quantity (mA	0,06
Thickness	13,00
Min. allowable thickness	8,00
Max. allowable thickness (	18,00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002 B9	1,00	Dalistick tool for Activators
Passivateur n°3	20150001 B3	0,00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

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DALIC®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Characterization Specimen 2 **Creation date :** 26/09/2017 10:49:34

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.38 Quantity of current (mAh) :318.24 Treatment duration (min) :0:03:49	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant

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28	Wetting Message Validate	Compliant
29	Information	Compliant

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Characterization Specimen 2
Creation date :	26/09/2017 10:49:34

	Message Validate	
30	Activator XF Setting Setting Solution (20160002 B9 - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002 B24 - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALIC®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Characterization Specimen 2
Creation date : 26/09/2017 10:49:34

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 8.5 Maximum (µm) : 21.4 Average (µm) : 13.45 Standard deviation (µm) : 4.25 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Emily Meredith	Compliant
66	Cleaning information Message Validate	Compliant

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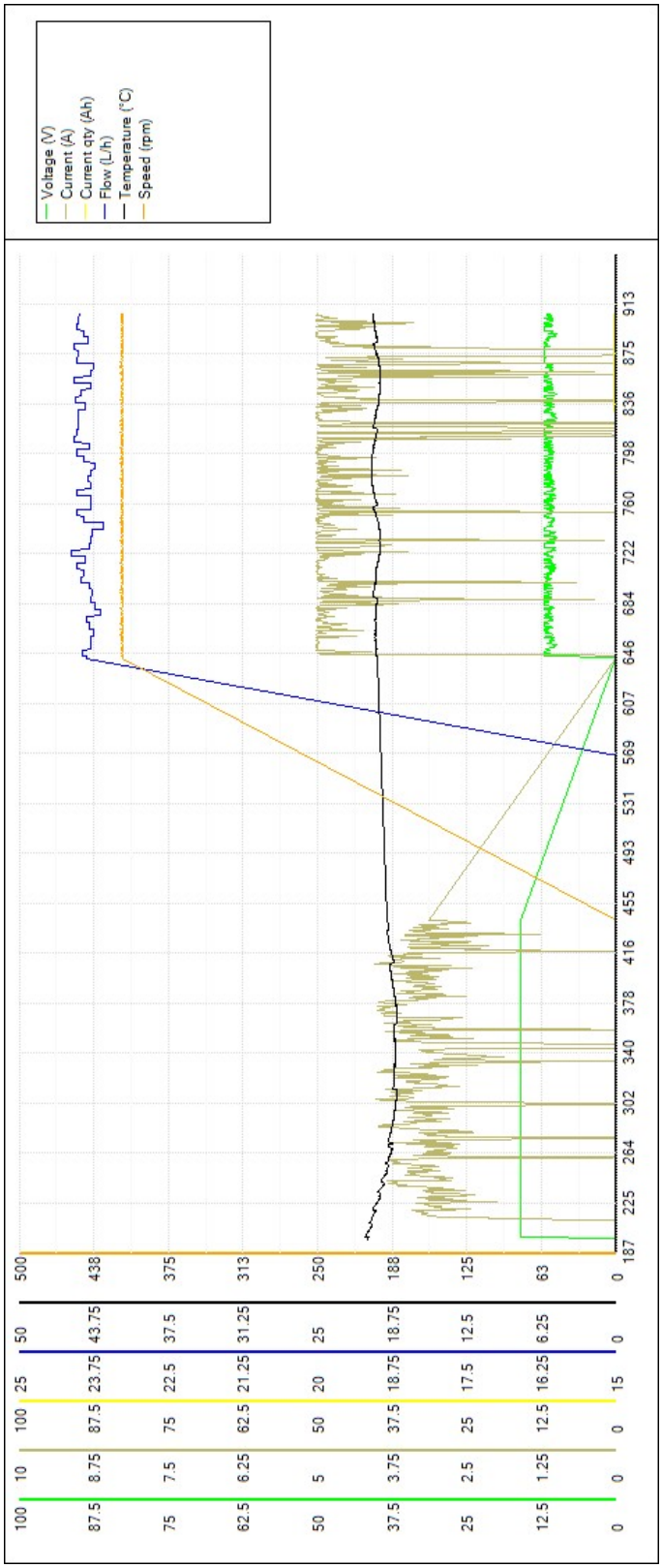
Zinc-Nickel with Dalistick tool
Characterization Specimen 2

26/09/2017 10:49:34



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Treatment : Zinc-Nickel with Dalistick tool
Part reference : Characterization Specimen 2
Creation date : 26/09/2017 10:49:34

Events

Date	N°	Type	Completion
11:13:12	66	Step over	
11:13:12	66	Operating mode complete	
11:13:11	66	Step started	Message Validate
11:13:11	65	Step over	
11:13:11	65	Step started	Control Final
11:13:11	64	Step over	
11:13:10	64	Step started	Message Validate
11:13:10	63	Step over	
11:13:09	63	Step started	Message Validate
11:13:09	62	Step over	
11:13:09	62	Step started	Message Validate
11:13:09	61	Step over	
11:13:08	61	Step started	Message Validate
11:13:08	60	Step over	
11:13:06	60	Step started	Message Validate
11:13:06	59	Step over	
11:13:05	59	Step started	Message Validate
11:13:05	58	Step over	
11:06:49	58	Step started	Control Thickness (µm)
11:06:49	57	Step over	
11:06:47	57	Step started	Message Validate
11:06:47	56	Step over	
11:06:46	56	Step started	Control Adhesion
11:06:46	55	Step over	
11:06:45	55	Step started	Control Aspect
11:06:45	54	Step over	
11:06:39	54	Step started	Message Validate
11:06:39	53	Step over	
11:06:37	53	Step started	Message Validate
11:06:37	52	Step over	
11:06:34	52	Step started	Message Validate
11:06:33	51	Step over	
11:06:30	51	Step started	Message Validate
11:06:30	50	Step over	
11:05:33	50	Step started	Message Validate
11:05:33	49	Step over	
11:04:55	49	Exception	port:3, slave:1, starting address:0 end:10 System.Exception: Time-out read serial port 3 at DalistickDevices.Rs232.AttendreBytesRS232(Int32 bnBytes) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 698 at DalistickDevices.Rs232.Read(Int32 Bytes2Read) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 713 at DalistickDevices.ClassModbus.AttentRéponseEqt(Byte[]& TableauRéponse, Int32& NbDonnéesDansTrame) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 331 at DalistickDevices.ClassModbus.Lecture(Int16& esclave, Int32& adresse, Int16& nbregistre, Int64[]& TablRéponse, Codefonction Code, Byte LgData, Boolean ignorerErreurs) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 478
11:04:50	49	Communication error	Dalipump

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11:04:50	49	Communication error	Dalipump

DALIC®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Characterization Specimen 2
Creation date : 26/09/2017 10:49:34

11:04:50	49	No compressed air	
11:04:49	49	Powering	
11:04:46	49	Step started	Message Validate
11:04:46	48	Step over	
11:04:46	48	Step started	Setting Pumping (Set point: Off)
11:04:46	47	Step over	
11:04:41	47	Step started	Message Validate
11:04:41	46	Step over	
11:04:40	46	Step started	Setting Generation (Set point: Off)
11:04:40	45	Step over	
11:00:18	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:00:18	44	Step over	
11:00:16	44	Step started	Setting Generation (Set point: On)
11:00:16	43	Step over	
11:00:16	43	Step started	Setting Solution (20160002 B24 - Zinidal Aero)
11:00:16	42	Step over	
11:00:16	42	Step started	Setting Polarity (Set point: Plating)
11:00:16	41	Step over	
11:00:16	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:00:16	40	Step over	
11:00:16	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:00:16	39	Step over	
11:00:15	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:00:15	38	Step over	
10:58:02	38	Step started	Message Validate
10:58:02	37	Step over	
10:57:41	37	Step started	Message Validate
10:57:41	36	Step over	
10:57:41	36	Step started	Setting Pumping (Set point: On)
10:57:41	35	Step over	
10:57:01	35	Step started	Message Validate
10:57:01	34	Step over	
10:56:56	34	Step started	Message Validate
10:56:56	33	Step over	
10:56:56	33	Step started	Setting Generation (Set point: Off)
10:56:56	32	Step over	
10:52:53	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:52:53	31	Step over	
10:52:51	31	Step started	Setting Generation (Set point: On)
10:52:51	30	Step over	
10:52:51	30	Step started	Setting Solution (20160002 B9 - Activator XF)
10:52:51	29	Step over	
10:52:49	29	Step started	Message Validate
10:52:49	28	Step over	
10:52:39	28	Step started	Message Validate
10:52:39	27	Step over	
10:52:33	27	Step started	Message Validate
10:52:33	26	Step over	
10:52:31	26	Step started	Message Validate
10:52:31	25	Step over	
10:51:39	25	Process defect: temperature upper limit reached	
10:51:35	25	Process defect: temperature upper limit reached	
10:51:30	24	Step over	
10:51:30	25	Step started	Setting Surface
10:51:29	24	Step started	Setting Pumping (Set point: Off)

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10:51:29	23	Step over	
10:51:16	23	Step started	Message Validate
10:51:16	22	Step over	

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Characterization Specimen 2
Creation date : 26/09/2017 10:49:34

10:51:13	22	Step started	Message Validate
10:51:13	21	Step over	
10:51:13	21	Step started	Setting Pumping (Set point: On)
10:51:13	20	Step over	
10:51:12	20	Step started	Message Validate
10:51:12	19	Step over	
10:51:11	18	Step over	
10:51:11	19	Step started	Message Validate
10:51:10	17	Step over	
10:51:10	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:51:10	17	Step started	Message Validate
10:51:10	16	Step over	
10:51:09	15	Step over	
10:51:09	16	Step started	Message Validate
10:51:09	14	Step over	
10:51:09	15	Step started	Message Validate
10:51:08	14	Step started	Message Validate
10:51:08	13	Step over	
10:51:08	12	Step over	
10:51:08	13	Step started	Message Validate
10:51:07	11	Step over	
10:51:07	12	Step started	Message Validate
10:51:06	11	Step started	Message Validate
10:51:06	10	Step over	
10:51:05	09	Step over	
10:51:05	10	Step started	Message Validate
10:51:04	09	Step started	Message Validate
10:51:04	08	Step over	
10:51:04	08	Powering	
10:51:03	08	No compressed air	
10:51:02	07	Step over	
10:51:02	08	Step started	Message Validate
10:49:35	06	Step over	
10:49:35	07	Step started	Message Validate
10:49:35	05	Step over	
10:49:35	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:49:35	04	Step over	
10:49:35	05	Step started	Setting Polarity (Set point: Anodizing)
10:49:35	03	Step over	
10:49:35	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:49:35	02	Step over	
10:49:35	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:49:35	01	Step over	
10:49:35	02	Step started	Setting Generation (Set point: Off)
10:49:35	01	Step started	Setting Pumping (Set point: Off)
10:49:34	01	Operating mode started	Characterization Specimen 2

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 1 Redo
Creation date :	29/09/2017 09:52:37

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	EP Speciman 1 Redo
Part designation	EP Speciman 1 Redo

Treatment

Surface (dm²)	0,58
Estimated duration	5,76

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002 B24
Beaker	Zinc Nickel unit
Initial volume	1,00
Total current quantity (mA	0,06
Thickness	13,00
Min. allowable thickness	8,00
Max. allowable thickness (	18,00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002 B9	1,00	Dalistick tool for Activators
Passivateur n°3	20150001 B4	0,00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant

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07	Information Message Validate	Compliant

DALIC®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 1 Redo
Creation date :	29/09/2017 09:52:37

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.58 Quantity of current (mAh) :479.73 Treatment duration (min) :0:05:45	Compliant
26	DKPL pump activation Message Validate	Compliant

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27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALIC®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : EP Speciman 1 Redo
Creation date : 29/09/2017 09:52:37

	Message Validate	
30	Activator XF Setting Setting Solution (20160002 B9 - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002 B24 - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant

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50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALIC®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 1 Redo
Creation date :	29/09/2017 09:52:37

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 7.8 Maximum (µm) : 14 Average (µm) : 10.17 Standard deviation (µm) : 1.75 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Emily Meredith	Compliant
66	Cleaning information Message Validate	Compliant

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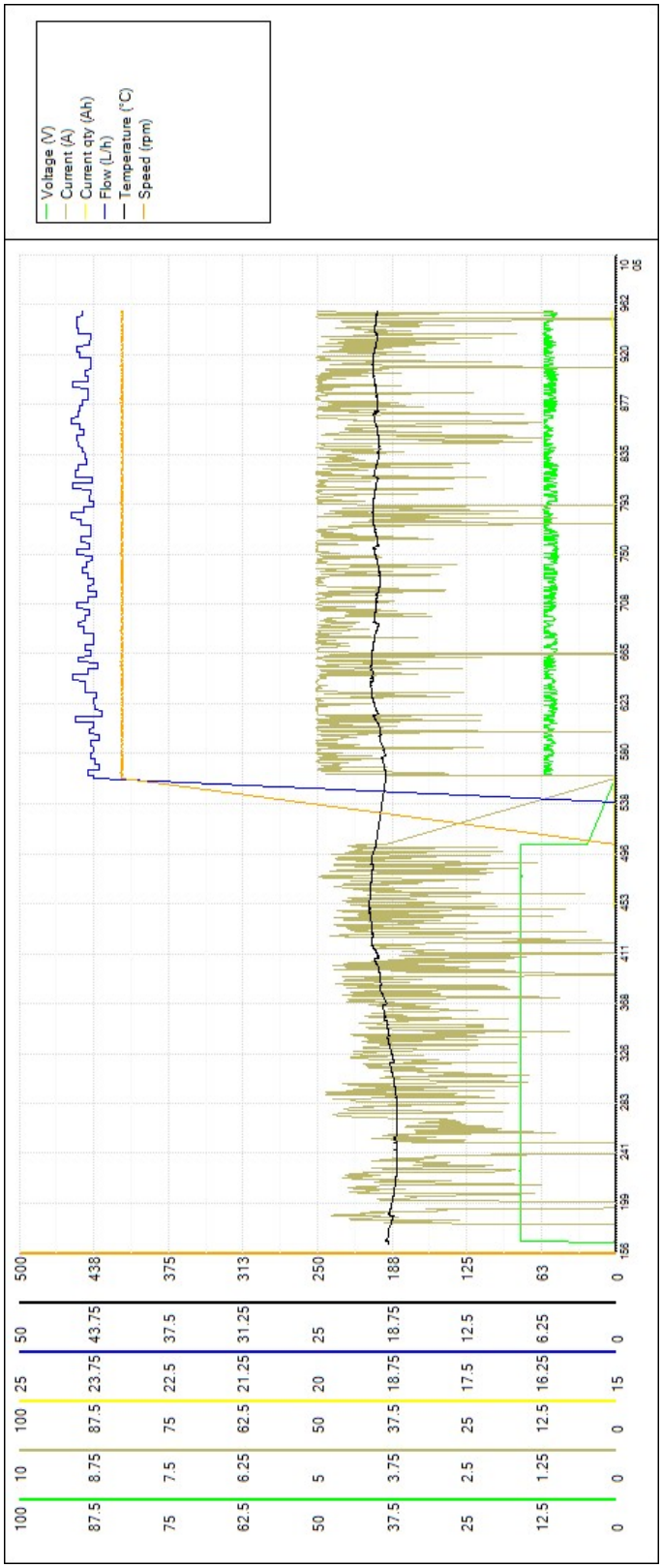
Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)

DALIC®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : EP Speciman 1 Redo
Creation date : 29/09/2017 09:52:37

Events

Date	N°	Type	Completion
10:20:39	66	Step over	
10:20:39	66	Operating mode complete	
10:20:39	66	Step started	Message Validate
10:20:39	65	Step over	
10:20:38	64	Step over	
10:20:38	65	Step started	Control Final
10:20:38	64	Step started	Message Validate
10:20:38	63	Step over	
10:20:37	62	Step over	
10:20:37	63	Step started	Message Validate
10:20:36	62	Step started	Message Validate
10:20:36	61	Step over	
10:17:09	61	Step started	Message Validate
10:17:09	60	Step over	
10:17:08	60	Step started	Message Validate
10:17:08	59	Step over	
10:17:02	59	Step started	Message Validate
10:17:02	58	Step over	
10:13:20	58	Step started	Control Thickness (µm)
10:13:20	57	Step over	
10:13:19	57	Step started	Message Validate
10:13:19	56	Step over	
10:13:17	55	Step over	
10:13:17	56	Step started	Control Adhesion
10:13:15	55	Step started	Control Aspect
10:13:15	54	Step over	
10:12:25	54	Step started	Message Validate
10:12:25	53	Step over	
10:12:02	53	Step started	Message Validate
10:12:02	52	Step over	
10:12:02	51	Step over	
10:12:02	52	Step started	Message Validate
10:12:01	51	Step started	Message Validate
10:12:01	50	Step over	
10:08:54	50	Exception	port:3, slave:1, starting address:0 end:10 System.Exception: Time-out read serial port 3 at DalistickDevices.Rs232.AttendreBytesRS232(Int32 bnBytes) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 698 at DalistickDevices.Rs232.Read(Int32 Bytes2Read) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 713 at DalistickDevices.ClassModbus.AttentRéponseEqt(Byte[]& TableauRéponse, Int32& NbDonnéesDansTrame) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 331 at DalistickDevices.ClassModbus.Lecture(Int16& esclave, Int32& adresse, Int16& nbregistre, Int64[]& TablRéponse, Codefonction Code, Byte LgData, Boolean ignorerErreurs) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 478
10:08:49	50	Communication error	Dalipump
10:08:49	50	Communication error	Dalipump
10:08:49	50	Step started	Message Validate
10:08:49	49	Step over	

10:08:49	49	No compressed air	
10:08:48	49	Powering	
10:08:42	48	Step over	
10:08:42	49	Step started	Message Validate
10:08:42	48	Step started	Setting Pumping (Set point: Off)
10:08:42	47	Step over	
10:08:35	47	Step started	Message Validate
10:08:35	46	Step over	
10:08:35	46	Step started	Setting Generation (Set point: Off)
10:08:35	45	Step over	
10:08:02	45	Low level	
10:08:02	45	Low level	
10:06:18	45	Low level	
10:06:18	45	Low level	
10:01:59	44	Step over	
10:01:59	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:01:58	44	Step started	Setting Generation (Set point: On)
10:01:58	43	Step over	
10:01:58	43	Step started	Setting Solution (20160002 B24 - Zinidal Aero)
10:01:58	42	Step over	
10:01:57	41	Step over	
10:01:57	42	Step started	Setting Polarity (Set point: Plating)
10:01:57	40	Step over	
10:01:57	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:01:57	39	Step over	
10:01:57	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:01:57	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:01:57	38	Step over	
10:01:43	38	Step started	Message Validate
10:01:43	37	Step over	
10:01:15	37	Step started	Message Validate
10:01:15	36	Step over	
10:01:14	35	Step over	
10:01:14	36	Step started	Setting Pumping (Set point: On)
10:01:08	35	Step started	Message Validate
10:01:08	34	Step over	
10:01:02	34	Step started	Message Validate
10:01:02	33	Step over	
10:01:02	33	Step started	Setting Generation (Set point: Off)
10:01:01	32	Step over	
09:55:23	32	Step started	Waiting Current quantity (%) (Set point: 100)
09:55:23	31	Step over	
09:55:22	31	Step started	Setting Generation (Set point: On)
09:55:22	30	Step over	
09:55:22	29	Step over	
09:55:22	30	Step started	Setting Solution (20160002 B9 - Activator XF)
09:55:21	29	Step started	Message Validate
09:55:20	28	Step over	
09:55:11	28	Step started	Message Validate
09:55:10	27	Step over	
09:54:49	26	Step over	
09:54:49	27	Step started	Message Validate
09:54:45	26	Step started	Message Validate
09:54:45	25	Step over	
09:53:31	25	Step started	Setting Surface
09:53:31	24	Step over	
09:53:31	24	Step started	Setting Pumping (Set point: Off)
09:53:31	23	Step over	
09:53:28	23	Step started	Message Validate

09:53:28	22	Step over	

Treatment : Zinc-Nickel with Dalistick tool
Part reference : EP Speciman 1 Redo
Creation date : 29/09/2017 09:52:37

09:53:25	21	Step over	
09:53:25	22	Step started	Message Validate
09:53:24	21	Step started	Setting Pumping (Set point: On)
09:53:24	20	Step over	
09:53:14	20	Step started	Message Validate
09:53:14	19	Step over	
09:53:08	18	Step over	
09:53:08	19	Step started	Message Validate
09:53:08	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
09:53:08	17	Step over	
09:52:55	16	Step over	
09:52:55	17	Step started	Message Validate
09:52:55	16	Step started	Message Validate
09:52:55	15	Step over	
09:52:54	14	Step over	
09:52:54	15	Step started	Message Validate
09:52:53	14	Step started	Message Validate
09:52:53	13	Step over	
09:52:52	13	Step started	Message Validate
09:52:52	12	Step over	
09:52:52	12	No compressed air	
09:52:51	12	Powering	
09:52:49	12	Step started	Message Validate
09:52:49	11	Step over	
09:52:49	10	Step over	
09:52:49	11	Step started	Message Validate
09:52:49	09	Step over	
09:52:49	10	Step started	Message Validate
09:52:48	09	Step started	Message Validate
09:52:48	08	Step over	
09:52:47	08	Step started	Message Validate
09:52:47	07	Step over	
09:52:39	06	Step over	
09:52:39	07	Step started	Message Validate
09:52:39	05	Step over	
09:52:39	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
09:52:39	04	Step over	
09:52:39	05	Step started	Setting Polarity (Set point: Anodizing)
09:52:38	03	Step over	
09:52:38	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
09:52:38	02	Step over	
09:52:38	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
09:52:38	01	Step over	
09:52:38	02	Step started	Setting Generation (Set point: Off)
09:52:38	01	Step started	Setting Pumping (Set point: Off)
09:52:38	01	Operating mode started	EP Speciman 1 Redo

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 2 Redo
Creation date :	29/09/2017 10:51:01

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	EP Speciman 2 Redo
Part designation	EP Speciman 2 Redo

Treatment

Surface (dm²)	0,63
Estimated duration	6,29

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002 B24
Beaker	Zinc Nickel unit
Initial volume	1,00
Total current quantity (mA	0,06
Thickness	13,00
Min. allowable thickness	8,00
Max. allowable thickness (	18,00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002 B9	1,00	Dalistick tool for Activators
Passivateur n°3	20150001 B4	0,00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 2 Redo
Creation date :	29/09/2017 10:51:01

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.63 Quantity of current (mAh) :523.99 Treatment duration (min) :0:06:17	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant

29	Information	Compliant

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Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 2 Redo
Creation date :	29/09/2017 10:51:01

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (20160002 B9 - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002 B24 - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

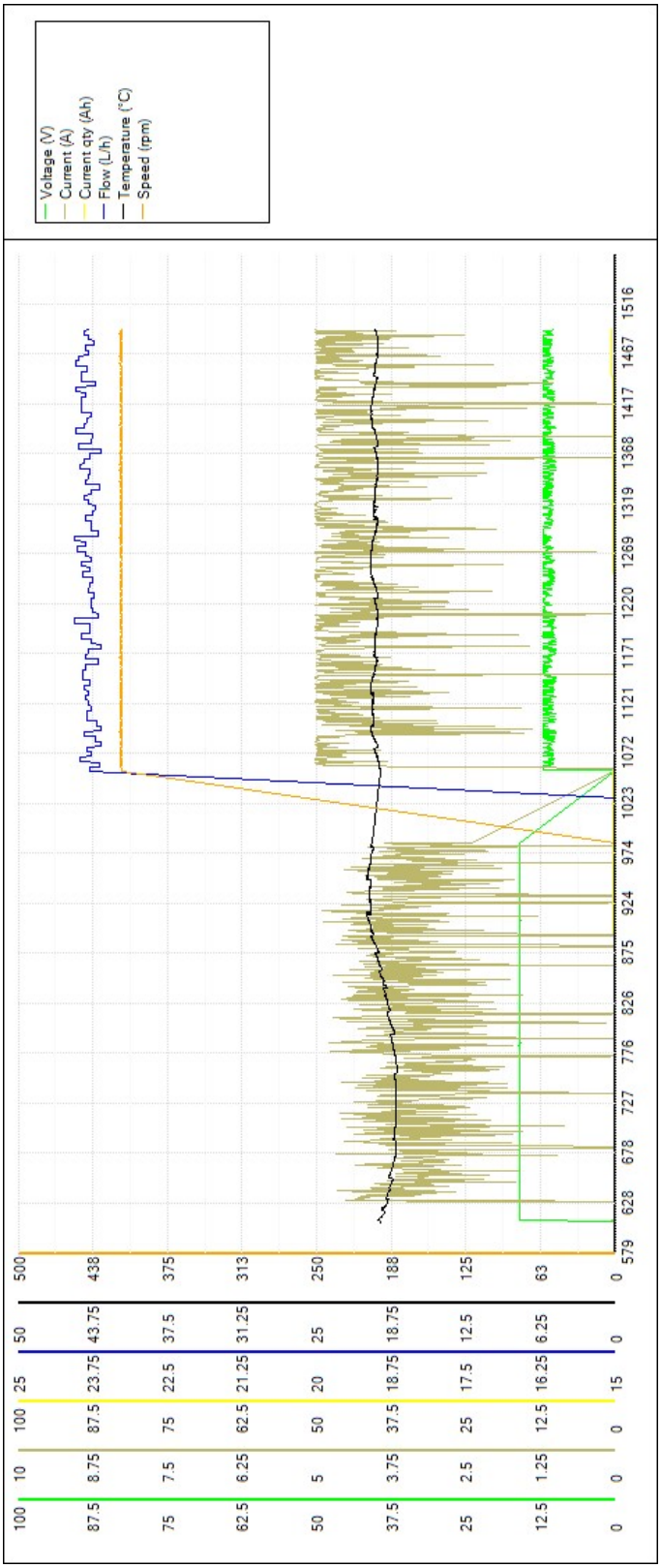
52	Unmasking Message Validate	Compliant

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 2 Redo
Creation date :	29/09/2017 10:51:01

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 9.9 Maximum (µm) : 15 Average (µm) : 11.75 Standard deviation (µm) : 1.42 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Emily Meredith	Compliant
66	Cleaning information Message Validate	Compliant

Zinc-Nickel with Dalistick tool

EP Speciman 2 Redo 29/09/2017 10:51:01



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Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	EP Speciman 2 Redo
Creation date :	29/09/2017 10:51:01

Events

Date	N°	Type	Completion
11:27:34	66	Step over	
11:27:34	66	Operating mode complete	
11:27:33	66	Step started	Message Validate
11:27:33	65	Step over	
11:27:33	64	Step over	
11:27:33	65	Step started	Control Final
11:27:32	64	Step started	Message Validate
11:27:31	63	Step over	
11:27:29	63	Step started	Message Validate
11:27:29	62	Step over	
11:27:27	61	Step over	
11:27:27	62	Step started	Message Validate
11:27:26	61	Step started	Message Validate
11:27:26	60	Step over	
11:27:24	60	Step started	Message Validate
11:27:24	59	Step over	
11:22:08	59	Step started	Message Validate
11:22:08	58	Step over	
11:20:23	58	Step started	Control Thickness (µm)
11:20:22	57	Step over	
11:20:19	57	Step started	Message Validate
11:20:19	56	Step over	
11:20:17	56	Step started	Control Adhesion
11:20:17	55	Step over	
11:20:15	55	Step started	Control Aspect
11:20:15	54	Step over	
11:20:13	53	Step over	
11:20:13	54	Step started	Message Validate
11:20:12	53	Step started	Message Validate
11:20:12	52	Step over	
11:20:10	52	Low level	
11:20:10	52	Step started	Message Validate
11:20:10	51	Step over	
11:20:06	51	Step started	Message Validate
11:20:06	50	Step over	
11:16:16	49	Step over	
11:16:16	50	Step started	Message Validate
11:16:14	49	Exception	port:3, slave:1, starting address:0 end:10 System.Exception: Time-out read serial port 3 at DalistickDevices.Rs232.AttendreBytesRS232(Int32 bnBytes) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 698 at DalistickDevices.Rs232.Read(Int32 Bytes2Read) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 713 at DalistickDevices.ClassModbus.AttentRéponseEqt(Byte[]& TableauRéponse, Int32& NbDonnéesDansTrame) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 331 at DalistickDevices.ClassModbus.Lecture(Int16& esclave, Int32& adresse, Int16& nbregistre, Int64[]& TablRéponse, Codefonction Code, Byte LgData, Boolean ignorerErreurs) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 478

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11:16:09	49	No compressed air	

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : EP Speciman 2 Redo
Creation date : 29/09/2017 10:51:01

11:16:08	49	Powering	
11:16:04	49	Low level	
11:16:04	48	Step over	
11:16:04	49	Step started	Message Validate
11:16:04	48	Step started	Setting Pumping (Set point: Off)
11:16:04	47	Step over	
11:16:02	47	Low level	
11:16:01	47	Low level	
11:16:00	47	Low level	
11:16:00	47	Low level	
11:15:53	46	Step over	
11:15:53	47	Step started	Message Validate
11:15:53	46	Step started	Setting Generation (Set point: Off)
11:15:53	45	Step over	
11:15:52	45	Low level	
11:15:52	45	Low level	
11:15:49	45	Low level	
11:15:49	45	Low level	
11:15:43	45	Low level	
11:15:43	45	Low level	
11:15:38	45	Low level	
11:15:38	45	Low level	
11:15:16	45	Low level	
11:15:15	45	Low level	
11:15:15	45	Low level	
11:15:15	45	Low level	
11:15:12	45	Low level	
11:15:12	45	Low level	
11:15:08	45	Low level	
11:15:08	45	Low level	
11:15:04	45	Low level	
11:15:04	45	Low level	
11:15:01	45	Low level	
11:15:01	45	Low level	
11:14:57	45	Low level	
11:14:57	45	Low level	
11:14:54	45	Low level	
11:14:54	45	Low level	
11:14:20	45	Low level	
11:14:20	45	Low level	
11:14:10	45	Low level	
11:14:10	45	Low level	
11:13:43	45	Low level	
11:13:43	45	Low level	
11:13:39	45	Low level	
11:13:38	45	Low level	
11:13:34	45	Low level	
11:13:34	45	Low level	
11:13:26	45	Low level	
11:13:26	45	Low level	
11:13:22	45	Low level	
11:13:21	45	Low level	
11:12:51	45	Low level	
11:12:51	45	Low level	
11:12:39	45	Low level	
11:12:39	45	Low level	
11:12:32	45	Low level	

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11:12:32	45	Low level	
11:12:23	45	Low level	
11:12:23	45	Low level	

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : EP Speciman 2 Redo
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11:11:49	45	Low level	
11:11:49	45	Low level	
11:11:42	45	Low level	
11:11:42	45	Low level	
11:10:09	45	Low level	
11:10:09	45	Low level	
11:09:57	45	Low level	
11:09:57	45	Low level	
11:08:38	44	Step over	
11:08:38	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:08:37	44	Step started	Setting Generation (Set point: On)
11:08:37	43	Step over	
11:08:37	42	Step over	
11:08:37	43	Step started	Setting Solution (20160002 B24 - Zinidal Aero)
11:08:37	41	Step over	
11:08:37	42	Step started	Setting Polarity (Set point: Plating)
11:08:36	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:08:36	40	Step over	
11:08:36	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:08:36	39	Step over	
11:08:36	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:08:36	38	Step over	
11:08:19	38	Step started	Message Validate
11:08:19	37	Step over	
11:08:05	37	Low level	
11:08:04	37	Low level	
11:07:44	37	Process defect: flow lower limit reached	
11:07:36	36	Step over	
11:07:36	37	Step started	Message Validate
11:07:36	36	Process defect: flow lower limit reached	
11:07:36	35	Step over	
11:07:36	36	Step started	Setting Pumping (Set point: On)
11:07:33	35	Step started	Message Validate
11:07:33	34	Step over	
11:07:26	34	Step started	Message Validate
11:07:26	33	Step over	
11:07:26	33	Step started	Setting Generation (Set point: Off)
11:07:26	32	Step over	
11:01:12	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:01:12	31	Step over	
11:01:11	31	Step started	Setting Generation (Set point: On)
11:01:11	30	Step over	
11:01:11	30	Step started	Setting Solution (20160002 B9 - Activator XF)
11:01:11	29	Step over	
11:01:09	29	Step started	Message Validate
11:01:09	28	Step over	
11:00:50	28	Step started	Message Validate
11:00:50	27	Step over	
11:00:45	26	Step over	
11:00:45	27	Step started	Message Validate
11:00:34	26	Step started	Message Validate
11:00:34	25	Step over	
10:59:16	24	Step over	
10:59:16	25	Step started	Setting Surface
10:59:16	24	Step started	Setting Pumping (Set point: Off)

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10:59:16	23	Step over	
10:59:11	23	Step started	Message Validate
10:59:11	22	Step over	

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : EP Speciman 2 Redo
Creation date : 29/09/2017 10:51:01

10:59:08	21	Step over	
10:59:08	22	Step started	Message Validate
10:59:08	21	Step started	Setting Pumping (Set point: On)
10:59:08	20	Step over	
10:59:01	20	Step started	Message Validate
10:59:01	19	Step over	
10:59:00	19	Step started	Message Validate
10:59:00	18	Step over	
10:59:00	17	Step over	
10:59:00	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:58:59	16	Step over	
10:58:59	17	Step started	Message Validate
10:58:59	15	Step over	
10:58:59	16	Step started	Message Validate
10:58:58	15	Step started	Message Validate
10:58:58	14	Step over	
10:58:58	14	Step started	Message Validate
10:58:58	13	Step over	
10:58:57	13	Step started	Message Validate
10:58:57	12	Step over	
10:56:48	11	Step over	
10:56:48	12	Step started	Message Validate
10:56:47	11	Step started	Message Validate
10:56:47	10	Step over	
10:55:57	10	Step started	Message Validate
10:55:57	09	Step over	
10:53:30	09	Step started	Message Validate
10:53:30	08	Step over	
10:53:29	08	Powering	
10:53:29	08	No compressed air	
10:53:27	07	Step over	
10:53:27	08	Step started	Message Validate
10:51:03	06	Step over	
10:51:03	07	Step started	Message Validate
10:51:03	05	Step over	
10:51:03	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:51:03	04	Step over	
10:51:03	05	Step started	Setting Polarity (Set point: Anodizing)
10:51:02	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:51:02	03	Step over	
10:51:02	02	Step over	
10:51:02	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:51:02	02	Step started	Setting Generation (Set point: Off)
10:51:02	01	Step over	
10:51:02	01	Step started	Setting Pumping (Set point: Off)
10:51:02	01	Operating mode started	EP Speciman 2 Redo

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Attachment No. 4 – IBECA Characterization Test Report

IBECA Technologies Corp.

RR 15-314 September 26, 2019

RESEARCH REPORT

HYDROGEN EMBRITTLEMENT CHARACTERIZATION OF NO-BAKE BRUSH PLATING ZINC-NICKEL PROCESSES

Submitted to

The University of Dayton Research Institute
Dayton, Ohio
United States

IBECA Project No. 15-314 Contract No. GS05Q15BMD0001/TO 06

Principal Engineer Salim Brahimi, P.Eng., Ph.D.

Prepared by Sriraman Rajagopalan, Ph.D.
Priyadarshi Behera, Ph.D.

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EXECUTIVE SUMMARY

The Zinidal Aero Zinc-Nickel (ZnNi) brush plating process is being qualified to replace cadmium (Cd) brush plating of high strength steel aircraft components for touch-up and repairs. This process is used notably on aircraft components for which hydrogen embrittlement relief baking is not permitted. Previous investigations conducted at Air Force Research Laboratory (AFRL) at Wright Patterson Air Force Base (WPAFB) in Ohio have shown inconsistent results with respect to hydrogen embrittlement for Zinidal Aero Zinc- Nickel brush plating. These previous investigations were performed using the standard 200- hour sustained load test in accordance with ASTM F519. The qualitative pass/fail nature of this test method is not well suited for analytical purposes, notably to understand the cause and effect of variation in processing. This current investigation follows a systematic analytical approach to examine and identify the key process parameters that must be controlled and optimized for the Zinidal Aero Zinc-Nickel process to reliably pass hydrogen embrittlement testing. To this end, the investigation was undertaken in two phases as described below.

PHASE I

Four types of brush plated ZnNi coatings, namely SIFCO 4018 solution plated at 6 V, Zinidal Aero solution plated at 8-9 V, Zinidal Aero solution plated at 12 V and Zinidal Aero solution plated at 12 V using Dalistick apparatus were evaluated and compared to SIFCO 2023 Cd coated specimens. The methodology comprised initial microstructural characterization, followed by mechanical testing, specifically by the incremental step loading (ISL) of coated ASTM F519 Type 1a1 high strength steel specimens (i.e., substrate) in conjunction with thermal desorption spectroscopy (TDS) for hydrogen quantification. Finally, hydrogen electrochemical permeation (EP) experiments were conducted to measure hydrogen permeability of the coatings.

The surface morphology of the coatings evaluated by scanning electron microscopy (SEM) showed extensive discontinuities for all the coatings. Cross-section of the coatings evaluated by transverse cut and focused ion beam (FIB) showed additional presence of extensive through thickness cracks for the Dalistick Zinidal Aero process. Compositional and phase analyses revealed the presence of some delta phase Zn-Ni for SIFCO 4018 ZnNi, while the other ZnNi coatings contained only gamma phase Zn-Ni. Hydrogen embrittlement evaluation by Incremental Step Load (ISL) testing expressed as percent notch fracture strength ($NFS_{\%}$) showed satisfactory results of 102.7 % and 96.4 % $NFS_{\%}$ respectively for SIFCO 2023 Cd and SIFCO 4018 ZnNi. For Zinidal Aero solution, low $NFS_{\%}$ values in the range of 62-68 % were obtained for samples plated at 8-9 V and 12 V. With the Dalistick apparatus, an average $NFS_{\%}$ value of 91% was obtained, however, the individual results

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exhibited very high scatter making the process outcome somewhat unreliable. The microstructural morphology of the coatings was found to be closely correlated with either low or high NFS% results. Notably, the Cd and 4018 ZnNi coatings contained high-density interconnected micropores. In the case of the Cd coating, these micropores translated into interconnected discontinuities that were observed to be "through-thickness." In other words, they traversed the entire thickness of the coating in an interconnected manner. The presence of interconnected micropores and through-thickness discontinuities apparent in the Cd and 4018 Zn-Ni coatings is thought to facilitate hydrogen effusion, thereby minimizing the embrittlement of the specimen. These observations corroborate the high NFS% values of 102.7 % and 96.4 % for SIFCO Cd and 4018 ZnNi values obtained by ISL testing.

The Zinidal Aero ZnNi process (applied with and without Dalistick) contained surface cracks and discontinuities. Only few cracks were through-thickness, while other cracks were confined to a limited depth and unevenly distributed. This more homogenous coating morphology is thought to limit hydrogen escape (effusion) pathways, and evidently contributed to lower $NFS_{\%}$ values than for Cd and 4018 Zn-Ni. As was stated earlier, the Dalistick Zinidal Aero $NFS_{\%}$ values were not sufficiently consistent to be considered acceptable. Fractographic observation by SEM corroborates the presence of intergranular (i.e., brittle) morphology at the crack initiation regions for all the Zinidal Aero coated specimens. However, these intergranular features were less apparent for Dalistick Zinidal Aero coated specimens; this observation is consistent with the higher average $NFS_{\%}$ value (i.e., 91 %).

Electrochemical permeation (EP) experiments provided hydrogen diffusivity results that further support the hypothesis correlating coating morphology and permeability with the ISL hydrogen embrittlement testing.

Thermal Desorption spectroscopy (TDS) measurements performed at temperature of 200 °C (392 °F) of the coated ASTM F519 Type 1a1 notch bars were performed in conjunction with ISL testing to correlate $NFS_{\%}$ values with quantities of hydrogen desorbed from the specimens. The TDS results showed high rates of hydrogen desorption for SIFCO 4018 ZnNi. This result corroborates the high $NFS_{\%}$ values obtained for SIFCO 4018 ZnNi and is attributed to the greater amount of scattered micropores in the coating. The lower desorption temperature used for SIFCO Cd (90 ^{0}C - 194 ^{0}F) coated notch bars naturally results in a decreased amount of hydrogen desorption. This difference in desorption temperature limits the ability to compare results between Cd and ZnNi coatings. Notch bars coated with Zinidal Aero solution without Dalistick apparatus at 8-9 V and 12 V showed similar rates of hydrogen desorption, but lower than for SIFCO 4018 ZnNi. Zinidal Aero solution with Dalistick apparatus exhibited the lowest rates of hydrogen desorption. This low rate of hydrogen desorption for Zinidal Aero solution with Dalistick apparatus is consistent with the high $NFS_{\%}$ values (avg. 91 %).

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PHASE II

Phase I showed that the Dalistick apparatus applying Zinidal Aero solution achieved better results during ISL hydrogen embrittlement testing than the non Dalistick Zinidal Aero process. This result is explained by the fact that Dalistick apparatus impresses a potential of 12 V and provides a very consistent and stable current during electrodeposition.

Separately, it is generally understood that the strike layer normally applied with Cd electroplating (as was done in Phase I) reduces the quantity of hydrogen absorbed by the substrate and thus lowers the risk of internal hydrogen embrittlement (IHE).

To further investigate the previous two points, in Phase II, the effect of the strike layer and the surface preparation method (e.g., pre-cleaning and surface activation) on the ISL hydrogen embrittlement test results was examined for Zinidal Aero, both with and without Dalistick apparatus.

FIB cross-section evaluation of the coatings revealed the strike layer deposited at 16 V and the coating layer deposited at 12 V were visually distinguishable. The presence of a strike layer did not have any effect on ISL hydrogen embrittlement results for Zinidal Aero both with and without Dalistick apparatus.

Two different mechanical activation methods of the surface were evaluated, namely, (i) abrasive cleaning using Scotch-Brite™ and (ii) grit blasting. ISL test results showed that specimens plated after surface preparation using Scotch-Brite™ were not hydrogen embrittled, with $NFS_{\%}$ values consistently reaching 90-100 %. The presence or absence of a strike layer did not have any affect on these results. On the other hand, grit blasted specimens achieved inconsistent results with $NFS_{\%}$ values ranging between 50-100 %. The presence or absence of a strike layer also did not have any affect on these results.

In summary, Phase II results also showed that for Zinidal Aero ZnNi process, unlike Cd, a strike layer has no beneficial effect. Furthermore, Phase II results showed that activation of the surface of the steel substrate using Scotch-Brite™ evidently reduces the amount of hydrogen absorbed by the substrate by altering the surface morphology of the substrate. However, an analysis of this phenomenon was not within the scope of the investigation.

In conclusion, the results of this investigation showed that the Zinidal Aero brush plating solution offers an acceptable alternative to Cd, from the perspective of internal hydrogen embrittlement (IHE) risk management. This conclusion holds true irrespective of the brush electroplating apparatus, provided the substrate surface is activated using the Scotch-BriteTM cleaning method or another method that achieves an equivalent surface morphology, notably roughness of the substrate.

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INTRODUCTION

Aircraft components are typically baked after cadmium (Cd) electroplating to remove hydrogen absorbed during the deposition process. However, in cases of repair and maintenance of these coatings on thin sectioned components such as panels, baking is not permitted because it may cause distortion owing to the small sections. Consequently, cadmium ***brush plating*** is employed for touch-up and repairs because brush plating typically introduces a low amount of hydrogen. As Cd electroplating is being eliminated and replaced by zinc nickel (ZnNi) electroplating, the risk of hydrogen embrittlement by ZnNi brush plating processes must be evaluated.

The objective of this investigation is to qualify the Zinidal Aero Zinc-Nickel (ZnNi) brush plating process to replace cadmium (Cd) brush plating of high strength steel aircraft components for touch-up and repairs.

SIFCO coatings of Cd and ZnNi were prepared at Boeing Research and Technology (BR&T) facility. Notch bars with Zinidal Aero solution (without using Dalistick apparatus) were prepared at BR&T facility using a potentiostat. Zinidal Aero coatings using Dalistick apparatus were prepared at University of Dayton Research Institute (UDRI).

Previous investigations conducted by Air Force Research Laboratory (AFRL) at Wright Patterson Airforce Base (WPAFB) in Ohio showed inconsistent results for Dalistick Zinidal Aero Zinc-Nickel with respect to hydrogen embrittlement. These investigations were performed using the standard 200-hour sustained load test specified in ASTM F519. The qualitative pass/fail nature of this test method is not well suited for analytical purposes, notably to understand the cause and effect of variation in processing.

This current investigation follows a systematic analytical approach to examine and identify the key process parameters that must be controlled and optimized for the Zinidal Aero zinc-nickel process to reliably pass hydrogen embrittlement testing. To this end, the investigation was undertaken in two phases. The methodology for Phase I comprised of initial microstructural characterization, followed by mechanical testing of coated ASTM F519 Type 1a1 notch bar specimens, specifically by the incremental step loading (ISL) method (bending load) in conjunction with thermal desorption spectroscopy (TDS) for hydrogen quantification. Finally, hydrogen electrochemical permeation (EP) experiments were conducted to measure hydrogen permeability of the coatings. In Phase II, the effect of the strike layer and the surface preparation method (e.g., pre-cleaning and surface activation) on the ISL hydrogen embrittlement test results were examined for Zinidal Aero both with and without Dalistick apparatus.

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PHASE I

Surface Morphology

The surface morphology of the coatings was examined using a FEI Quanta F50 field emission gun equipped with scanning electron microscope (FE-SEM). Clear topographical images were generated at magnifications up to 2,500 X at an accelerating voltage of 5 KV. SIFCO Cd coating has uniform morphology (Figure 1), the ZnNi coatings on the other hand exhibit extensive surface crack formation. Zinidal Aero ZnNi at 8 V and 12 V exhibit uniform surface morphologies with smaller surface cracks. The Dalistick ZnNi coating has similar crack morphology as that of SIFCO 4018 ZnNi coating, but the islands formed by cracking are larger.

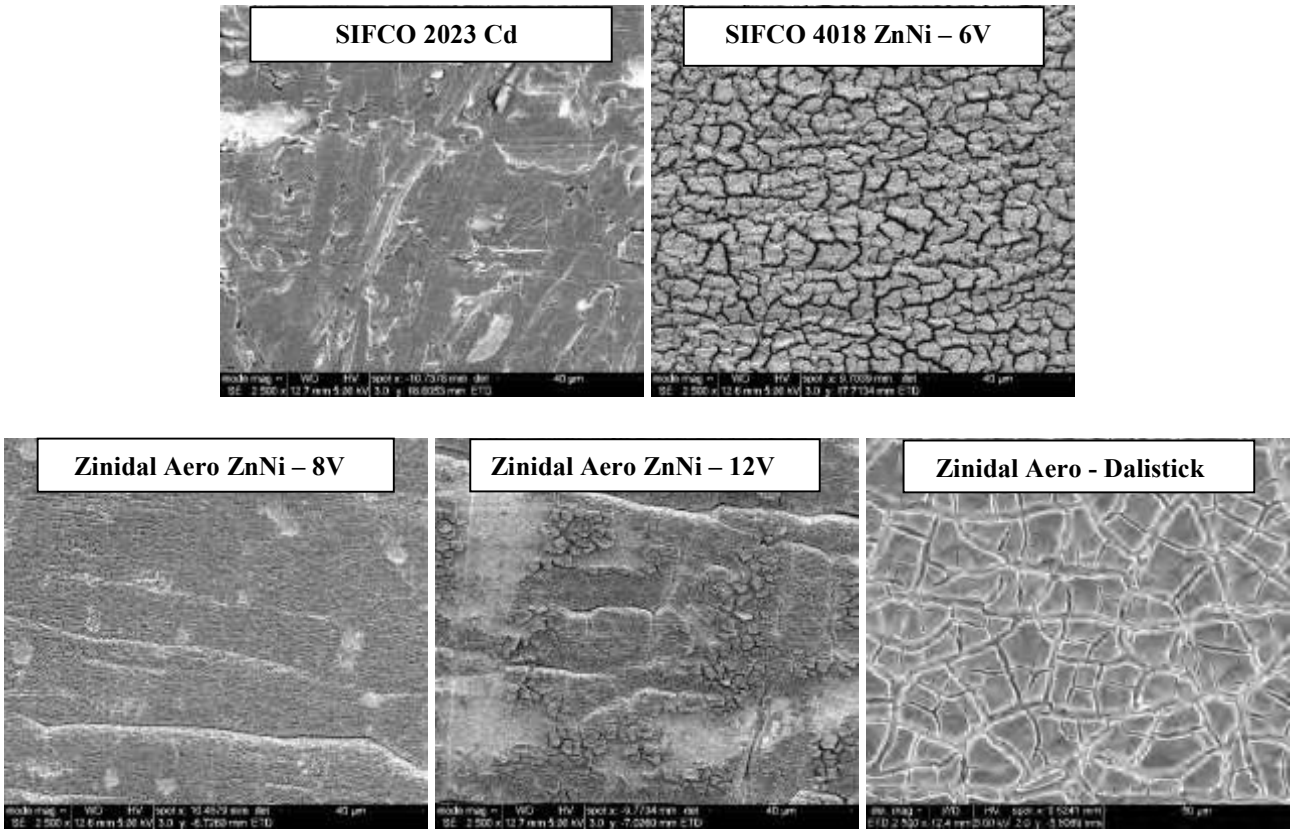

Figure 1 Surface morphology of brush plated coating showing extensive crack formation for SIFCO 4018 ZnNi and Zinidal Aero Dalistick ZnNi coating

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CROSS-SECTION

Cross-sections of the coatings were observed after sectioning and mounting. The metallurgical mounts were polished to 1 µm diamond suspension for observation using F- 50 FEG SEM at 1000x magnification and 10 kV accelerating voltage. The Dalistick ZnNi

coating shows formation of extensive cracking (Figure 2), whereas the cracks observed for SIFCO 4018 ZnNi, Zinidal Aero 8V, Zinidal Aero 12V and SIFCO 2023 Cd are in order of decreasing size. The thickness of the coatings was measured and reported in Table 1.

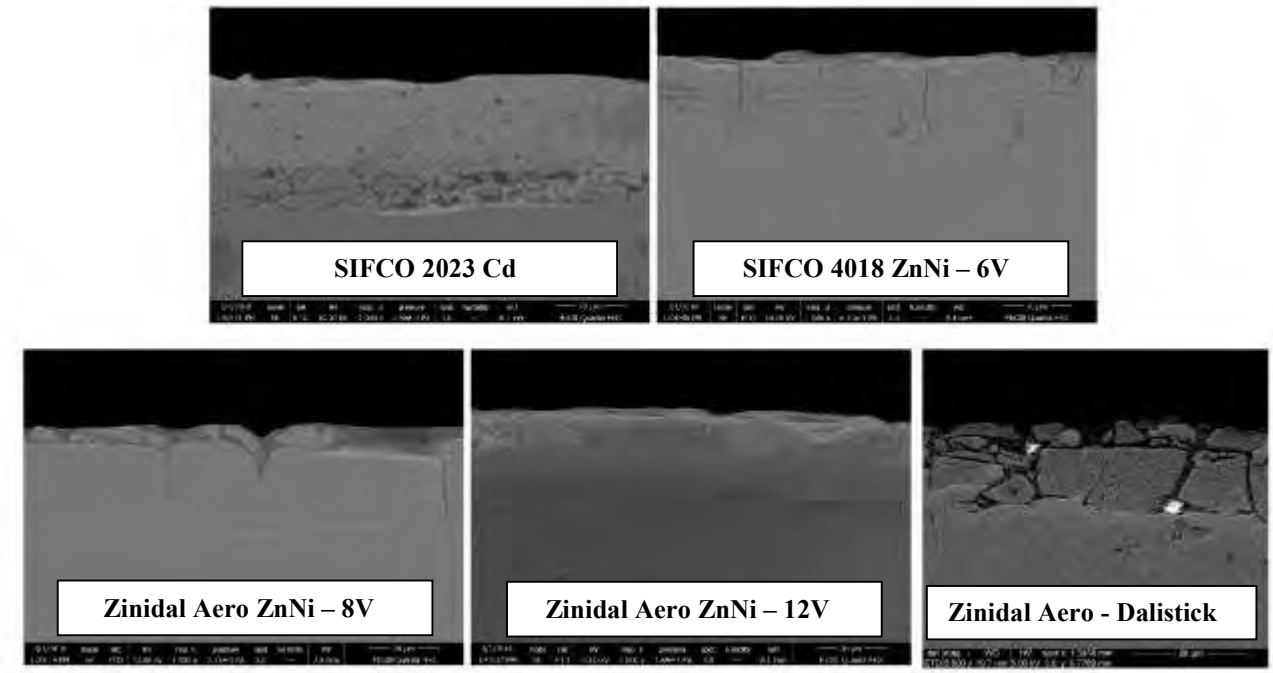

Figure 2 Cross-section morphology of Cd and ZnNi coating showing extensive crack formation for Zinidal Aero-Dalsitick ZnNi

Table 1 Thickness of the coating measured after metallurgical mounting

Sample	SIFCO 2023 Cd	SIFCO 4018 ZnNi - 6V	Zinidal Aero ZnNi - 8V	Zinidal Aero ZnNi - 12V	Zinidal Aero - Dalistick
Average Thickness (µm)	37.3 ± 1.1	26.0 ± 1.0	24.0 ± 1.2	11.9 ± 0.5	16.0 ± 1.6

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XRD CHARACTERIZATION

X-ray diffraction (XRD) analysis of the coatings was performed using a Bruker discover D8 diffractometer with 2D HISTAR area detector, source of Cu Kα radiation (1.54 Å) at 35 kV and 45 mA and indexed from ICDD JCPDS Standards.
XRD results of ZnNi coatings confirm the single phase crystal structure i.e., γ(Ni_2Zn_{11}) except for SIFCO 4018 ZnNi where traces of δ (Ni_3Zn_{22}) are also present. SIFCO 2023 Cd coating shows characteristics peak of Cd with no impurities (Figure 3).

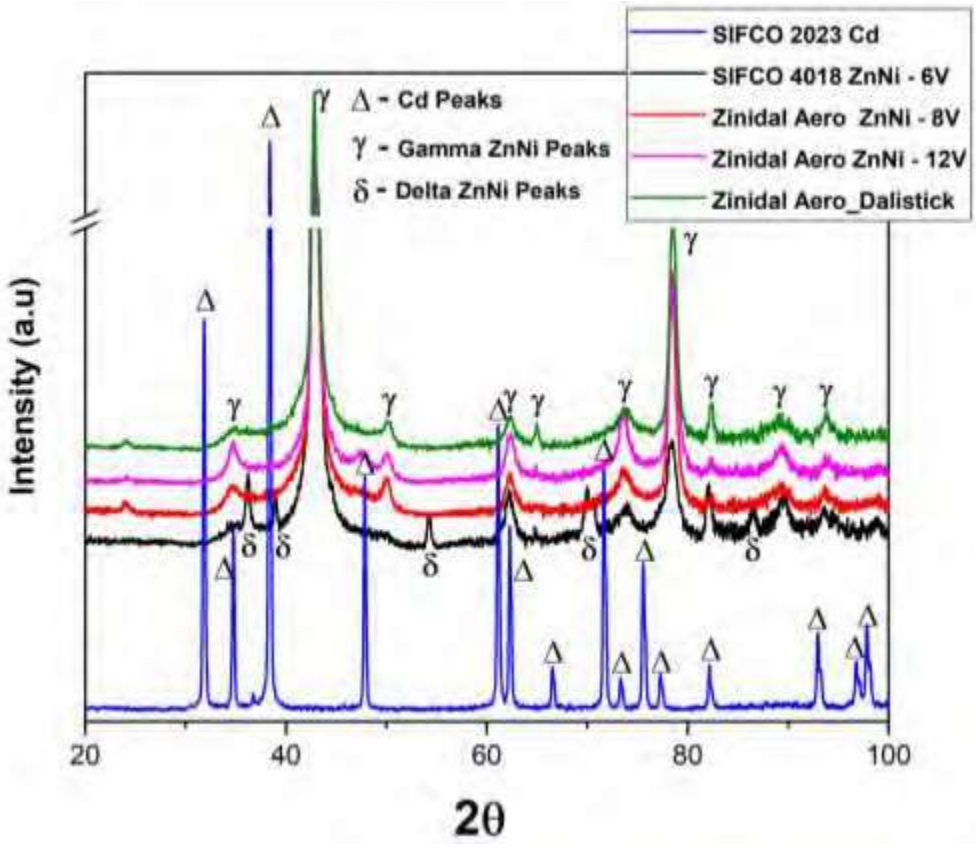

Figure 3 XRD characterization of brush plated Cd and ZnNi coating

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FOCUSED ION BEAM (FIB) CROSS-SECTION

The metallurgical cross-section does not completely reveal the original cross-sectional morphology of the coating. The reason is that while polishing, artifacts are sometimes removed or mechanically smoothened, thereby concealing the micropores and lamellar microstructure of an electrolytically deposited coating. Hence, a precise focused Ion Beam (FIB) milling of the coating is done using Ga ions bombardment to the coating in vacuum. To protect the surface layer from oxidation and artifacts due to ion beam irradiation, a platinum (Pt) layer was initially sputtered. A trench was cut to observe the cross-section along the Pt sputtered area that reveals the bulk cross-section, including the substrate.

FIB cross-sections of the coatings confirm the presence of porosity and voids for SIFCO 2023 Cd coating with higher oxygen concentration at the surface, possibly due to surface oxidation (Figure 4). The extensive cracks observed on the surface of SIFCO 4018 ZnNi only penetrate a few micrometers in depth. The bulk of the cross-section is crack free with some micro porosity. Cross-section of Zinidal Aero 8V showed few through thickness cracks. Increasing the deposition voltage to 12V resulted in a decrease of the number of through thickness cracks. Zinidal Aero coatings, at 8V and 12 V, are compact with little to no porosity. As with SIFCO 4018 ZnNi, the crack formed at surface of Dalistick Zinidal Aero are

limited to few micrometers from the surface. On the other hand, through thickness cracks observed for Dalistick Zinidal Aero were more apparent than for Cd and the other ZnNi coatings. Higher oxygen content at the surface of Dalistick Zinidal Aero was also observed. The formation of cracks in the coating can be due to residual stresses created during electrodeposition.

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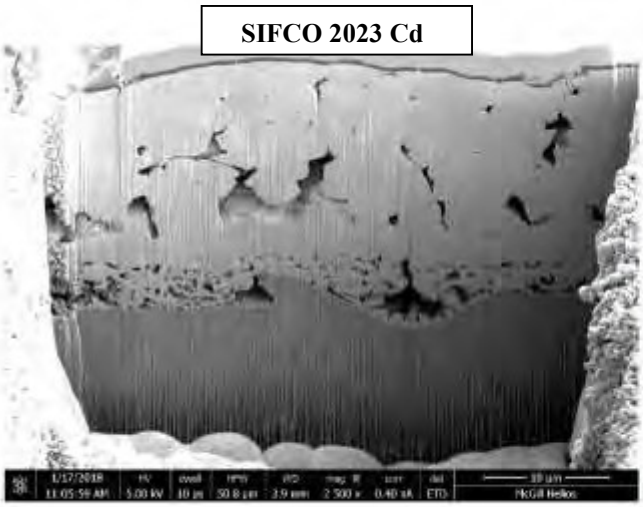

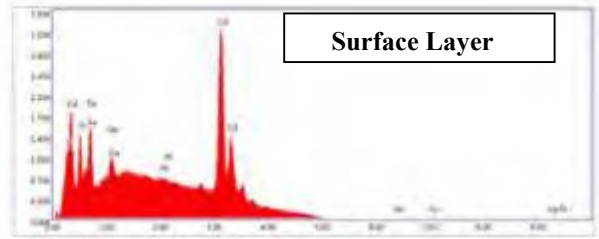

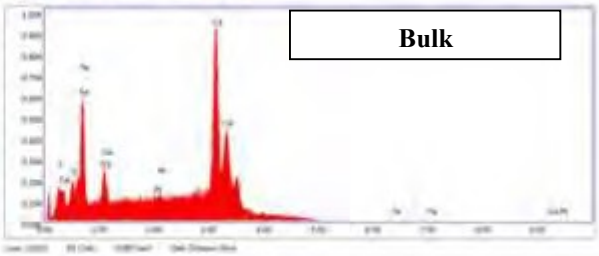

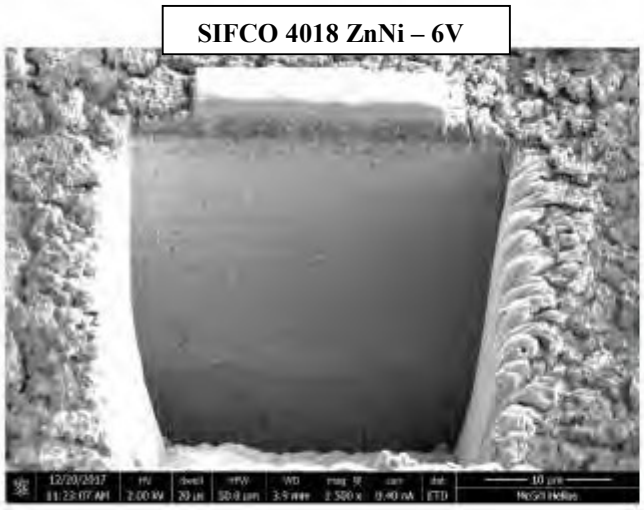

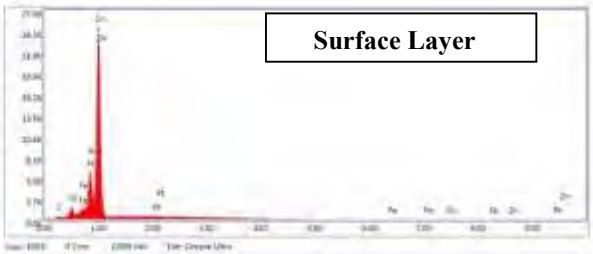

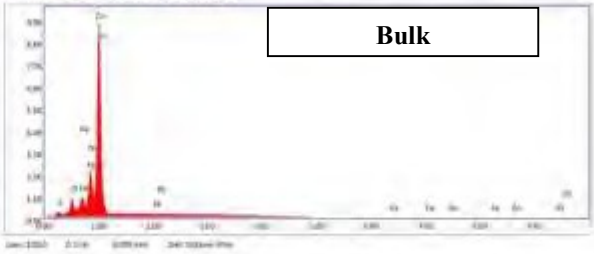

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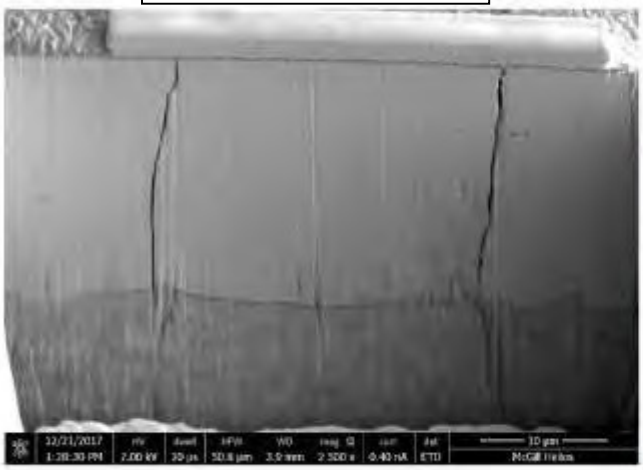
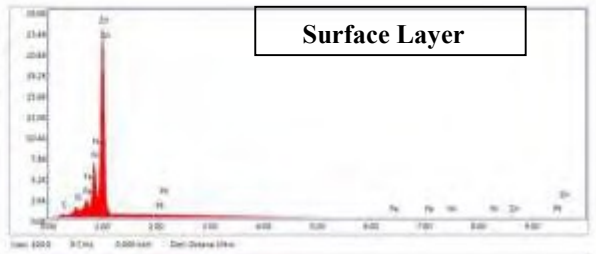
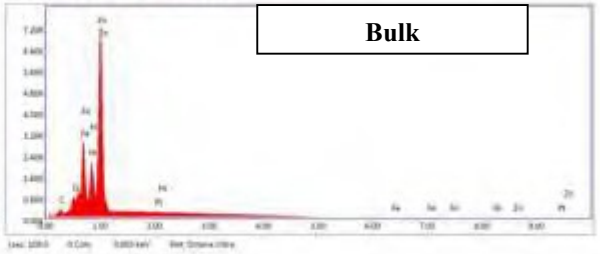
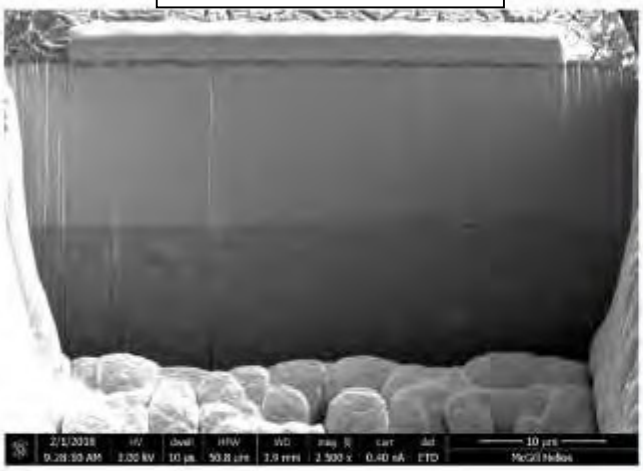
Zinidal Aero ZnNi – 8V

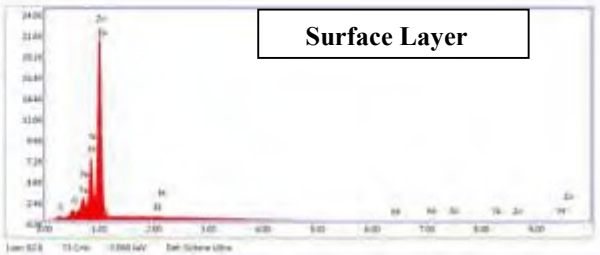


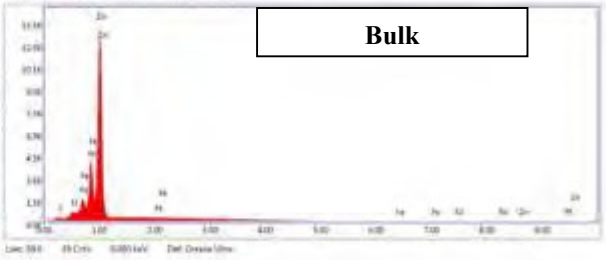




Zinidal Aero ZnNi – 12V







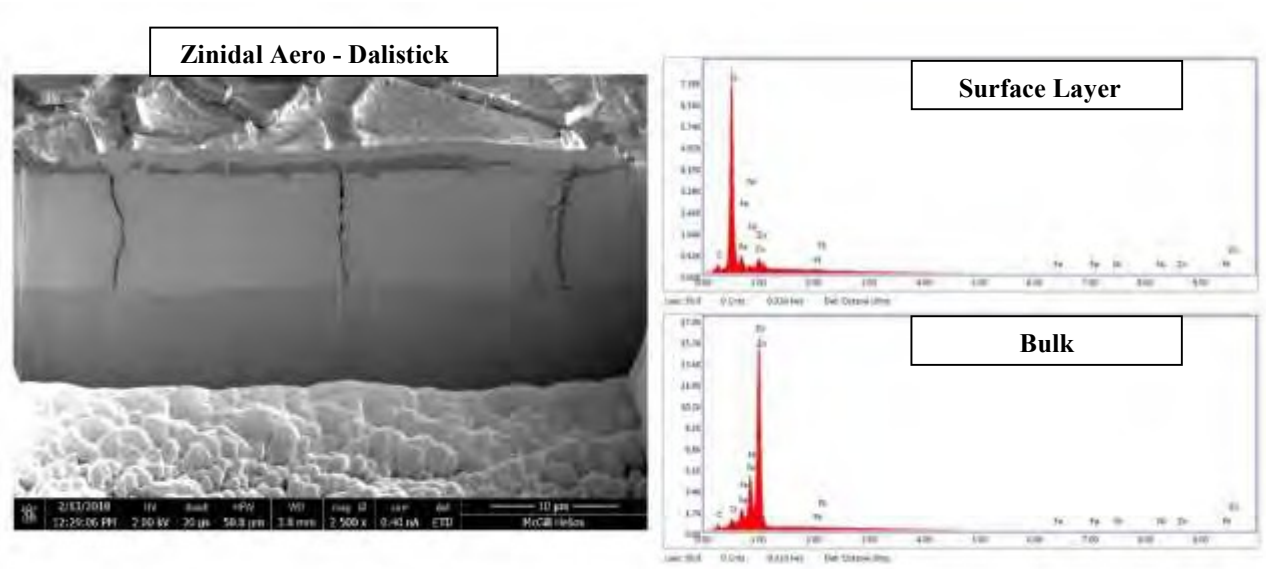


Figure 4 FIB cross-section of Cd and ZnNi coating to observe through thickness cracks and porosity within the coating

TRANSMISSION ELECTRON MICROSCOPY (TEM)

Transmission Electron Microscope (TEM) foils were micromachined using the method described above for FIB in a vacuum. Thin foils, 100 nm thick, were welded to a TEM observation grid (Cu), and the imaging was performed using FEI Tecnai G F20 200 kV TEM. Some of the ZnNi coatings showed nanocrystalline platelets with dislocations present within the platelets. The presence of microporosity was also evident for SIFCO 4018 ZnNi. Unlike SIFCO 4018 ZnNi, Zinidal Aero ZnNi at 8V showed elongated platelets with extensive dislocation formation. These dislocations can act as hydrogen trapping sites that serve as a hydrogen reservoir during application of stress.

The crystallite size ZnNi is in the nanometer range (Figure 5), whereas Cd crystallite size is larger than 2-3 µm. The atomic arrangement of the Cd coating shows presence of oxides on the surface with dislocations formed inside the bulk of the coating. The oxide layer for SIFCO 4018 and Zinidal Aero 8V coating is thinner when compared to Cd. The crystallite size of Zinidal Aero 12V and Zinidal Aero Dalistick is coarser than that of SIFCO 4018 and Zinidal Aero 8. Zinidal Aero 12V and Zinidal Aero Dalistick exhibit higher defect density than SIFCO 4018 ZnNi.

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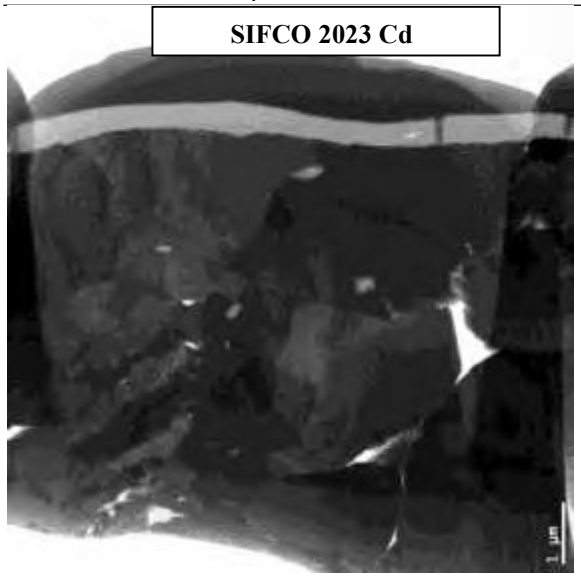
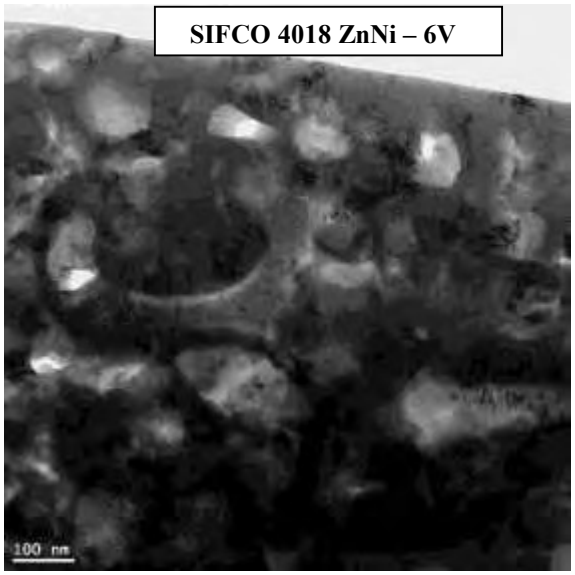
SIFCO 2023 Cd

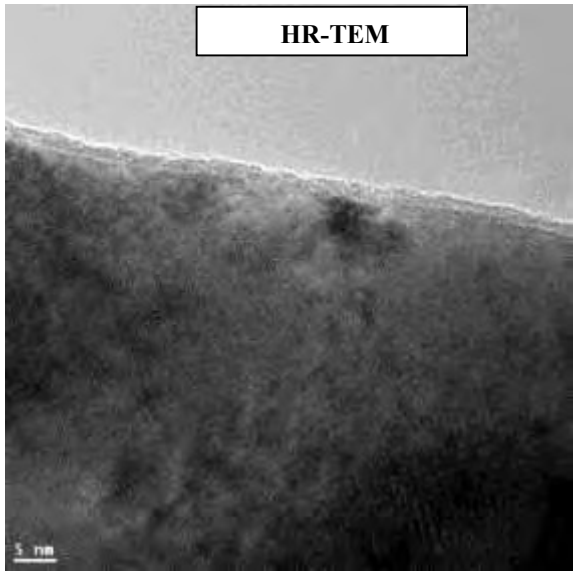


HR-TEM

SIFCO 4018 ZnNi – 6V

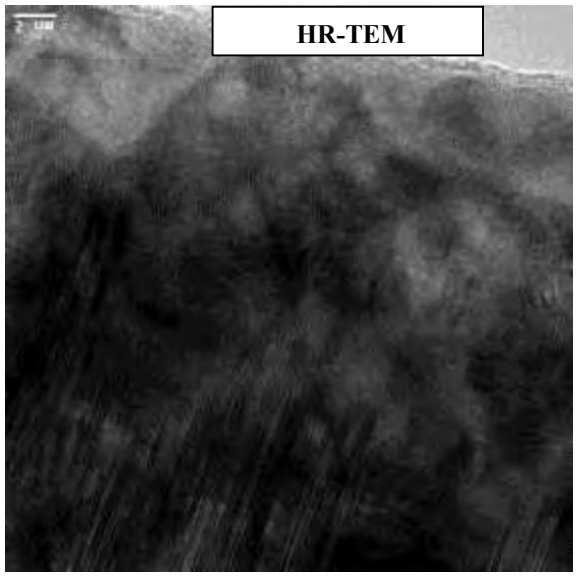


HR-TEM



Zinidal Aero ZnNi – 8V

HR-TEM



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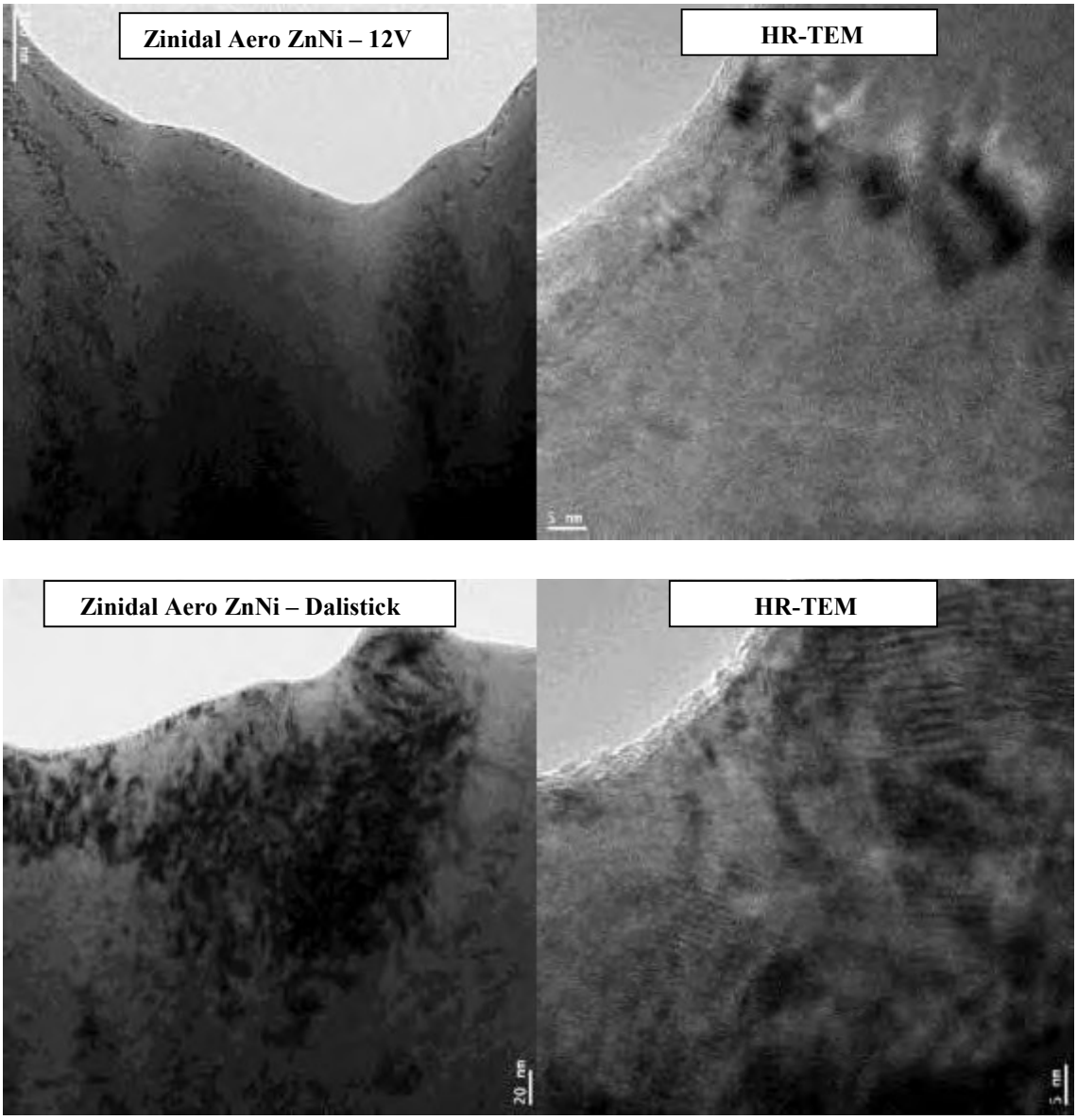

Figure 5 TEM investigation of coating showing dislocation formation and nanocrystalline size of platelets for few coatings

INCREMENTAL STEP LOAD (ISL) TESTING

Average fracture load and percent notch fracture strength ($NFS_{\%}$) values obtained for ASTM F519 Type 1a1 notch bar specimens coated by the various brush plating processes is given in

Table 2. Testing was conducted by incremental step load (ISL) method in four-point bending using a predefined loading profile to reach maximum load in 30 hours (i.e., 10 steps 5%-1h + 10 steps 5%-2h). For a condition to be considered "pass," all three samples must achieve at least 90 % (i.e., $NFS_{\%} \geq 90\%$).

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The NFS% results for SIFCO 2023 Cd and 4018 ZnNi coating were effectively 100 %, indicating no embrittlement. Zinidal Aero at 8 V and 12 V failed the 90 % qualification criterion with NFS% results of 61.7 % and 68.2 % respectively. The Dalistick Zinidal Aero coating achieved an average NFS% value of 90.7 %, however, one sample broke at 80 %, indicating some degree of inconsistency in the process outcome as reflected by the high standard deviation.

Table 2 Incremental Step Load Test Results

	Average (lbf)	Std. Dev. (lbf)	$NFS_{\%}$	Std. Dev. ($NFS_{\%}$)
FF - Bare Steel	41.0	0.3	-	-
ISL - Bare Steel	36.6	0.5	89.3	1.2
SIFCO 2023 Cd	37.6	0.7	102.7	1.8
SIFCO 4018 ZnNi 6V	35.3	0.7	96.4	2.0
Zinidal Aero 8-9V	22.6	1.0	61.7	2.8
Zinidal Aero 12V	25.0	1.0	68.2	2.8
Zinidal Aero Dalistick	33.2	3.4	90.7*	9.4

The green color code denotes a “pass” condition. For a condition to be considered “pass,” all three samples must achieve at least 90 % (i.e., $NFS_{\%} \geq 90\%$).

* One sample broke at 80 %

ELECTROCHEMICAL PERMEATION MEASUREMENTS

Thin shims of coated 1018 low alloy steel were used as substrate for the coatings for electrochemical permeation measurement experiments. The shims were sectioned and polished to 600 grit finish (on the exposed steel surface side). Permeation measurements were performed by the Devanathan-Stachurski method. A twin cell with an exposed area of 0.66 cm^{-2} was used. A 6 V battery with a variable rheostat was used to generate atomic hydrogen at the charging side. An addition of 200 ppm of arsenic oxide was used as a poison for hydrogen atom recombination. The electrolyte used in the charging side was 0.5M boric acid and sodium sulfate solution with 0.1M sodium hydroxide. The discharge side was prepared using 0.1M sodium hydroxide solution. A constant current of 0.1 mA was applied at the charging side using the 6 V battery. Palladium (Pd) coating was sputtered on the hydrogen exit side using e-beam deposition method.

As expected, the permeation flux (J_{ss}) and effective diffusivity (D_{eff}) for uncoated 1018 steel shim were higher than for the coated samples (Figure 6, Table 3). Permeation flux was found to be similar for uncoated steel shims and shims coated with Zinidal Aero 8V coatings (Figure 6). The similarity in the uncoated and coated Zinidal Aero 8V coatings can be attributed to the presence of through thickness cracks observed from FIB cross-section samples. The absence of cracks in Zinidal Aero 12V decreases the hydrogen permeation

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flux. In other words, increasing the electrodeposition potential to 12 V makes the coating less permeable. SIFCO 4018 and Dalistick Zinidal Aero coatings achieved the lowest permeation flux amongst the ZnNi coatings. This finding can be attributed to the fact that these coatings have less interconnected crack networks from the surface to the bulk of the coating. The coating with the lowest permeation flux Jss was Cd. The effective diffusivity (Deff) values follow the same pattern **(Table 3).**

Table 3 Effective diffusivity, subsurface H concentration and permeation flux of bare steel and coated steel samples

Material	Effective Diffusion Coefficient D_{eff} (x 10^{-11} cm^2 s^{-1})	Subsurface hydrogen Conc. C_0 x 10^{-2} (Mol cm^{-3})	Permeation Flux J_{ss} x 10^{-11} (Mol cm^{-2} s^{-1})
1018 Steel	4.8	5.5	5.3
SIFCO 2023 Cd	1.3	2.2	5.8
SIFCO 4018 ZnNi	1.8	6.9	6.9
Zinidal Aero – 8-9V	1.6	2.1	2.1
Zinidal Aero – 12V	1.2	1.1	1.1
Zinidal Aero - Dalistick	1.7	1.5	1.5

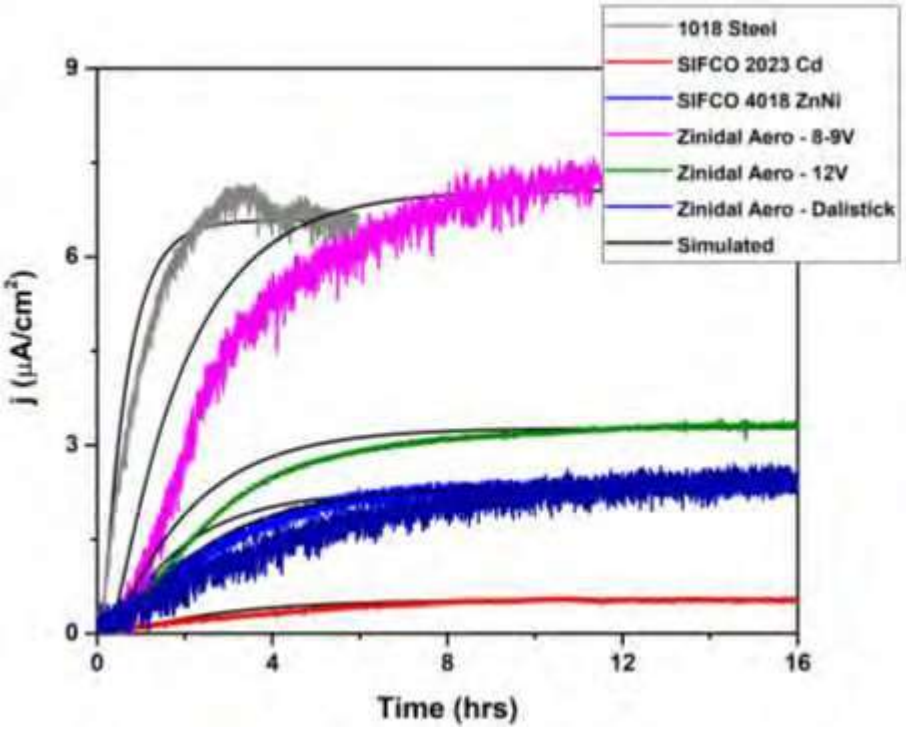

Figure 6 Permeation flux of bare steel and coatings

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THERMAL DESORPTION SPECTROSCOPY (TDS) MEASUREMENTS

Thermal desorption spectroscopy (TDS) is used to quantify the amount of hydrogen desorbed from the coated notch bars with heating rate of 5 ^{0}C. The vacuum pressure inside the furnace is kept at 6 x 10^{-6} mbar during the heating. Heating of the sample inside the vacuum chamber is done at 200 ^{o}C for ZnNi coatings and 90 ^{0}C for Cd coatings. The lower temperature for Cd is due to the risk of volatization of the coating (refer to the vapor pressure diagram of metals).

The Ion current measured by the TDS can be used to quantify the quantity of hydrogen molecules desorbed from the sample by using Faraday's law:

$$N = \frac{IXt}{e}$$

Where, N is Total number of hydrogen molecules detected, I is Ion current measured (A), t is total time (Sec), and e is the electron charge.

The highest ion current was obtained for SIFCO 4018 ZnNi coating. This result is attributed to scattered pores present in the SIFCO 4018 ZnNi coating (Figure 7). Hydrogen desorption current for Zinidal Aero 6 V and 8 V is similar. Whereas, lowest current was measured for Dalistick Zinidal Aero. The difference in coating microstructure (defects and cracks) and process (SIFCO and Zinidal Aero solution) explains the difference of the amount of hydrogen desorbed from the coated samples. The amount of H_2^+ ions desorbed from the coatings is shown in Figure 8. Similar trends between hydrogen desorption current and amount of hydrogen molecules desorbed can be observed. The lower temperature of heating Cd (90 ^{0}C vs. 200 ^{0}C) results in lower amount of hydrogen molecules desorbed for Cd coatings.

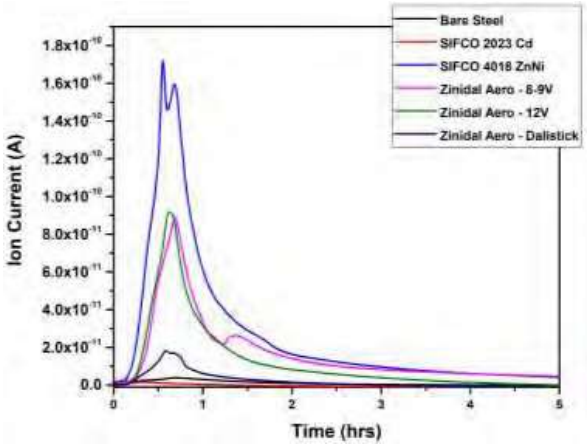

Figure 7 Thermal Desoprtion Spectra of Bare steel and coated notch bar

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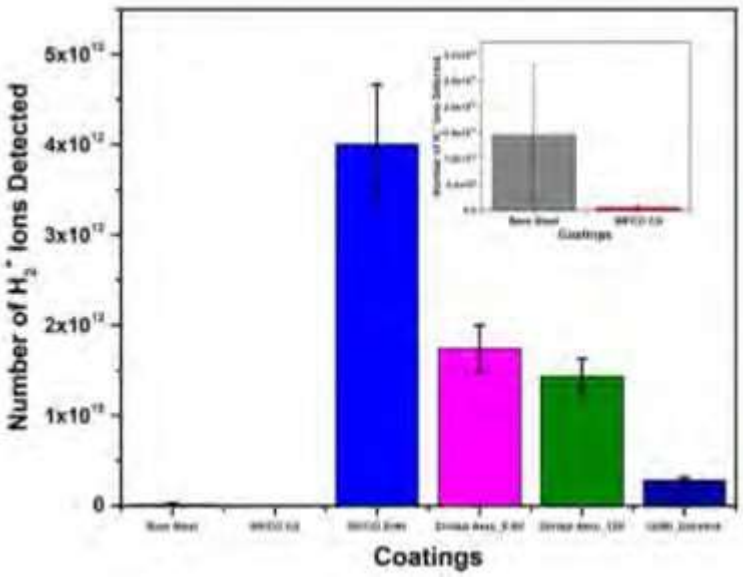

Figure 8 Quantification of hydrogen molecules desorbed

FRACTOGRAPHIC ANALYSIS

The fracture surfaces of broken notch bars were initially photographed after failure using a Nikon SMZ1500 stereomicroscope. The fracture surface was examined using a FEI Quanta F450 field emission gun equipped scanning electron microscope (FE-SEM). Clear topographical images were generated at magnifications up to roughly 1000 X at an accelerating voltage of 10 KV. Each fracture surface was delineated by zones beginning from the perimeter inward in a counter clockwise direction.

The fracture surfaces of fast fractured and incremental step load tested bare 4340 steel sample show formation of fibrous microstructure, typical for ductile fracture (Figure 9 and Figure 10). The fracture surface of SIFCO 2023 Cd coated notch bars also exhibited ductile fracture features with minor appearance of grain boundary facets. SIFCO 4018 ZnNi coated notch bar exhibited mixed mode fracture with predominant ductile features. Intergranular features typical of hydrogen assisted cracking at the crack initiation sites can be observed for Zinidal Aero 8V and 12V. Dalistick Zinidal Aero coated notch bars exhibited mixed mode features, however, these brittle features were less apparent than for Zinidal Aero 8V and 12V.

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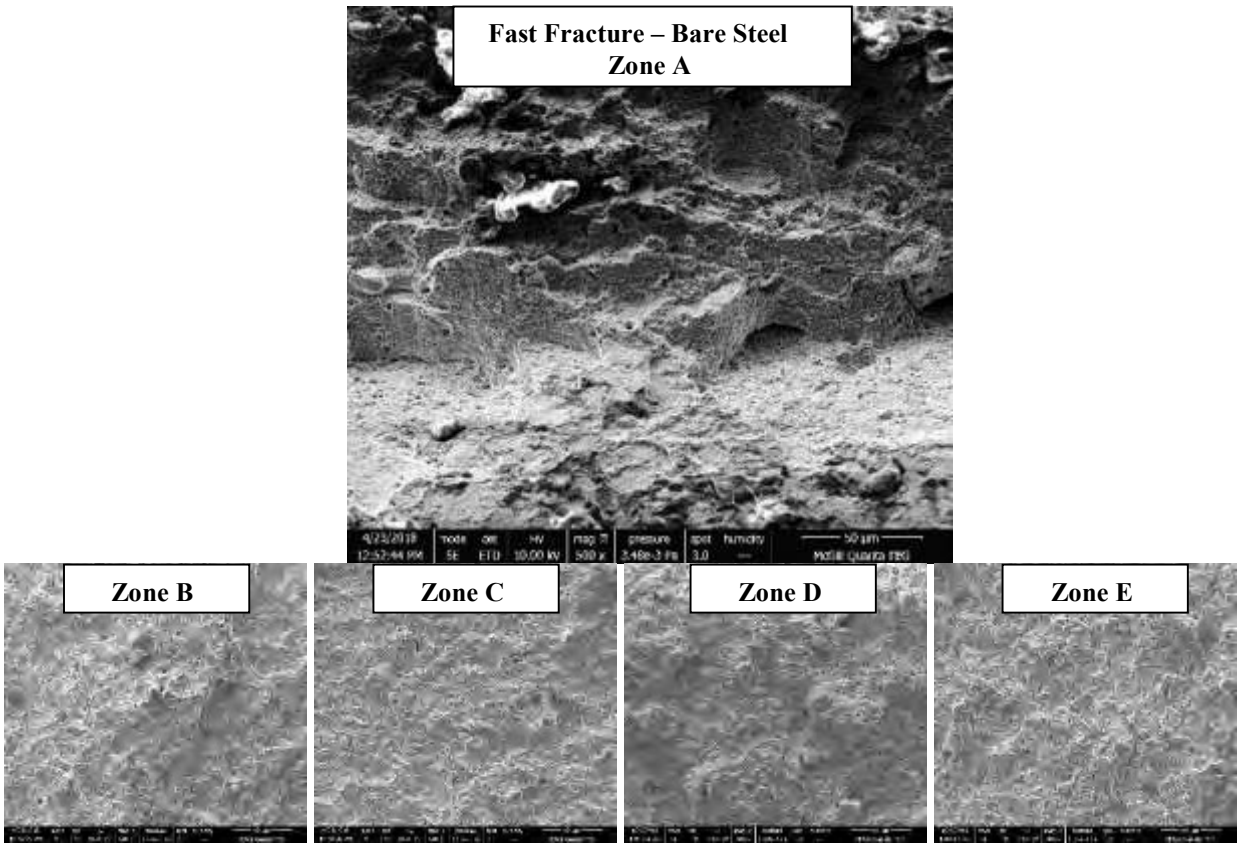
Figure 9 Overview of fracture surface of the notch bar used for zoning the features



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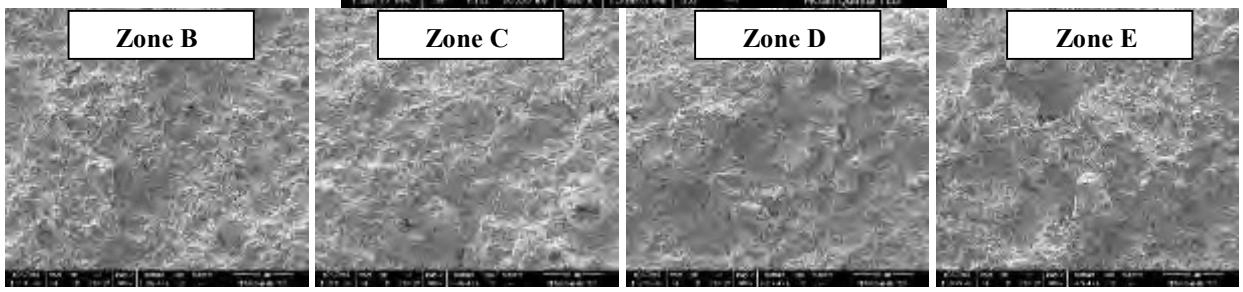
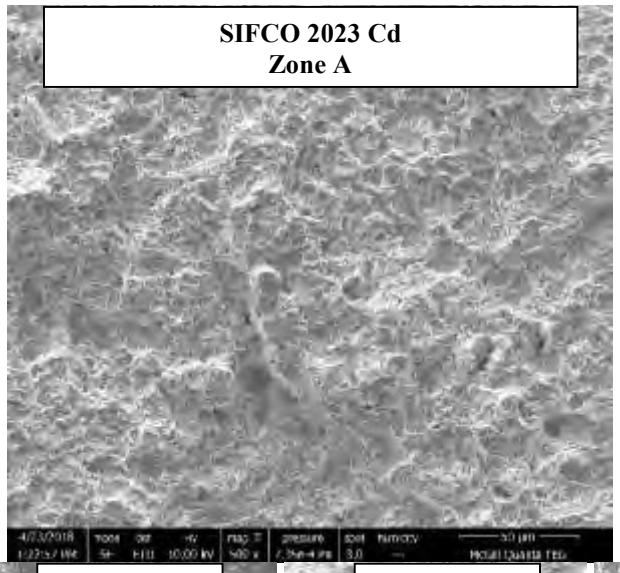
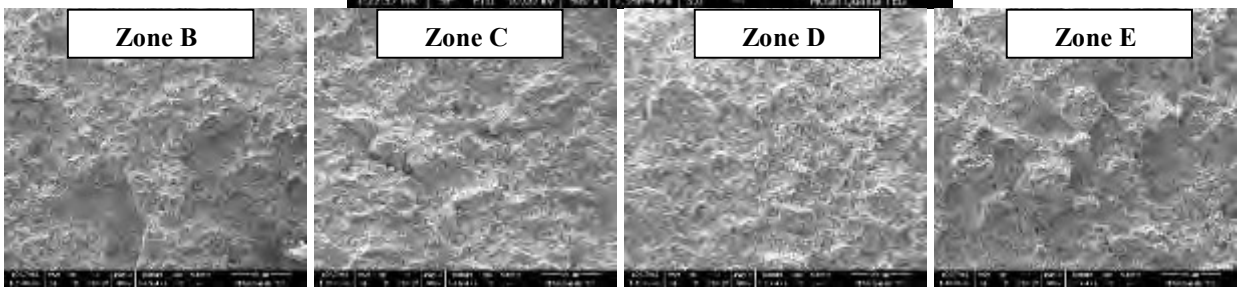
Incremental Step Load – Bare Steel
Zone A



SIFCO 2023 Cd
Zone A





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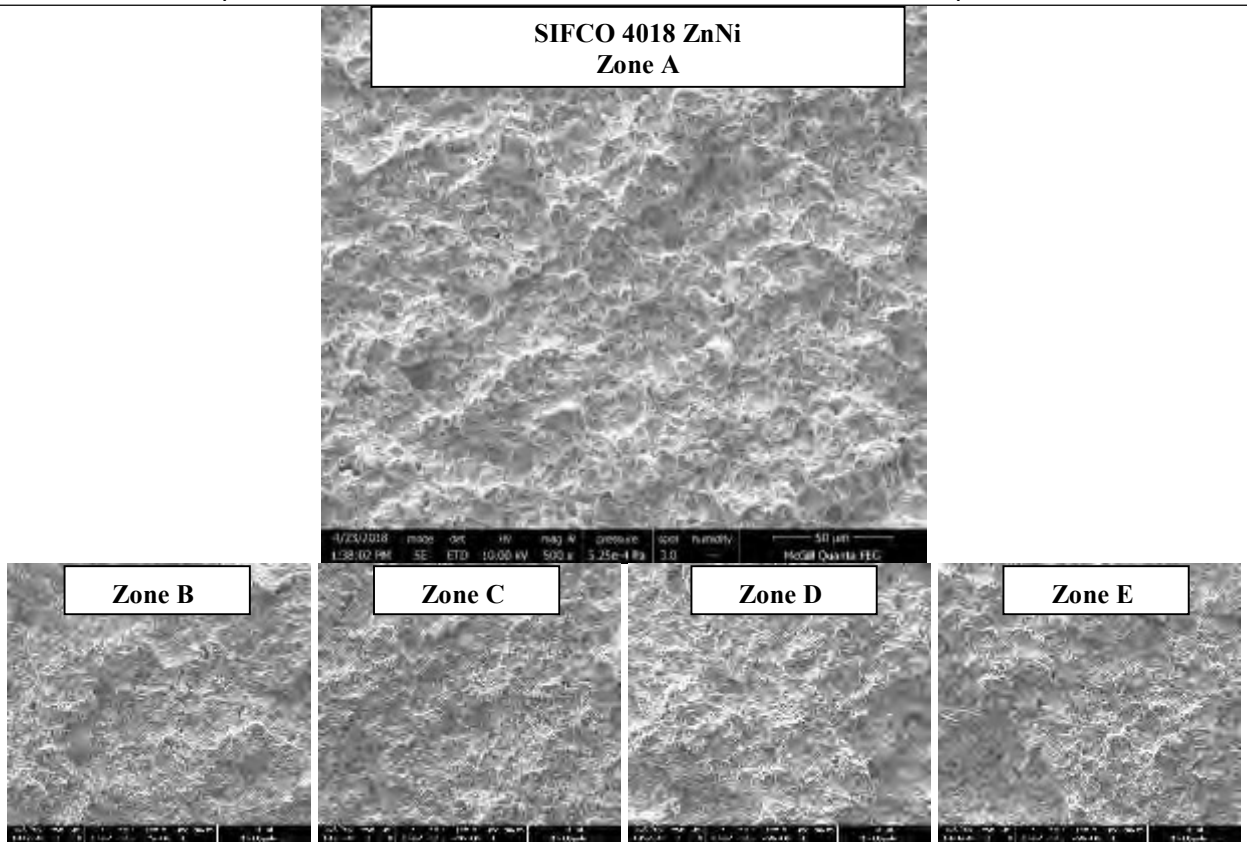

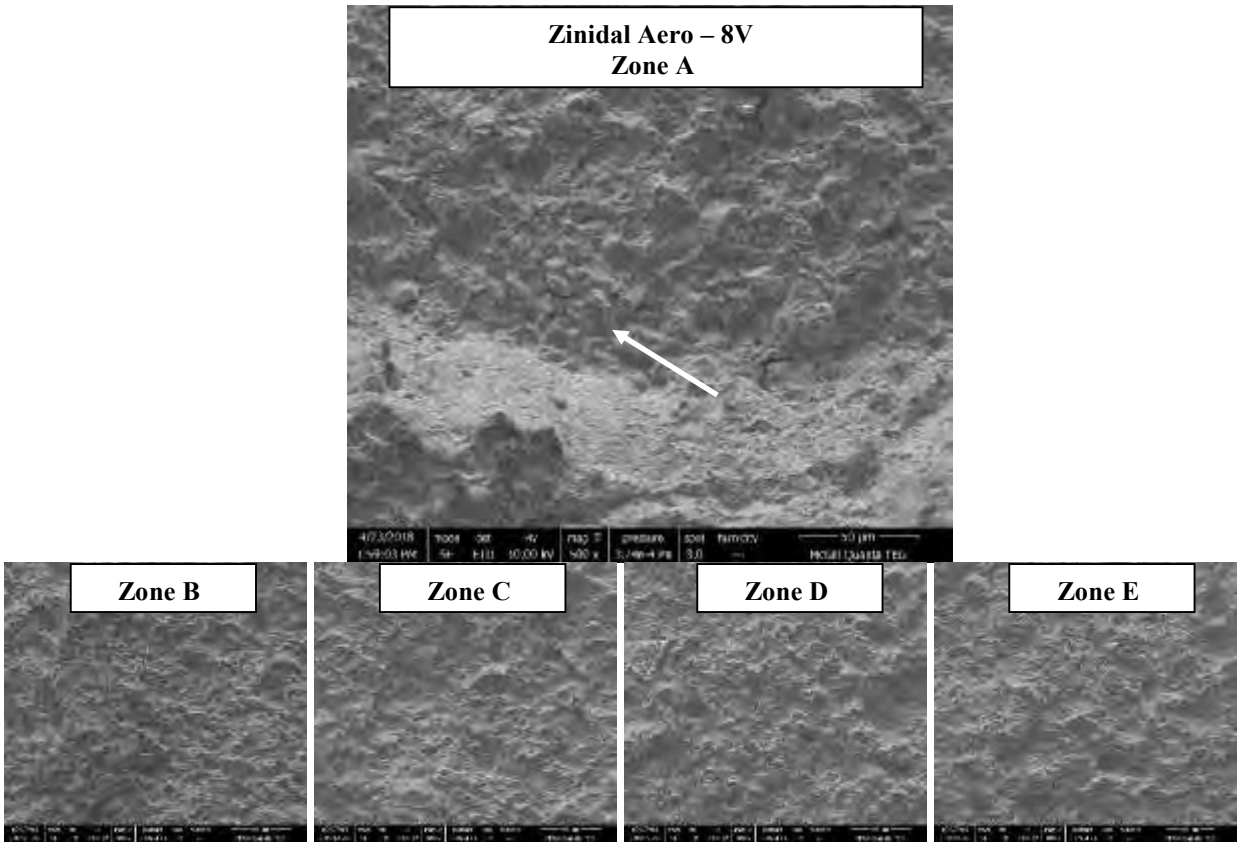

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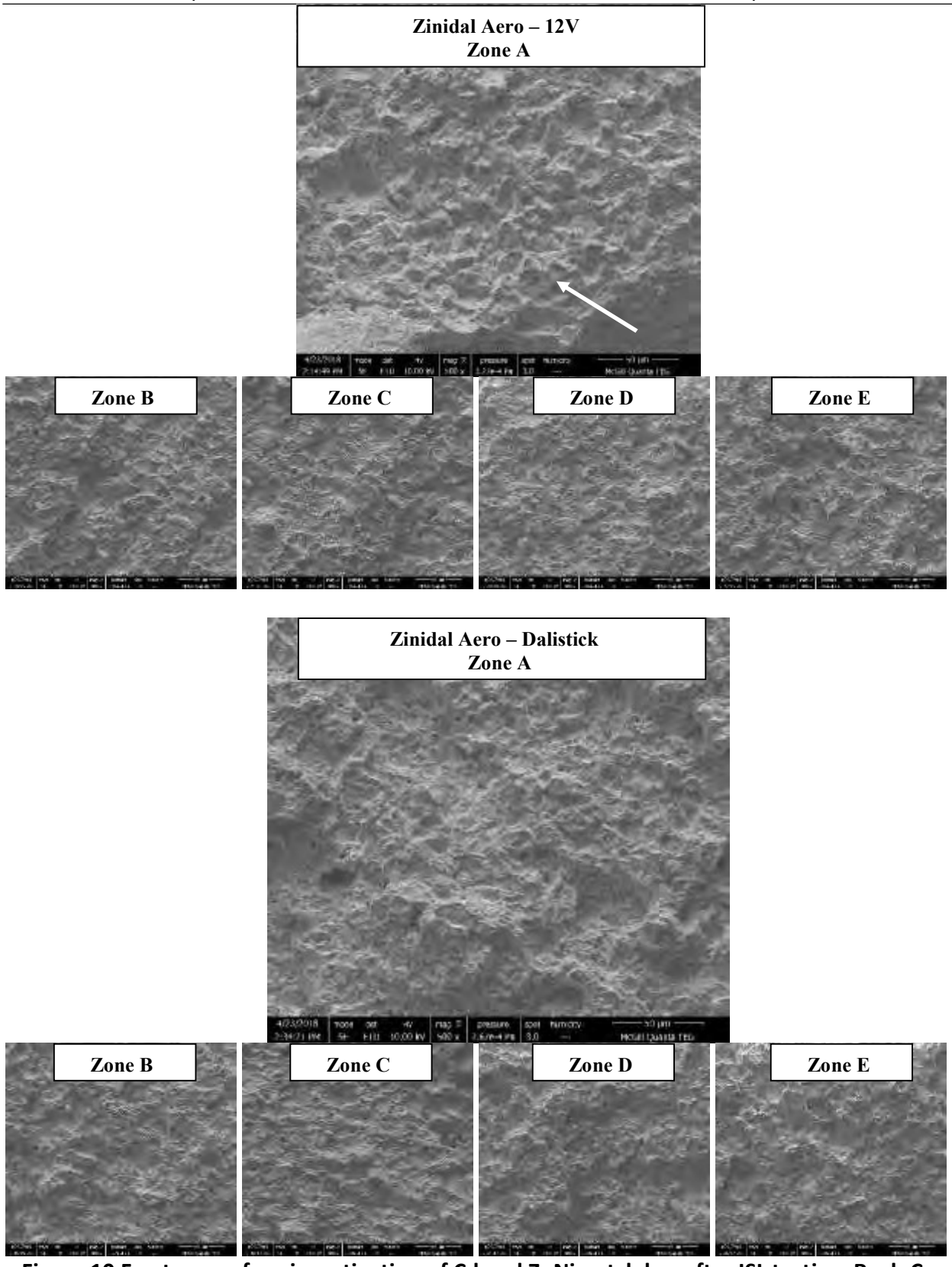

Figure 10 Fracture surface investigation of Cd and ZnNi notch bar after ISL testing. Rock-Candy structure present for Zinidal Aero at 8V and 12V suggests hydrogen embrittlement

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PHASE II

Phase I showed that the Dalistick apparatus applying Zinidal Aero solution achieved better results during ISL hydrogen embrittlement testing than the non Dalistick Zinidal Aero process. This result is explained by the fact that Dalistick apparatus impresses a potential of 12 V and provides a very consistent and stable current during electrodeposition.

Separately, it is generally understood that the strike layer normally applied with Cd electroplating (as was done in Phase I) reduces the quantity of hydrogen absorbed by the substrate and thus lowers the risk of internal hydrogen embrittlement (IHE).

To further investigate the previous two points, in Phase II, the effect of the strike layer and the surface preparation method (e.g., pre-cleaning and surface activation) on the ISL hydrogen embrittlement test results was examined for Zinidal Aero, both with and without Dalistick apparatus.

FOCUSED ION BEAM CROSS-SECTION

Focused Ion Beam (FIB) milling of the coating was performed using Ga ions bombardment to the coating in vacuum. To protect the surface layer from oxidation and artifacts due to ion beam irradiation, platinum (Pt) layer was initially sputtered. A trench was cut to observe the cross-section along the Pt sputtered area that reveals the bulk cross-section, including the substrate.

Coatings deposited with a strike layer at 14 V and a subsequent coating at 12 V showed no distinct morphological difference in microstructure (Figure 11). Some through thickness cracks are observed for 14 V strike 12 V coating, which can be beneficial as a desorption pathway for hydrogen. When a strike layer at 16 V was applied, a distinct morphological feature of the coating can be identified with Zinidal Aero. The strike layer is compact with no cracks, signifying hindrance in diffusion of hydrogen to the substrate material when regular coating is applied on top of the strike layer. No distinct feature between strike layer and regular coating layer was observed for samples plated with Dalistick Zinidal Aero after a strike voltage of 16V.

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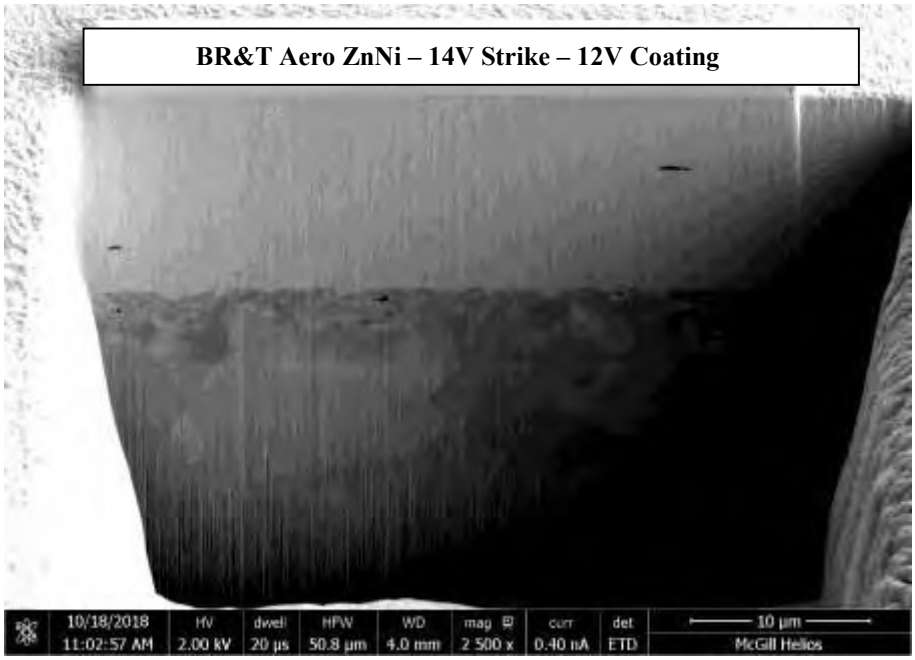

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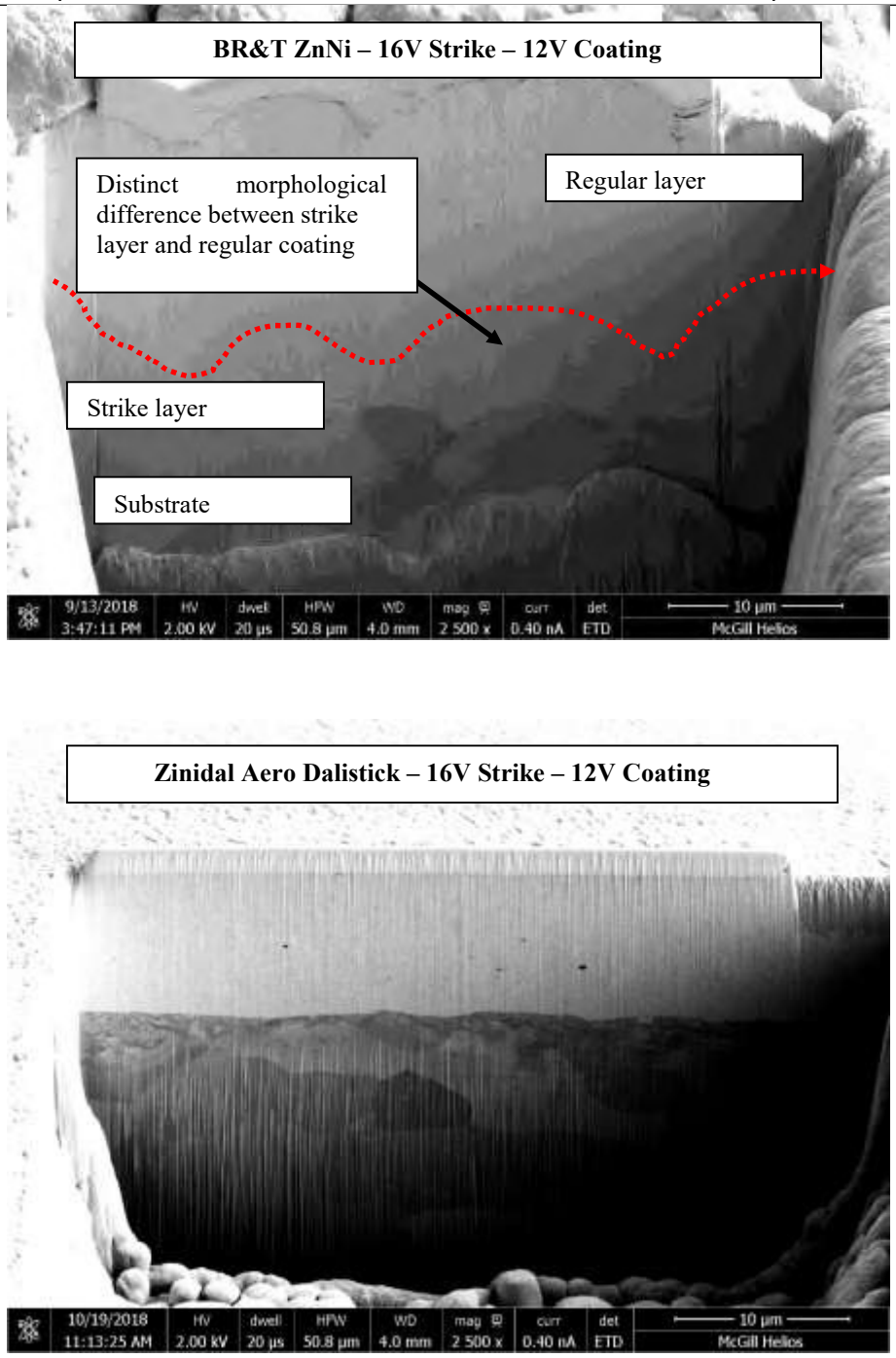

Figure 11 FIB Cross-section of ZnNi coating to observe distinct morphological difference between strike layer and regular coating

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INCREMENTAL STEP LOAD TESTING

Average fracture load and percent notch fracture strength ($NFS_{\%}$) values for ASTM F519 Type 1a1 notch bar specimens coated by the various brush plating processes is shown in Table 4. Testing was conducted by incremental step load (ISL) method in four-point bending using a predefined loading profile to reach maximum load in 30 hours (i.e., 10 steps 5%-1h + 10 steps 5%-2h). The $NFS_{\%}$ results given in Table 4 are color coded. Green signifies "pass" condition. The green color code denotes a "pass" condition. For a condition to be considered "pass," all three samples must achieve at least 90 % (i.e., $NFS_{\%} \geq 90\%$).

In summary, coatings applied at BR&T and UDRI with/without strike layer, with and without activation achieved the highest $NFS_{\%}$ values, indicating little or no propensity for internal hydrogen embrittlement.

For samples plated at UDRI using Dalistick equipment and the Scotch-Brite™ method of cleaning, better process control is required to achieve more consistent results.

The primary criterion to minimize the propensity for internal hydrogen embrittlement is the surface preparation step. $NFS_{\%}$ values for grit blasted samples are not consistent. The most reliable method to minimize the propensity for internal hydrogen embrittlement is by using the Scotch-Brite™ method for surface preparation.

Table 4 Incremental Step Load Test Results – Phase II

Specimen #	Strike	Surface Prep	Activation	Plating Site	Fracture Load	$NFS_{\%}$	Condition
1	Strike	Grit Blast	Yes	BR&T	18.3	50	Fail
8	Strike	Grit Blast	Yes	BR&T	18.3	50	
11	Strike	Grit Blast	Yes	BR&T	22	60.1	
29	Strike	Grit Blast	Yes	UDRI	22	60	Fail
30	Strike	Grit Blast	Yes	UDRI	23.8	65	
42	Strike	Grit Blast	Yes	UDRI	27.5	75	
10	Strike	Grit Blast	No	BR&T	21	57.4	Fail
16	Strike	Grit Blast	No	BR&T	22	60	
12	Strike	Grit Blast	No	BR&T	22	60.2	
33	Strike	Grit Blast	No	UDRI	36.4	99.5	Pass
38	Strike	Grit Blast	No	UDRI	37.1	101.4	
48	Strike	Grit Blast	No	UDRI	38.2	104.5	
13	Strike	Scotch-Brite	Yes	BR&T	36.3	99.2	Pass
14	Strike	Scotch-Brite	Yes	BR&T	36.6	100	
24	Strike	Scotch-Brite	Yes	BR&T	36.1	98.7	
26	Strike	Scotch-Brite	Yes	UDRI	33.5	91.4	

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35	Strike	Scotch-Brite	Yes	UDRI	35.5	96.9	Pass
44	Strike	Scotch-Brite	Yes	UDRI	36.6	100	
5	Strike	Scotch-Brite	No	BR&T	33	90.1	Pass
18	Strike	Scotch-Brite	No	BR&T	36.6	100.1	
21	Strike	Scotch-Brite	No	BR&T	36.6	100	
40	Strike	Scotch-Brite	No	UDRI	34.4	94	Fail
41	Strike	Scotch-Brite	No	UDRI	23.8	65	
47	Strike	Scotch-Brite	No	UDRI	35	95.6	
7	No Strike	Grit Blast	Yes	BR&T	18.3	50.1	Fail
19	No Strike	Grit Blast	Yes	BR&T	22	60	
22	No Strike	Grit Blast	Yes	BR&T	20.1	55	
31	No Strike	Grit Blast	Yes	UDRI	19.9	54.4	Fail
39	No Strike	Grit Blast	Yes	UDRI	23.8	65	
43	No Strike	Grit Blast	Yes	UDRI	36.5	99.8	
2	No Strike	Grit Blast	No	BR&T	22	60	Fail
3	No Strike	Grit Blast	No	BR&T	22	60	
9	No Strike	Grit Blast	No	BR&T	18.3	50.1	
25	No Strike	Grit Blast	No	UDRI	23.8	65	Fail
32	No Strike	Grit Blast	No	UDRI	35.9	98.1	
46	No Strike	Grit Blast	No	UDRI	36.5	99.8	
6	No Strike	Scotch-Brite	Yes	BR&T	35.4	96.8	Pass
17	No Strike	Scotch-Brite	Yes	BR&T	36.6	100.1	
23	No Strike	Scotch-Brite	Yes	BR&T	35.6	97.4	
27	No Strike	Scotch-Brite	Yes	UDRI	29.7	81.2	Fail
37	No Strike	Scotch-Brite	Yes	UDRI	34.8	95	
45	No Strike	Scotch-Brite	Yes	UDRI	36.3	99.2	
4	No Strike	Scotch-Brite	No	BR&T	34.3	93.7	Pass
15	No Strike	Scotch-Brite	No	BR&T	34.7	94.9	
20	No Strike	Scotch-Brite	No	BR&T	37.6	102.7	
28	No Strike	Scotch-Brite	No	UDRI	32.8	**89.6**	Pass*
34	No Strike	Scotch-Brite	No	UDRI	33	90.2	
36	No Strike	Scotch-Brite	No	UDRI	34	92.9	

The green color code denotes a “pass” condition for each sample tested. For a condition to be considered “pass,” all three samples must achieve at least 90 % (i.e., $NFS_{\%} \geq 90\%$).

*The condition was considered a “pass” despite one sample having failed at 89.6 % which, was marginally below the “pass” threshold, and when rounded up can be considered a “pass.”

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SUMMARY – PHASE II

The summary of the results of Phase II is given inTable 5. Comparing the test results of the coatings plated at both BR&T and UDRI, it is observed that activation and strike layer had no significant effect on the propensity for internal hydrogen embrittlement for brush plated ZnNi. The Scotch-Brite™ method for surface preparation before brush plating is superior to grit blasting for minimizing the propensity for internal hydrogen embrittlement.

Table 5 Summary of ISL test result

Facility	Strike	Activation		No-Activation	
Surface Prep		**Grit Blast**	**Scotch-Brite™**	**Grit Blast**	**Scotch-Brite™**
BR&T	Strike	Fail	Pass	Fail	Pass
	No Strike	Fail	Pass	Fail	Pass
UDRI	Strike	Fail	Pass	Pass	Fail
	No Strike	Fail	Fail	Fail	Pass

The green color code denotes a “pass” condition. For a condition to be considered “pass,” all three samples must achieve at least 90 % (i.e., $NFS_{\%} \geq 90\%$).

CONCLUSIONS

- SIFCO 2023 Cd and SIFCO 4018 ZnNi (6V) brush plating processes had the lowest propensity to cause internal hydrogen embrittlement (IHE). This result is an effect of extensive cracks and micropore, given they provide H effusion pathways.
- The use of the Dalistick apparatus with the Zinidal Aero reduces propensity to cause internal hydrogen embrittlement (IHE).
- TDS measurements showed highest desorption of hydrogen for SIFCO 4018 ZnNi followed by Zinidal Aero 8V, Zinidal Aero 12V and Dalistick Zinidal Aero.
- Unlike with Cd, the application of a strike layer does not reduce the propensity to cause internal hydrogen embrittlement (IHE) for ZnNi coatings.
- Surface preparation using Scotch-Brite™ was more consistent than grit blasting for reducing propensity to cause internal hydrogen embrittlement (IHE).

In conclusion, the results of this investigation showed that the Zinidal Aero brush plating solution offers an acceptable alternative to Cd, from the perspective of internal hydrogen embrittlement (IHE) risk management. This conclusion holds true irrespective of the brush

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electroplating apparatus, provided the substrate surface is activated using the Scotch-Brite™ cleaning method or another method that achieves an equivalent surface morphology, notably roughness of the substrate.

The experimental work was performed by Drs. Rajagopalan and Behera who also compiled the data presented in this report.

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APPENDIX

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #1 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a 1	**Area Plated:**	1.25 in^2 **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM
Solution Supply:	Pour	**Solution Temperature:**	RT
Notes:	Plating Formula for Zinidal Aero. A-Hr = 105 * Area (sq.in.) * Thickness (inches)		
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105			

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #2 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #3 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #4 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #5 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #6 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #7 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2 **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM
Solution Supply:	Pour	**Solution Temperature:**	RT
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)		
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105			

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						**Proceed to step 9.**
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #8 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2 **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM
Solution Supply:	Pour	**Solution Temperature:**	RT
Notes:	Plating Formula for Zinidal Aero. A-Hr = 105 * Area (sq.in.) * Thickness (inches)		
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105			

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #9 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #10 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

TEST RESULTS

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #11 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero. A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #12 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

TEST RESULTS

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #13 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero. A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #14 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero. A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #15 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #16 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #17 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #18 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #19 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						**Proceed to step 9.**
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #20 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

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DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #21 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

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DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #22 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						**Proceed to step 9.**
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #23 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel – Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - SIFCO #24 BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero. A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a,1	**Area Plated:**	0.07 in² (.451 cm²)	**Quantity of Test Specimens:** 1	
Deposit Required:	Zinidal Aero 2084	**Thickness Required:**	5.0 - 15.0 µm (0.2 - 0.7 mil)		
Plating Tool:	Dalicstick C(2020 Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	12 (slow)		
Solution Supply:	Dalicstick Tank	**Solution Temperature:**	18.0 - 27.0 °C (64.4 - 81.0 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator 2F				

Step	Operation	Material	Volts	Polarity	Amps(+) in Solution	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe	Complete				Remove heavy visible oil with MEK and kemwipe
2	Soak	MEK	Complete				Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast	Complete - Do not re-blast across PTI gasket R-Seal area				Grit Blast with Al-Oxide 120 Grit or finer. Prevent inwards from grit blast
3B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK	Complete				Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air	Complete				Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape	Complete				Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR 2F 30054					Pre-wet surface
8A2	Activate	ACTIVATOR 2F 30054	10	Rev	Station Limiting (5 A)	0.05	Activated surface should become light grey with no black residue
8B	1st Activate	Al Oxide abrasive paper	Complete - 220 Grit (max)				Lightly sand surface with 240 grit Al Oxide abrasive paper to activate surface
9	Rinse	DI Water	Complete				If stripping, absorb excess water with kemwipe
10	Pre-Wet	Zinidal Aero 11040	Complete				Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning
11B	No Strike		Complete				Proceed to step 12
12	Zn-Ni Plate	Zinidal Aero 11040	12	Fwd	Station Limiting (5A)	0.1667	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
13	Rinse, Demask, Rinse and Air Dry		Complete				Rinse again after demasking
14	Visual Inspection		Complete				View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D4585	Complete				Use tape to check for plating adhesion
16	Degrease	Acetone	Complete				Degrease with Acetone
17	Conversion Coat	Passivateur No. 3	Complete				Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
18	Rinse		Complete				
19	Dry		Complete				
NOTES:							
FOR STEPS 8, 9 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT							
Ship 3 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A							
1.1A							
1.1A							
Cover: Specialty Lot 1.1A, ASTM F 519 Type 1a,1, 90 degree notch							

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4330 Steel - Type 1a 1	**Area Plated:**	0.87 in² (567 mm²)	**Quantity of Test Specimens:**	6
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 16.0 µin (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020 Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	12 in/min		
Solution Supply:	Dalistick Tank	**Solution Temperature**	18.0 - 27.0 °C (64.4 - 80.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator #F				

Step	Operation	Material	Volts	Polarity	Amp/sq in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Demotion	Al Oxide Grit Blast					Grit Blast with Al Oxide 120 Grit or Finer - Protect threads from grit blast
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse quickly
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR #F 19054					Pre-wet surface
8A2	Activate	ACTIVATOR #F 19054	18	Rev	Station Limiting (5A)	0.5A	Activated surface should be pre-light gray with no black residue
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 240 grit Al Oxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			A dripping absorb excess water with kemwipe
10	Pre-Wet	Zinidal Aero 11048		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11048	18	Rev	3A	0.03	Start at 18 volts and maintain voltage at 18 V for about 15 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning
11B	No Strike						Proceed to step 12
12	Zn-Ni Plate	Zinidal Aero 11048	12V	Rev	Station Limiting (5A)	0.1AH	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D6677		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
17	Conversion Coat	Passivate No. 3		Complete			Apply Passivate No. 3 solution. Submerge specimen in solution for 8 sec
18	Rinse			Complete			
19	Dry			Complete			

NOTES:

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

Ship 3 for HE Testing within 72 hours

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
11A							
11a							
11A							

Steen Specialty Lot 1 Ph, ASTM F 519 Type 1a 1, 90 degree notch

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:		4340 Steel - Type 1a 1		**Area Plated:**		0.87 in² (561 mm²)	**Quantity of Test Specimens:** 1
Deposit Required		Zinidal Aero ZnNi		**Thickness Required:**		8.0 - 15.0 µm (0.3 - 0.7 mil)	
Plating Tool:		Dalstick D2020 Platinized Titanium / White Scotch Bright Jacket		**Tool Speed:**		12 in/min	
Solution Supply:		Dalstick Tank		**Solution Temperature:**		18.0 - 27.0 °C (64.4 - 71.6 °F)	
Notes:		Maintain Adjusted Plating Formula for Zinidal Aero and Activator 3E					
Step	**Operation**	**Material**	**Volts**	**Polarity**	**Amps/sq in.**	**A-hr**	**Visual Test - What you are looking for:**
1	Degrease	MEK & Kemwipe			Complete		Remove fingerprints and visible oil with MEK and Kemwipe
2	Soak	MEK			Complete		Soak in MEK for 5 min
3A	Dry Grit Blast	Al Oxide Grit Blast					Grit Blast with Al Oxide 120 Grit or Finer. Protect threads from grit blast
3B	Dry Grit Blast	Scotch Brite			Complete		Scotch Brite with water rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK			Complete		Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air			Complete		Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape Aluminum tape			Complete		Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section. Ensure aluminum tape under clamped section of turning mandrel. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR 3E 10054					Pre-wet surface
8A2	Activate	ACTIVATOR 3E 10054	16	Rev	Station Limiting (SA)	0.50	Activated surface should become light gray with no black residue
8B	No Activate	Al Oxide abrasive paper					Lightly scrub surface with 240 grit Al Oxide abrasive paper to activate surface
9	Rinse	DI Water			Complete		If dripping absorb excess water with kemwipe
10	Pre-Wet	Zinidal Aero 11040			Complete		Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning
11B	N/A Strike				Complete		Proceed to step 12
12	Zn/Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (SA)	0.047	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
13	Rinse, Demask, Rinse and Air Dry				Complete		Rinse again after demasking
14	Visual Inspection				Complete		Inser for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359			Complete		Use tape to check for plating adhesion
16	Degrease	Acetone			Complete		Degrease with Acetone
17	Conversion Coat	Passivator No. 3			Complete		Apply Passivator No. 3 solution. Submerge specimen in solution for 5 sec
18	Rinse				Complete		
19	Dry				Complete		
NOTES:							
FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT							
Ship 3 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated	Date & Time Tested	Pass/Fail	Comments
1.1A					
1.1a					
1.1A					
Sheet Optically Lot 1.1A: ASTM F 519 Type 1a 1 190 degree notch					

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DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a 1	**Area Plated:**	0.93 in² (600 mm²)	**Quantity of Test Specimens:** 1	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 15.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2030 Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	12 m/min		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.9 - 22.8 °C (plate ~R.T.)		
Notes:	Machine calculated Plating Formula for Zinidal Aero and Activator 1F				

Step	Operation	Material	Volts	Polarity	Amps/sq.in.	A-hr	Visual Test - What you are looking for
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide 120 Grit or Finer. Protect threads from grit blast
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded slit to expose 1.25 sq. in. Reduced Gage Section. Ensure aluminum tape under clamped section of burning lead. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR 1F 10054		Complete			Pre-wet surface
8A2	Activate	ACTIVATOR 1F 10054	12	Pos+	5 min (Limiting Dim)	0.001	Activated surface should become light grey, with no black residue
8B	No Activate	4/0 Grade abrasive paper		Complete (Single pass)			Lightly sand surface with 4/0 grit abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 1 Kit@		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040					Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning
11B	No Strike			Complete			Proceed to step 12
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Pos+	5 min (Limiting Dim)	0.001	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
17	Chromate Coat	Passivate No. 5		Complete			Apply Passivate No. 5 solution. Submerge specimen in solution for 5 sec
18	Rinse			Complete			
19	Dry			Complete			

NOTES:

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

Ship 3 for HE Testing within 72 hours

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1 1A							
1 1A							
1 1A							
Other Specialty Lot 1 1A: ASTM F519 Type 1a 1 90 degree notch							

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DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:		4340 Steel - Type 1a 1		**Area Plated:**		0.96 in² (~662 mm²)	**Quantity of Test Specimens:** 1
Deposit Required:		Zinidal Aero ZnNi		**Thickness Required:**		5.0 - 18.0 µm (0.8 - 0.7 mil)	
Plating Tool:		Dalistick D3837 Platinized Titanium / White-Scotch Bright Jacket		**Tool Speed:**		12 in/min	
Solution Supply:		Dalistick Tank		**Solution Temperature:**		18.0 - 23.0 °C (64.4 - 73.4 °F)	
Notes:		Machine calculated Plating Formula for Zinidal Aero and Activator 4E					
Step	**Operation**	**Material**	**Volts**	**Polarity**	**Amps/sq.in.**	**A-hr**	**Visual Test - What you are looking for:**
1	Degrease	MEK & Kimwipe			Complete		Remove heavy solder oil with MEK and Kimwipe
2	Soak	MEK			Complete		Soak in MEK for 5 min.
3A	Degrease	Air Gun and Grit Blast			Complete		Grit Blast with Al Oxide (30 psi or Less Prevent threaded area grit blast
3E	Degrease	Scotch Brite					Scotch Brite with water rinse and dry
4	Degrease	MEK & Kimwipe					Soak in MEK for 5 min. This step is optional.
5	Rinse	MEK			Complete		Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air			Complete		Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl DeFTape Aluminum tape			Complete		Mask threaded ends to expose 1.25 sq in Reduced Cross Section. Ensure aluminum tape under clamped section of turning thread. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR 4E 11054			Complete		Pre-wet surface
8A2	Activate	ACTIVATOR 4E 11054	18	Cath	Current (A) 0.96	0.0	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 340 grit Al Oxide abrasive paper to activate surface
9	Rinse	DI Water			Complete		If dripping absorb excess water with Kimwipe
10	Pre-Wet	Zinidal Aero 11040			Complete		Pre-wet surface
11A	Strike	ZincWAL Aero 11040	18	Anod	10		Start at 18 volts and maintain voltage at 18 V for about 10 seconds. Reduce voltage to 13 V and proceed to step 12 ASAP. Desired should be dull - not bright and/or burning
11B	No Strike						Proceed to step 12
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Anod	Current (A) 0.96	0.950	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning
13	Rinse, Demask, Rinse and Air Dry				Complete		Rinse again after demasking
14	Visual Inspection				Complete		View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D4541			Complete		Use tape to check for plating adhesion
16	Degrease	Acetone			Complete		Degrease with Acetone
17	Conversion Coat	Passivate# No. 3			Complete		Apply Passivate# No. 3 solution. Submerge specimen in solution for 8 sec.
18	Rinse				Complete		
19	Dry				Complete		

NOTES:

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

Ship 3 for HE Testing within 72 hours

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A							
1.1A							
1.1A							
Forest Steel city Lot 1.1A, ASTM F 519 Type 1a 1, (K) degree notch							

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a1	**Area Plated:**	(0.08 in²)	**Quantity of Test Specimens:** 1	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.0 - 10.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick DX(20) Platinized Titanium / White Scotch Brite Jacket	**Tool Speed:**	2 m/min		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	15.0 - 23.0 °C (Ideal - 18.5 °C)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator 3F				

Step	Operation	Material	Volts	Polarity	Amps/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe			Complete		Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK			Complete		Soak in MEK for 5 min
3A	Dry Blast	Al. Oxide Grit Blast			Complete		Grit Blast with Al. Oxide Grit 240 or finer. Protect threads from grit blast
3B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK			Complete		Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air			Complete		Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape			Complete		Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section. Ensure aluminum tape under clamped section of tummy head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR 3F 10054			Complete		Pre-wet surface
8A2	Activate	ACTIVATOR 3F 10054	12	Anode	Optimum Loading (1A)	0.005	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 280 grit Al Oxide abrasive paper to activate surface
9	Rinse	DI Water			Complete		If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11043			Complete		Pre-wet surface
11A	Strike	ZINIDAL Aero 11043	16	Anode	20	0.003	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning
11B	No Strike						Proceed to step 12
12	Zn-Ni Plate	Zinidal Aero 11043	12	Anode	Optimum Loading (1A)	0.050	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and non-burning
13	Rinse, Demask, Rinse and Air Dry				Complete		Rinse again after demasking
14	Visual Inspection				Complete		View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359			Complete		Use tape to check for plating adhesion
16	Degrease	Acetone			Complete		Degrease with Acetone
17	Conversion Coat	Passivation No. 3			Complete		Apply Passivation No. 3 solution. Submerge specimen in solution for 8 sec.
18	Rinse				Complete		
19	Dry				Complete		

NOTES: Typical Cycle Temperature: 18 to 38 °C (65 to 100 °F)

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

Ship 3 for HE Testing within 72 hours

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1 1A							
1 1B							
1 1C							
Lower Specialty Lot 1 1A, ASTM F 519 Type 1a 1, Mil Degree notch							

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		N/A			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper		N/A			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			Complete			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

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DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	0.93 in²	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020V Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	12 m/min		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe	Complete				Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK	Complete				Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast	Complete 120 Grit Al Oxide at 60 psi, 6-8" standoff distance				Grit Blast with Al Oxide 120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional.
5	Rinse	MEK	Complete				Rinse with MEK from spray bottle. This step is optional.
6	Air Blast	Air	Complete				Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape	Complete				Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054					Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054					Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper	Complete				Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water	Complete				If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040	Complete				Pre-wet surface
11A	Strike	ZINIDAL Aero 11040					Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike						Proceed to step 12.
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Pwd	Station Limiting (5A)	0.050	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry		Complete				Rinse again after demasking.
14	Visual Inspection		Complete				View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359	Complete				Use tape to check for plating adhesion
16	Degrease	Acetone	Complete				Degrease with Acetone
11	Conversion Coat	Passivateur No. 3	Complete				Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse		Complete				
13	Dry		Complete				
NOTES:							

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DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	0.93 in²	**Quantity of Test Specimens:** 1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)	
Plating Tool:	Dalistick D202V Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	12 m/min	
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)	
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF			

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe	Complete				Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK	Complete				Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast	Complete 120 Grit Al Oxide at 60 psi at 6" standoff distance				Grit Blast with Al Oxide 120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK	Complete				Rinse with MEK from spray bottle. This step is optional.
6	Air Blast	Air	Complete				Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape	Complete				Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054					Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054					Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper	Complete				Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water	Complete				If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040	Complete				Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16V	Fwd	Station Limiting (SA)	0.012	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike						Proceed to step 12.
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (SA)	0.060	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry		Complete				Rinse again after demasking.
14	Visual Inspection		Complete				View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359	Complete				Use tape to check for plating adhesion
16	Degrease	Acetone	Complete				Degrease with Acetone
11	Conversion Coat	Passivateur No. 3	Complete				Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse		Complete				
13	Dry		Complete				
NOTES:							

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2 **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		N/A			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.031	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			N/A			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2 **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		NA			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper		NA			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.031	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			NA			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.8	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in² **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		
	Completed 12:09 PM		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			Complete			Proceed to step 12 *
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in² **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			Complete			Proceed to step 12 *
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in² **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		N/A			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional.
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete (220 grit)			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			N/A			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		N/A			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper		N/A			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			Complete			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		NA			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			NA			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1		**Area Plated:**		1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi		**Thickness Required:**		8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket		**Tool Speed:**		120 RPM		
Solution Supply:	Dalistick Tank		**Solution Temperature:**		18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF						
Step	**Operation**	**Material**	**Volts**	**Polarity**	**Amp/sq.in.**	**A-hr**	**Visual Test - What you are looking for:**
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		NA			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		NA			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			NA			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	0.93 in² (Last revised) **Quantity of Test Specimens:** 1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020V Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	12 m/min
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete - 120 Grit Al Oxide @ 60 psi, 6-8" standoff distance			Grit Blast with Al Oxide 120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional.
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional.
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054		Complete			Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	12V	Rev	Station Limiting (5A)	0.010	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16V	Fwd	Station Limiting (5A)	0.011	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike						Proceed to step 12.
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.051	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking.
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse			Complete			
13	Dry			Complete			
NOTES:		Small amount of hydrogen gassing at first due to air bubbles from DI water					

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in²	**Quantity of Test Specimens:** 1	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		N/A			Scotch Brite with water, rinse and dry.
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional.
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.08	Activated surface should become light gray with no black residue
8B	No Activate	Al Oxide abrasive paper		N/A			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning
11B	No Strike			Complete			Proceed to step 12 *
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.10	Start at 12 volts and maintain volatage at 12 V. Deposit should be a dull - not bright and no burning
13	Rinse, Demask, Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 9 sec.
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.Activator process performed intermittintly due to small leak in supply tubing causing a slower delivery of solution compaired to normal. No adverse effects or burning observed

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in² **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		NA			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper		NA			Lightly sand surface with 240 grit Al/Oxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			NA			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			Complete			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		N/A			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		N/A			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			Complete			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10. Some missing passivator possibly due to air bubbles formed during dipping process

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a 1	**Area Plated:**	1.25 in^2 **Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF		

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		NA			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		Complete			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			NA			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DOE - Zinidal Aero 12V No Bake ZnNi - DALICSTICK BRUSH PLATE WORKSHEET

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in²	**Quantity of Test Specimens:**	1
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)		
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM		
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)		
Notes:	Machine calculates Plating Formula for Zinidal Aero and Activator XF				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe		Complete			Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK		Complete			Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast		Complete			Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite		N/A			Scotch Brite with water, rinse and dry
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional
5	Rinse	MEK		Complete			Rinse with MEK from spray bottle. This step is optional
6	Air Blast	Air		Complete			Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape		Complete			Mask threaded ends to expose 1.25 sq. in Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper		Complete			Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water		Complete			If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040		Complete			Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.02	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike			N/A			Proceed to step 12.*
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask. Rinse and Air Dry			Complete			Rinse again after demasking
14	Visual Inspection			Complete			View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359		Complete			Use tape to check for plating adhesion
16	Degrease	Acetone		Complete			Degrease with Acetone
11	Conversion Coat	Passivateur No. 3		Complete			Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec
12	Rinse			Complete			
13	Dry			Complete			

NOTES: * Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

2019-09-26 Page 1 of 1 Serial Number:

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Attachment No. 5 – Phase 2 DoE Test Plan for Optimizing Dalistick Zinidal Aero Zinc-Nickel

DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

Test Plan for Optimizing Dalic Zinidal Aero Zinc-Nickel Brush Plating

Stephen Gaydos and Shobbo Basu

Introduction

The following are options for test plans so that we can optimize the Dalic Zinidal Aero brush zinc-nickel (Dalic Zn-Ni) process to be a no-bake non-embrittling process for high strength steel (260 - 280 ksi UTS).

Experiments will be done at BR&T and UDRI (University of Dayton Research Institute) to apply Dalic Zn-Ni to high strength steel ASTM F 519 Type 1a.1 hydrogen embritlement test specimens and then carry-out an ISL (Incremental Step Load) test on the Type 1a.1 test specimens to see if they have been embrittled. The ISL will be as follows: 10 steps – 5% NFS / step – held for 1 hour per step followed by 5 steps – 5% NFS / step – held for 2 hour per step or until failure. A result of $\geq$ 90% NFS before failure is considered passing the test. If it fails before achieving the 90% NFS, we will record at what step the failure happened. Based on the initial experiments and on past experience, it was decided that three factors are of importance to and they are strike, surface prep, and activation.

A designed experiment will be done to fully characterize the effects of these factors on the brush plating (with no embritlement relief baking) with the Dalic ZnNi on high strength steel.

Test Plan

The factors and levels for the test are given below

Factor Description	# Levels	Values	Comments
Strike	2	Strike or No Strike	Strike = Plate at 16V for 1 minute then finish plating at 12V. No Strike = Plate only at 12V
Surface Prep	2	Scotch Brite or Grit Blast	Use either Scotch Brite or Grit Blast to clean steel before brush plating.
Activation	2	Activation or No Activation	Activate = Apply acid anodic etch at 16V for 1 minute after abrasive cleaning and before brush plating. No Activation = Apply brush plating immediately after abrasive cleaning.
Brush Plating Site	2	BR&T and UDRI	Since brush plating is a manual operation, the test specimens will be brush plated at UDRI and BR&T to insure that results are not affected by brush plating site.

Since the number of factors is small, it is decided that full factorial (2^4) design will be used with replications. It is suggested that the replications are important so that any unusual results from a single test run does not affect the overall results. We strongly

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suggest 3 replications (48 specimens, 24 at each site). The 48 specimen DoE test matrix is shown below.

Each test condition will be done separately and the conditions will be randomized so that there is no unintentional bias affecting the results.

We will send 3 specimens at a time to the testing site (IBECA) for the ISL testing. The site will receive specimens from BR&T and UDRI alternatively to test.

Analysis Plan

After data are collected, we will fit a statistical model to the %NFS at which the specimen broke to understand the effect of each factor and their interactions on the results.

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Specimen #	Strike	Surface Prep	Activation	Plating Site
1	Strike	Grit Blast	Yes	BR&T
2	No Strike	Grit Blast	No	BR&T
3	No Strike	Grit Blast	No	BR&T
4	No Strike	Scotch Brite	No	BR&T
5	Strike	Scotch Brite	No	BR&T
6	No Strike	Scotch Brite	Yes	BR&T
7	No Strike	Grit Blast	Yes	BR&T
8	Strike	Grit Blast	Yes	BR&T
9	No Strike	Grit Blast	No	BR&T
10	Strike	Grit Blast	No	BR&T
11	Strike	Grit Blast	Yes	BR&T
12	Strike	Grit Blast	No	BR&T
13	Strike	Scotch Brite	Yes	BR&T
14	Strike	Scotch Brite	Yes	BR&T
15	No Strike	Scotch Brite	No	BR&T
16	Strike	Grit Blast	No	BR&T
17	No Strike	Scotch Brite	Yes	BR&T
18	Strike	Scotch Brite	No	BR&T
19	No Strike	Grit Blast	Yes	BR&T
20	No Strike	Scotch Brite	No	BR&T
21	Strike	Scotch Brite	No	BR&T
22	No Strike	Grit Blast	Yes	BR&T
23	No Strike	Scotch Brite	Yes	BR&T
24	Strike	Scotch Brite	Yes	BR&T
25	No Strike	Grit Blast	No	UDRI
26	Strike	Scotch Brite	Yes	UDRI
27	No Strike	Scotch Brite	Yes	UDRI
28	No Strike	Scotch Brite	No	UDRI
29	Strike	Grit Blast	Yes	UDRI
30	Strike	Grit Blast	Yes	UDRI
31	No Strike	Grit Blast	Yes	UDRI
32	No Strike	Grit Blast	No	UDRI
33	Strike	Grit Blast	No	UDRI
34	No Strike	Scotch Brite	No	UDRI
35	Strike	Scotch Brite	Yes	UDRI
36	No Strike	Scotch Brite	No	UDRI
37	No Strike	Scotch Brite	Yes	UDRI
38	Strike	Grit Blast	No	UDRI
39	No Strike	Grit Blast	Yes	UDRI
40	Strike	Scotch Brite	No	UDRI
41	Strike	Scotch Brite	No	UDRI
42	Strike	Grit Blast	Yes	UDRI
43	No Strike	Grit Blast	Yes	UDRI
44	Strike	Scotch Brite	Yes	UDRI
45	No Strike	Scotch Brite	Yes	UDRI
46	No Strike	Grit Blast	No	UDRI
47	Strike	Scotch Brite	No	UDRI
48	Strike	Grit Blast	No	UDRI

Attachment No. 6 – Phase 2 Master Brush Plate Work Sheets for Application of Dalistick Zinidal Aero Zinc-Nickel at BR&T (using SIFCO Equipment) and UDRI (using Dalistick Equipment)

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
8B	No Strike						**Proceed to step 9.***
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	**0.08***	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES: *** Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.**

FOR STEPS 2, 5 AND 8 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

Ship 3 for HE Testing within 72 hours.

TEST RESULTS							
Lot #	**Specimen #**	**Date & Time Plated**		**Date & Time Tested**		**Pass/Fail**	**Comments**
1.1A							
1.1A							
1.1A							
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	8.0 - 18.0 µm (0.3 - 0.7 mil)	
Plating Tool:	Dalistick D2020/ Platinized Titanium / White Scotch Bright Jacket	**Tool Speed:**	120 RPM	
Solution Supply:	Dalistick Tank	**Solution Temperature:**	18.0 - 22.0 °C (64.4 - 71.6 °F)	
Notes:	Machine calculates Plating Formula for Zinidal Aero and Axtivator XF			

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MEK & Kemwipe					Remove heavy visible oil with MEK and Kemwipe
2	Soak	MEK					Soak in MEK for 5 min
3A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
4	Degrease	MEK & Kemwipe					Soak in MEK for 5 min. This step is optional.
5	Rinse	MEK					Rinse with MEK from spray bottle. This step is optional.
6	Air Blast	Air					Remove grit blast debris or solvent with air nozzle
7	Mask Threads	Vinyl Cap/Tape, Aluminum tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section. Ensure aluminum tape under clamped section of turning head. Use aluminum tape and vinyl tape outside clamped area
8A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-wet surface
8A2	Activate	ACTIVATOR XF 10054	16	Rev	Station Limiting (5A)	0.06	Activated surface should become light grey with no black residue.
8B	No Activate	Al Oxide abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
9	Rinse	DI Water					If dripping absorb excess water with Kemwipe
10	Pre-Wet	Zinidal Aero 11040	0				Pre-wet surface
11A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 12 ASAP. Deposit should be dull - not bright and no burning.
11B	No Strike						**Proceed to step 12.***
12	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	Station Limiting (5A)	**0.08***	Start at 12 volts and maintain volatage at 12 V. Deposit should be a dull - not bright and no burning.
13	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.

14	Visual Inspection						View for plating abnormalities
15	Adhesion Test	Adhesion test tape per ASTM D3359					Use tape to check for plating adhesion
16	Degrease	Acetone					Degrease with Acetone
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Submerge specimen in solution for 8 sec.
12	Rinse						
13	Dry						

NOTES: *** Add 0.02 Amp-Hrs if No Strike option is used. Total Amp-Hrs should be 0.10.**

FOR STEPS 3, 8 AND 11 - SELECT EITHER A OR B DEPENDING ON THE DOE REQUIREMENT

Ship 3 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated	Date & Time Tested	Pass/Fail	Comments
1.1A					
1.1A					
1.1A					
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.					

Attachment No. 7 – Phase 2 BR&T Brush Plate Work Sheets

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-31: #1	11/27/2018	11:35				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-33; #2	11/27/2018	11:50				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-34;#3	11/27/2018	12:10				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-53;#4	12/3/2018	14:35				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-37;#5	12/3/2018	14:50				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-120;#6	12/3/2018	15:03				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						**Proceed to step 9.**
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-50:#7	12/10/2018	13:30				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-57: #8	12/10/2018	13:50				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-53 ;#9	12/10/2018	14:45				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-35: #10	1/22/2019	8:26				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							
Ship 1 for HE Testing within 72 hours.							

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-59: #11	1/22/2019	8:55				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-60: #12	1/22/2019	9:46				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-35;#13	1/28/2019	13:23				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-89;#14	1/28/2019	13:40				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:			
Ship 1 for HE Testing within 72 hours.			

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-87;#15	1/28/2019	13:50				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-47: #16	2/4/2019	13:35				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated	Date & Time Tested	Pass/Fail	Comments
1.1A	SN:1.1A-48;#17	2/4/2019 13:50			
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.					

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated	Date & Time Tested	Pass/Fail	Comments
1.1A	SN:1.1A-45;#18	2/4/2019 14:00			
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.					

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						**Proceed to step 9.**
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-46:#19	2/26/2019	12:45				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:			
Ship 1 for HE Testing within 72 hours.			

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-55;#20	2/26/2019	12:55				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to activate surface
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated	Date & Time Tested	Pass/Fail	Comments
1.1A	SN:1.1A-56;#21	2/26/2019 13:06			
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.					

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2A	Deoxidize	Al Oxide Grit Blast					Grit Blast with Al Oxide120 Grit or Finer - Protect threads from grit blast.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						**Proceed to step 9.**
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.1	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-53:#22	3/11/2019	10:33				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						

NOTES:				
Ship 1 for HE Testing within 72 hours.				

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-54 ;#23	3/11/2019	10:45				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8A	Strike	ZINIDAL Aero 11040	16	Fwd	20	0.03	Start at 16 volts and maintain voltage at 16 V for about 10 seconds. Reduce voltage to 12 V and proceed to step 9 ASAP. Deposit should be dull - not bright and no burning.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.08	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse						
13	Dry						
NOTES:							

Ship 1 for HE Testing within 72 hours.

TEST RESULTS

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-76 ;#24	3/11/2019	10:56				
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Attachment No. 8 – Phase 2 UDRI Brush Plate Work Sheets

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/1/2018 11:07:08 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA HE
Part designation	#25-2

Treatment

Surface (dm²)	0.06
Estimated duration	0.56

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	Grit Blast	0.00	manual application
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/1/2018 11:07:08 AM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :47.05 Treatment duration (min) :0:00:34	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant

29	Information	Compliant

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/1/2018 11:07:08 AM

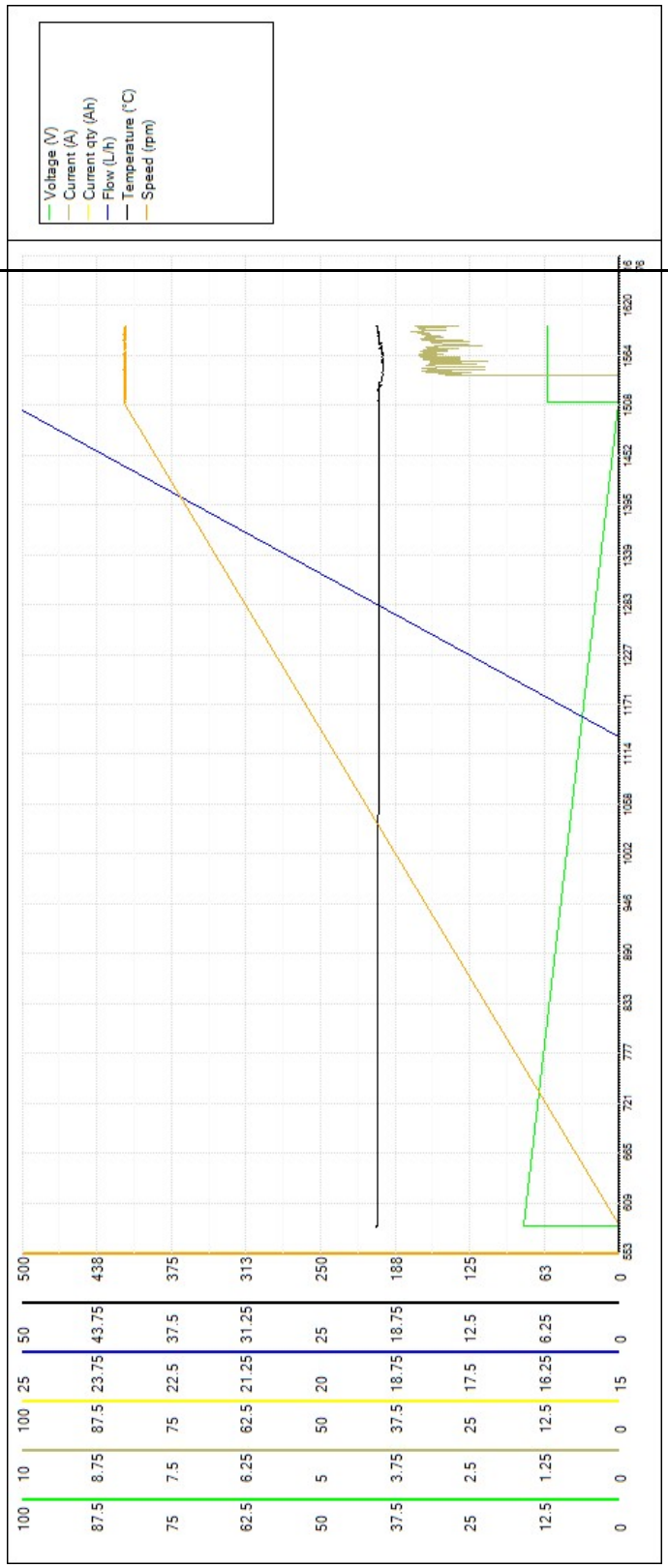
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (Grit Blast - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/1/2018 11:07:08 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 11:07:08 AM

Events

Date	N°	Type	Completion
11:41:59AM	66	Step over	
11:41:59AM	66	Operating mode complete	
11:41:57AM	66	Step started	Message Validate
11:41:57AM	65	Step over	
11:41:55AM	65	Step started	Control Final
11:41:55AM	64	Step over	
11:41:51AM	64	No compressed air	
11:41:51AM	64	No compressed air	
11:41:50AM	64	Step started	Message Validate
11:41:49AM	63	Step over	
11:41:49AM	63	No compressed air	
11:41:46AM	63	Step started	Message Validate
11:41:46AM	62	Step over	
11:41:43AM	62	Step started	Message Validate
11:41:43AM	61	Step over	
11:41:41AM	61	Step started	Message Validate
11:41:41AM	60	Step over	
11:39:33AM	60	No compressed air	
11:39:12AM	59	Step over	
11:39:12AM	60	Step started	Message Validate
11:39:08AM	59	Step started	Message Validate
11:39:08AM	58	Step over	
11:37:31AM	58	Step started	Control Thickness (µm)
11:37:31AM	57	Step over	
11:37:27AM	57	Step started	Message Validate
11:37:27AM	56	Step over	
11:37:24AM	56	Step started	Control Adhesion
11:37:24AM	55	Step over	
11:37:22AM	55	Step started	Control Aspect
11:37:22AM	54	Step over	
11:36:41AM	54	No compressed air	
11:36:10AM	54	Step started	Message Validate
11:36:09AM	53	Step over	
11:36:07AM	53	Step started	Message Validate
11:36:07AM	52	Step over	
11:35:20AM	52	No compressed air	
11:34:41AM	52	Step started	Message Validate
11:34:41AM	51	Step over	
11:34:15AM	51	Step started	Message Validate
11:34:15AM	50	Step over	
11:34:07AM	50	Step started	Message Validate
11:34:07AM	49	Step over	
11:34:07AM	49	No compressed air	
11:34:04AM	48	Step over	
11:34:04AM	49	Step started	Message Validate
11:34:04AM	48	Process defect: flow high limit reached	
11:34:04AM	48	Step started	Setting Pumping (Set point: Off)
11:34:04AM	47	Step over	
11:33:46AM	46	Step over	
11:33:46AM	47	Step started	Message Validate
11:33:46AM	46	Step started	Setting Generation (Set point: Off)
11:33:46AM	45	Step over	
11:33:28AM	45	No compressed air	
11:32:43AM	45	No compressed air	
11:32:40AM	45	No compressed air	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 11:07:08 AM

11:32:39AM	45	No compressed air	
11:32:20AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:32:20AM	44	Step over	
11:32:18AM	43	Step over	
11:32:18AM	44	Step started	Setting Generation (Set point: On)
11:32:18AM	42	Step over	
11:32:18AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
11:32:18AM	41	Step over	
11:32:18AM	42	Step started	Setting Polarity (Set point: Plating)
11:32:18AM	40	Step over	
11:32:18AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:32:18AM	39	Step over	
11:32:18AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:32:17AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:32:17AM	38	Step over	
11:32:12AM	38	No compressed air	
11:32:11AM	38	No compressed air	
11:32:10AM	38	No compressed air	
11:32:02AM	38	Step started	Message Validate
11:32:02AM	37	Step over	
11:31:20AM	37	No compressed air	
11:30:51AM	37	No compressed air	
11:30:46AM	37	No compressed air	
11:30:45AM	37	No compressed air	
11:30:41AM	37	Process defect: flow high limit reached	
11:30:26AM	37	Process defect: flow high limit reached	
11:30:01AM	37	Process defect: flow high limit reached	
11:29:48AM	37	No compressed air	
11:29:45AM	37	Process defect: flow high limit reached	
11:29:30AM	37	Process defect: flow high limit reached	
11:29:15AM	37	Process defect: flow high limit reached	
11:29:13AM	37	No compressed air	
11:29:00AM	37	Process defect: flow high limit reached	
11:28:39AM	37	Process defect: flow high limit reached	
11:28:14AM	37	Process defect: flow high limit reached	
11:28:11AM	37	No compressed air	
11:27:59AM	37	Process defect: flow high limit reached	
11:27:40AM	37	No compressed air	
11:27:39AM	37	Process defect: flow high limit reached	
11:27:23AM	37	Process defect: flow high limit reached	
11:26:58AM	37	No compressed air	
11:26:57AM	37	No compressed air	
11:26:56AM	37	No compressed air	
11:26:49AM	37	No compressed air	
11:26:48AM	37	No compressed air	
11:26:31AM	37	No compressed air	
11:26:30AM	37	No compressed air	
11:26:27AM	37	No compressed air	

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA HE
	Creation date :	11/1/2018 11:07:08 AM

11:25:42AM	37	No compressed air	
11:25:08AM	37	No compressed air	
11:24:59AM	37	Process defect: flow high limit reached	
11:24:44AM	37	Process defect: flow high limit reached	
11:24:38AM	37	Process defect: flow high limit reached	
11:24:27AM	37	No compressed air	
11:24:23AM	37	No compressed air	
11:24:20AM	37	No compressed air	
11:24:18AM	37	Process defect: flow high limit reached	
11:24:18AM	37	Process defect: flow high limit reached	
11:24:03AM	37	Process defect: flow high limit reached	
11:23:56AM	37	No compressed air	
11:23:53AM	37	Process defect: flow high limit reached	
11:23:37AM	37	Process defect: flow high limit reached	
11:23:12AM	37	No compressed air	
11:22:38AM	37	No compressed air	
11:21:51AM	37	No compressed air	
11:21:44AM	37	Process defect: flow high limit reached	
11:21:29AM	37	Process defect: flow high limit reached	
11:21:03AM	37	No compressed air	
11:20:37AM	37	Process defect: flow high limit reached	
11:20:30AM	37	No compressed air	
11:20:29AM	37	No compressed air	
11:20:24AM	37	No compressed air	
11:20:22AM	37	Process defect: flow high limit reached	
11:20:22AM	37	No compressed air	
11:20:21AM	37	No compressed air	
11:19:51AM	37	No compressed air	
11:19:36AM	37	Step started	Message Validate
11:19:36AM	36	Step over	
11:19:36AM	36	Process defect: flow high limit reached	
11:19:35AM	35	Step over	
11:19:35AM	36	Step started	Setting Pumping (Set point: On)
11:17:19AM	35	No compressed air	
11:16:57AM	35	Step started	Message Validate
11:16:57AM	34	Step over	
11:16:54AM	33	Step over	
11:16:54AM	34	Step started	Message Validate
11:16:53AM	33	Step started	Setting Generation (Set point: Off)
11:16:53AM	32	Step over	
11:16:52AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:16:52AM	31	Step over	
11:16:51AM	31	Step started	Setting Generation (Set point: On)
11:16:51AM	30	Step over	
11:16:50AM	29	Step over	
11:16:50AM	30	Step started	Setting Solution (Grit Blast - Activator XF)
11:16:49AM	29	Step started	Message Validate

11:16:49AM	28	Step over	
11:16:46AM	28	Step started	Message Validate
11:16:46AM	27	Step over	
11:16:42AM	27	Step started	Message Validate
11:16:42AM	26	Step over	
11:16:36AM	26	Step started	Message Validate
11:16:36AM	25	Step over	
11:15:45AM	25	No compressed air	
11:14:35AM	25	Step started	Setting Surface
11:14:35AM	24	Step over	
11:14:35AM	24	Process defect: flow high limit reached	
11:14:34AM	24	Step started	Setting Pumping (Set point: Off)
11:14:34AM	23	Step over	
11:14:27AM	23	No compressed air	
11:13:55AM	23	No compressed air	
11:12:53AM	23	No compressed air	
11:12:21AM	23	No compressed air	
11:11:26AM	23	No compressed air	
11:11:03AM	23	No compressed air	
11:09:15AM	23	No compressed air	
11:08:25AM	23	Process defect: flow high limit reached	
11:08:05AM	23	Process defect: flow lower limit reached	
11:07:47AM	23	Step started	Message Validate
11:07:47AM	22	Step over	
11:07:43AM	22	Step started	Message Validate
11:07:43AM	21	Step over	
11:07:43AM	21	Process defect: flow lower limit reached	
11:07:42AM	21	Step started	Setting Pumping (Set point: On)
11:07:42AM	20	Step over	
11:07:40AM	20	Step started	Message Validate
11:07:39AM	19	Step over	
11:07:37AM	18	Step over	
11:07:37AM	19	Step started	Message Validate
11:07:37AM	18	No compressed air	
11:07:36AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
11:07:36AM	17	Step over	
11:07:33AM	17	Step started	Message Validate
11:07:33AM	16	Step over	
11:07:31AM	15	Step over	
11:07:31AM	16	Step started	Message Validate
11:07:29AM	15	Step started	Message Validate
11:07:29AM	14	Step over	
11:07:26AM	14	Step started	Message Validate
11:07:26AM	13	Step over	
11:07:24AM	13	Step started	Message Validate
11:07:24AM	12	Step over	
11:07:21AM	11	Step over	
11:07:21AM	12	Step started	Message Validate
11:07:19AM	10	Step over	
11:07:19AM	11	Step started	Message Validate
11:07:17AM	09	Step over	
11:07:17AM	10	Step started	Message Validate
11:07:15AM	09	Step started	Message Validate
11:07:15AM	08	Step over	
11:07:13AM	08	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 11:07:08 AM

11:07:13AM	07	Step over	
11:07:10AM	06	Step over	
11:07:10AM	07	Step started	Message Validate
11:07:10AM	05	Step over	
11:07:10AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
11:07:10AM	04	Step over	
11:07:10AM	05	Step started	Setting Polarity (Set point: Anodizing)
11:07:10AM	03	Step over	
11:07:10AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:07:10AM	02	Step over	
11:07:10AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
11:07:10AM	01	Step over	
11:07:10AM	02	Step started	Setting Generation (Set point: Off)
11:07:09AM	01	Step started	Setting Pumping (Set point: Off)
11:07:09AM	01	Operating mode started	Boeing/IBECA HE

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/1/2018 12:02:22 PM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA HE
Part designation	#26-2

Treatment

Surface (dm²)	0.06
Estimated duration	0.56

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/1/2018 12:02:22 PM

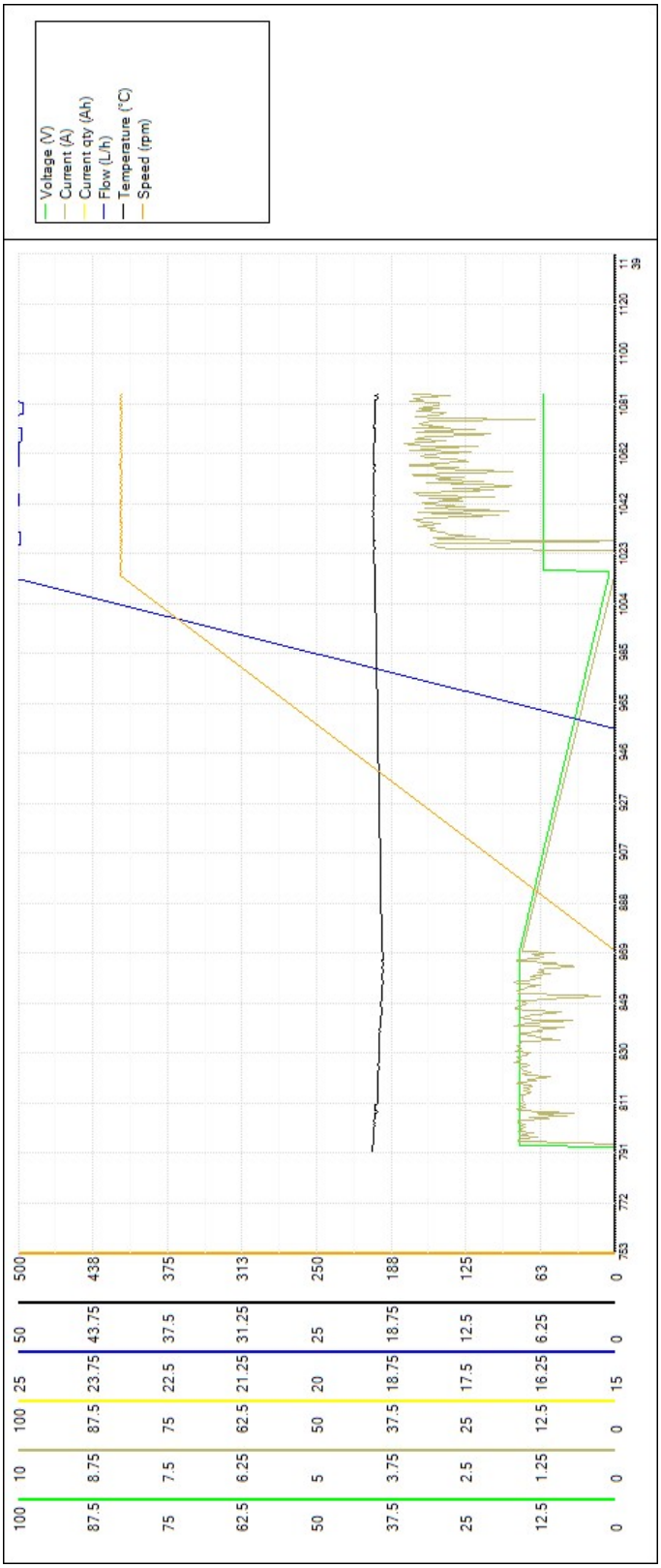
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :47.05 Treatment duration (min) :0:00:34	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (20160002-HE - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/1/2018 12:02:22 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant

DALISTICK®


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 12:02:22 PM

Events

Date	N°	Type	Completion
12:27:53PM	66	Operating mode complete	
12:27:53PM	66	Step over	
12:27:51PM	66	Step started	Message Validate
12:27:51PM	65	Step over	
12:27:49PM	64	Step over	
12:27:49PM	65	Step started	Control Final
12:27:48PM	64	Step started	Message Validate
12:27:47PM	63	Step over	
12:27:46PM	63	Step started	Message Validate
12:27:46PM	62	Step over	
12:27:44PM	62	Step started	Message Validate
12:27:44PM	61	Step over	
12:27:42PM	61	Step started	Message Validate
12:27:42PM	60	Step over	
12:27:40PM	59	Step over	
12:27:40PM	60	Step started	Message Validate
12:26:20PM	59	No compressed air	
12:25:25PM	59	Step started	Message Validate
12:25:24PM	58	Step over	
12:25:20PM	58	Step started	Control Thickness (µm)
12:25:19PM	57	Step over	
12:23:50PM	57	No compressed air	
12:22:43PM	57	Step started	Message Validate
12:22:43PM	56	Step over	
12:22:30PM	56	No compressed air	
12:22:23PM	56	No compressed air	
12:22:20PM	56	No compressed air	
12:22:10PM	56	No compressed air	
12:22:08PM	56	No compressed air	
12:21:32PM	56	Step started	Control Adhesion
12:21:32PM	55	Step over	
12:21:30PM	55	Step started	Control Aspect
12:21:29PM	54	Step over	
12:21:29PM	54	No compressed air	
12:21:01PM	54	No compressed air	
12:20:58PM	54	Step started	Message Validate
12:20:58PM	53	Step over	
12:20:58PM	53	No compressed air	
12:20:56PM	53	No compressed air	
12:20:55PM	53	Step started	Message Validate
12:20:54PM	52	Step over	
12:20:52PM	52	No compressed air	
12:20:52PM	52	Step started	Message Validate
12:20:52PM	51	Step over	
12:20:51PM	51	No compressed air	
12:20:49PM	51	Step started	Message Validate
12:20:49PM	50	Step over	
12:20:43PM	50	Step started	Message Validate
12:20:43PM	49	Step over	
12:20:38PM	48	Step over	
12:20:38PM	49	Step started	Message Validate
12:20:38PM	48	Step started	Setting Pumping (Set point: Off)
12:20:38PM	47	Step over	
12:20:34PM	47	No compressed air	
12:20:32PM	46	Step over	
12:20:32PM	47	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 12:02:22 PM

12:20:32PM	46	Step started	Setting Generation (Set point: Off)
12:20:32PM	45	Step over	
12:20:04PM	45	Process defect: flow high limit reached	
12:20:04PM	45	Process defect: flow high limit reached	
12:19:49PM	45	Process defect: flow high limit reached	
12:19:48PM	45	Process defect: flow high limit reached	
12:19:33PM	45	Process defect: flow high limit reached	
12:19:27PM	45	No compressed air	
12:19:23PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
12:19:23PM	44	Step over	
12:19:22PM	43	Step over	
12:19:22PM	44	Step started	Setting Generation (Set point: On)
12:19:22PM	42	Step over	
12:19:22PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
12:19:21PM	41	Step over	
12:19:21PM	42	Step started	Setting Polarity (Set point: Plating)
12:19:21PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:19:21PM	40	Step over	
12:19:21PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
12:19:21PM	39	Step over	
12:19:21PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
12:19:21PM	38	Step over	
12:19:06PM	38	No compressed air	
12:18:02PM	38	No compressed air	
12:17:32PM	38	Step started	Message Validate
12:17:32PM	37	Step over	
12:17:32PM	37	Process defect: flow high limit reached	
12:17:17PM	37	Process defect: flow high limit reached	
12:17:06PM	37	Step started	Message Validate
12:17:06PM	36	Step over	
12:17:06PM	36	Process defect: flow high limit reached	
12:17:06PM	35	Step over	
12:17:06PM	36	Step started	Setting Pumping (Set point: On)
12:17:04PM	35	Step started	Message Validate
12:17:04PM	34	Step over	
12:16:57PM	34	Step started	Message Validate
12:16:57PM	33	Step over	
12:16:57PM	33	Step started	Setting Generation (Set point: Off)
12:16:57PM	32	Step over	
12:15:59PM	32	No compressed air	
12:15:41PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
12:15:41PM	31	Step over	
12:15:39PM	30	Step over	
12:15:39PM	31	Step started	Setting Generation (Set point: On)
12:15:39PM	29	Step over	
12:15:39PM	30	Step started	Setting Solution (20160002-HE - Activator XF)
12:15:20PM	29	Step started	Message Validate
12:15:20PM	28	Step over	
12:13:43PM	28	No compressed air	
12:11:35PM	28	No compressed air	
12:09:51PM	28	No compressed air	
12:07:33PM	28	No compressed air	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 12:02:22 PM

12:05:46PM	28	No compressed air	
12:05:23PM	28	Step started	Message Validate
12:05:23PM	27	Step over	
12:05:13PM	27	Step started	Message Validate
12:05:13PM	26	Step over	
12:05:10PM	26	Step started	Message Validate
12:05:10PM	25	Step over	
12:03:18PM	25	No compressed air	
12:03:11PM	25	Step started	Setting Surface
12:03:11PM	24	Step over	
12:03:11PM	24	Process defect: flow high limit reached	
12:03:11PM	24	Step started	Setting Pumping (Set point: Off)
12:03:11PM	23	Step over	
12:03:07PM	23	Step started	Message Validate
12:03:07PM	22	Step over	
12:03:04PM	22	Step started	Message Validate
12:03:04PM	21	Step over	
12:03:04PM	21	Process defect: flow high limit reached	
12:03:03PM	21	Step started	Setting Pumping (Set point: On)
12:03:03PM	20	Step over	
12:03:01PM	19	Step over	
12:03:01PM	20	Step started	Message Validate
12:03:00PM	18	Step over	
12:03:00PM	19	Step started	Message Validate
12:02:59PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ;
12:02:59PM	17	Step over	
12:02:57PM	17	Step started	Message Validate
12:02:57PM	16	Step over	
12:02:55PM	15	Step over	
12:02:55PM	16	Step started	Message Validate
12:02:53PM	15	Step started	Message Validate
12:02:53PM	14	Step over	
12:02:52PM	14	Step started	Message Validate
12:02:51PM	13	Step over	
12:02:50PM	13	Step started	Message Validate
12:02:50PM	12	Step over	
12:02:43PM	12	Step started	Message Validate
12:02:43PM	11	Step over	
12:02:42PM	11	Step started	Message Validate
12:02:41PM	10	Step over	
12:02:40PM	09	Step over	
12:02:40PM	10	Step started	Message Validate
12:02:38PM	09	Step started	Message Validate
12:02:38PM	08	Step over	
12:02:32PM	07	Step over	
12:02:32PM	08	Step started	Message Validate
12:02:28PM	06	Step over	
12:02:28PM	07	Step started	Message Validate
12:02:28PM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
12:02:28PM	05	Step over	
12:02:28PM	04	Step over	
12:02:28PM	05	Step started	Setting Polarity (Set point: Anodizing)
12:02:28PM	03	Step over	
12:02:28PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:02:28PM	02	Step over	
12:02:28PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
12:02:28PM	01	Step over	

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/1/2018 12:28:12 PM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA HE
Part designation	#27

Treatment

Surface (dm²)	0.06
Estimated duration	0.56

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

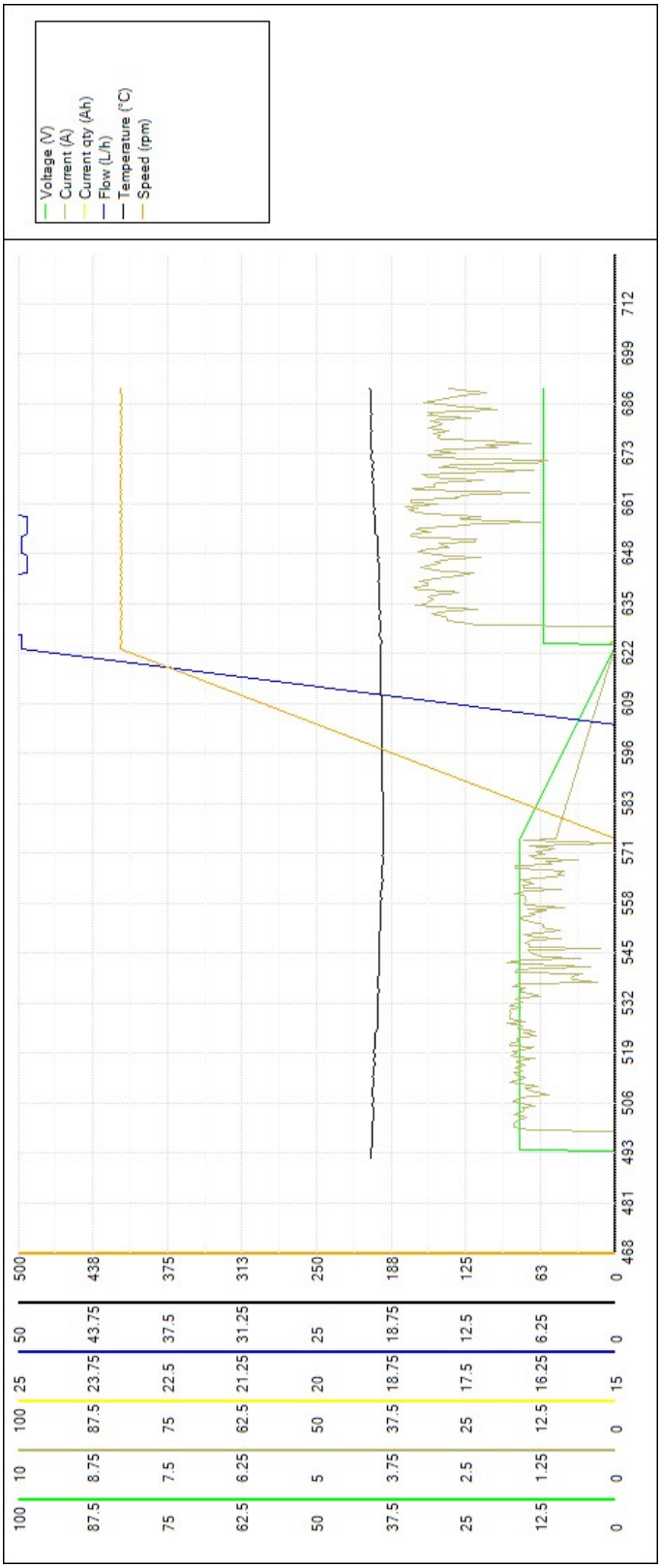
DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/1/2018 12:28:12 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :47.05 Treatment duration (min) :0:00:34	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/1/2018 12:28:12 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
468 481 493 506 519 532 545 558 571 583 596 609 622 635 648 661 673 686 699 712
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/1/2018 12:28:12 PM

Events

Date	N°	Type	Completion
12:59:48PM	66	Step over	
12:59:48PM	66	Operating mode complete	
12:59:47PM	65	Step over	
12:59:47PM	66	Step started	Message Validate
12:59:46PM	64	Step over	
12:59:46PM	65	Step started	Control Final
12:59:45PM	63	Step over	
12:59:45PM	64	Step started	Message Validate
12:59:44PM	63	Step started	Message Validate
12:59:43PM	62	Step over	
12:59:42PM	62	Step started	Message Validate
12:59:42PM	61	Step over	
12:59:40PM	61	Step started	Message Validate
12:59:40PM	60	Step over	
12:59:38PM	59	Step over	
12:59:38PM	60	Step started	Message Validate
12:59:36PM	59	Step started	Message Validate
12:59:36PM	58	Step over	
12:59:32PM	58	Step started	Control Thickness (µm)
12:59:32PM	57	Step over	
12:59:30PM	57	Step started	Message Validate
12:59:30PM	56	Step over	
12:59:01PM	56	No compressed air	
12:57:02PM	56	No compressed air	
12:54:38PM	56	No compressed air	
12:52:46PM	56	No compressed air	
12:50:34PM	56	No compressed air	
12:48:35PM	56	No compressed air	
12:46:19PM	56	No compressed air	
12:43:52PM	56	No compressed air	
12:41:35PM	56	No compressed air	
12:40:21PM	55	Step over	
12:40:21PM	56	Step started	Control Adhesion
12:40:19PM	55	Step started	Control Aspect
12:40:19PM	54	Step over	
12:40:16PM	54	Step started	Message Validate
12:40:16PM	53	Step over	
12:40:14PM	53	Step started	Message Validate
12:40:13PM	52	Step over	
12:40:12PM	52	Step started	Message Validate
12:40:12PM	51	Step over	
12:40:00PM	51	Step started	Message Validate
12:40:00PM	50	Step over	
12:39:58PM	50	Step started	Message Validate
12:39:58PM	49	Step over	
12:39:55PM	49	Step started	Message Validate
12:39:55PM	48	Step over	
12:39:55PM	48	Process defect: flow high limit reached	
12:39:55PM	48	Step started	Setting Pumping (Set point: Off)
12:39:55PM	47	Step over	
12:39:45PM	46	Step over	
12:39:45PM	47	Step started	Message Validate
12:39:44PM	46	Step started	Setting Generation (Set point: Off)
12:39:44PM	45	Step over	

12:39:21PM	45	Process defect: flow high limit reached	
12:39:12PM	45	No compressed air	
12:38:56PM	45	Process defect: flow high limit reached	
12:38:51PM	45	Process defect: flow high limit reached	
12:38:38PM	44	Step over	
12:38:38PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
12:38:37PM	43	Step over	
12:38:37PM	44	Step started	Setting Generation (Set point: On)
12:38:37PM	42	Step over	
12:38:37PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
12:38:36PM	41	Step over	
12:38:36PM	42	Step started	Setting Polarity (Set point: Plating)
12:38:36PM	40	Step over	
12:38:36PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:38:36PM	39	Step over	
12:38:36PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
12:38:36PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
12:38:36PM	38	Step over	
12:38:31PM	38	Process defect: flow high limit reached	
12:38:31PM	38	Process defect: flow high limit reached	
12:38:16PM	38	Step started	Message Validate
12:38:16PM	37	Step over	
12:38:11PM	37	Process defect: flow high limit reached	
12:38:03PM	37	Step started	Message Validate
12:38:03PM	36	Step over	
12:38:03PM	36	Process defect: flow high limit reached	
12:38:03PM	35	Step over	
12:38:03PM	36	Step started	Setting Pumping (Set point: On)
12:37:56PM	35	Step started	Message Validate
12:37:56PM	34	Step over	
12:37:49PM	33	Step over	
12:37:49PM	34	Step started	Message Validate
12:37:49PM	33	Step started	Setting Generation (Set point: Off)
12:37:48PM	32	Step over	
12:37:04PM	32	No compressed air	
12:36:27PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
12:36:27PM	31	Step over	
12:36:26PM	30	Step over	
12:36:26PM	31	Step started	Setting Generation (Set point: On)
12:36:26PM	30	Step started	Setting Solution (20160002-HE - Activator XF)
12:36:26PM	29	Step over	
12:36:24PM	29	Step started	Message Validate
12:36:23PM	28	Step over	
12:36:01PM	28	Step started	Message Validate
12:36:01PM	27	Step over	
12:35:57PM	26	Step over	
12:35:57PM	27	Step started	Message Validate
12:35:54PM	26	Step started	Message Validate
12:35:53PM	25	Step over	
12:35:12PM	25	No compressed air	
12:33:07PM	24	Step over	
12:33:07PM	25	Step started	Setting Surface

12:33:07PM	24	Process defect: flow high limit reached	
12:33:07PM	24	Step started	Setting Pumping (Set point: Off)
12:33:07PM	23	Step over	
12:33:04PM	23	Step started	Message Validate
12:33:04PM	22	Step over	
12:33:01PM	22	Step started	Message Validate
12:33:01PM	21	Step over	
12:33:01PM	21	Process defect: flow high limit reached	
12:33:00PM	21	Step started	Setting Pumping (Set point: On)
12:33:00PM	20	Step over	
12:32:58PM	20	Step started	Message Validate
12:32:57PM	19	Step over	
12:32:55PM	18	Step over	
12:32:55PM	19	Step started	Message Validate
12:32:55PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
12:32:55PM	17	Step over	
12:32:52PM	17	Step started	Message Validate
12:32:52PM	16	Step over	
12:32:50PM	16	Step started	Message Validate
12:32:50PM	15	Step over	
12:32:47PM	15	Step started	Message Validate
12:32:47PM	14	Step over	
12:32:46PM	14	Step started	Message Validate
12:32:46PM	13	Step over	
12:32:44PM	13	Step started	Message Validate
12:32:44PM	12	Step over	
12:32:43PM	12	No compressed air	
12:32:42PM	12	Step started	Message Validate
12:32:42PM	11	Step over	
12:32:40PM	10	Step over	
12:32:40PM	11	Step started	Message Validate
12:32:39PM	10	Step started	Message Validate
12:32:39PM	09	Step over	
12:32:37PM	09	Step started	Message Validate
12:32:37PM	08	Step over	
12:32:30PM	07	Step over	
12:32:30PM	08	Step started	Message Validate
12:30:50PM	07	No compressed air	
12:28:19PM	07	No compressed air	
12:28:15PM	06	Step over	
12:28:15PM	07	Step started	Message Validate
12:28:15PM	05	Step over	
12:28:15PM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
12:28:14PM	04	Step over	
12:28:14PM	05	Step started	Setting Polarity (Set point: Anodizing)
12:28:14PM	03	Step over	
12:28:14PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:28:14PM	02	Step over	
12:28:14PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
12:28:14PM	01	Step over	
12:28:14PM	02	Step started	Setting Generation (Set point: Off)
12:28:14PM	01	Step started	Setting Pumping (Set point: Off)
12:28:14PM	01	Operating mode started	Boeing/IBECA HE

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	11/12/2018 12:15:25 PM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#28

Treatment

Surface (dm²)	0.06
Estimated duration	0.60

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	11/12/2018 12:15:25 PM

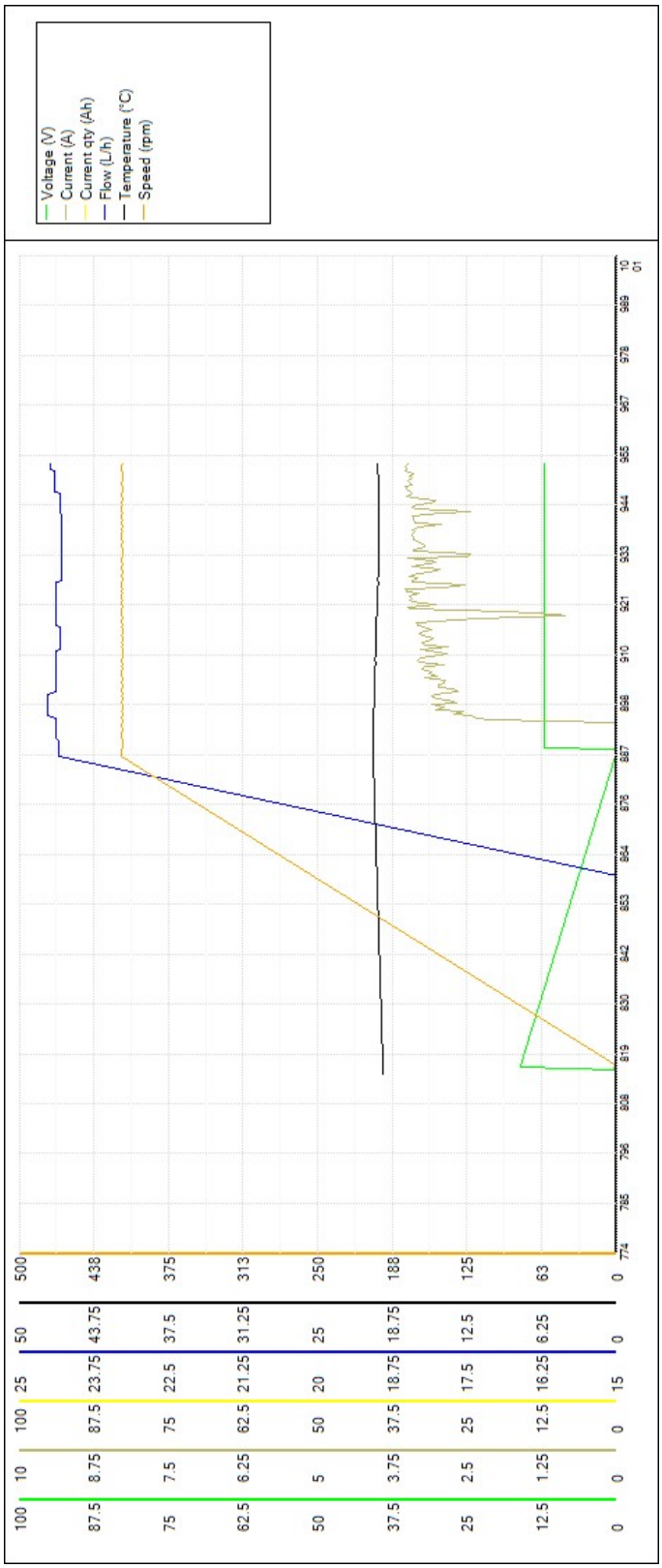
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :50.19 Treatment duration (min) :0:00:36	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	11/12/2018 12:15:25 PM

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (None - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 11/12/2018 12:15:25 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 12:15:25 PM

Events

Date	N°	Type	Completion
12:41:12PM	66	Operating mode complete	
12:41:12PM	66	Step over	
12:41:09PM	66	Step started	Message Validate
12:41:09PM	65	Step over	
12:41:07PM	65	Step started	Control Final
12:41:07PM	64	Step over	
12:41:05PM	64	Step started	Message Validate
12:41:05PM	63	Step over	
12:40:49PM	63	No compressed air	
12:39:41PM	63	Step started	Message Validate
12:39:41PM	62	Step over	
12:38:51PM	62	Step started	Message Validate
12:38:51PM	61	Step over	
12:38:49PM	61	Step started	Message Validate
12:38:49PM	60	Step over	
12:38:47PM	60	Step started	Message Validate
12:38:47PM	59	Step over	
12:38:44PM	59	Step started	Message Validate
12:38:43PM	58	Step over	
12:38:28PM	58	Step started	Control Thickness (µm)
12:38:28PM	57	Step over	
12:38:23PM	57	No compressed air	
12:36:03PM	57	No compressed air	
12:35:26PM	57	Step started	Message Validate
12:35:26PM	56	Step over	
12:34:41PM	56	Step started	Control Adhesion
12:34:41PM	55	Step over	
12:34:06PM	55	Step started	Control Aspect
12:34:06PM	54	Step over	
12:34:02PM	54	Step started	Message Validate
12:34:01PM	53	Step over	
12:33:52PM	53	Step started	Message Validate
12:33:52PM	52	Step over	
12:33:29PM	52	No compressed air	
12:32:32PM	52	Step started	Message Validate
12:32:32PM	51	Step over	
12:31:40PM	51	Step started	Message Validate
12:31:40PM	50	Step over	
12:31:37PM	50	Step started	Message Validate
12:31:37PM	49	Step over	
12:31:35PM	49	Step started	Message Validate
12:31:35PM	48	Step over	
12:31:35PM	48	Step started	Setting Pumping (Set point: Off)
12:31:35PM	47	Step over	
12:31:34PM	47	No compressed air	
12:31:21PM	46	Step over	
12:31:21PM	47	Step started	Message Validate
12:31:20PM	46	Step started	Setting Generation (Set point: Off)
12:31:20PM	45	Step over	
12:30:53PM	45	No compressed air	
12:30:15PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
12:30:15PM	44	Step over	
12:30:13PM	43	Step over	
12:30:13PM	44	Step started	Setting Generation (Set point: On)
12:30:13PM	42	Step over	
12:30:13PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 12:15:25 PM

12:30:13PM	41	Step over	
12:30:13PM	42	Step started	Setting Polarity (Set point: Plating)
12:30:13PM	40	Step over	
12:30:13PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:30:13PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
12:30:13PM	39	Step over	
12:30:12PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
12:30:12PM	38	Step over	
12:29:55PM	38	No compressed air	
12:29:41PM	38	Step started	Message Validate
12:29:40PM	37	Step over	
12:29:09PM	36	Step over	
12:29:09PM	37	Step started	Message Validate
12:29:09PM	36	Step started	Setting Pumping (Set point: On)
12:29:09PM	35	Step over	
12:29:06PM	35	Step started	Message Validate
12:29:06PM	34	Step over	
12:29:04PM	33	Step over	
12:29:04PM	34	Step started	Message Validate
12:29:04PM	33	Step started	Setting Generation (Set point: Off)
12:29:04PM	32	Step over	
12:29:02PM	31	Step over	
12:29:02PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
12:29:01PM	30	Step over	
12:29:01PM	31	Step started	Setting Generation (Set point: On)
12:29:01PM	30	Step started	Setting Solution (None - Activator XF)
12:29:01PM	29	Step over	
12:28:59PM	29	Step started	Message Validate
12:28:59PM	28	Step over	
12:27:00PM	28	No compressed air	
12:25:31PM	28	Step started	Message Validate
12:25:31PM	27	Step over	
12:25:28PM	27	Step started	Message Validate
12:25:28PM	26	Step over	
12:25:25PM	26	Step started	Message Validate
12:25:25PM	25	Step over	
12:24:58PM	25	No compressed air	
12:24:46PM	24	Step over	
12:24:46PM	25	Step started	Setting Surface
12:24:46PM	24	Step started	Setting Pumping (Set point: Off)
12:24:46PM	23	Step over	
12:23:52PM	23	No compressed air	
12:23:07PM	23	No compressed air	
12:21:36PM	23	No compressed air	
12:21:02PM	23	No compressed air	
12:18:46PM	23	No compressed air	
12:17:49PM	23	Process defect: flow lower limit reached	
12:17:43PM	23	Step started	Message Validate
12:17:42PM	22	Step over	
12:17:38PM	21	Step over	
12:17:38PM	22	Step started	Message Validate
12:17:38PM	21	Process defect: flow lower limit reached	
12:17:37PM	21	Step started	Setting Pumping (Set point: On)
12:17:37PM	20	Step over	
12:17:32PM	19	Step over	
12:17:32PM	20	Step started	Message Validate
12:17:31PM	19	Step started	Message Validate
12:17:31PM	18	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 12:15:25 PM

12:17:31PM	18	No compressed air	
12:17:30PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
12:17:30PM	17	Step over	
12:17:28PM	17	Step started	Message Validate
12:17:28PM	16	Step over	
12:17:26PM	15	Step over	
12:17:26PM	16	Step started	Message Validate
12:17:24PM	15	Step started	Message Validate
12:17:24PM	14	Step over	
12:17:22PM	14	Step started	Message Validate
12:17:22PM	13	Step over	
12:17:20PM	13	Step started	Message Validate
12:17:19PM	12	Step over	
12:17:17PM	11	Step over	
12:17:17PM	12	Step started	Message Validate
12:17:15PM	11	Step started	Message Validate
12:17:15PM	10	Step over	
12:17:14PM	09	Step over	
12:17:14PM	10	Step started	Message Validate
12:17:12PM	09	Step started	Message Validate
12:17:12PM	08	Step over	
12:17:10PM	07	Step over	
12:17:10PM	08	Step started	Message Validate
12:15:32PM	06	Step over	
12:15:32PM	07	Step started	Message Validate
12:15:32PM	05	Step over	
12:15:32PM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
12:15:31PM	04	Step over	
12:15:31PM	05	Step started	Setting Polarity (Set point: Anodizing)
12:15:31PM	03	Step over	
12:15:31PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:15:31PM	02	Step over	
12:15:31PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
12:15:31PM	02	Step started	Setting Generation (Set point: Off)
12:15:31PM	01	Step over	
12:15:29PM	01	Step started	Setting Pumping (Set point: Off)
12:15:29PM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	11/12/2018 12:45:23 PM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#29

Treatment

Surface (dm²)	0.06
Estimated duration	0.62

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

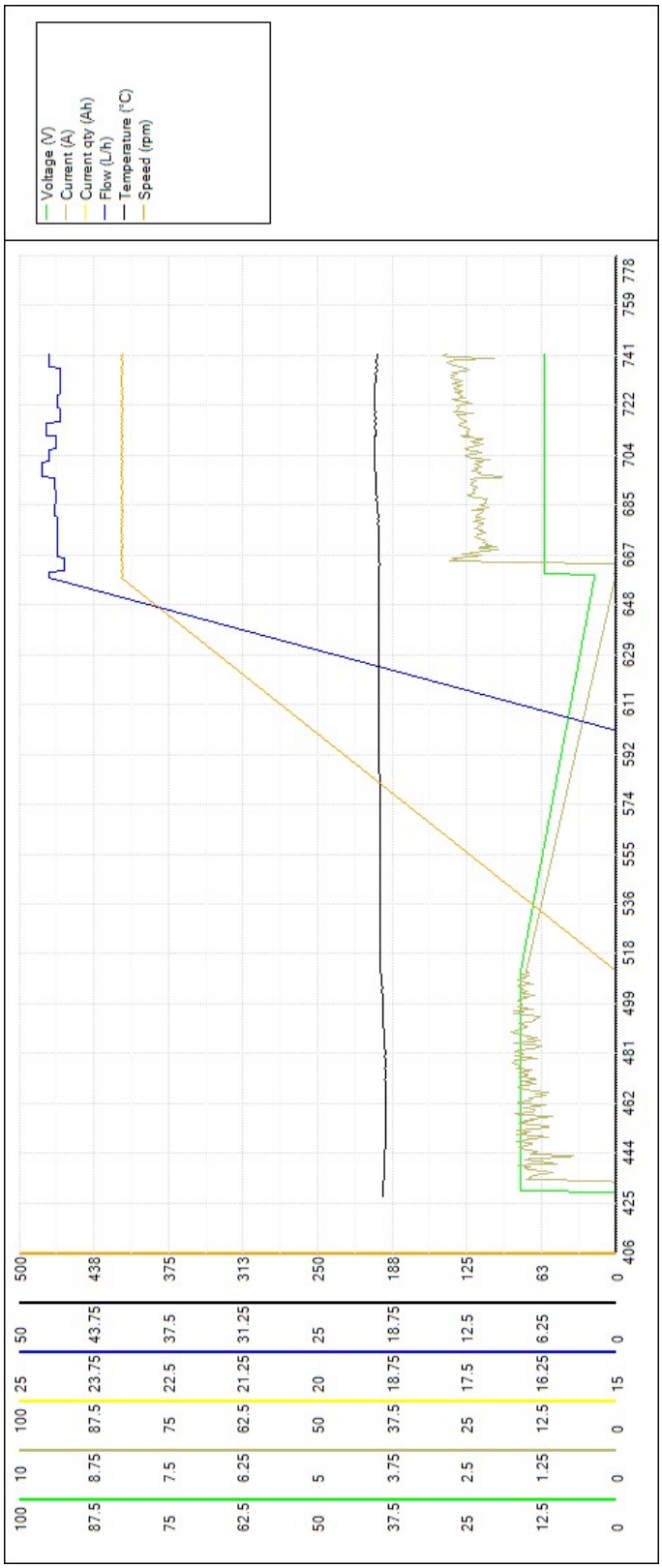
DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 11/12/2018 12:45:23 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :51.75 Treatment duration (min) :0:00:37	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 11/12/2018 12:45:23 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
406 425 444 462 481 499 518 536 555 574 592 611 629 648 667 685 704 722 741 759 778
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 12:45:23 PM

Events

Date	N°	Type	Completion
1:03:47PM	66	Operating mode complete	
1:03:47PM	66	Step over	
1:03:45PM	66	Step started	Message Validate
1:03:45PM	65	Step over	
1:03:43PM	65	Step started	Control Final
1:03:43PM	64	Step over	
1:03:42PM	64	Step started	Message Validate
1:03:41PM	63	Step over	
1:02:59PM	63	Step started	Message Validate
1:02:59PM	62	Step over	
1:02:56PM	62	No compressed air	
1:02:09PM	62	Step started	Message Validate
1:02:09PM	61	Step over	
1:02:07PM	61	Step started	Message Validate
1:02:07PM	60	Step over	
1:02:06PM	60	Step started	Message Validate
1:02:06PM	59	Step over	
1:02:04PM	59	Step started	Message Validate
1:02:03PM	58	Step over	
1:01:56PM	58	Step started	Control Thickness (µm)
1:01:55PM	57	Step over	
1:00:21PM	57	Step started	Message Validate
1:00:21PM	56	Step over	
1:00:21PM	56	No compressed air	
12:59:56PM	56	Step started	Control Adhesion
12:59:56PM	55	Step over	
12:59:19PM	55	Step started	Control Aspect
12:59:18PM	54	Step over	
12:59:15PM	54	Step started	Message Validate
12:59:15PM	53	Step over	
12:58:47PM	53	No compressed air	
12:58:11PM	53	Step started	Message Validate
12:58:11PM	52	Step over	
12:58:08PM	52	Step started	Message Validate
12:58:08PM	51	Step over	
12:57:57PM	51	Step started	Message Validate
12:57:57PM	50	Step over	
12:57:55PM	50	Step started	Message Validate
12:57:55PM	49	Step over	
12:57:54PM	49	Step started	Message Validate
12:57:54PM	48	Step over	
12:57:54PM	48	Step started	Setting Pumping (Set point: Off)
12:57:54PM	47	Step over	
12:57:52PM	47	No compressed air	
12:57:47PM	47	Step started	Message Validate
12:57:47PM	46	Step over	
12:57:46PM	46	Step started	Setting Generation (Set point: Off)
12:57:46PM	45	Step over	
12:56:52PM	45	No compressed air	
12:56:24PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
12:56:24PM	44	Step over	
12:56:23PM	44	Step started	Setting Generation (Set point: On)
12:56:23PM	43	Step over	
12:56:23PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
12:56:23PM	42	Step over	
12:56:23PM	42	Step started	Setting Polarity (Set point: Plating)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 12:45:23 PM

12:56:23PM	41	Step over	
12:56:22PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:56:22PM	40	Step over	
12:56:22PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
12:56:22PM	39	Step over	
12:56:22PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
12:56:22PM	38	Step over	
12:56:20PM	38	No compressed air	
12:55:35PM	38	No compressed air	
12:55:13PM	38	Step started	Message Validate
12:55:13PM	37	Step over	
12:55:06PM	37	No compressed air	
12:54:17PM	37	Process defect: flow lower limit reached	
12:54:16PM	37	No compressed air	
12:54:06PM	37	Step started	Message Validate
12:54:06PM	36	Step over	
12:54:06PM	36	Process defect: flow lower limit reached	
12:54:05PM	36	Step started	Setting Pumping (Set point: On)
12:54:05PM	35	Step over	
12:54:03PM	35	Step started	Message Validate
12:54:03PM	34	Step over	
12:53:57PM	34	Step started	Message Validate
12:53:57PM	33	Step over	
12:53:57PM	33	Step started	Setting Generation (Set point: Off)
12:53:57PM	32	Step over	
12:52:34PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
12:52:34PM	31	Step over	
12:52:33PM	31	Step started	Setting Generation (Set point: On)
12:52:33PM	30	Step over	
12:52:32PM	30	Step started	Setting Solution (20160002-HE - Activator XF)
12:52:32PM	29	Step over	
12:52:31PM	29	Step started	Message Validate
12:52:30PM	28	Step over	
12:52:03PM	28	No compressed air	
12:51:50PM	28	Step started	Message Validate
12:51:50PM	27	Step over	
12:51:47PM	27	Step started	Message Validate
12:51:47PM	26	Step over	
12:51:24PM	26	Step started	Message Validate
12:51:24PM	25	Step over	
12:50:27PM	25	Step started	Setting Surface
12:50:27PM	24	Step over	
12:50:27PM	24	Step started	Setting Pumping (Set point: Off)
12:50:27PM	23	Step over	
12:50:24PM	23	Step started	Message Validate
12:50:24PM	22	Step over	
12:50:22PM	22	Step started	Message Validate
12:50:22PM	21	Step over	
12:50:22PM	21	Step started	Setting Pumping (Set point: On)
12:50:22PM	20	Step over	
12:50:19PM	20	Step started	Message Validate
12:50:19PM	19	Step over	
12:50:18PM	19	Step started	Message Validate
12:50:18PM	18	Step over	
12:50:17PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
12:50:17PM	17	Step over	
12:50:16PM	17	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 12:45:23 PM

12:50:16PM	16	Step over	
12:50:14PM	16	Step started	Message Validate
12:50:14PM	15	Step over	
12:50:12PM	15	Step started	Message Validate
12:50:12PM	14	Step over	
12:50:11PM	14	Step started	Message Validate
12:50:11PM	13	Step over	
12:49:47PM	13	No compressed air	
12:49:46PM	13	Step started	Message Validate
12:49:46PM	12	Step over	
12:49:44PM	12	Step started	Message Validate
12:49:44PM	11	Step over	
12:49:41PM	11	Step started	Message Validate
12:49:41PM	10	Step over	
12:49:40PM	10	Step started	Message Validate
12:49:40PM	09	Step over	
12:49:39PM	09	Step started	Message Validate
12:49:39PM	08	Step over	
12:49:37PM	08	Step started	Message Validate
12:49:37PM	07	Step over	
12:47:37PM	07	No compressed air	
12:45:26PM	07	Step started	Message Validate
12:45:26PM	06	Step over	
12:45:26PM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
12:45:26PM	05	Step over	
12:45:26PM	05	Step started	Setting Polarity (Set point: Anodizing)
12:45:26PM	04	Step over	
12:45:26PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:45:26PM	03	Step over	
12:45:25PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
12:45:25PM	02	Step over	
12:45:25PM	02	Step started	Setting Generation (Set point: Off)
12:45:25PM	01	Step over	
12:45:25PM	01	Step started	Setting Pumping (Set point: Off)
12:45:25PM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	11/12/2018 1:08:40 PM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#30

Treatment

Surface (dm²)	0.06
Estimated duration	0.60

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 11/12/2018 1:08:40 PM

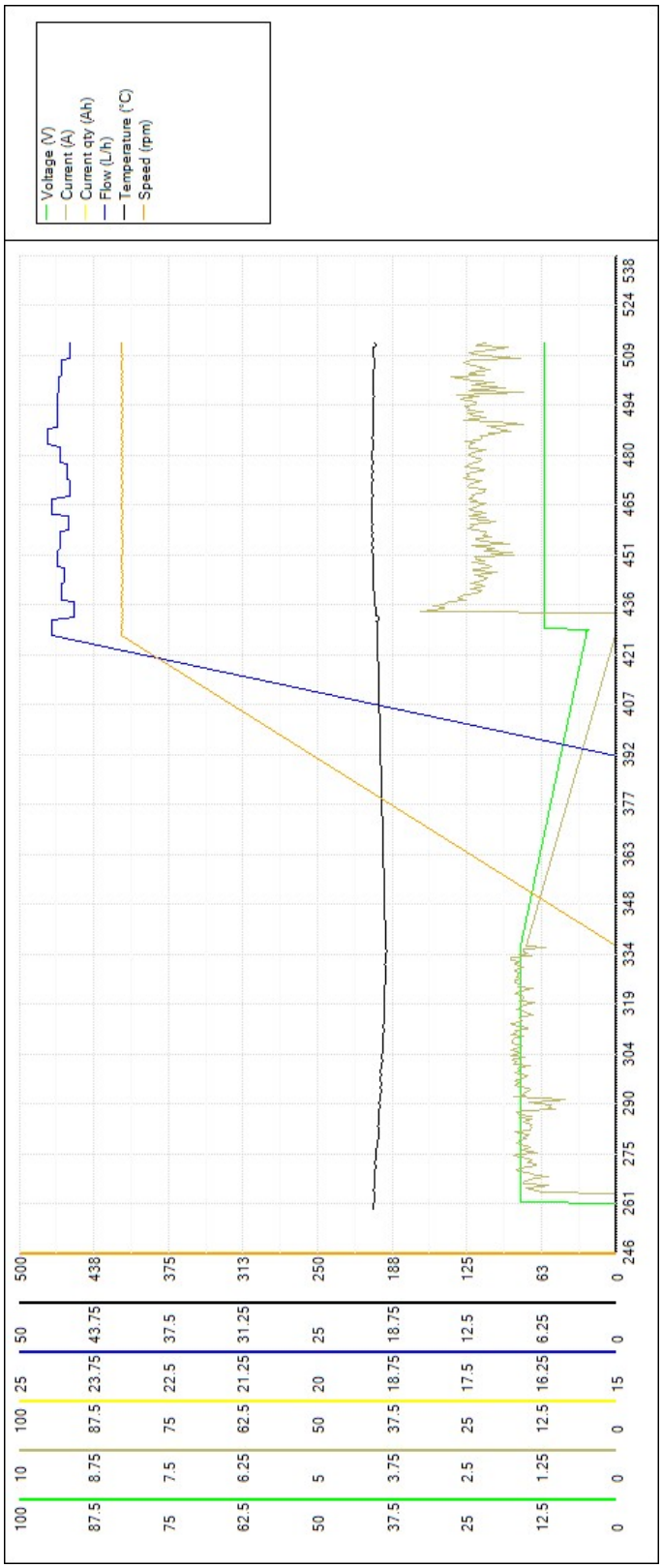
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :50.19 Treatment duration (min) :0:00:36	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	11/12/2018 1:08:40 PM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 11/12/2018 1:08:40 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
246 261 275 290 304 319 334 348 363 377 392 407 421 436 451 465 480 494 509 524 538
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	11/12/2018 1:08:40 PM

Events

Date	N°	Type	Completion
1:23:35PM	66	Operating mode complete	
1:23:35PM	66	Step over	
1:23:33PM	66	Step started	Message Validate
1:23:33PM	65	Step over	
1:23:32PM	65	Step started	Control Final
1:23:32PM	64	Step over	
1:23:30PM	64	Step started	Message Validate
1:23:30PM	63	Step over	
1:23:13PM	63	No compressed air	
1:21:35PM	63	Step started	Message Validate
1:21:35PM	62	Step over	
1:21:33PM	62	Step started	Message Validate
1:21:33PM	61	Step over	
1:21:31PM	61	Step started	Message Validate
1:21:31PM	60	Step over	
1:21:30PM	60	Step started	Message Validate
1:21:30PM	59	Step over	
1:21:28PM	59	Step started	Message Validate
1:21:28PM	58	Step over	
1:21:03PM	58	No compressed air	
1:19:43PM	58	Step started	Control Thickness (µm)
1:19:43PM	57	Step over	
1:19:41PM	57	Step started	Message Validate
1:19:41PM	56	Step over	
1:18:38PM	56	No compressed air	
1:17:47PM	56	Step started	Control Adhesion
1:17:47PM	55	Step over	
1:17:45PM	55	Step started	Control Aspect
1:17:45PM	54	Step over	
1:17:40PM	54	Step started	Message Validate
1:17:40PM	53	Step over	
1:17:38PM	53	Step started	Message Validate
1:17:38PM	52	Step over	
1:17:36PM	52	Step started	Message Validate
1:17:35PM	51	Step over	
1:17:26PM	51	Step started	Message Validate
1:17:26PM	50	Step over	
1:17:23PM	50	Step started	Message Validate
1:17:23PM	49	Step over	
1:17:20PM	49	Step started	Message Validate
1:17:20PM	48	Step over	
1:17:20PM	48	Step started	Setting Pumping (Set point: Off)
1:17:19PM	47	Step over	
1:17:14PM	47	Step started	Message Validate
1:17:14PM	46	Step over	
1:17:14PM	46	Step started	Setting Generation (Set point: Off)
1:17:14PM	45	Step over	
1:15:56PM	45	No compressed air	
1:15:49PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
1:15:49PM	44	Step over	
1:15:48PM	44	Step started	Setting Generation (Set point: On)
1:15:48PM	43	Step over	
1:15:47PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
1:15:47PM	42	Step over	
1:15:47PM	42	Step started	Setting Polarity (Set point: Plating)
1:15:47PM	41	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 1:08:40 PM

1:15:47PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
1:15:47PM	40	Step over	
1:15:47PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
1:15:47PM	39	Step over	
1:15:47PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
1:15:46PM	38	Step over	
1:14:48PM	38	Step started	Message Validate
1:14:48PM	37	Step over	
1:14:33PM	37	Step started	Message Validate
1:14:33PM	36	Step over	
1:14:33PM	36	Step started	Setting Pumping (Set point: On)
1:14:33PM	35	Step over	
1:14:22PM	35	Step started	Message Validate
1:14:22PM	34	Step over	
1:14:17PM	34	Step started	Message Validate
1:14:17PM	33	Step over	
1:14:17PM	33	Step started	Setting Generation (Set point: Off)
1:14:17PM	32	Step over	
1:13:20PM	32	No compressed air	
1:13:01PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
1:13:01PM	31	Step over	
1:12:59PM	31	Step started	Setting Generation (Set point: On)
1:12:59PM	30	Step over	
1:12:59PM	30	Step started	Setting Solution (20160002-HE - Activator XF)
1:12:59PM	29	Step over	
1:12:57PM	29	Step started	Message Validate
1:12:57PM	28	Step over	
1:12:33PM	28	Step started	Message Validate
1:12:33PM	27	Step over	
1:12:31PM	27	Step started	Message Validate
1:12:31PM	26	Step over	
1:12:27PM	26	Step started	Message Validate
1:12:27PM	25	Step over	
1:11:32PM	25	Step started	Setting Surface
1:11:32PM	24	Step over	
1:11:32PM	24	Step started	Setting Pumping (Set point: Off)
1:11:32PM	23	Step over	
1:11:21PM	23	No compressed air	
1:09:15PM	23	No compressed air	
1:09:08PM	23	Step started	Message Validate
1:09:08PM	22	Step over	
1:09:06PM	22	Step started	Message Validate
1:09:06PM	21	Step over	
1:09:06PM	21	Step started	Setting Pumping (Set point: On)
1:09:06PM	20	Step over	
1:09:04PM	20	Step started	Message Validate
1:09:04PM	19	Step over	
1:09:01PM	19	Step started	Message Validate
1:09:01PM	18	Step over	
1:09:01PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
1:09:01PM	17	Step over	
1:08:59PM	17	Step started	Message Validate
1:08:59PM	16	Step over	
1:08:57PM	16	Step started	Message Validate
1:08:57PM	15	Step over	
1:08:55PM	15	Step started	Message Validate
1:08:55PM	14	Step over	

1:08:53PM	14	Step started	Message Validate
1:08:53PM	13	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 11/12/2018 1:08:40 PM

1:08:52PM	13	Step started	Message Validate
1:08:51PM	12	Step over	
1:08:50PM	12	Step started	Message Validate
1:08:50PM	11	Step over	
1:08:48PM	11	Step started	Message Validate
1:08:48PM	10	Step over	
1:08:47PM	10	Step started	Message Validate
1:08:47PM	09	Step over	
1:08:46PM	09	Step started	Message Validate
1:08:45PM	08	Step over	
1:08:44PM	08	Step started	Message Validate
1:08:44PM	07	Step over	
1:08:42PM	07	Step started	Message Validate
1:08:42PM	06	Step over	
1:08:42PM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
1:08:42PM	05	Step over	
1:08:42PM	05	Step started	Setting Polarity (Set point: Anodizing)
1:08:42PM	04	Step over	
1:08:41PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
1:08:41PM	03	Step over	
1:08:41PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
1:08:41PM	02	Step over	
1:08:41PM	02	Step started	Setting Generation (Set point: Off)
1:08:41PM	01	Step over	
1:08:41PM	01	Step started	Setting Pumping (Set point: Off)
1:08:41PM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	1/14/2019 8:55:32 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#31

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 1/14/2019 8:55:32 AM

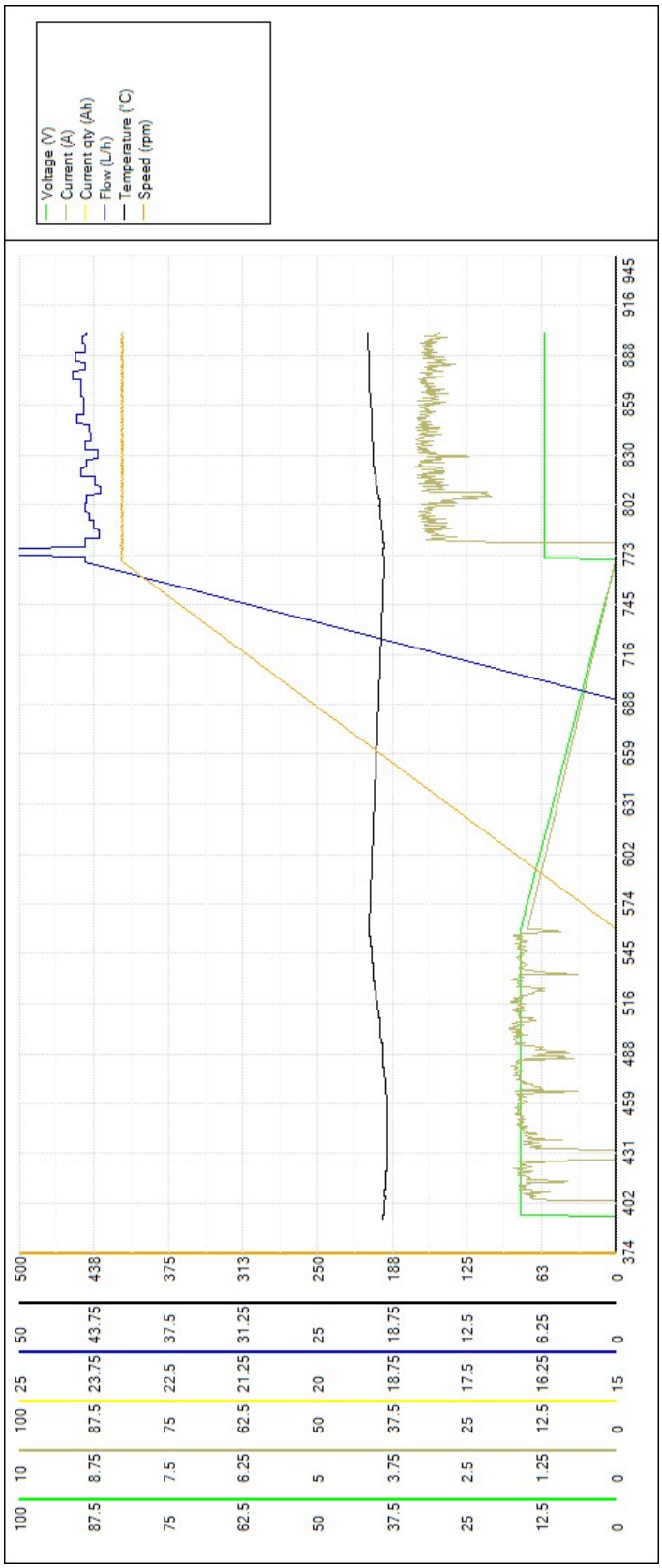
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	1/14/2019 8:55:32 AM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 1/14/2019 8:55:32 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
945 916 888 859 830 802 773 745 716 688 659 631 602 574 545 516 488 459 431 402 374
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 8:55:32 AM

Events

Date	N°	Type	Completion
9:33:49AM	66	Operating mode complete	
9:33:49AM	66	Step over	
9:33:47AM	66	Step started	Message Validate
9:33:46AM	65	Step over	
9:33:45AM	65	Step started	Control Final
9:33:45AM	64	Step over	
9:33:42AM	64	Step started	Message Validate
9:33:42AM	63	Step over	
9:33:21AM	63	Step started	Message Validate
9:33:21AM	62	Step over	
9:33:15AM	62	Step started	Message Validate
9:33:15AM	61	Step over	
9:26:45AM	61	Step started	Message Validate
9:26:45AM	60	Step over	
9:26:44AM	60	Step started	Message Validate
9:26:43AM	59	Step over	
9:26:41AM	59	Step started	Message Validate
9:26:41AM	58	Step over	
9:26:30AM	58	Step started	Control Thickness (µm)
9:26:30AM	57	Step over	
9:26:28AM	57	Step started	Message Validate
9:26:28AM	56	Step over	
9:26:26AM	56	Step started	Control Adhesion
9:26:26AM	55	Step over	
9:26:25AM	54	Step over	
9:26:25AM	55	Step started	Control Aspect
9:26:23AM	53	Step over	
9:26:23AM	54	Step started	Message Validate
9:26:22AM	52	Step over	
9:26:22AM	53	Step started	Message Validate
9:26:21AM	52	Step started	Message Validate
9:26:20AM	51	Step over	
9:26:20AM	50	Step over	
9:26:20AM	51	Step started	Message Validate
9:26:18AM	50	Step started	Message Validate
9:26:18AM	49	Step over	
9:10:44AM	48	Step over	
9:10:44AM	49	Step started	Message Validate
9:10:43AM	48	Step started	Setting Pumping (Set point: Off)
9:10:43AM	47	Step over	
9:10:34AM	46	Step over	
9:10:34AM	47	Step started	Message Validate
9:10:34AM	46	Step started	Setting Generation (Set point: Off)
9:10:34AM	45	Step over	
9:08:24AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
9:08:24AM	44	Step over	
9:08:23AM	43	Step over	
9:08:23AM	44	Step started	Setting Generation (Set point: On)
9:08:23AM	42	Step over	
9:08:23AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
9:08:23AM	42	Step started	Setting Polarity (Set point: Plating)
9:08:23AM	41	Step over	
9:08:23AM	40	Step over	
9:08:23AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:08:22AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
9:08:22AM	39	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 8:55:32 AM

9:08:22AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:08:22AM	38	Step over	
9:07:30AM	38	Process defect: flow lower limit reached	
9:07:22AM	38	Step started	Message Validate
9:07:22AM	37	Step over	
9:07:20AM	37	Step started	Message Validate
9:07:20AM	36	Step over	
9:07:20AM	36	Process defect: flow lower limit reached	
9:07:19AM	36	Step started	Setting Pumping (Set point: On)
9:07:19AM	35	Step over	
9:05:10AM	35	Step started	Message Validate
9:05:10AM	34	Step over	
9:04:53AM	33	Step over	
9:04:53AM	34	Step started	Message Validate
9:04:53AM	33	Step started	Setting Generation (Set point: Off)
9:04:53AM	32	Step over	
9:02:08AM	31	Step over	
9:02:08AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
9:02:07AM	31	Step started	Setting Generation (Set point: On)
9:02:07AM	30	Step over	
9:02:07AM	29	Step over	
9:02:07AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
9:01:45AM	29	Step started	Message Validate
9:01:45AM	28	Step over	
9:01:13AM	28	Step started	Message Validate
9:01:12AM	27	Step over	
9:00:42AM	27	Step started	Message Validate
9:00:42AM	26	Step over	
9:00:31AM	26	Step started	Message Validate
9:00:31AM	25	Step over	
8:59:40AM	25	Step started	Setting Surface
8:59:40AM	24	Step over	
8:59:40AM	24	Step started	Setting Pumping (Set point: Off)
8:59:40AM	23	Step over	
8:59:37AM	23	Step started	Message Validate
8:59:37AM	22	Step over	
8:59:34AM	22	Step started	Message Validate
8:59:34AM	21	Step over	
8:59:34AM	21	Step started	Setting Pumping (Set point: On)
8:59:34AM	20	Step over	
8:59:31AM	20	Step started	Message Validate
8:59:31AM	19	Step over	
8:59:29AM	18	Step over	
8:59:29AM	19	Step started	Message Validate
8:59:29AM	17	Step over	
8:59:29AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:59:28AM	17	Step started	Message Validate
8:59:28AM	16	Step over	
8:59:26AM	15	Step over	
8:59:26AM	16	Step started	Message Validate
8:59:25AM	15	Step started	Message Validate
8:59:24AM	14	Step over	
8:58:35AM	14	Step started	Message Validate
8:58:35AM	13	Step over	
8:58:34AM	13	Step started	Message Validate
8:58:34AM	12	Step over	
8:58:33AM	12	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 8:55:32 AM

8:58:33AM	11	Step over	
8:58:31AM	10	Step over	
8:58:31AM	11	Step started	Message Validate
8:58:30AM	09	Step over	
8:58:30AM	10	Step started	Message Validate
8:58:28AM	09	Step started	Message Validate
8:58:28AM	08	Step over	
8:55:45AM	07	Step over	
8:55:45AM	08	Step started	Message Validate
8:55:38AM	06	Step over	
8:55:38AM	07	Step started	Message Validate
8:55:38AM	05	Step over	
8:55:38AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:55:38AM	04	Step over	
8:55:38AM	05	Step started	Setting Polarity (Set point: Anodizing)
8:55:38AM	03	Step over	
8:55:38AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:55:38AM	02	Step over	
8:55:38AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
8:55:38AM	02	Step started	Setting Generation (Set point: Off)
8:55:38AM	01	Step over	
8:55:36AM	01	Step started	Setting Pumping (Set point: Off)
8:55:36AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/20/2018 11:18:07 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA HE
Part designation	#32

Treatment

Surface (dm²)	0.06
Estimated duration	0.60

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	Grit Blast	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/20/2018 11:18:07 AM

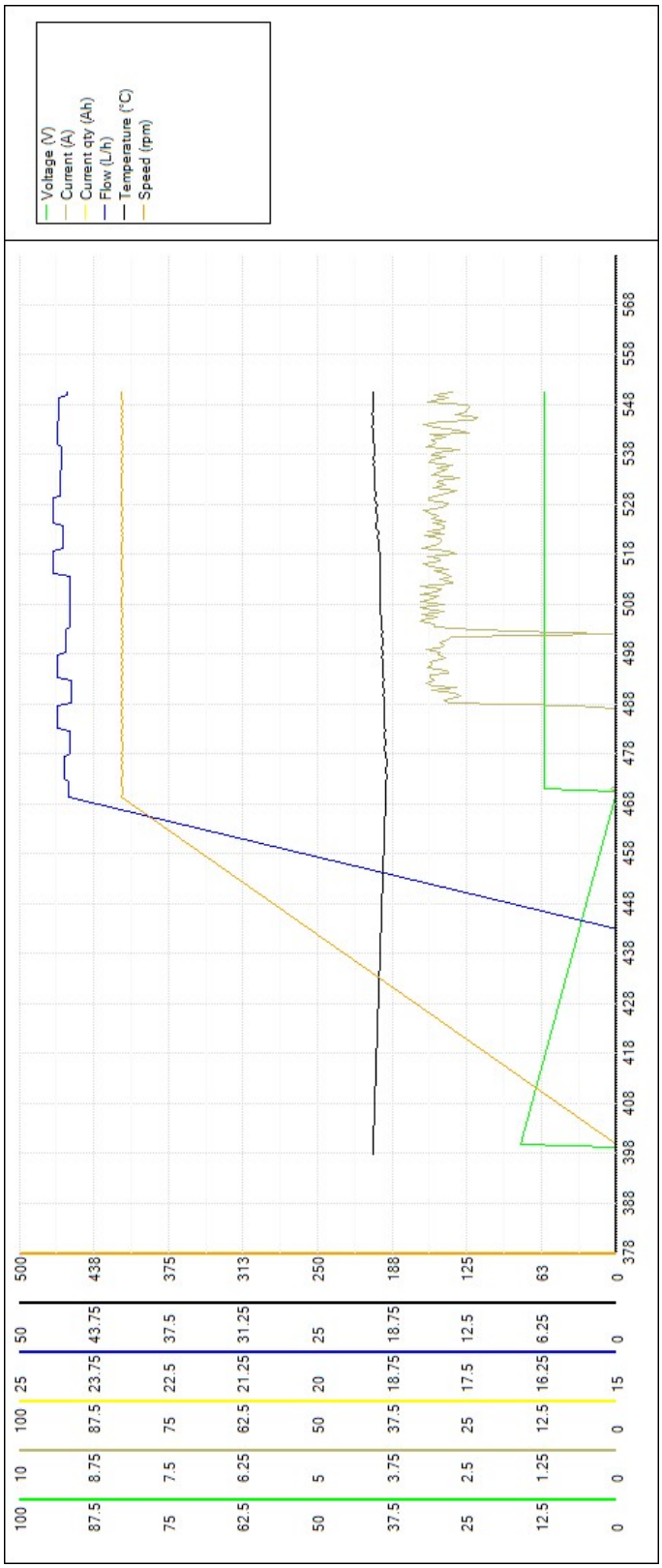
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :50.19 Treatment duration (min) :0:00:36	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA HE
	Creation date :	11/20/2018 11:18:07 AM

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (Grit Blast - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/20/2018 11:18:07 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
378 388 398 408 418 428 438 448 458 468 478 488 498 508 518 528 538 548 558 568

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/20/2018 11:18:07 AM

Events

Date	N°	Type	Completion
11:35:02AM	66	Step over	
11:35:02AM	66	Operating mode complete	
11:35:00AM	66	Step started	Message Validate
11:35:00AM	65	Step over	
11:34:58AM	65	Step started	Control Final
11:34:58AM	64	Step over	
11:34:50AM	64	Step started	Message Validate
11:34:50AM	63	Step over	
11:34:26AM	62	Step over	
11:34:26AM	63	Step started	Message Validate
11:34:25AM	62	Step started	Message Validate
11:34:25AM	61	Step over	
11:34:24AM	61	Step started	Message Validate
11:34:24AM	60	Step over	
11:34:18AM	60	Step started	Message Validate
11:34:18AM	59	Step over	
11:34:16AM	59	Step started	Message Validate
11:34:16AM	58	Step over	
11:33:36AM	58	No compressed air	
11:31:47AM	58	No compressed air	
11:30:59AM	58	Step started	Control Thickness (µm)
11:30:59AM	57	Step over	
11:30:56AM	57	Step started	Message Validate
11:30:56AM	56	Step over	
11:29:10AM	56	No compressed air	
11:27:52AM	55	Step over	
11:27:52AM	56	Step started	Control Adhesion
11:27:48AM	55	Step started	Control Aspect
11:27:48AM	54	Step over	
11:27:45AM	54	Step started	Message Validate
11:27:45AM	53	Step over	
11:27:44AM	53	Step started	Message Validate
11:27:44AM	52	Step over	
11:27:41AM	52	Step started	Message Validate
11:27:41AM	51	Step over	
11:27:39AM	51	Step started	Message Validate
11:27:39AM	50	Step over	
11:27:37AM	49	Step over	
11:27:37AM	50	Step started	Message Validate
11:27:36AM	49	Step started	Message Validate
11:27:36AM	48	Step over	
11:27:36AM	48	Step started	Setting Pumping (Set point: Off)
11:27:36AM	47	Step over	
11:27:19AM	46	Step over	
11:27:19AM	47	Step started	Message Validate
11:27:18AM	46	Step started	Setting Generation (Set point: Off)
11:27:18AM	45	Step over	
11:26:57AM	45	No compressed air	
11:25:58AM	44	Step over	
11:25:58AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:25:57AM	43	Step over	
11:25:57AM	44	Step started	Setting Generation (Set point: On)
11:25:56AM	42	Step over	
11:25:56AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
11:25:56AM	42	Step started	Setting Polarity (Set point: Plating)
11:25:56AM	41	Step over	

11:25:56AM	40	Step over	
11:25:56AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:25:56AM	39	Step over	
11:25:56AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:25:56AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:25:56AM	38	Step over	
11:25:06AM	38	No compressed air	
11:25:04AM	38	Step started	Message Validate
11:25:03AM	37	Step over	
11:24:52AM	37	Step started	Message Validate
11:24:52AM	36	Step over	
11:24:51AM	35	Step over	
11:24:51AM	36	Step started	Setting Pumping (Set point: On)
11:24:49AM	35	Step started	Message Validate
11:24:49AM	34	Step over	
11:24:47AM	33	Step over	
11:24:47AM	34	Step started	Message Validate
11:24:47AM	32	Step over	
11:24:47AM	33	Step started	Setting Generation (Set point: Off)
11:24:46AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:24:46AM	31	Step over	
11:24:45AM	30	Step over	
11:24:45AM	31	Step started	Setting Generation (Set point: On)
11:24:44AM	30	Step started	Setting Solution (Grit Blast - Activator XF)
11:24:44AM	29	Step over	
11:24:43AM	29	Step started	Message Validate
11:24:43AM	28	Step over	
11:24:39AM	28	Step started	Message Validate
11:24:39AM	27	Step over	
11:24:36AM	26	Step over	
11:24:36AM	27	Step started	Message Validate
11:24:33AM	26	Step started	Message Validate
11:24:33AM	25	Step over	
11:23:48AM	24	Step over	
11:23:48AM	25	Step started	Setting Surface
11:23:47AM	24	Step started	Setting Pumping (Set point: Off)
11:23:47AM	23	Step over	
11:23:33AM	23	No compressed air	
11:22:38AM	23	No compressed air	
11:21:58AM	23	No compressed air	
11:21:12AM	23	No compressed air	
11:20:18AM	23	No compressed air	
11:19:05AM	23	No compressed air	
11:18:47AM	23	Step started	Message Validate
11:18:47AM	22	Step over	
11:18:45AM	21	Step over	
11:18:45AM	22	Step started	Message Validate
11:18:44AM	20	Step over	
11:18:44AM	21	Step started	Setting Pumping (Set point: On)
11:18:43AM	20	Step started	Message Validate
11:18:43AM	19	Step over	
11:18:41AM	18	Step over	
11:18:41AM	19	Step started	Message Validate
11:18:41AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
11:18:41AM	17	Step over	
11:18:39AM	17	Step started	Message Validate
11:18:39AM	16	Step over	
11:18:37AM	15	Step over	
11:18:37AM	16	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/20/2018 11:18:07 AM

11:18:36AM	15	Step started	Message Validate
11:18:36AM	14	Step over	
11:18:34AM	14	Step started	Message Validate
11:18:34AM	13	Step over	
11:18:32AM	13	Step started	Message Validate
11:18:32AM	12	Step over	
11:18:24AM	11	Step over	
11:18:24AM	12	Step started	Message Validate
11:18:22AM	10	Step over	
11:18:22AM	11	Step started	Message Validate
11:18:20AM	09	Step over	
11:18:20AM	10	Step started	Message Validate
11:18:18AM	09	Step started	Message Validate
11:18:18AM	08	Step over	
11:18:16AM	07	Step over	
11:18:16AM	08	Step started	Message Validate
11:18:09AM	06	Step over	
11:18:09AM	07	Step started	Message Validate
11:18:09AM	05	Step over	
11:18:09AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
11:18:08AM	05	Step started	Setting Polarity (Set point: Anodizing)
11:18:08AM	04	Step over	
11:18:08AM	03	Step over	
11:18:08AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:18:08AM	02	Step over	
11:18:08AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
11:18:08AM	02	Step started	Setting Generation (Set point: Off)
11:18:08AM	01	Step over	
11:18:08AM	01	Step started	Setting Pumping (Set point: Off)
11:18:07AM	01	Operating mode started	Boeing/IBECA HE

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/20/2018 11:36:41 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA HE
Part designation	#33

Treatment

Surface (dm²)	0.06
Estimated duration	0.60

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	Grit Blast	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/20/2018 11:36:41 AM

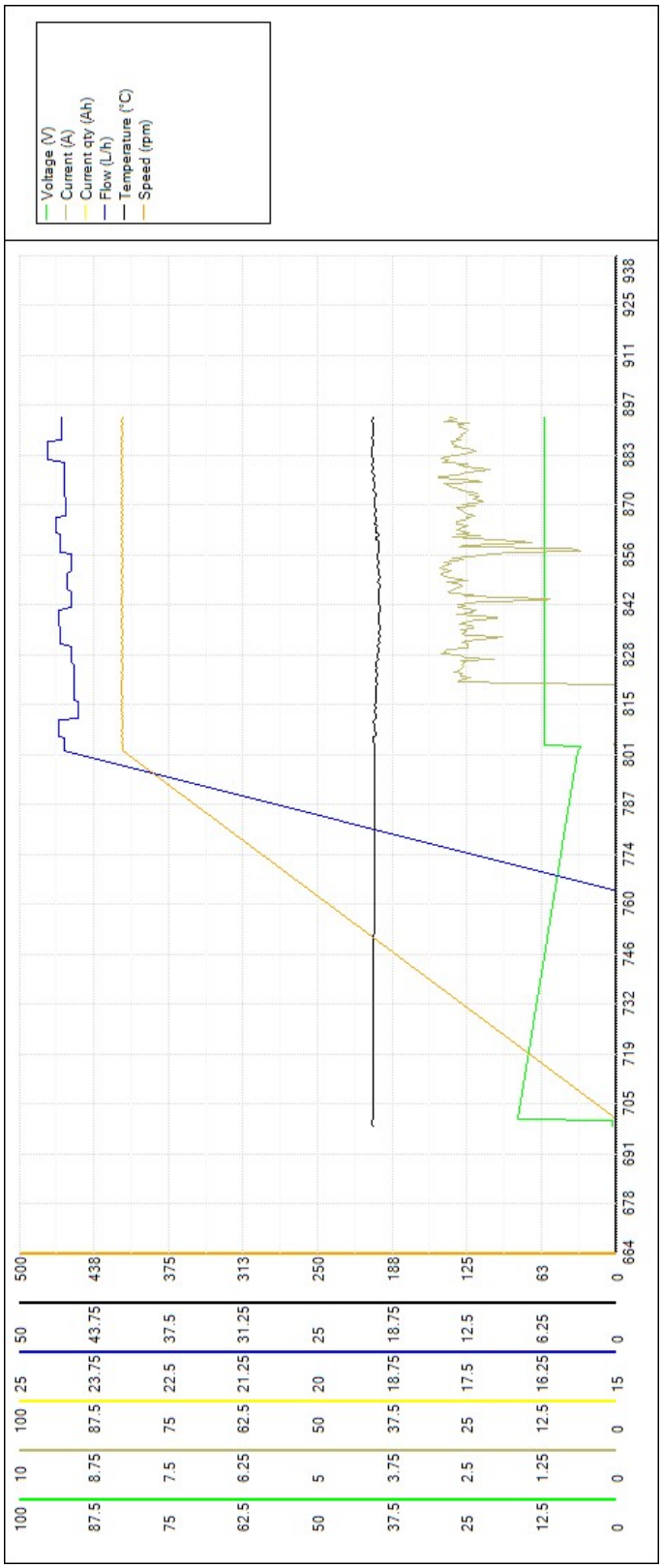
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :50.19 Treatment duration (min) :0:00:36	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA HE
	Creation date :	11/20/2018 11:36:41 AM

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (Grit Blast - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/20/2018 11:36:41 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
664 678 691 705 719 732 746 760 774 787 801 815 828 842 856 870 883 897 911 925 938

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/20/2018 11:36:41 AM

Events

Date	N°	Type	Completion
12:02:04PM	66	Step over	
12:02:04PM	66	Operating mode complete	
12:02:01PM	66	Step started	Message Validate
12:02:01PM	65	Step over	
12:01:59PM	65	Step started	Control Final
12:01:59PM	64	Step over	
12:01:55PM	64	No compressed air	
11:59:40AM	64	No compressed air	
11:58:22AM	64	Step started	Message Validate
11:58:22AM	63	Step over	
11:58:18AM	63	Step started	Message Validate
11:58:18AM	62	Step over	
11:58:16AM	62	Step started	Message Validate
11:58:15AM	61	Step over	
11:58:12AM	61	Step started	Message Validate
11:58:12AM	60	Step over	
11:58:10AM	59	Step over	
11:58:10AM	60	Step started	Message Validate
11:58:08AM	59	Step started	Message Validate
11:58:08AM	58	Step over	
11:57:39AM	58	No compressed air	
11:57:32AM	58	Step started	Control Thickness (µm)
11:57:32AM	57	Step over	
11:57:30AM	57	Step started	Message Validate
11:57:30AM	56	Step over	
11:56:51AM	55	Step over	
11:56:51AM	56	Step started	Control Adhesion
11:56:49AM	55	Step started	Control Aspect
11:56:49AM	54	Step over	
11:56:47AM	54	Step started	Message Validate
11:56:46AM	53	Step over	
11:55:54AM	53	Step started	Message Validate
11:55:54AM	52	Step over	
11:55:31AM	52	No compressed air	
11:53:14AM	52	No compressed air	
11:52:11AM	52	Step started	Message Validate
11:52:11AM	51	Step over	
11:52:08AM	51	Step started	Message Validate
11:52:08AM	50	Step over	
11:51:52AM	49	Step over	
11:51:52AM	50	Step started	Message Validate
11:51:43AM	49	Step started	Message Validate
11:51:43AM	48	Step over	
11:51:43AM	48	Step started	Setting Pumping (Set point: Off)
11:51:43AM	47	Step over	
11:51:36AM	47	Step started	Message Validate
11:51:36AM	46	Step over	
11:51:36AM	46	Step started	Setting Generation (Set point: Off)
11:51:36AM	45	Step over	
11:51:07AM	45	No compressed air	
11:50:33AM	45	No compressed air	
11:50:05AM	44	Step over	
11:50:05AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:50:04AM	43	Step over	
11:50:04AM	44	Step started	Setting Generation (Set point: On)
11:50:04AM	42	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
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11:50:04AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
11:50:04AM	41	Step over	
11:50:04AM	42	Step started	Setting Polarity (Set point: Plating)
11:50:04AM	40	Step over	
11:50:04AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:50:04AM	39	Step over	
11:50:04AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:50:03AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:50:03AM	38	Step over	
11:49:39AM	38	No compressed air	
11:49:09AM	38	No compressed air	
11:48:45AM	38	Step started	Message Validate
11:48:44AM	37	Step over	
11:48:36AM	37	Process defect: flow lower limit reached	
11:48:28AM	36	Step over	
11:48:28AM	37	Step started	Message Validate
11:48:28AM	36	Process defect: flow lower limit reached	
11:48:27AM	35	Step over	
11:48:27AM	36	Step started	Setting Pumping (Set point: On)
11:48:25AM	35	Step started	Message Validate
11:48:25AM	34	Step over	
11:48:23AM	33	Step over	
11:48:23AM	34	Step started	Message Validate
11:48:23AM	32	Step over	
11:48:23AM	33	Step started	Setting Generation (Set point: Off)
11:48:22AM	31	Step over	
11:48:22AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:48:21AM	30	Step over	
11:48:21AM	31	Step started	Setting Generation (Set point: On)
11:48:21AM	30	Step started	Setting Solution (Grit Blast - Activator XF)
11:48:21AM	29	Step over	
11:48:19AM	29	Step started	Message Validate
11:48:19AM	28	Step over	
11:48:17AM	28	Step started	Message Validate
11:48:16AM	27	Step over	
11:48:15AM	26	Step over	
11:48:15AM	27	Step started	Message Validate
11:48:12AM	26	Step started	Message Validate
11:48:12AM	25	Step over	
11:48:10AM	25	No compressed air	
11:48:10AM	25	No compressed air	
11:48:08AM	25	No compressed air	
11:48:07AM	25	No compressed air	
11:48:06AM	25	No compressed air	
11:47:09AM	24	Step over	
11:47:09AM	25	Step started	Setting Surface
11:47:09AM	24	Step started	Setting Pumping (Set point: Off)
11:47:09AM	23	Step over	
11:47:06AM	23	Step started	Message Validate
11:47:06AM	22	Step over	
11:47:03AM	22	Step started	Message Validate
11:47:03AM	21	Step over	
11:47:03AM	21	Step started	Setting Pumping (Set point: On)
11:47:03AM	20	Step over	
11:47:00AM	20	Step started	Message Validate
11:47:00AM	19	Step over	
11:46:58AM	19	Step started	Message Validate
11:46:58AM	18	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
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11:46:57AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
11:46:57AM	17	Step over	
11:46:55AM	17	Step started	Message Validate
11:46:55AM	16	Step over	
11:46:52AM	15	Step over	
11:46:52AM	16	Step started	Message Validate
11:46:51AM	15	Step started	Message Validate
11:46:50AM	14	Step over	
11:46:49AM	14	Step started	Message Validate
11:46:49AM	13	Step over	
11:46:46AM	13	Step started	Message Validate
11:46:46AM	12	Step over	
11:46:44AM	11	Step over	
11:46:44AM	12	Step started	Message Validate
11:46:42AM	11	Step started	Message Validate
11:46:42AM	10	Step over	
11:46:41AM	09	Step over	
11:46:41AM	10	Step started	Message Validate
11:46:38AM	09	Step started	Message Validate
11:46:38AM	08	Step over	
11:46:36AM	07	Step over	
11:46:36AM	08	Step started	Message Validate
11:45:53AM	07	No compressed air	
11:44:06AM	07	No compressed air	
11:42:01AM	07	No compressed air	
11:40:00AM	07	No compressed air	
11:37:38AM	07	No compressed air	
11:36:43AM	06	Step over	
11:36:43AM	07	Step started	Message Validate
11:36:43AM	05	Step over	
11:36:43AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
11:36:43AM	04	Step over	
11:36:43AM	05	Step started	Setting Polarity (Set point: Anodizing)
11:36:43AM	03	Step over	
11:36:43AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:36:43AM	02	Step over	
11:36:43AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
11:36:43AM	01	Step over	
11:36:43AM	02	Step started	Setting Generation (Set point: Off)
11:36:42AM	01	Step started	Setting Pumping (Set point: Off)
11:36:42AM	01	Operating mode started	Boeing/IBECA HE

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	12/17/2018 10:27:12 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#34

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

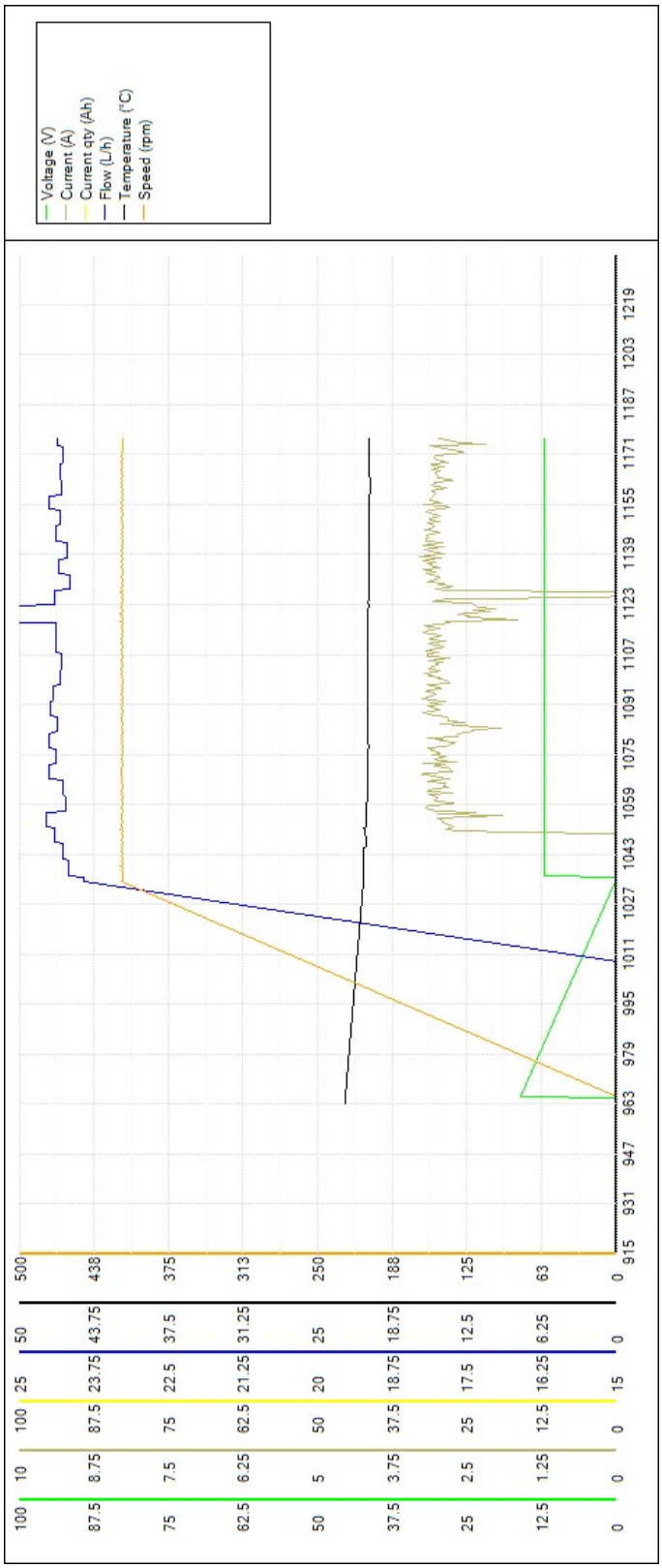
DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 12/17/2018 10:27:12 AM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (None - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 12/17/2018 10:27:12 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
915 931 947 963 979 995 1011 1027 1043 1059 1075 1091 1107 1123 1139 1155 1171 1187 1203 1219
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 10:27:12 AM

Events

Date	N°	Type	Completion
10:55:05AM	66	Step over	
10:55:05AM	66	Operating mode complete	
10:55:03AM	66	Step started	Message Validate
10:55:03AM	65	Step over	
10:55:01AM	64	Step over	
10:55:01AM	65	Step started	Control Final
10:54:59AM	64	Step started	Message Validate
10:54:59AM	63	Step over	
10:54:57AM	63	Step started	Message Validate
10:54:57AM	62	Step over	
10:54:55AM	62	Step started	Message Validate
10:54:55AM	61	Step over	
10:51:03AM	61	Step started	Message Validate
10:51:03AM	60	Step over	
10:51:00AM	60	Step started	Message Validate
10:51:00AM	59	Step over	
10:50:58AM	59	Step started	Message Validate
10:50:58AM	58	Step over	
10:50:44AM	58	Step started	Control Thickness (µm)
10:50:43AM	57	Step over	
10:50:40AM	57	Step started	Message Validate
10:50:40AM	56	Step over	
10:49:26AM	55	Step over	
10:49:26AM	56	Step started	Control Adhesion
10:47:58AM	55	Step started	Control Aspect
10:47:58AM	54	Step over	
10:47:51AM	54	Step started	Message Validate
10:47:51AM	53	Step over	
10:47:49AM	53	Step started	Message Validate
10:47:49AM	52	Step over	
10:47:47AM	52	Step started	Message Validate
10:47:47AM	51	Step over	
10:47:20AM	51	Step started	Message Validate
10:47:20AM	50	Step over	
10:47:02AM	50	Step started	Message Validate
10:47:02AM	49	Step over	
10:46:59AM	48	Step over	
10:46:59AM	49	Step started	Message Validate
10:46:59AM	48	Step started	Setting Pumping (Set point: Off)
10:46:59AM	47	Step over	
10:46:52AM	47	Step started	Message Validate
10:46:52AM	46	Step over	
10:46:52AM	46	Step started	Setting Generation (Set point: Off)
10:46:52AM	45	Step over	
10:44:30AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:44:30AM	44	Step over	
10:44:29AM	43	Step over	
10:44:29AM	44	Step started	Setting Generation (Set point: On)
10:44:29AM	42	Step over	
10:44:29AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
10:44:29AM	41	Step over	
10:44:29AM	42	Step started	Setting Polarity (Set point: Plating)
10:44:28AM	40	Step over	
10:44:28AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:44:28AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:44:28AM	39	Step over	

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 10:27:12 AM

10:44:28AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:44:28AM	38	Step over	
10:43:51AM	38	Step started	Message Validate
10:43:51AM	37	Step over	
10:43:42AM	37	Process defect: temperature upper limit reached	
10:43:35AM	37	Process defect: flow lower limit reached	
10:43:35AM	37	Process defect: flow lower limit reached	
10:43:25AM	37	Step started	Message Validate
10:43:25AM	36	Step over	
10:43:25AM	35	Step over	
10:43:25AM	36	Step started	Setting Pumping (Set point: On)
10:43:23AM	35	Step started	Message Validate
10:43:23AM	34	Step over	
10:43:20AM	33	Step over	
10:43:20AM	34	Step started	Message Validate
10:43:20AM	33	Step started	Setting Generation (Set point: Off)
10:43:20AM	32	Step over	
10:43:19AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:43:19AM	31	Step over	
10:43:18AM	31	Step started	Setting Generation (Set point: On)
10:43:18AM	30	Step over	
10:43:17AM	29	Step over	
10:43:17AM	30	Step started	Setting Solution (None - Activator XF)
10:43:16AM	29	Step started	Message Validate
10:43:16AM	28	Step over	
10:43:13AM	28	Step started	Message Validate
10:43:13AM	27	Step over	
10:43:11AM	27	Step started	Message Validate
10:43:11AM	26	Step over	
10:43:08AM	26	Step started	Message Validate
10:43:08AM	25	Step over	
10:40:51AM	25	Process defect: temperature upper limit reached	
10:36:01AM	24	Step over	
10:36:01AM	25	Step started	Setting Surface
10:36:01AM	24	Step started	Setting Pumping (Set point: Off)
10:36:01AM	23	Step over	
10:35:58AM	23	Step started	Message Validate
10:35:58AM	22	Step over	
10:35:41AM	22	Process defect: flow lower limit reached	
10:35:33AM	21	Step over	
10:35:33AM	22	Step started	Message Validate
10:35:32AM	21	Process defect: flow lower limit reached	
10:35:31AM	21	Step started	Setting Pumping (Set point: On)
10:35:31AM	20	Step over	
10:35:29AM	20	Step started	Message Validate
10:35:29AM	19	Step over	
10:35:19AM	18	Step over	
10:35:19AM	19	Step started	Message Validate
10:35:19AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:35:19AM	17	Step over	
10:35:17AM	17	Step started	Message Validate
10:35:17AM	16	Step over	
10:35:15AM	15	Step over	

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 10:27:12 AM

10:35:15AM	16	Step started	Message Validate
10:35:14AM	15	Step started	Message Validate
10:35:14AM	14	Step over	
10:35:14AM	14	Step started	Message Validate
10:35:13AM	13	Step over	
10:35:12AM	13	Step started	Message Validate
10:35:12AM	12	Step over	
10:35:10AM	12	Step started	Message Validate
10:35:10AM	11	Step over	
10:35:09AM	10	Step over	
10:35:09AM	11	Step started	Message Validate
10:35:07AM	09	Step over	
10:35:07AM	10	Step started	Message Validate
10:35:05AM	09	Step started	Message Validate
10:35:05AM	08	Step over	
10:35:02AM	07	Step over	
10:35:02AM	08	Step started	Message Validate
10:27:20AM	06	Step over	
10:27:20AM	07	Step started	Message Validate
10:27:20AM	05	Step over	
10:27:20AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:27:19AM	04	Step over	
10:27:19AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:27:19AM	03	Step over	
10:27:19AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:27:19AM	02	Step over	
10:27:19AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:27:19AM	01	Step over	
10:27:19AM	02	Step started	Setting Generation (Set point: Off)
10:27:17AM	01	Step started	Setting Pumping (Set point: Off)
10:27:17AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	12/17/2018 10:55:39 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#35

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
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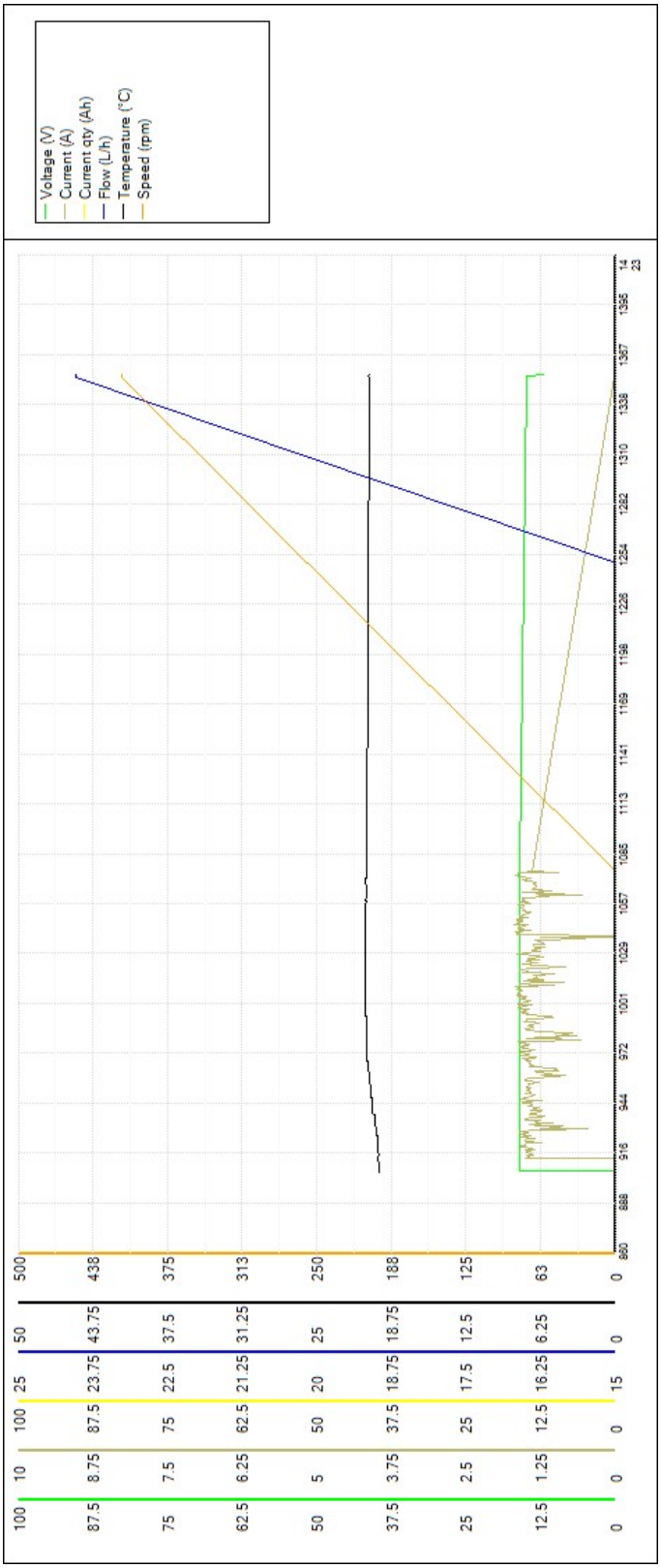
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 12/17/2018 10:55:39 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 10:55:39 AM

Events

Date	N°	Type	Completion
11:28:16AM	66	Step over	
11:28:16AM	66	Operating mode complete	
11:28:14AM	65	Step over	
11:28:14AM	66	Step started	Message Validate
11:28:07AM	64	Step over	
11:28:07AM	65	Step started	Control Final
11:28:04AM	64	Step started	Message Validate
11:28:04AM	63	Step over	
11:27:59AM	63	Step started	Message Validate
11:27:59AM	62	Step over	
11:24:14AM	62	Step started	Message Validate
11:24:14AM	61	Step over	
11:24:12AM	61	Step started	Message Validate
11:24:12AM	60	Step over	
11:24:09AM	59	Step over	
11:24:09AM	60	Step started	Message Validate
11:24:07AM	59	Step started	Message Validate
11:24:07AM	58	Step over	
11:23:58AM	58	Step started	Control Thickness (µm)
11:23:58AM	57	Step over	
11:21:45AM	57	Step started	Message Validate
11:21:45AM	56	Step over	
11:21:42AM	55	Step over	
11:21:42AM	56	Step started	Control Adhesion
11:19:01AM	55	Step started	Control Aspect
11:19:01AM	54	Step over	
11:18:59AM	54	Step started	Message Validate
11:18:59AM	53	Step over	
11:18:57AM	53	Step started	Message Validate
11:18:57AM	52	Step over	
11:18:55AM	52	Step started	Message Validate
11:18:55AM	51	Step over	
11:18:39AM	51	Step started	Message Validate
11:18:39AM	50	Step over	
11:18:37AM	50	Step started	Message Validate
11:18:37AM	49	Step over	
11:18:34AM	48	Step over	
11:18:34AM	49	Step started	Message Validate
11:18:33AM	48	Step started	Setting Pumping (Set point: Off)
11:18:33AM	47	Step over	
11:18:16AM	46	Step over	
11:18:16AM	47	Step started	Message Validate
11:18:15AM	45	Step over	
11:18:15AM	46	Step started	Setting Generation (Set point: Off)
11:18:14AM	44	Step over	
11:18:14AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:18:13AM	43	Step over	
11:18:13AM	44	Step started	Setting Generation (Set point: On)
11:18:13AM	42	Step over	
11:18:13AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
11:18:13AM	41	Step over	
11:18:13AM	42	Step started	Setting Polarity (Set point: Plating)
11:18:13AM	40	Step over	
11:18:13AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:18:13AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:18:13AM	39	Step over	

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Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 10:55:39 AM

11:18:12AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:18:12AM	38	Step over	
11:14:25AM	38	Step started	Message Validate
11:14:25AM	37	Step over	
11:13:45AM	37	Step started	Message Validate
11:13:45AM	36	Step over	
11:13:45AM	35	Step over	
11:13:45AM	36	Step started	Setting Pumping (Set point: On)
11:13:43AM	35	Step started	Message Validate
11:13:43AM	34	Step over	
11:13:36AM	33	Step over	
11:13:36AM	34	Step started	Message Validate
11:13:35AM	33	Step started	Setting Generation (Set point: Off)
11:13:35AM	32	Step over	
11:10:46AM	31	Step over	
11:10:46AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:10:45AM	31	Step started	Setting Generation (Set point: On)
11:10:45AM	30	Step over	
11:10:44AM	29	Step over	
11:10:44AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
11:10:42AM	29	Step started	Message Validate
11:10:41AM	28	Step over	
11:09:51AM	28	Step started	Message Validate
11:09:51AM	27	Step over	
11:09:48AM	27	Step started	Message Validate
11:09:48AM	26	Step over	
11:09:43AM	26	Step started	Message Validate
11:09:43AM	25	Step over	
11:09:23AM	24	Step over	
11:09:23AM	25	Step started	Setting Surface
11:09:23AM	24	Step started	Setting Pumping (Set point: Off)
11:09:23AM	23	Step over	
11:09:18AM	23	Step started	Message Validate
11:09:18AM	22	Step over	
11:09:16AM	21	Step over	
11:09:16AM	22	Step started	Message Validate
11:09:16AM	21	Step started	Setting Pumping (Set point: On)
11:09:16AM	20	Step over	
11:09:14AM	20	Step started	Message Validate
11:09:14AM	19	Step over	
11:09:13AM	19	Step started	Message Validate
11:09:13AM	18	Step over	
11:09:13AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
11:09:13AM	17	Step over	
11:09:12AM	17	Step started	Message Validate
11:09:12AM	16	Step over	
11:09:10AM	16	Step started	Message Validate
11:09:10AM	15	Step over	
11:09:08AM	15	Step started	Message Validate
11:09:08AM	14	Step over	
11:09:06AM	14	Step started	Message Validate
11:09:06AM	13	Step over	
11:09:04AM	13	Step started	Message Validate
11:09:04AM	12	Step over	
11:09:03AM	11	Step over	
11:09:03AM	12	Step started	Message Validate
11:08:53AM	11	Step started	Message Validate
11:08:53AM	10	Step over	
11:08:51AM	10	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 10:55:39 AM

11:08:51AM	09	Step over	
11:08:43AM	09	Step started	Message Validate
11:08:43AM	08	Step over	
11:08:10AM	08	Step started	Message Validate
11:08:10AM	07	Step over	
10:55:41AM	07	Step started	Message Validate
10:55:41AM	06	Step over	
10:55:41AM	05	Step over	
10:55:41AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:55:40AM	04	Step over	
10:55:40AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:55:40AM	03	Step over	
10:55:40AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:55:40AM	02	Step over	
10:55:40AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:55:40AM	02	Step started	Setting Generation (Set point: Off)
10:55:40AM	01	Step over	
10:55:40AM	01	Step started	Setting Pumping (Set point: Off)
10:55:40AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	12/17/2018 11:28:37 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#36

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 12/17/2018 11:28:37 AM

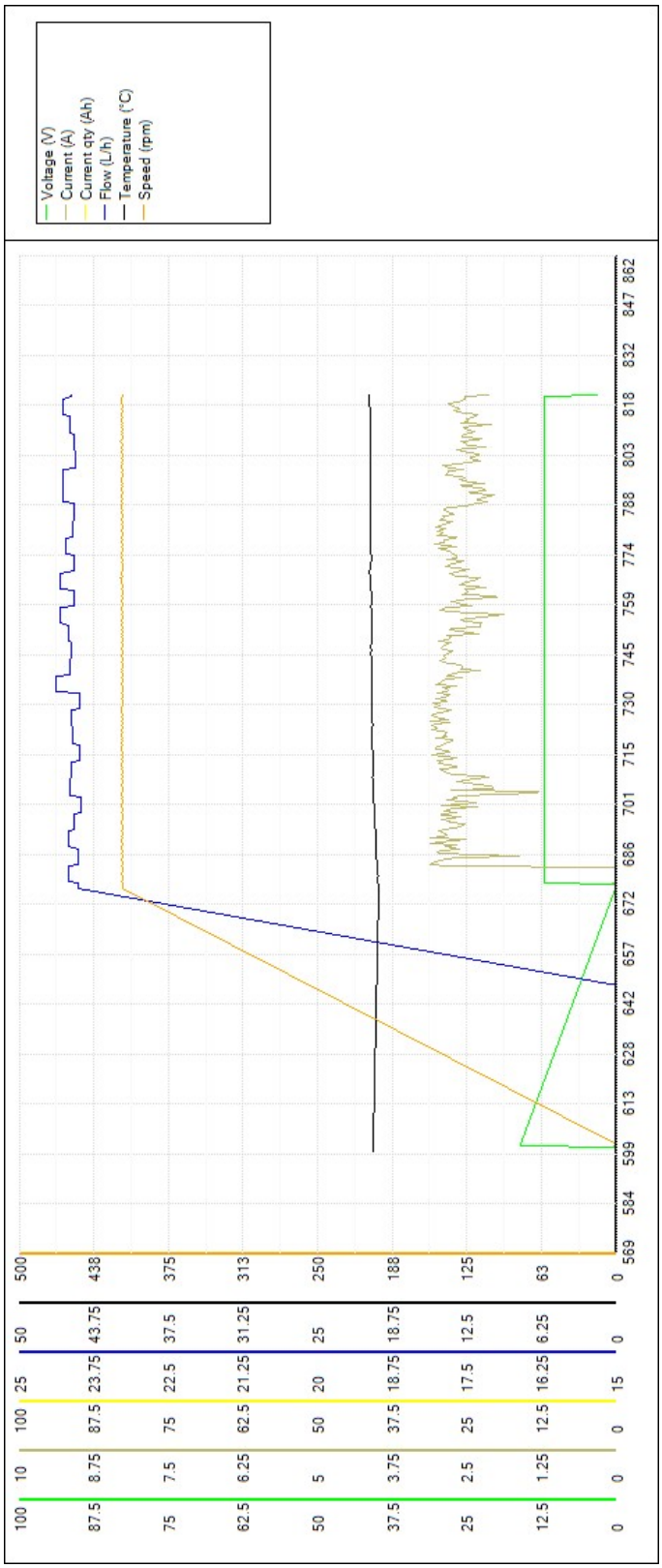
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	12/17/2018 11:28:37 AM

	Message Validate	
30	Activator XF Setting Setting Solution (None - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 12/17/2018 11:28:37 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
569 584 599 613 628 642 657 672 686 701 715 730 745 759 774 788 803 818 832 847 862

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 11:28:37 AM

Events

Date	N°	Type	Completion
11:50:15AM	66	Operating mode complete	
11:50:15AM	66	Step over	
11:50:13AM	66	Step started	Message Validate
11:50:13AM	65	Step over	
11:50:11AM	65	Step started	Control Final
11:50:11AM	64	Step over	
11:50:09AM	64	Step started	Message Validate
11:50:09AM	63	Step over	
11:48:35AM	63	Step started	Message Validate
11:48:34AM	62	Step over	
11:48:31AM	62	Step started	Message Validate
11:48:30AM	61	Step over	
11:48:27AM	61	Step started	Message Validate
11:48:27AM	60	Step over	
11:48:25AM	60	Step started	Message Validate
11:48:25AM	59	Step over	
11:48:23AM	59	Step started	Message Validate
11:48:23AM	58	Step over	
11:48:08AM	58	Step started	Control Thickness (µm)
11:48:08AM	57	Step over	
11:48:05AM	57	Step started	Message Validate
11:48:05AM	56	Step over	
11:48:02AM	56	Step started	Control Adhesion
11:48:02AM	55	Step over	
11:48:00AM	55	Step started	Control Aspect
11:48:00AM	54	Step over	
11:47:54AM	54	Step started	Message Validate
11:47:54AM	53	Step over	
11:47:51AM	53	Step started	Message Validate
11:47:51AM	52	Step over	
11:47:50AM	52	Step started	Message Validate
11:47:50AM	51	Step over	
11:47:48AM	51	Step started	Message Validate
11:47:48AM	50	Step over	
11:47:46AM	49	Step over	
11:47:46AM	50	Step started	Message Validate
11:42:25AM	48	Step over	
11:42:25AM	49	Step started	Message Validate
11:42:24AM	48	Step started	Setting Pumping (Set point: Off)
11:42:24AM	47	Step over	
11:42:18AM	47	Step started	Message Validate
11:42:18AM	46	Step over	
11:42:18AM	46	Step started	Setting Generation (Set point: Off)
11:42:18AM	45	Step over	
11:39:55AM	44	Step over	
11:39:55AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:39:53AM	43	Step over	
11:39:53AM	44	Step started	Setting Generation (Set point: On)
11:39:53AM	42	Step over	
11:39:53AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
11:39:53AM	41	Step over	
11:39:53AM	42	Step started	Setting Polarity (Set point: Plating)
11:39:53AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:39:53AM	40	Step over	
11:39:53AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
11:39:53AM	39	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 11:28:37 AM

11:39:52AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:39:52AM	38	Step over	
11:39:49AM	38	Step started	Message Validate
11:39:49AM	37	Step over	
11:38:54AM	37	Process defect: flow lower limit reached	
11:38:54AM	37	Process defect: flow lower limit reached	
11:38:44AM	36	Step over	
11:38:44AM	37	Step started	Message Validate
11:38:44AM	36	Step started	Setting Pumping (Set point: On)
11:38:44AM	35	Step over	
11:38:41AM	35	Step started	Message Validate
11:38:41AM	34	Step over	
11:38:39AM	34	Step started	Message Validate
11:38:39AM	33	Step over	
11:38:39AM	33	Step started	Setting Generation (Set point: Off)
11:38:39AM	32	Step over	
11:38:38AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:38:38AM	31	Step over	
11:38:36AM	30	Step over	
11:38:36AM	31	Step started	Setting Generation (Set point: On)
11:38:36AM	30	Step started	Setting Solution (None - Activator XF)
11:38:36AM	29	Step over	
11:38:34AM	29	Step started	Message Validate
11:38:34AM	28	Step over	
11:38:32AM	28	Step started	Message Validate
11:38:32AM	27	Step over	
11:38:30AM	27	Step started	Message Validate
11:38:30AM	26	Step over	
11:38:27AM	26	Step started	Message Validate
11:38:27AM	25	Step over	
11:38:01AM	24	Step over	
11:38:01AM	25	Step started	Setting Surface
11:38:00AM	24	Step started	Setting Pumping (Set point: Off)
11:38:00AM	23	Step over	
11:37:54AM	23	Step started	Message Validate
11:37:54AM	22	Step over	
11:37:51AM	22	Step started	Message Validate
11:37:51AM	21	Step over	
11:37:51AM	21	Step started	Setting Pumping (Set point: On)
11:37:51AM	20	Step over	
11:29:04AM	20	Step started	Message Validate
11:29:04AM	19	Step over	
11:29:03AM	18	Step over	
11:29:03AM	19	Step started	Message Validate
11:29:02AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
11:29:02AM	17	Step over	
11:29:00AM	17	Step started	Message Validate
11:29:00AM	16	Step over	
11:28:58AM	15	Step over	
11:28:58AM	16	Step started	Message Validate
11:28:56AM	15	Step started	Message Validate
11:28:55AM	14	Step over	
11:28:53AM	14	Step started	Message Validate
11:28:53AM	13	Step over	
11:28:50AM	13	Step started	Message Validate
11:28:50AM	12	Step over	
11:28:48AM	12	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 12/17/2018 11:28:37 AM

11:28:48AM	11	Step over	
11:28:46AM	10	Step over	
11:28:46AM	11	Step started	Message Validate
11:28:44AM	09	Step over	
11:28:44AM	10	Step started	Message Validate
11:28:42AM	09	Step started	Message Validate
11:28:42AM	08	Step over	
11:28:40AM	08	Step started	Message Validate
11:28:40AM	07	Step over	
11:28:38AM	06	Step over	
11:28:38AM	07	Step started	Message Validate
11:28:38AM	05	Step over	
11:28:38AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
11:28:38AM	04	Step over	
11:28:38AM	05	Step started	Setting Polarity (Set point: Anodizing)
11:28:38AM	03	Step over	
11:28:38AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:28:38AM	02	Step over	
11:28:38AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
11:28:38AM	01	Step over	
11:28:38AM	02	Step started	Setting Generation (Set point: Off)
11:28:38AM	01	Step started	Setting Pumping (Set point: Off)
11:28:37AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	BOEING/IBECA
Creation date :	1/8/2019 10:10:45 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	BOEING/IBECA
Part designation	37

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** BOEING/IBECA **Creation date :** 1/8/2019 10:10:45 AM

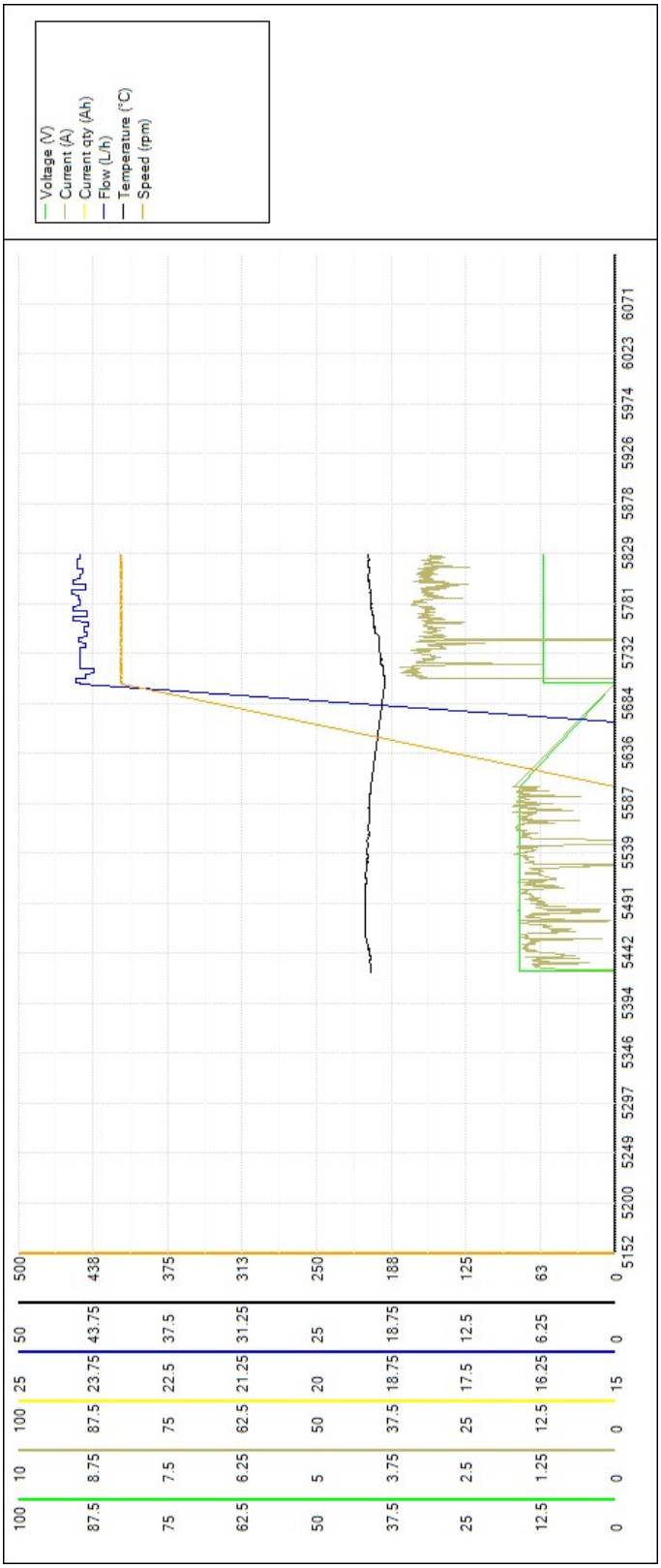
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.37 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	BOEING/IBECA
	Creation date :	1/8/2019 10:10:45 AM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** BOEING/IBECA **Creation date :** 1/8/2019 10:10:45 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
5152 5200 5249 5297 5346 5394 5442 5491 5539 5587 5636 5684 5732 5781 5829 5878 5926 5974 6023 6071
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 10:10:45 AM

Events

Date	N°	Type	Completion
11:55:50AM	66	Operating mode complete	
11:55:50AM	66	Step over	
11:55:48AM	66	Step started	Message Validate
11:55:48AM	65	Step over	
11:55:47AM	64	Step over	
11:55:47AM	65	Step started	Control Final
11:55:45AM	64	Step started	Message Validate
11:55:45AM	63	Step over	
11:55:43AM	63	Step started	Message Validate
11:55:43AM	62	Step over	
11:55:41AM	62	Step started	Message Validate
11:55:41AM	61	Step over	
11:55:40AM	61	Step started	Message Validate
11:55:40AM	60	Step over	
11:55:36AM	60	Step started	Message Validate
11:55:36AM	59	Step over	
11:51:40AM	59	Step started	Message Validate
11:51:40AM	58	Step over	
11:51:28AM	58	Step started	Control Thickness (µm)
11:51:27AM	57	Step over	
11:51:24AM	57	Step started	Message Validate
11:51:24AM	56	Step over	
11:50:53AM	55	Step over	
11:50:53AM	56	Step started	Control Adhesion
11:50:51AM	55	Step started	Control Aspect
11:50:51AM	54	Step over	
11:49:02AM	54	Step started	Message Validate
11:49:02AM	53	Step over	
11:48:12AM	53	Step started	Message Validate
11:48:12AM	52	Step over	
11:48:09AM	52	Step started	Message Validate
11:48:08AM	51	Step over	
11:48:07AM	51	Step started	Message Validate
11:48:07AM	50	Step over	
11:48:05AM	49	Step over	
11:48:05AM	50	Step started	Message Validate
11:48:03AM	48	Step over	
11:48:03AM	49	Step started	Message Validate
11:48:03AM	48	Step started	Setting Pumping (Set point: Off)
11:48:03AM	47	Step over	
11:47:56AM	46	Step over	
11:47:56AM	47	Step started	Message Validate
11:47:56AM	46	Step started	Setting Generation (Set point: Off)
11:47:56AM	45	Step over	
11:45:51AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
11:45:51AM	44	Step over	
11:45:50AM	43	Step over	
11:45:50AM	44	Step started	Setting Generation (Set point: On)
11:45:50AM	42	Step over	
11:45:50AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
11:45:50AM	41	Step over	
11:45:50AM	42	Step started	Setting Polarity (Set point: Plating)
11:45:49AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:45:49AM	40	Step over	
11:45:49AM	39	Step over	
11:45:49AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 10:10:45 AM

11:45:49AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
11:45:49AM	38	Step over	
11:45:29AM	38	Step started	Message Validate
11:45:28AM	37	Step over	
11:45:11AM	36	Step over	
11:45:11AM	37	Step started	Message Validate
11:45:11AM	35	Step over	
11:45:11AM	36	Step started	Setting Pumping (Set point: On)
11:44:24AM	35	Step started	Message Validate
11:44:24AM	34	Step over	
11:44:12AM	33	Step over	
11:44:12AM	34	Step started	Message Validate
11:44:12AM	33	Step started	Setting Generation (Set point: Off)
11:44:12AM	32	Step over	
11:41:12AM	31	Step over	
11:41:12AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
11:41:10AM	31	Step started	Setting Generation (Set point: On)
11:41:10AM	30	Step over	
11:41:10AM	29	Step over	
11:41:10AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
11:41:08AM	29	Step started	Message Validate
11:41:08AM	28	Step over	
11:40:38AM	28	Step started	Message Validate
11:40:38AM	27	Step over	
11:40:08AM	27	Step started	Message Validate
11:40:08AM	26	Step over	
10:27:18AM	26	Step started	Message Validate
10:27:18AM	25	Step over	
10:19:17AM	25	Step started	Setting Surface
10:19:17AM	24	Step over	
10:19:17AM	24	Step started	Setting Pumping (Set point: Off)
10:19:16AM	23	Step over	
10:19:06AM	23	Step started	Message Validate
10:19:06AM	22	Step over	
10:18:53AM	22	Process defect: flow lower limit reached	
10:18:53AM	22	Process defect: flow lower limit reached	
10:18:43AM	21	Step over	
10:18:43AM	22	Step started	Message Validate
10:18:42AM	21	Step started	Setting Pumping (Set point: On)
10:18:42AM	20	Step over	
10:18:15AM	20	Step started	Message Validate
10:18:15AM	19	Step over	
10:18:13AM	18	Step over	
10:18:13AM	19	Step started	Message Validate
10:18:12AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:18:12AM	17	Step over	
10:18:11AM	16	Step over	
10:18:11AM	17	Step started	Message Validate
10:18:09AM	15	Step over	
10:18:09AM	16	Step started	Message Validate
10:18:08AM	15	Step started	Message Validate
10:18:08AM	14	Step over	
10:18:07AM	14	Step started	Message Validate
10:18:07AM	13	Step over	
10:18:05AM	12	Step over	
10:18:05AM	13	Step started	Message Validate

10:18:04AM	11	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 10:10:45 AM

10:18:04AM	12	Step started	Message Validate
10:18:03AM	11	Step started	Message Validate
10:18:03AM	10	Step over	
10:18:02AM	09	Step over	
10:18:02AM	10	Step started	Message Validate
10:18:01AM	09	Step started	Message Validate
10:18:01AM	08	Step over	
10:17:56AM	08	Step started	Message Validate
10:17:56AM	07	Step over	
10:10:52AM	06	Step over	
10:10:52AM	07	Step started	Message Validate
10:10:52AM	05	Step over	
10:10:52AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:10:51AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:10:51AM	04	Step over	
10:10:51AM	03	Step over	
10:10:51AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:10:51AM	02	Step over	
10:10:51AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:10:51AM	02	Step started	Setting Generation (Set point: Off)
10:10:51AM	01	Step over	
10:10:50AM	01	Step started	Setting Pumping (Set point: Off)
10:10:49AM	01	Operating mode started	BOEING/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	BOEING/IBECA
Creation date :	1/8/2019 11:59:08 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	BOEING/IBECA
Part designation	38

Treatment

Surface (dm²)	0.10
Estimated duration	0.97

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

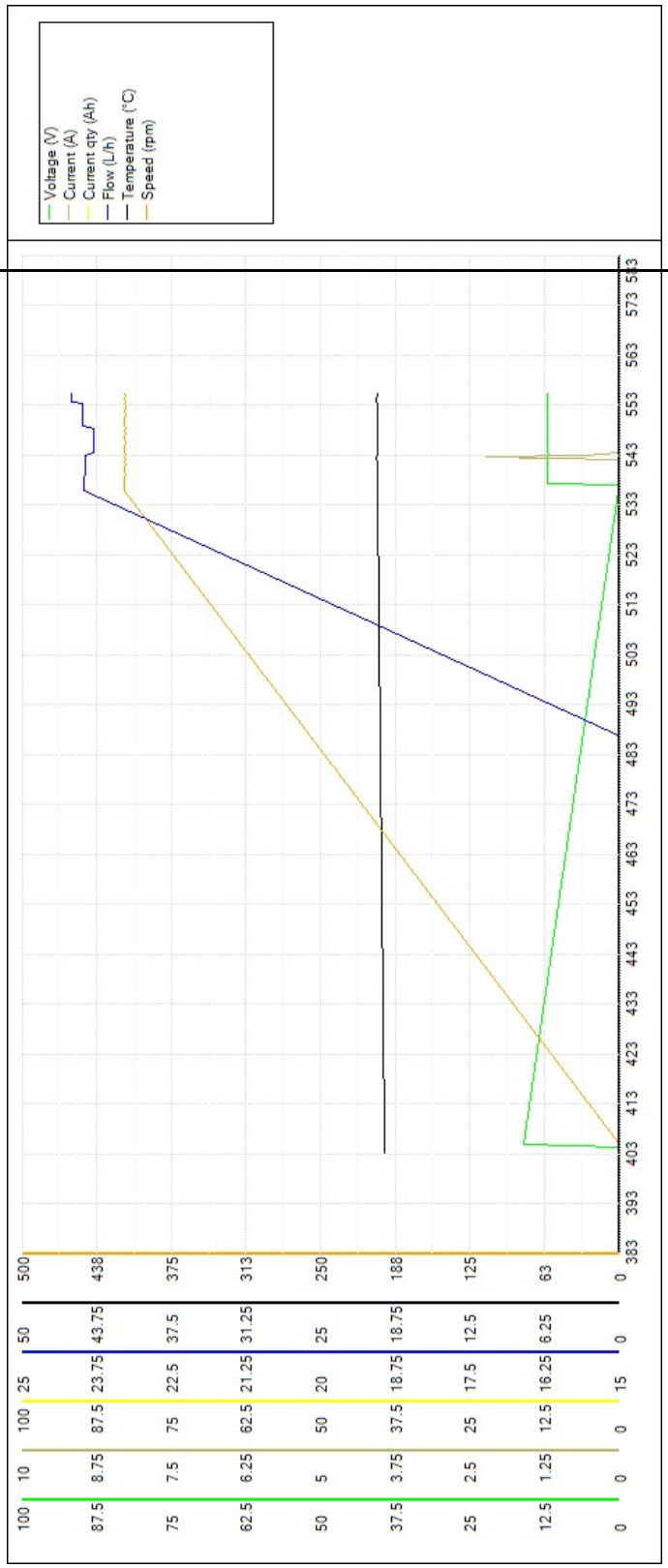
DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** BOEING/IBECA **Creation date :** 1/8/2019 11:59:08 AM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.1 Quantity of current (mAh) :80.7 Treatment duration (min) :0:00:58	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting Setting Solution (None - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** BOEING/IBECA **Creation date :** 1/8/2019 11:59:08 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
383 393 403 413 423 433 443 453 463 473 483 493 503 513 523 533 543 553 563 573 583

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 11:59:08 AM

Events

Date	N°	Type	Completion
12:18:52PM	66	Step over	
12:18:52PM	66	Operating mode complete	
12:18:51PM	66	Step started	Message Validate
12:18:51PM	65	Step over	
12:18:50PM	65	Step started	Control Final
12:18:50PM	64	Step over	
12:18:49PM	63	Step over	
12:18:49PM	64	Step started	Message Validate
12:18:48PM	62	Step over	
12:18:48PM	63	Step started	Message Validate
12:18:47PM	62	Step started	Message Validate
12:18:47PM	61	Step over	
12:18:46PM	60	Step over	
12:18:46PM	61	Step started	Message Validate
12:18:45PM	59	Step over	
12:18:45PM	60	Step started	Message Validate
12:18:43PM	59	Step started	Message Validate
12:18:43PM	58	Step over	
12:18:34PM	58	Step started	Control Thickness (µm)
12:18:34PM	57	Step over	
12:18:32PM	57	Step started	Message Validate
12:18:32PM	56	Step over	
12:12:49PM	56	Step started	Control Adhesion
12:12:49PM	55	Step over	
12:12:47PM	55	Step started	Control Aspect
12:12:47PM	54	Step over	
12:12:45PM	54	Step started	Message Validate
12:12:45PM	53	Step over	
12:12:44PM	53	Step started	Message Validate
12:12:44PM	52	Step over	
12:12:43PM	52	Step started	Message Validate
12:12:43PM	51	Step over	
12:12:41PM	51	Step started	Message Validate
12:12:41PM	50	Step over	
12:12:18PM	50	Powering	
12:12:13PM	50	Exception	port:3, slave:1, starting address:0 end:10 System.Exception: Time-out read serial port 3 at DalistickDevices.Rs232.AttendreBytesRS232(Int32 bnBytes) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 698 at DalistickDevices.Rs232.Read(Int32 Bytes2Read) in C:\VFI\DALIC\svn\Devices\Protocoles\Rs232.vb:line 713 at DalistickDevices.ClassModbus.AttentRéponseEqt(Byte[]& TableauRéponse, Int32& NbDonnéesDansTrame) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 331 at DalistickDevices.ClassModbus.Lecture(Int16& esclave, Int32& adresse, Int16& nbregistre, Int64[]& TablRéponse, Codefonction Code, Byte LgData, Boolean ignorerErreurs) in C:\VFI\DALIC\svn\Devices\Protocoles\ClassModbus.vb:line 478
12:12:10PM	50	Communication error	Dalipump
12:12:09PM	50	Communication error	Dalipump
12:12:08PM	50	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 11:59:08 AM

12:12:08PM	49	Step over	
12:12:08PM	49	Powering	
12:09:21PM	48	Step over	
12:09:21PM	49	Step started	Message Validate
12:09:21PM	48	Step started	Setting Pumping (Set point: Off)
12:09:21PM	47	Step over	
12:08:25PM	46	Step over	
12:08:25PM	47	Step started	Message Validate
12:08:24PM	46	Step started	Setting Generation (Set point: Off)
12:08:24PM	45	Step over	
12:08:05PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
12:08:05PM	44	Step over	
12:08:04PM	43	Step over	
12:08:04PM	44	Step started	Setting Generation (Set point: On)
12:08:04PM	42	Step over	
12:08:04PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
12:08:04PM	41	Step over	
12:08:04PM	42	Step started	Setting Polarity (Set point: Plating)
12:08:03PM	40	Step over	
12:08:03PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:08:03PM	39	Step over	
12:08:03PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
12:08:03PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
12:08:03PM	38	Step over	
12:07:41PM	38	Process defect: flow lower limit reached	
12:07:32PM	38	Step started	Message Validate
12:07:32PM	37	Step over	
12:07:30PM	36	Step over	
12:07:30PM	37	Step started	Message Validate
12:07:30PM	36	Process defect: flow lower limit reached	
12:07:30PM	35	Step over	
12:07:30PM	36	Step started	Setting Pumping (Set point: On)
12:05:56PM	35	Step started	Message Validate
12:05:56PM	34	Step over	
12:05:54PM	33	Step over	
12:05:54PM	34	Step started	Message Validate
12:05:54PM	32	Step over	
12:05:54PM	33	Step started	Setting Generation (Set point: Off)
12:05:53PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
12:05:53PM	31	Step over	
12:05:51PM	31	Step started	Setting Generation (Set point: On)
12:05:51PM	30	Step over	
12:05:51PM	29	Step over	
12:05:51PM	30	Step started	Setting Solution (None - Activator XF)
12:05:50PM	29	Step started	Message Validate
12:05:50PM	28	Step over	
12:05:47PM	28	Step started	Message Validate
12:05:47PM	27	Step over	
12:05:27PM	26	Step over	
12:05:27PM	27	Step started	Message Validate
12:00:39PM	26	Step started	Message Validate
12:00:38PM	25	Step over	
11:59:33AM	25	Step started	Setting Surface
11:59:33AM	24	Step over	
11:59:33AM	24	Step started	Setting Pumping (Set point: Off)
11:59:33AM	23	Step over	
11:59:30AM	23	Step started	Message Validate

11:59:30AM	22	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 11:59:08 AM

11:59:28AM	22	Step started	Message Validate
11:59:28AM	21	Step over	
11:59:28AM	21	Step started	Setting Pumping (Set point: On)
11:59:28AM	20	Step over	
11:59:26AM	19	Step over	
11:59:26AM	20	Step started	Message Validate
11:59:25AM	18	Step over	
11:59:25AM	19	Step started	Message Validate
11:59:25AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
11:59:25AM	17	Step over	
11:59:24AM	17	Step started	Message Validate
11:59:24AM	16	Step over	
11:59:22AM	16	Step started	Message Validate
11:59:22AM	15	Step over	
11:59:21AM	14	Step over	
11:59:21AM	15	Step started	Message Validate
11:59:21AM	14	Step started	Message Validate
11:59:21AM	13	Step over	
11:59:19AM	13	Step started	Message Validate
11:59:19AM	12	Step over	
11:59:18AM	11	Step over	
11:59:18AM	12	Step started	Message Validate
11:59:17AM	11	Step started	Message Validate
11:59:17AM	10	Step over	
11:59:16AM	09	Step over	
11:59:16AM	10	Step started	Message Validate
11:59:15AM	09	Step started	Message Validate
11:59:15AM	08	Step over	
11:59:12AM	08	Step started	Message Validate
11:59:12AM	07	Step over	
11:59:10AM	06	Step over	
11:59:10AM	07	Step started	Message Validate
11:59:10AM	05	Step over	
11:59:10AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
11:59:09AM	04	Step over	
11:59:09AM	05	Step started	Setting Polarity (Set point: Anodizing)
11:59:09AM	03	Step over	
11:59:09AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
11:59:09AM	02	Step over	
11:59:09AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
11:59:09AM	01	Step over	
11:59:09AM	02	Step started	Setting Generation (Set point: Off)
11:59:09AM	01	Step started	Setting Pumping (Set point: Off)
11:59:08AM	01	Operating mode started	BOEING/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	BOEING/IBECA
Creation date :	1/8/2019 12:19:59 PM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	BOEING/IBECA
Part designation	39

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** BOEING/IBECA **Creation date :** 1/8/2019 12:19:59 PM

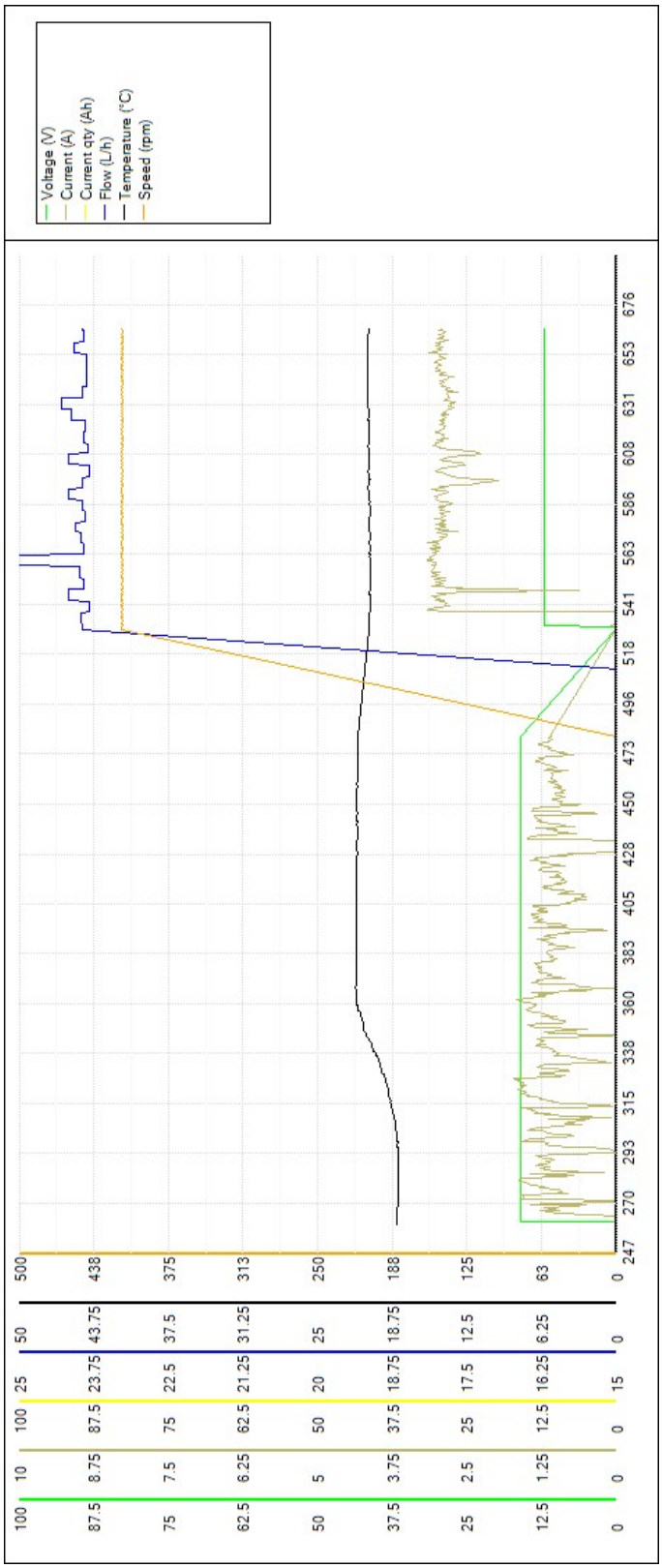
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	BOEING/IBECA
Creation date :	1/8/2019 12:19:59 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
247 270 293 315 338 360 383 405 428 450 473 496 518 541 563 586 608 631 653 676

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 12:19:59 PM

Events

Date	N°	Type	Completion
12:36:44PM	66	Operating mode complete	
12:36:44PM	66	Step over	
12:36:43PM	66	Step started	Message Validate
12:36:43PM	65	Step over	
12:36:43PM	64	Step over	
12:36:43PM	65	Step started	Control Final
12:36:42PM	64	Step started	Message Validate
12:36:42PM	63	Step over	
12:36:42PM	62	Step over	
12:36:42PM	63	Step started	Message Validate
12:36:41PM	61	Step over	
12:36:41PM	62	Step started	Message Validate
12:36:41PM	61	Step started	Message Validate
12:36:40PM	60	Step over	
12:36:40PM	60	Step started	Message Validate
12:36:40PM	59	Step over	
12:36:39PM	59	Step started	Message Validate
12:36:39PM	58	Step over	
12:36:32PM	58	Step started	Control Thickness (µm)
12:36:32PM	57	Step over	
12:36:29PM	57	Step started	Message Validate
12:36:29PM	56	Step over	
12:31:35PM	55	Step over	
12:31:35PM	56	Step started	Control Adhesion
12:31:34PM	54	Step over	
12:31:34PM	55	Step started	Control Aspect
12:31:33PM	53	Step over	
12:31:33PM	54	Step started	Message Validate
12:31:32PM	53	Step started	Message Validate
12:31:32PM	52	Step over	
12:31:30PM	52	Step started	Message Validate
12:31:30PM	51	Step over	
12:31:14PM	51	Step started	Message Validate
12:31:14PM	50	Step over	
12:31:12PM	49	Step over	
12:31:12PM	50	Step started	Message Validate
12:31:10PM	49	Step started	Message Validate
12:31:10PM	48	Step over	
12:31:10PM	48	Step started	Setting Pumping (Set point: Off)
12:31:10PM	47	Step over	
12:31:05PM	46	Step over	
12:31:05PM	47	Step started	Message Validate
12:31:05PM	46	Step started	Setting Generation (Set point: Off)
12:31:05PM	45	Step over	
12:28:50PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
12:28:50PM	44	Step over	
12:28:49PM	43	Step over	
12:28:49PM	44	Step started	Setting Generation (Set point: On)
12:28:49PM	42	Step over	
12:28:49PM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
12:28:49PM	42	Step started	Setting Polarity (Set point: Plating)
12:28:49PM	41	Step over	
12:28:48PM	40	Step over	
12:28:48PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:28:48PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
12:28:48PM	39	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 12:19:59 PM

12:28:48PM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
12:28:48PM	38	Step over	
12:28:29PM	38	Step started	Message Validate
12:28:28PM	37	Step over	
12:28:21PM	37	Process defect: flow lower limit reached	
12:28:12PM	36	Step over	
12:28:12PM	37	Step started	Message Validate
12:28:12PM	36	Process defect: flow lower limit reached	
12:28:12PM	36	Step started	Setting Pumping (Set point: On)
12:28:12PM	35	Step over	
12:28:07PM	35	Step started	Message Validate
12:28:07PM	34	Step over	
12:28:01PM	33	Step over	
12:28:01PM	34	Step started	Message Validate
12:28:01PM	33	Step started	Setting Generation (Set point: Off)
12:28:01PM	32	Step over	
12:24:21PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
12:24:21PM	31	Step over	
12:24:20PM	30	Step over	
12:24:20PM	31	Step started	Setting Generation (Set point: On)
12:24:20PM	29	Step over	
12:24:20PM	30	Step started	Setting Solution (20160002-HE - Activator XF)
12:23:58PM	29	Step started	Message Validate
12:23:57PM	28	Step over	
12:23:41PM	28	Step started	Message Validate
12:23:41PM	27	Step over	
12:23:34PM	27	Step started	Message Validate
12:23:34PM	26	Step over	
12:20:43PM	26	Step started	Message Validate
12:20:43PM	25	Step over	
12:20:25PM	24	Step over	
12:20:25PM	25	Step started	Setting Surface
12:20:25PM	24	Step started	Setting Pumping (Set point: Off)
12:20:25PM	23	Step over	
12:20:23PM	23	Step started	Message Validate
12:20:23PM	22	Step over	
12:20:21PM	21	Step over	
12:20:21PM	22	Step started	Message Validate
12:20:20PM	21	Step started	Setting Pumping (Set point: On)
12:20:20PM	20	Step over	
12:20:18PM	20	Step started	Message Validate
12:20:18PM	19	Step over	
12:20:13PM	18	Step over	
12:20:13PM	19	Step started	Message Validate
12:20:13PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
12:20:13PM	17	Step over	
12:20:11PM	17	Step started	Message Validate
12:20:11PM	16	Step over	
12:20:10PM	15	Step over	
12:20:10PM	16	Step started	Message Validate
12:20:10PM	15	Step started	Message Validate
12:20:10PM	14	Step over	
12:20:09PM	14	Step started	Message Validate
12:20:09PM	13	Step over	
12:20:07PM	12	Step over	
12:20:07PM	13	Step started	Message Validate

12:20:06PM	12	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : BOEING/IBECA
Creation date : 1/8/2019 12:19:59 PM

12:20:06PM	11	Step over	
12:20:05PM	11	Step started	Message Validate
12:20:05PM	10	Step over	
12:20:04PM	09	Step over	
12:20:04PM	10	Step started	Message Validate
12:20:04PM	08	Step over	
12:20:04PM	09	Step started	Message Validate
12:20:03PM	07	Step over	
12:20:03PM	08	Step started	Message Validate
12:20:01PM	06	Step over	
12:20:01PM	07	Step started	Message Validate
12:20:01PM	05	Step over	
12:20:01PM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
12:20:01PM	04	Step over	
12:20:01PM	05	Step started	Setting Polarity (Set point: Anodizing)
12:20:00PM	03	Step over	
12:20:00PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
12:20:00PM	02	Step over	
12:20:00PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
12:20:00PM	01	Step over	
12:20:00PM	02	Step started	Setting Generation (Set point: Off)
12:20:00PM	01	Step started	Setting Pumping (Set point: Off)
12:19:59PM	01	Operating mode started	BOEING/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	1/14/2019 9:35:43 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#40

Treatment

Surface (dm²)	0.10
Estimated duration	0.96

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	1/14/2019 9:35:43 AM

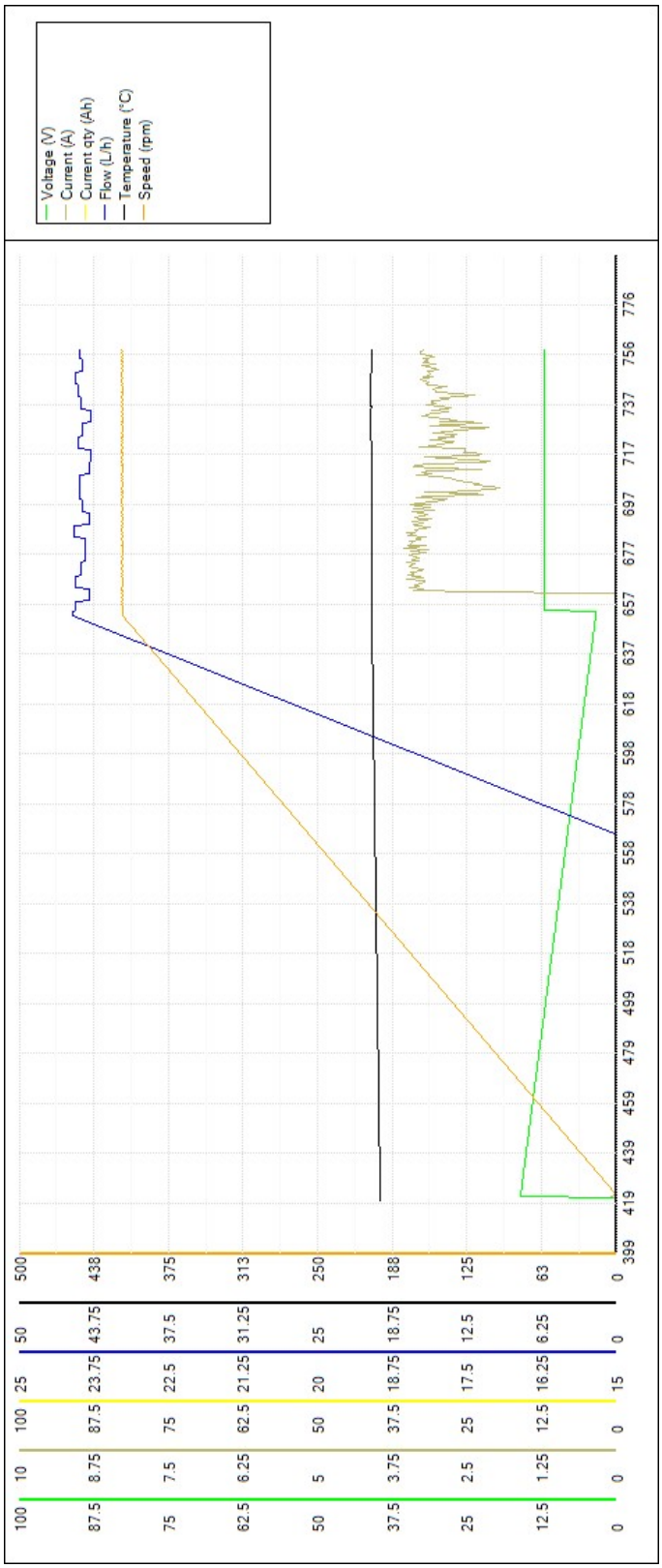
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.1 Quantity of current (mAh) :80.29 Treatment duration (min) :0:00:58	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	1/14/2019 9:35:43 AM

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (None - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 1/14/2019 9:35:43 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
399 419 439 459 479 499 518 538 558 578 598 618 637 657 677 697 717 737 756 776

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 9:35:43 AM

Events

Date	N°	Type	Completion
9:54:38AM	66	Step over	
9:54:38AM	66	Operating mode complete	
9:54:24AM	66	Step started	Message Validate
9:54:24AM	65	Step over	
9:54:22AM	65	Step started	Control Final
9:54:22AM	64	Step over	
9:54:20AM	64	Step started	Message Validate
9:54:19AM	63	Step over	
9:54:09AM	63	Step started	Message Validate
9:54:09AM	62	Step over	
9:54:07AM	62	Step started	Message Validate
9:54:07AM	61	Step over	
9:54:06AM	61	Step started	Message Validate
9:54:06AM	60	Step over	
9:54:00AM	60	Step started	Message Validate
9:54:00AM	59	Step over	
9:53:58AM	59	Step started	Message Validate
9:53:58AM	58	Step over	
9:53:48AM	58	Step started	Control Thickness (µm)
9:53:47AM	57	Step over	
9:53:46AM	57	Step started	Message Validate
9:53:46AM	56	Step over	
9:53:43AM	55	Step over	
9:53:43AM	56	Step started	Control Adhesion
9:53:41AM	55	Step started	Control Aspect
9:53:41AM	54	Step over	
9:53:37AM	54	Step started	Message Validate
9:53:37AM	53	Step over	
9:53:35AM	52	Step over	
9:53:35AM	53	Step started	Message Validate
9:53:34AM	52	Step started	Message Validate
9:53:33AM	51	Step over	
9:53:32AM	51	Step started	Message Validate
9:53:32AM	50	Step over	
9:53:14AM	50	Step started	Message Validate
9:53:14AM	49	Step over	
9:48:28AM	48	Step over	
9:48:28AM	49	Step started	Message Validate
9:48:28AM	48	Step started	Setting Pumping (Set point: Off)
9:48:28AM	47	Step over	
9:48:22AM	46	Step over	
9:48:22AM	47	Step started	Message Validate
9:48:22AM	46	Step started	Setting Generation (Set point: Off)
9:48:22AM	45	Step over	
9:46:38AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
9:46:38AM	44	Step over	
9:46:36AM	43	Step over	
9:46:36AM	44	Step started	Setting Generation (Set point: On)
9:46:36AM	42	Step over	
9:46:36AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
9:46:36AM	41	Step over	
9:46:36AM	42	Step started	Setting Polarity (Set point: Plating)
9:46:36AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:46:36AM	40	Step over	
9:46:36AM	39	Step over	
9:46:36AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 9:35:43 AM

9:46:35AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:46:35AM	38	Step over	
9:44:52AM	38	Step started	Message Validate
9:44:52AM	37	Step over	
9:44:51AM	37	Process defect: flow lower limit reached	
9:44:40AM	36	Step over	
9:44:40AM	37	Step started	Message Validate
9:44:40AM	36	Process defect: flow lower limit reached	
9:44:40AM	35	Step over	
9:44:40AM	36	Step started	Setting Pumping (Set point: On)
9:42:47AM	35	Step started	Message Validate
9:42:47AM	34	Step over	
9:42:46AM	34	Step started	Message Validate
9:42:46AM	33	Step over	
9:42:46AM	32	Step over	
9:42:46AM	33	Step started	Setting Generation (Set point: Off)
9:42:45AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
9:42:45AM	31	Step over	
9:42:44AM	30	Step over	
9:42:44AM	31	Step started	Setting Generation (Set point: On)
9:42:44AM	29	Step over	
9:42:44AM	30	Step started	Setting Solution (None - Activator XF)
9:42:41AM	29	Step started	Message Validate
9:42:41AM	28	Step over	
9:42:19AM	28	Step started	Message Validate
9:42:18AM	27	Step over	
9:42:02AM	27	Step started	Message Validate
9:42:02AM	26	Step over	
9:37:46AM	26	Step started	Message Validate
9:37:45AM	25	Step over	
9:36:37AM	24	Step over	
9:36:37AM	25	Step started	Setting Surface
9:36:37AM	24	Step started	Setting Pumping (Set point: Off)
9:36:37AM	23	Step over	
9:36:32AM	23	Step started	Message Validate
9:36:32AM	22	Step over	
9:36:28AM	22	Step started	Message Validate
9:36:28AM	21	Step over	
9:36:28AM	21	Step started	Setting Pumping (Set point: On)
9:36:28AM	20	Step over	
9:36:25AM	20	Step started	Message Validate
9:36:24AM	19	Step over	
9:36:17AM	19	Step started	Message Validate
9:36:17AM	18	Step over	
9:36:17AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
9:36:17AM	17	Step over	
9:36:10AM	17	Step started	Message Validate
9:36:10AM	16	Step over	
9:36:08AM	15	Step over	
9:36:08AM	16	Step started	Message Validate
9:36:06AM	15	Step started	Message Validate
9:36:05AM	14	Step over	
9:36:03AM	14	Step started	Message Validate
9:36:03AM	13	Step over	
9:36:00AM	13	Step started	Message Validate
9:36:00AM	12	Step over	
9:35:57AM	11	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 9:35:43 AM

9:35:57AM	12	Step started	Message Validate
9:35:55AM	11	Step started	Message Validate
9:35:55AM	10	Step over	
9:35:52AM	10	Step started	Message Validate
9:35:52AM	09	Step over	
9:35:50AM	09	Step started	Message Validate
9:35:50AM	08	Step over	
9:35:49AM	08	Step started	Message Validate
9:35:48AM	07	Step over	
9:35:45AM	06	Step over	
9:35:45AM	07	Step started	Message Validate
9:35:45AM	05	Step over	
9:35:45AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:35:45AM	04	Step over	
9:35:45AM	05	Step started	Setting Polarity (Set point: Anodizing)
9:35:44AM	03	Step over	
9:35:44AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:35:44AM	02	Step over	
9:35:44AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
9:35:44AM	01	Step over	
9:35:44AM	02	Step started	Setting Generation (Set point: Off)
9:35:44AM	01	Step started	Setting Pumping (Set point: Off)
9:35:44AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	1/14/2019 9:55:55 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#41

Treatment

Surface (dm²)	0.10
Estimated duration	0.97

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	1/14/2019 9:55:55 AM

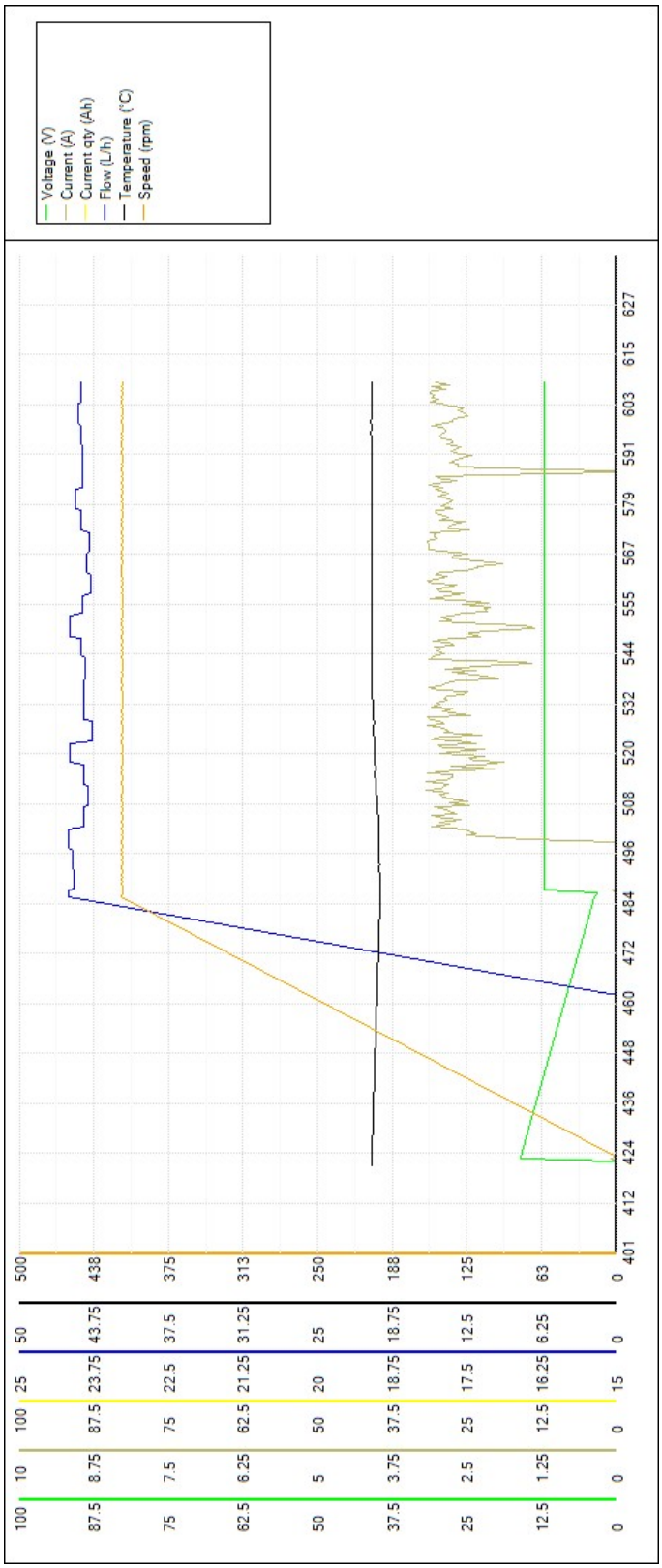
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.1 Quantity of current (mAh) :80.7 Treatment duration (min) :0:00:58	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	1/14/2019 9:55:55 AM

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (None - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 1/14/2019 9:55:55 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
401 412 424 436 448 460 472 484 496 508 520 532 544 555 567 579 591 603 615 627
0 63 125 188 250 313 375 438 500
0 6.25 12.5 18.75 25 31.25 37.5 43.75 50
0 15 0 16.25 12.5 17.5 25 18.75 37.5 20 50 21.25 62.5 23.75 87.5 25 100
0 0 1.25 2.5 3.75 5 6.25 7.5 8.75 10
0 12.5 25 37.5 50 62.5 75 87.5 100

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 9:55:55 AM

Events

Date	N°	Type	Completion
10:09:52AM	66	Step over	
10:09:52AM	66	Operating mode complete	
10:09:50AM	65	Step over	
10:09:50AM	66	Step started	Message Validate
10:09:49AM	65	Step started	Control Final
10:09:49AM	64	Step over	
10:09:48AM	64	Step started	Message Validate
10:09:48AM	63	Step over	
10:09:46AM	63	Step started	Message Validate
10:09:46AM	62	Step over	
10:09:45AM	61	Step over	
10:09:45AM	62	Step started	Message Validate
10:09:45AM	61	Step started	Message Validate
10:09:44AM	60	Step over	
10:09:43AM	60	Step started	Message Validate
10:09:43AM	59	Step over	
10:09:41AM	59	Step started	Message Validate
10:09:41AM	58	Step over	
10:09:34AM	58	Step started	Control Thickness (µm)
10:09:34AM	57	Step over	
10:09:33AM	57	Step started	Message Validate
10:09:33AM	56	Step over	
10:09:32AM	56	Step started	Control Adhesion
10:09:32AM	55	Step over	
10:09:31AM	55	Step started	Control Aspect
10:09:31AM	54	Step over	
10:09:30AM	53	Step over	
10:09:30AM	54	Step started	Message Validate
10:09:29AM	53	Step started	Message Validate
10:09:29AM	52	Step over	
10:09:28AM	52	Step started	Message Validate
10:09:28AM	51	Step over	
10:09:28AM	51	Step started	Message Validate
10:09:28AM	50	Step over	
10:06:11AM	50	Step started	Message Validate
10:06:11AM	49	Step over	
10:06:10AM	48	Step over	
10:06:10AM	49	Step started	Message Validate
10:06:09AM	48	Step started	Setting Pumping (Set point: Off)
10:06:09AM	47	Step over	
10:06:04AM	46	Step over	
10:06:04AM	47	Step started	Message Validate
10:06:04AM	46	Step started	Setting Generation (Set point: Off)
10:06:04AM	45	Step over	
10:04:02AM	44	Step over	
10:04:02AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:04:01AM	43	Step over	
10:04:01AM	44	Step started	Setting Generation (Set point: On)
10:04:01AM	42	Step over	
10:04:01AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
10:04:00AM	41	Step over	
10:04:00AM	42	Step started	Setting Polarity (Set point: Plating)
10:04:00AM	40	Step over	
10:04:00AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:04:00AM	39	Step over	
10:04:00AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 9:55:55 AM

10:04:00AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:04:00AM	38	Step over	
10:03:11AM	38	Process defect: flow lower limit reached	
10:03:05AM	38	Step started	Message Validate
10:03:05AM	37	Step over	
10:03:03AM	37	Step started	Message Validate
10:03:03AM	36	Step over	
10:03:03AM	36	Process defect: flow lower limit reached	
10:03:02AM	36	Step started	Setting Pumping (Set point: On)
10:03:02AM	35	Step over	
10:03:01AM	35	Step started	Message Validate
10:03:01AM	34	Step over	
10:02:59AM	34	Step started	Message Validate
10:02:59AM	33	Step over	
10:02:59AM	33	Step started	Setting Generation (Set point: Off)
10:02:59AM	32	Step over	
10:02:58AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:02:58AM	31	Step over	
10:02:57AM	30	Step over	
10:02:57AM	31	Step started	Setting Generation (Set point: On)
10:02:57AM	30	Step started	Setting Solution (None - Activator XF)
10:02:57AM	29	Step over	
10:02:55AM	28	Step over	
10:02:55AM	29	Step started	Message Validate
10:02:54AM	27	Step over	
10:02:54AM	28	Step started	Message Validate
10:02:53AM	26	Step over	
10:02:53AM	27	Step started	Message Validate
10:02:50AM	26	Step started	Message Validate
10:02:50AM	25	Step over	
10:01:06AM	25	Step started	Setting Surface
10:01:06AM	24	Step over	
10:01:06AM	24	Step started	Setting Pumping (Set point: Off)
10:01:06AM	23	Step over	
10:01:03AM	23	Step started	Message Validate
10:01:03AM	22	Step over	
10:01:01AM	21	Step over	
10:01:01AM	22	Step started	Message Validate
10:01:01AM	21	Step started	Setting Pumping (Set point: On)
10:01:01AM	20	Step over	
10:01:00AM	20	Step started	Message Validate
10:01:00AM	19	Step over	
10:00:58AM	18	Step over	
10:00:58AM	19	Step started	Message Validate
10:00:58AM	17	Step over	
10:00:58AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:00:57AM	17	Step started	Message Validate
10:00:57AM	16	Step over	
10:00:46AM	15	Step over	
10:00:46AM	16	Step started	Message Validate
10:00:44AM	15	Step started	Message Validate
10:00:44AM	14	Step over	
10:00:43AM	14	Step started	Message Validate
10:00:43AM	13	Step over	
10:00:41AM	13	Step started	Message Validate
10:00:41AM	12	Step over	
10:00:32AM	12	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 1/14/2019 9:55:55 AM

10:00:32AM	11	Step over	
10:00:30AM	11	Step started	Message Validate
10:00:30AM	10	Step over	
9:59:55AM	10	Step started	Message Validate
9:59:55AM	09	Step over	
9:59:52AM	09	Step started	Message Validate
9:59:52AM	08	Step over	
9:55:59AM	08	Step started	Message Validate
9:55:59AM	07	Step over	
9:55:56AM	06	Step over	
9:55:56AM	07	Step started	Message Validate
9:55:56AM	05	Step over	
9:55:56AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:55:56AM	04	Step over	
9:55:56AM	05	Step started	Setting Polarity (Set point: Anodizing)
9:55:56AM	03	Step over	
9:55:56AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:55:56AM	02	Step over	
9:55:56AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
9:55:56AM	02	Step started	Setting Generation (Set point: Off)
9:55:56AM	01	Step over	
9:55:56AM	01	Step started	Setting Pumping (Set point: Off)
9:55:55AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA HE
Creation date :	11/20/2018 10:45:33 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA HE
Part designation	#31

Treatment

Surface (dm²)	0.06
Estimated duration	0.60

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/20/2018 10:45:33 AM

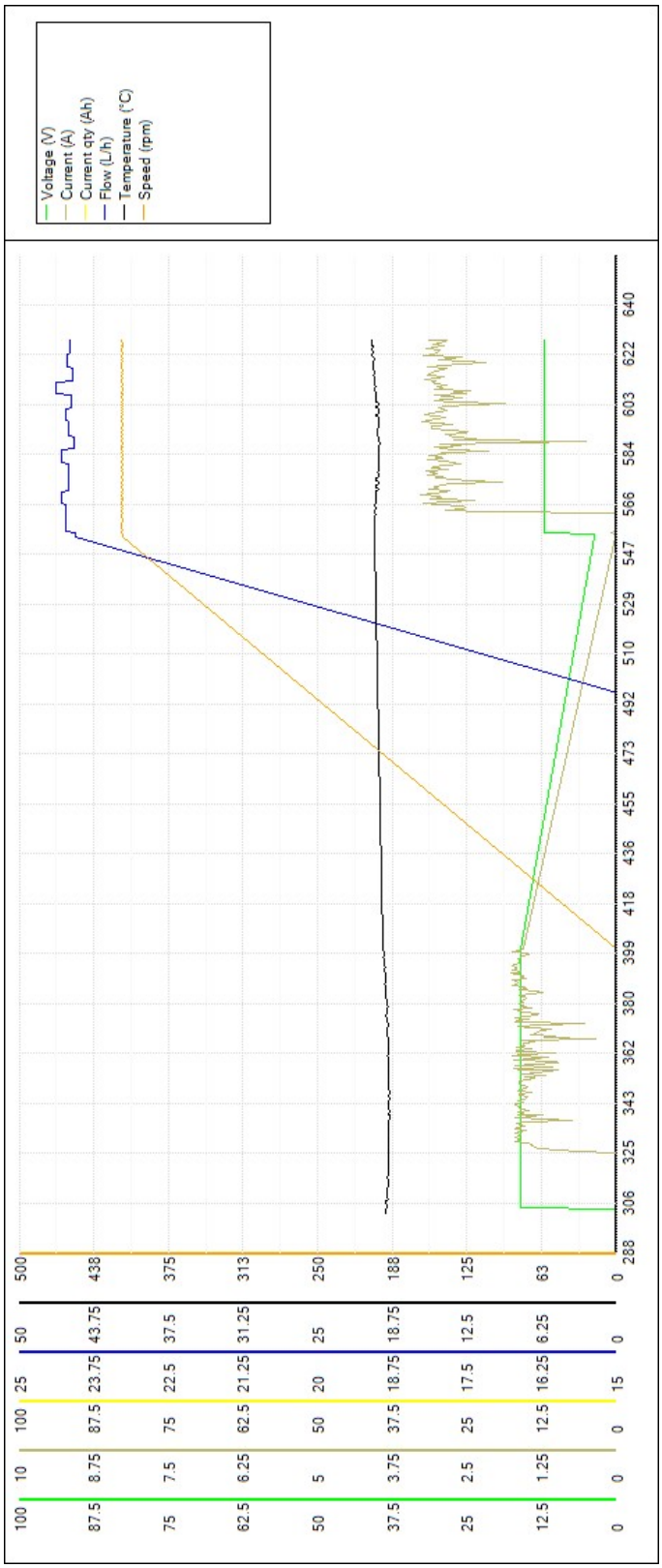
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.06 Quantity of current (mAh) :50.19 Treatment duration (min) :0:00:36	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA HE
	Creation date :	11/20/2018 10:45:33 AM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA HE **Creation date :** 11/20/2018 10:45:33 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
288 306 325 343 362 380 399 418 436 455 473 492 510 529 547 566 584 603 622 640
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/20/2018 10:45:33 AM

Events

Date	N°	Type	Completion
11:04:11AM	66	Operating mode complete	
11:04:11AM	66	Step over	
11:04:09AM	66	Step started	Message Validate
11:04:09AM	65	Step over	
11:04:06AM	65	Step started	Control Final
11:04:06AM	64	Step over	
11:04:04AM	64	Step started	Message Validate
11:04:04AM	63	Step over	
11:04:02AM	63	Step started	Message Validate
11:04:02AM	62	Step over	
11:04:00AM	62	Step started	Message Validate
11:04:00AM	61	Step over	
11:03:42AM	61	No compressed air	
11:01:26AM	61	No compressed air	
11:00:34AM	61	Step started	Message Validate
11:00:33AM	60	Step over	
11:00:30AM	59	Step over	
11:00:30AM	60	Step started	Message Validate
11:00:28AM	59	Step started	Message Validate
11:00:28AM	58	Step over	
11:00:19AM	58	Step started	Control Thickness (µm)
11:00:19AM	57	Step over	
11:00:08AM	57	Step started	Message Validate
11:00:07AM	56	Step over	
10:59:06AM	56	No compressed air	
10:57:41AM	56	No compressed air	
10:57:28AM	55	Step over	
10:57:28AM	56	Step started	Control Adhesion
10:57:24AM	55	Step started	Control Aspect
10:57:24AM	54	Step over	
10:57:19AM	54	Step started	Message Validate
10:57:19AM	53	Step over	
10:57:17AM	53	Step started	Message Validate
10:57:17AM	52	Step over	
10:57:14AM	52	Step started	Message Validate
10:57:14AM	51	Step over	
10:57:12AM	51	Step started	Message Validate
10:57:12AM	50	Step over	
10:57:10AM	49	Step over	
10:57:10AM	50	Step started	Message Validate
10:56:50AM	49	No compressed air	
10:56:47AM	49	Step started	Message Validate
10:56:47AM	48	Step over	
10:56:47AM	48	Step started	Setting Pumping (Set point: Off)
10:56:47AM	47	Step over	
10:56:03AM	46	Step over	
10:56:03AM	47	Step started	Message Validate
10:56:03AM	46	Step started	Setting Generation (Set point: Off)
10:56:03AM	45	Step over	
10:55:44AM	45	No compressed air	
10:55:09AM	45	No compressed air	
10:54:50AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:54:50AM	44	Step over	
10:54:49AM	44	Step started	Setting Generation (Set point: On)
10:54:49AM	43	Step over	
10:54:49AM	42	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/20/2018 10:45:33 AM

10:54:49AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
10:54:49AM	41	Step over	
10:54:49AM	42	Step started	Setting Polarity (Set point: Plating)
10:54:49AM	40	Step over	
10:54:49AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:54:48AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:54:48AM	39	Step over	
10:54:48AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:54:48AM	38	Step over	
10:54:07AM	38	No compressed air	
10:53:34AM	38	No compressed air	
10:52:56AM	38	Step started	Message Validate
10:52:56AM	37	Step over	
10:52:53AM	37	Step started	Message Validate
10:52:53AM	36	Step over	
10:52:53AM	35	Step over	
10:52:53AM	36	Step started	Setting Pumping (Set point: On)
10:52:43AM	35	No compressed air	
10:52:32AM	35	Step started	Message Validate
10:52:31AM	34	Step over	
10:52:17AM	33	Step over	
10:52:17AM	34	Step started	Message Validate
10:52:16AM	33	Step started	Setting Generation (Set point: Off)
10:52:16AM	32	Step over	
10:50:39AM	31	Step over	
10:50:39AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:50:38AM	30	Step over	
10:50:38AM	31	Step started	Setting Generation (Set point: On)
10:50:38AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
10:50:38AM	29	Step over	
10:50:36AM	29	Step started	Message Validate
10:50:36AM	28	Step over	
10:50:09AM	28	Step started	Message Validate
10:50:09AM	27	Step over	
10:50:06AM	26	Step over	
10:50:06AM	27	Step started	Message Validate
10:49:58AM	26	No compressed air	
10:48:54AM	26	Step started	Message Validate
10:48:54AM	25	Step over	
10:48:40AM	25	No compressed air	
10:48:37AM	25	No compressed air	
10:48:33AM	25	No compressed air	
10:48:26AM	25	No compressed air	
10:48:24AM	25	No compressed air	
10:48:05AM	25	Step started	Setting Surface
10:48:05AM	24	Step over	
10:48:05AM	24	Step started	Setting Pumping (Set point: Off)
10:48:05AM	23	Step over	
10:48:00AM	23	Step started	Message Validate
10:48:00AM	22	Step over	
10:47:21AM	22	No compressed air	
10:46:39AM	22	Process defect: flow lower limit reached	
10:46:37AM	22	Process defect: flow lower limit reached	
10:46:26AM	22	Step started	Message Validate
10:46:26AM	21	Step over	
10:46:25AM	21	Step started	Setting Pumping (Set point: On)
10:46:25AM	20	Step over	
10:46:16AM	20	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA HE
Creation date : 11/20/2018 10:45:33 AM

10:46:16AM	19	Step over	
10:46:14AM	19	No compressed air	
10:46:09AM	18	Step over	
10:46:09AM	19	Step started	Message Validate
10:46:09AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:46:09AM	17	Step over	
10:46:07AM	17	Step started	Message Validate
10:46:07AM	16	Step over	
10:46:04AM	15	Step over	
10:46:04AM	16	Step started	Message Validate
10:46:03AM	15	Step started	Message Validate
10:46:03AM	14	Step over	
10:46:01AM	14	Step started	Message Validate
10:46:01AM	13	Step over	
10:45:59AM	13	Step started	Message Validate
10:45:59AM	12	Step over	
10:45:57AM	11	Step over	
10:45:57AM	12	Step started	Message Validate
10:45:55AM	10	Step over	
10:45:55AM	11	Step started	Message Validate
10:45:54AM	09	Step over	
10:45:54AM	10	Step started	Message Validate
10:45:53AM	09	Step started	Message Validate
10:45:53AM	08	Step over	
10:45:50AM	07	Step over	
10:45:50AM	08	Step started	Message Validate
10:45:38AM	06	Step over	
10:45:38AM	07	Step started	Message Validate
10:45:38AM	05	Step over	
10:45:38AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:45:37AM	04	Step over	
10:45:37AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:45:37AM	03	Step over	
10:45:37AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:45:37AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:45:37AM	02	Step over	
10:45:37AM	02	Step started	Setting Generation (Set point: Off)
10:45:37AM	01	Step over	
10:45:36AM	01	Step started	Setting Pumping (Set point: Off)
10:45:35AM	01	Operating mode started	Boeing/IBECA HE

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/19/2019 10:10:26 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#43

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/19/2019 10:10:26 AM

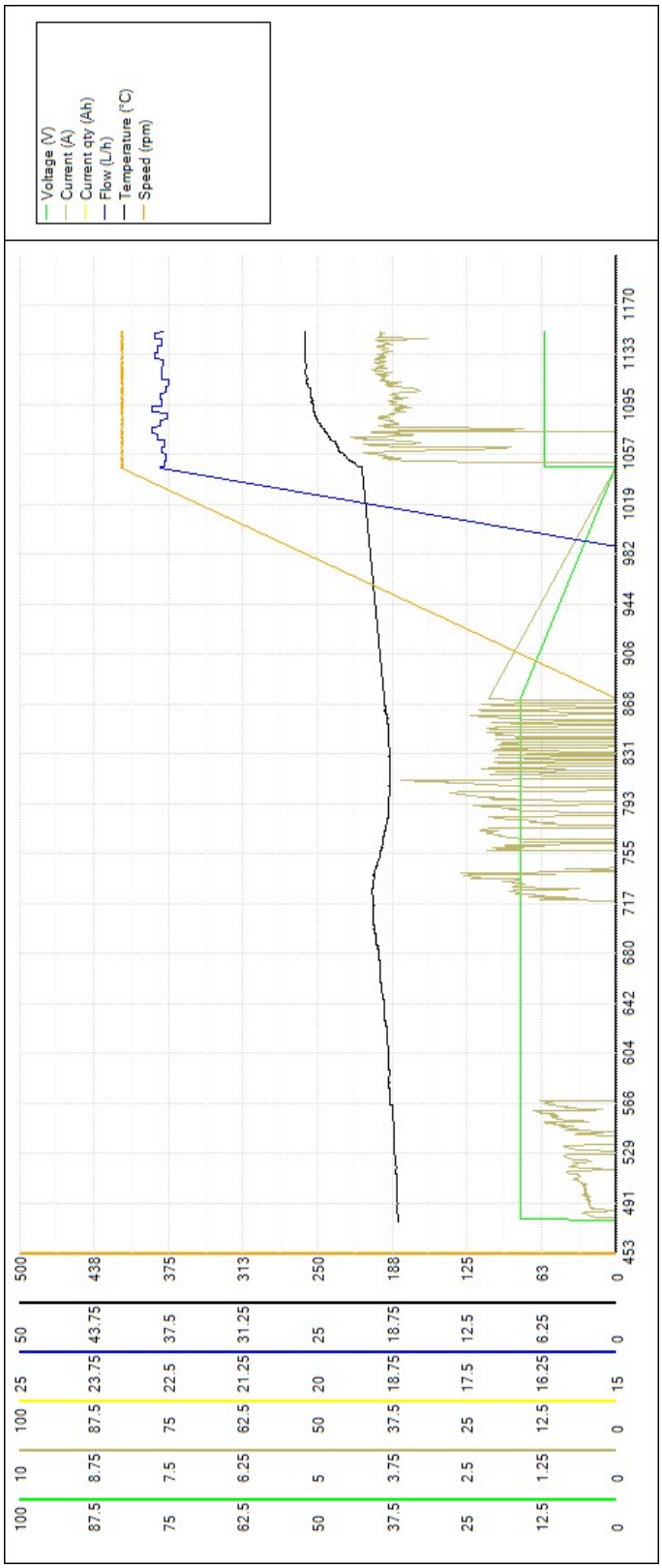
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	2/19/2019 10:10:26 AM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/19/2019 10:10:26 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
453 491 529 566 604 642 680 717 755 793 831 868 906 944 982 1019 1057 1095 1133 1170

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:10:26 AM

Events

Date	N°	Type	Completion
10:36:21AM	66	Step over	
10:36:21AM	66	Operating mode complete	
10:36:20AM	66	Step started	Message Validate
10:36:20AM	65	Step over	
10:36:18AM	65	Step started	Control Final
10:36:18AM	64	Step over	
10:36:16AM	64	Step started	Message Validate
10:36:16AM	63	Step over	
10:33:32AM	63	Step started	Message Validate
10:33:32AM	62	Step over	
10:33:31AM	62	Step started	Message Validate
10:33:31AM	61	Step over	
10:33:30AM	61	Step started	Message Validate
10:33:30AM	60	Step over	
10:33:29AM	60	Step started	Message Validate
10:33:29AM	59	Step over	
10:33:27AM	59	Step started	Message Validate
10:33:27AM	58	Step over	
10:32:42AM	57	Step over	
10:32:42AM	58	Step started	Control Thickness (µm)
10:32:40AM	57	Step started	Message Validate
10:32:40AM	56	Step over	
10:31:18AM	56	Process defect: temperature upper limit reached	
10:30:07AM	56	Step started	Control Adhesion
10:30:07AM	55	Step over	
10:30:05AM	55	Step started	Control Aspect
10:30:05AM	54	Step over	
10:30:04AM	53	Step over	
10:30:04AM	54	Step started	Message Validate
10:30:02AM	53	Step started	Message Validate
10:30:02AM	52	Step over	
10:30:01AM	52	Step started	Message Validate
10:30:01AM	51	Step over	
10:29:59AM	51	Step started	Message Validate
10:29:59AM	50	Step over	
10:29:58AM	49	Step over	
10:29:58AM	50	Step started	Message Validate
10:29:44AM	48	Step over	
10:29:44AM	49	Step started	Message Validate
10:29:44AM	48	Step started	Setting Pumping (Set point: Off)
10:29:44AM	47	Step over	
10:29:40AM	46	Step over	
10:29:40AM	47	Step started	Message Validate
10:29:39AM	46	Step started	Setting Generation (Set point: Off)
10:29:39AM	45	Step over	
10:28:06AM	45	Process defect: temperature upper limit reached	
10:27:56AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:27:56AM	44	Step over	
10:27:55AM	44	Step started	Setting Generation (Set point: On)
10:27:55AM	43	Step over	
10:27:55AM	42	Step over	
10:27:55AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
10:27:55AM	41	Step over	
10:27:55AM	42	Step started	Setting Polarity (Set point: Plating)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:10:26 AM

10:27:54AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:27:54AM	40	Step over	
10:27:54AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:27:54AM	39	Step over	
10:27:54AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:27:54AM	38	Step over	
10:27:46AM	38	Process defect: flow lower limit reached	
10:27:45AM	38	Process defect: flow lower limit reached	
10:27:37AM	38	Step started	Message Validate
10:27:37AM	37	Step over	
10:27:35AM	37	Step started	Message Validate
10:27:35AM	36	Step over	
10:27:34AM	35	Step over	
10:27:34AM	36	Step started	Setting Pumping (Set point: On)
10:25:10AM	35	Step started	Message Validate
10:25:10AM	34	Step over	
10:25:02AM	33	Step over	
10:25:02AM	34	Step started	Message Validate
10:25:02AM	33	Step started	Setting Generation (Set point: Off)
10:25:02AM	32	Step over	
10:18:27AM	31	Step over	
10:18:27AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:18:25AM	31	Step started	Setting Generation (Set point: On)
10:18:25AM	30	Step over	
10:18:25AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
10:18:25AM	29	Step over	
10:17:54AM	29	Step started	Message Validate
10:17:54AM	28	Step over	
10:17:22AM	28	Process default: temperature lower limit reached	
10:16:44AM	28	Step started	Message Validate
10:16:44AM	27	Step over	
10:13:02AM	27	Process default: temperature lower limit reached	
10:12:46AM	26	Step over	
10:12:46AM	27	Step started	Message Validate
10:12:42AM	26	Step started	Message Validate
10:12:42AM	25	Step over	
10:11:27AM	24	Step over	
10:11:27AM	25	Step started	Setting Surface
10:11:27AM	24	Step started	Setting Pumping (Set point: Off)
10:11:27AM	23	Step over	
10:11:17AM	23	Process defect: flow lower limit reached	
10:11:11AM	23	Process defect: flow lower limit reached	
10:11:02AM	23	Step started	Message Validate
10:11:02AM	22	Step over	
10:11:00AM	22	Step started	Message Validate
10:11:00AM	21	Step over	
10:10:59AM	21	Step started	Setting Pumping (Set point: On)
10:10:59AM	20	Step over	
10:10:57AM	19	Step over	
10:10:57AM	20	Step started	Message Validate
10:10:55AM	18	Step over	
10:10:55AM	19	Step started	Message Validate
10:10:55AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:10:26 AM

10:10:55AM	17	Step over	
10:10:54AM	17	Step started	Message Validate
10:10:54AM	16	Step over	
10:10:52AM	16	Step started	Message Validate
10:10:52AM	15	Step over	
10:10:51AM	15	Step started	Message Validate
10:10:50AM	14	Step over	
10:10:49AM	14	Step started	Message Validate
10:10:49AM	13	Step over	
10:10:47AM	13	Step started	Message Validate
10:10:47AM	12	Step over	
10:10:46AM	11	Step over	
10:10:46AM	12	Step started	Message Validate
10:10:46AM	11	Step started	Message Validate
10:10:46AM	10	Step over	
10:10:45AM	10	Step started	Message Validate
10:10:45AM	09	Step over	
10:10:44AM	09	Step started	Message Validate
10:10:43AM	08	Step over	
10:10:41AM	07	Step over	
10:10:41AM	08	Step started	Message Validate
10:10:34AM	06	Step over	
10:10:34AM	07	Step started	Message Validate
10:10:34AM	05	Step over	
10:10:34AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:10:33AM	04	Step over	
10:10:33AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:10:33AM	03	Step over	
10:10:33AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:10:33AM	02	Step over	
10:10:33AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:10:33AM	02	Step started	Setting Generation (Set point: Off)
10:10:33AM	01	Step over	
10:10:31AM	01	Step started	Setting Pumping (Set point: Off)
10:10:31AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/11/2019 8:53:59 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#44

Treatment

Surface (dm²)	0.10
Estimated duration	0.97

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/11/2019 8:53:59 AM

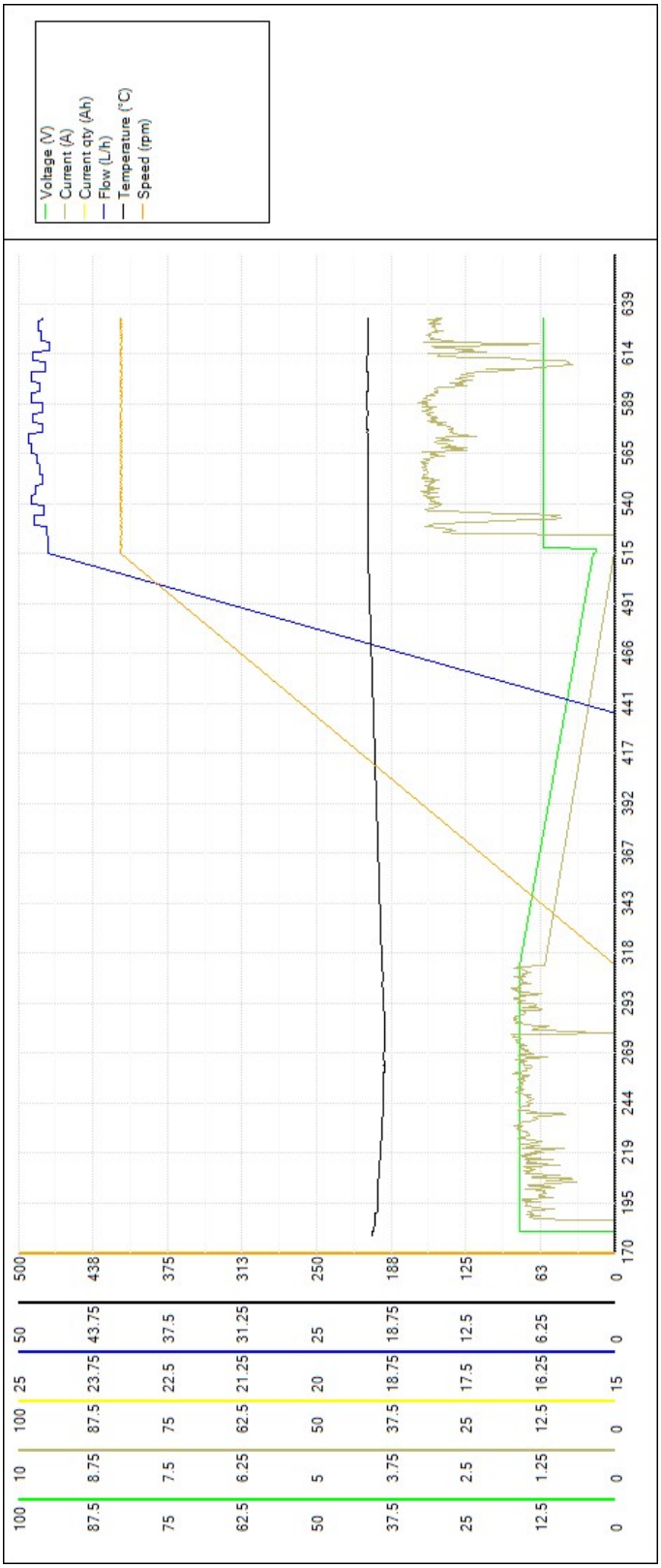
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.1 Quantity of current (mAh) :80.7 Treatment duration (min) :0:00:58	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	2/11/2019 8:53:59 AM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/11/2019 8:53:59 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
170 195 219 244 269 293 318 343 367 392 417 441 466 491 515 540 565 589 614 639

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 8:53:59 AM

Events

Date	N°	Type	Completion
9:11:51AM	66	Operating mode complete	
9:11:51AM	66	Step over	
9:11:50AM	66	Step started	Message Validate
9:11:50AM	65	Step over	
9:11:49AM	65	Step started	Control Final
9:11:49AM	64	Step over	
9:11:47AM	64	Step started	Message Validate
9:11:47AM	63	Step over	
9:11:46AM	63	Step started	Message Validate
9:11:46AM	62	Step over	
9:11:44AM	61	Step over	
9:11:44AM	62	Step started	Message Validate
9:11:43AM	60	Step over	
9:11:43AM	61	Step started	Message Validate
9:11:42AM	60	Step started	Message Validate
9:11:42AM	59	Step over	
9:11:40AM	59	Step started	Message Validate
9:11:40AM	58	Step over	
9:11:31AM	58	Step started	Control Thickness (µm)
9:11:31AM	57	Step over	
9:11:28AM	57	Step started	Message Validate
9:11:28AM	56	Step over	
9:05:09AM	56	Step started	Control Adhesion
9:05:09AM	55	Step over	
9:05:07AM	55	Step started	Control Aspect
9:05:07AM	54	Step over	
9:05:05AM	53	Step over	
9:05:05AM	54	Step started	Message Validate
9:05:04AM	52	Step over	
9:05:04AM	53	Step started	Message Validate
9:05:02AM	52	Step started	Message Validate
9:05:02AM	51	Step over	
9:04:45AM	51	Step started	Message Validate
9:04:45AM	50	Step over	
9:04:43AM	50	Step started	Message Validate
9:04:43AM	49	Step over	
9:04:40AM	48	Step over	
9:04:40AM	49	Step started	Message Validate
9:04:40AM	48	Step started	Setting Pumping (Set point: Off)
9:04:40AM	47	Step over	
9:04:35AM	46	Step over	
9:04:35AM	47	Step started	Message Validate
9:04:34AM	46	Step started	Setting Generation (Set point: Off)
9:04:34AM	45	Step over	
9:02:39AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
9:02:39AM	44	Step over	
9:02:38AM	43	Step over	
9:02:38AM	44	Step started	Setting Generation (Set point: On)
9:02:38AM	42	Step over	
9:02:38AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
9:02:37AM	41	Step over	
9:02:37AM	42	Step started	Setting Polarity (Set point: Plating)
9:02:37AM	40	Step over	
9:02:37AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:02:37AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
9:02:37AM	39	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 8:53:59 AM

9:02:37AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:02:37AM	38	Step over	
9:00:52AM	38	Low level	
9:00:02AM	38	Step started	Message Validate
9:00:01AM	37	Step over	
8:59:44AM	37	Process defect: flow lower limit reached	
8:59:39AM	37	Process defect: flow lower limit reached	
8:59:35AM	37	Step started	Message Validate
8:59:35AM	36	Step over	
8:59:34AM	36	Step started	Setting Pumping (Set point: On)
8:59:34AM	35	Step over	
8:59:32AM	35	Step started	Message Validate
8:59:32AM	34	Step over	
8:59:15AM	34	Step started	Message Validate
8:59:15AM	33	Step over	
8:59:14AM	33	Step started	Setting Generation (Set point: Off)
8:59:14AM	32	Step over	
8:57:02AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
8:57:02AM	31	Step over	
8:57:01AM	31	Step started	Setting Generation (Set point: On)
8:57:01AM	30	Step over	
8:57:00AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
8:57:00AM	29	Step over	
8:56:58AM	29	Step started	Message Validate
8:56:58AM	28	Step over	
8:56:07AM	28	Step started	Message Validate
8:56:07AM	27	Step over	
8:56:04AM	26	Step over	
8:56:04AM	27	Step started	Message Validate
8:56:02AM	26	Step started	Message Validate
8:56:01AM	25	Step over	
8:54:42AM	25	Step started	Setting Surface
8:54:42AM	24	Step over	
8:54:42AM	24	Step started	Setting Pumping (Set point: Off)
8:54:41AM	23	Step over	
8:54:39AM	22	Step over	
8:54:39AM	23	Step started	Message Validate
8:54:39AM	22	Step started	Message Validate
8:54:39AM	21	Step over	
8:54:38AM	21	Step started	Setting Pumping (Set point: On)
8:54:38AM	20	Step over	
8:54:36AM	19	Step over	
8:54:36AM	20	Step started	Message Validate
8:54:35AM	19	Step started	Message Validate
8:54:35AM	18	Step over	
8:54:35AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:54:35AM	17	Step over	
8:54:33AM	16	Step over	
8:54:33AM	17	Step started	Message Validate
8:54:32AM	15	Step over	
8:54:32AM	16	Step started	Message Validate
8:54:30AM	14	Step over	
8:54:30AM	15	Step started	Message Validate
8:54:29AM	14	Step started	Message Validate
8:54:29AM	13	Step over	
8:54:27AM	13	Step started	Message Validate
8:54:27AM	12	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 8:53:59 AM

8:54:25AM	12	Step started	Message Validate
8:54:25AM	11	Step over	
8:54:24AM	10	Step over	
8:54:24AM	11	Step started	Message Validate
8:54:23AM	09	Step over	
8:54:23AM	10	Step started	Message Validate
8:54:21AM	09	Step started	Message Validate
8:54:21AM	08	Step over	
8:54:16AM	07	Step over	
8:54:16AM	08	Step started	Message Validate
8:54:07AM	07	Step started	Message Validate
8:54:07AM	06	Step over	
8:54:07AM	05	Step over	
8:54:07AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:54:07AM	04	Step over	
8:54:07AM	05	Step started	Setting Polarity (Set point: Anodizing)
8:54:07AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:54:07AM	03	Step over	
8:54:06AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
8:54:06AM	02	Step over	
8:54:06AM	01	Step over	
8:54:06AM	02	Step started	Setting Generation (Set point: Off)
8:54:05AM	01	Step started	Setting Pumping (Set point: Off)
8:54:04AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/11/2019 9:12:58 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#45

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	20160002-HE	1.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/11/2019 9:12:58 AM

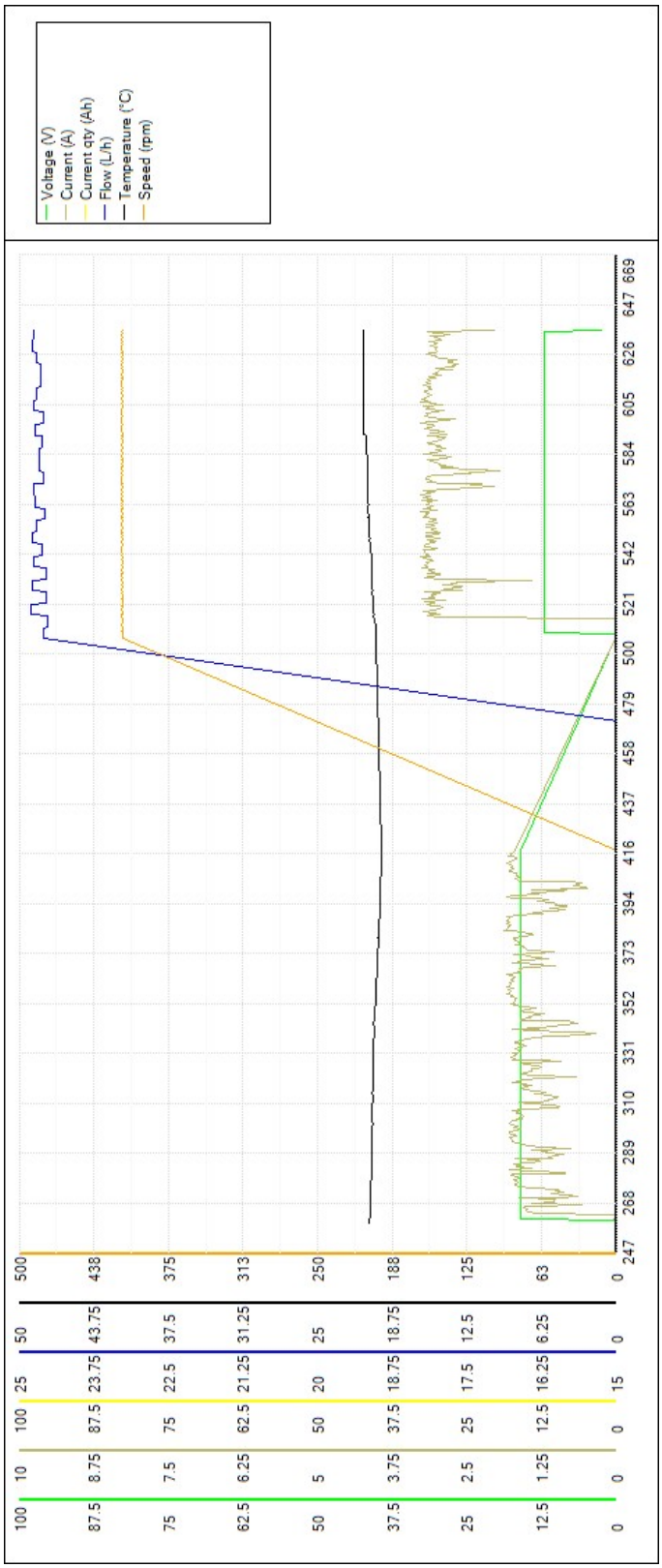
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	2/11/2019 9:12:58 AM

	Message Validate	
30	Activator XF Setting Setting Solution (20160002-HE - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/11/2019 9:12:58 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
247 268 289 310 331 352 373 394 416 437 458 479 500 521 542 563 584 605 626 647 669

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 9:12:58 AM

Events

Date	N°	Type	Completion
9:26:28AM	66	Step over	
9:26:28AM	66	Operating mode complete	
9:26:26AM	65	Step over	
9:26:26AM	66	Step started	Message Validate
9:26:23AM	65	Step started	Control Final
9:26:23AM	64	Step over	
9:26:21AM	64	Step started	Message Validate
9:26:21AM	63	Step over	
9:26:20AM	63	Step started	Message Validate
9:26:19AM	62	Step over	
9:26:16AM	62	Step started	Message Validate
9:26:16AM	61	Step over	
9:26:14AM	61	Step started	Message Validate
9:26:14AM	60	Step over	
9:26:13AM	60	Step started	Message Validate
9:26:13AM	59	Step over	
9:26:11AM	59	Step started	Message Validate
9:26:11AM	58	Step over	
9:26:04AM	57	Step over	
9:26:04AM	58	Step started	Control Thickness (µm)
9:26:03AM	57	Step started	Message Validate
9:26:03AM	56	Step over	
9:26:02AM	56	Step started	Control Adhesion
9:26:01AM	55	Step over	
9:26:01AM	54	Step over	
9:26:01AM	55	Step started	Control Aspect
9:26:00AM	54	Step started	Message Validate
9:26:00AM	53	Step over	
9:26:00AM	52	Step over	
9:26:00AM	53	Step started	Message Validate
9:25:59AM	51	Step over	
9:25:59AM	52	Step started	Message Validate
9:25:58AM	51	Step started	Message Validate
9:25:58AM	50	Step over	
9:25:56AM	49	Step over	
9:25:56AM	50	Step started	Message Validate
9:23:42AM	48	Step over	
9:23:42AM	49	Step started	Message Validate
9:23:41AM	48	Step started	Setting Pumping (Set point: Off)
9:23:41AM	47	Step over	
9:23:36AM	47	Step started	Message Validate
9:23:36AM	46	Step over	
9:23:36AM	46	Step started	Setting Generation (Set point: Off)
9:23:36AM	45	Step over	
9:21:27AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
9:21:27AM	44	Step over	
9:21:26AM	43	Step over	
9:21:26AM	44	Step started	Setting Generation (Set point: On)
9:21:25AM	42	Step over	
9:21:25AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
9:21:25AM	41	Step over	
9:21:25AM	42	Step started	Setting Polarity (Set point: Plating)
9:21:25AM	40	Step over	
9:21:25AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:21:25AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
9:21:25AM	39	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 9:12:58 AM

9:21:25AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:21:24AM	38	Step over	
9:20:24AM	38	Process defect: flow lower limit reached	
9:20:18AM	38	Step started	Message Validate
9:20:18AM	37	Step over	
9:20:16AM	37	Step started	Message Validate
9:20:16AM	36	Step over	
9:20:16AM	36	Process defect: flow lower limit reached	
9:20:16AM	36	Step started	Setting Pumping (Set point: On)
9:20:16AM	35	Step over	
9:20:13AM	35	Step started	Message Validate
9:20:13AM	34	Step over	
9:19:56AM	33	Step over	
9:19:56AM	34	Step started	Message Validate
9:19:56AM	33	Step started	Setting Generation (Set point: Off)
9:19:56AM	32	Step over	
9:17:20AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
9:17:20AM	31	Step over	
9:17:19AM	30	Step over	
9:17:19AM	31	Step started	Setting Generation (Set point: On)
9:17:18AM	30	Step started	Setting Solution (20160002-HE - Activator XF)
9:17:18AM	29	Step over	
9:17:16AM	29	Step started	Message Validate
9:17:16AM	28	Step over	
9:16:54AM	28	Step started	Message Validate
9:16:53AM	27	Step over	
9:16:52AM	27	Step started	Message Validate
9:16:52AM	26	Step over	
9:16:49AM	26	Step started	Message Validate
9:16:48AM	25	Step over	
9:13:18AM	24	Step over	
9:13:18AM	25	Step started	Setting Surface
9:13:18AM	24	Step started	Setting Pumping (Set point: Off)
9:13:18AM	23	Step over	
9:13:16AM	23	Step started	Message Validate
9:13:16AM	22	Step over	
9:13:14AM	21	Step over	
9:13:14AM	22	Step started	Message Validate
9:13:14AM	21	Step started	Setting Pumping (Set point: On)
9:13:14AM	20	Step over	
9:13:12AM	20	Step started	Message Validate
9:13:12AM	19	Step over	
9:13:10AM	19	Step started	Message Validate
9:13:10AM	18	Step over	
9:13:10AM	17	Step over	
9:13:10AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
9:13:09AM	17	Step started	Message Validate
9:13:09AM	16	Step over	
9:13:09AM	15	Step over	
9:13:09AM	16	Step started	Message Validate
9:13:08AM	15	Step started	Message Validate
9:13:08AM	14	Step over	
9:13:07AM	13	Step over	
9:13:07AM	14	Step started	Message Validate
9:13:06AM	13	Step started	Message Validate
9:13:06AM	12	Step over	
9:13:05AM	12	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 9:12:58 AM

9:13:05AM	11	Step over	
9:13:05AM	11	Step started	Message Validate
9:13:04AM	10	Step over	
9:13:04AM	09	Step over	
9:13:04AM	10	Step started	Message Validate
9:13:03AM	09	Step started	Message Validate
9:13:03AM	08	Step over	
9:13:02AM	07	Step over	
9:13:02AM	08	Step started	Message Validate
9:13:00AM	07	Step started	Message Validate
9:13:00AM	06	Step over	
9:13:00AM	05	Step over	
9:13:00AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:13:00AM	04	Step over	
9:13:00AM	05	Step started	Setting Polarity (Set point: Anodizing)
9:13:00AM	03	Step over	
9:13:00AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:13:00AM	02	Step over	
9:13:00AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
9:12:59AM	01	Step over	
9:12:59AM	02	Step started	Setting Generation (Set point: Off)
9:12:59AM	01	Step started	Setting Pumping (Set point: Off)
9:12:59AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/19/2019 10:37:49 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#46

Treatment

Surface (dm²)	0.12
Estimated duration	1.21

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/19/2019 10:37:49 AM

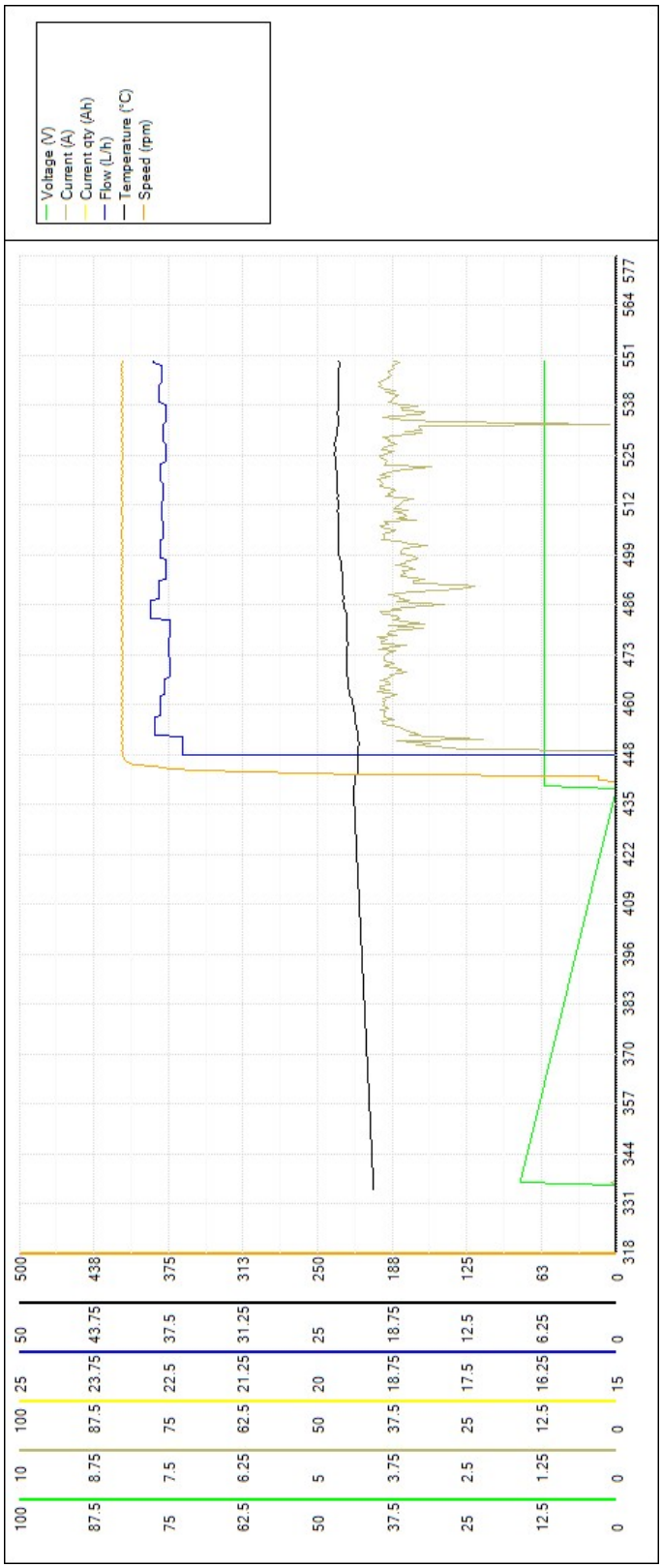
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :100.67 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	2/19/2019 10:37:49 AM

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (None - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/19/2019 10:37:49 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
318 331 344 357 370 383 396 409 422 435 448 460 473 486 499 512 525 538 551 564 577
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:37:49 AM

Events

Date	N°	Type	Completion
10:52:51AM	66	Step over	
10:52:51AM	66	Operating mode complete	
10:52:50AM	66	Step started	Message Validate
10:52:50AM	65	Step over	
10:52:49AM	65	Step started	Control Final
10:52:49AM	64	Step over	
10:52:48AM	64	Step started	Message Validate
10:52:48AM	63	Step over	
10:52:45AM	63	Step started	Message Validate
10:52:45AM	62	Step over	
10:50:30AM	62	Step started	Message Validate
10:50:30AM	61	Step over	
10:50:28AM	61	Step started	Message Validate
10:50:28AM	60	Step over	
10:50:26AM	60	Step started	Message Validate
10:50:26AM	59	Step over	
10:50:24AM	59	Step started	Message Validate
10:50:24AM	58	Step over	
10:50:13AM	58	Process default: temperature lower limit reached	
10:50:11AM	58	Step started	Control Thickness (µm)
10:50:11AM	57	Step over	
10:50:10AM	57	Step started	Message Validate
10:50:10AM	56	Step over	
10:50:07AM	55	Step over	
10:50:07AM	56	Step started	Control Adhesion
10:50:06AM	54	Step over	
10:50:06AM	55	Step started	Control Aspect
10:50:05AM	54	Step started	Message Validate
10:50:05AM	53	Step over	
10:50:04AM	53	Step started	Message Validate
10:50:04AM	52	Step over	
10:48:52AM	52	Process default: temperature lower limit reached	
10:47:24AM	52	Process defect: temperature upper limit reached	
10:47:11AM	51	Step over	
10:47:11AM	52	Step started	Message Validate
10:47:10AM	51	Step started	Message Validate
10:47:10AM	50	Step over	
10:47:08AM	50	Step started	Message Validate
10:47:08AM	49	Step over	
10:47:06AM	48	Step over	
10:47:06AM	49	Step started	Message Validate
10:47:06AM	48	Step started	Setting Pumping (Set point: Off)
10:47:06AM	47	Step over	
10:47:00AM	46	Step over	
10:47:00AM	47	Step started	Message Validate
10:47:00AM	46	Step started	Setting Generation (Set point: Off)
10:46:59AM	45	Step over	
10:45:36AM	45	Process defect: temperature upper limit reached	
10:45:09AM	44	Step over	
10:45:09AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:45:07AM	43	Step over	
10:45:07AM	44	Step started	Setting Generation (Set point: On)

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:37:49 AM

10:45:07AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
10:45:07AM	42	Step over	
10:45:07AM	41	Step over	
10:45:07AM	42	Step started	Setting Polarity (Set point: Plating)
10:45:07AM	40	Step over	
10:45:07AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:45:07AM	40	Process defect: temperature upper limit reached	
10:45:07AM	39	Step over	
10:45:07AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:43:54AM	39	Process defect: temperature upper limit reached	
10:43:51AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:43:51AM	38	Step over	
10:43:40AM	38	Process defect: flow lower limit reached	
10:43:33AM	38	Step started	Message Validate
10:43:33AM	37	Step over	
10:43:31AM	36	Step over	
10:43:31AM	37	Step started	Message Validate
10:43:31AM	36	Process defect: flow lower limit reached	
10:43:31AM	36	Step started	Setting Pumping (Set point: On)
10:43:31AM	35	Step over	
10:43:29AM	35	Step started	Message Validate
10:43:29AM	34	Step over	
10:43:27AM	33	Step over	
10:43:27AM	34	Step started	Message Validate
10:43:27AM	33	Step started	Setting Generation (Set point: Off)
10:43:27AM	32	Step over	
10:43:26AM	31	Step over	
10:43:26AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:43:25AM	31	Step started	Setting Generation (Set point: On)
10:43:25AM	30	Step over	
10:43:24AM	30	Step started	Setting Solution (None - Activator XF)
10:43:24AM	29	Step over	
10:43:23AM	29	Step started	Message Validate
10:43:23AM	28	Step over	
10:43:21AM	28	Step started	Message Validate
10:43:21AM	27	Step over	
10:43:19AM	27	Step started	Message Validate
10:43:19AM	26	Step over	
10:39:04AM	26	Step started	Message Validate
10:39:04AM	25	Step over	
10:38:22AM	25	Step started	Setting Surface
10:38:22AM	24	Step over	
10:38:22AM	24	Step started	Setting Pumping (Set point: Off)
10:38:21AM	23	Step over	
10:38:19AM	23	Step started	Message Validate
10:38:19AM	22	Step over	
10:38:12AM	21	Step over	
10:38:12AM	22	Step started	Message Validate
10:38:12AM	21	Step started	Setting Pumping (Set point: On)
10:38:12AM	20	Step over	
10:38:09AM	20	Step started	Message Validate
10:38:09AM	19	Step over	
10:38:06AM	18	Step over	
10:38:06AM	19	Step started	Message Validate
10:38:06AM	17	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:37:49 AM

10:38:06AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:38:05AM	17	Step started	Message Validate
10:38:05AM	16	Step over	
10:38:02AM	15	Step over	
10:38:02AM	16	Step started	Message Validate
10:38:01AM	14	Step over	
10:38:01AM	15	Step started	Message Validate
10:38:00AM	14	Step started	Message Validate
10:38:00AM	13	Step over	
10:37:58AM	12	Step over	
10:37:58AM	13	Step started	Message Validate
10:37:57AM	11	Step over	
10:37:57AM	12	Step started	Message Validate
10:37:56AM	10	Step over	
10:37:56AM	11	Step started	Message Validate
10:37:56AM	09	Step over	
10:37:56AM	10	Step started	Message Validate
10:37:55AM	09	Step started	Message Validate
10:37:55AM	08	Step over	
10:37:53AM	07	Step over	
10:37:53AM	08	Step started	Message Validate
10:37:51AM	06	Step over	
10:37:51AM	07	Step started	Message Validate
10:37:51AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:37:51AM	05	Step over	
10:37:51AM	04	Step over	
10:37:51AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:37:51AM	03	Step over	
10:37:51AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:37:51AM	02	Step over	
10:37:51AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:37:50AM	01	Step over	
10:37:50AM	02	Step started	Setting Generation (Set point: Off)
10:37:50AM	01	Step started	Setting Pumping (Set point: Off)
10:37:50AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/11/2019 9:29:48 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#47

Treatment

Surface (dm²)	0.10
Estimated duration	0.97

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/11/2019 9:29:48 AM

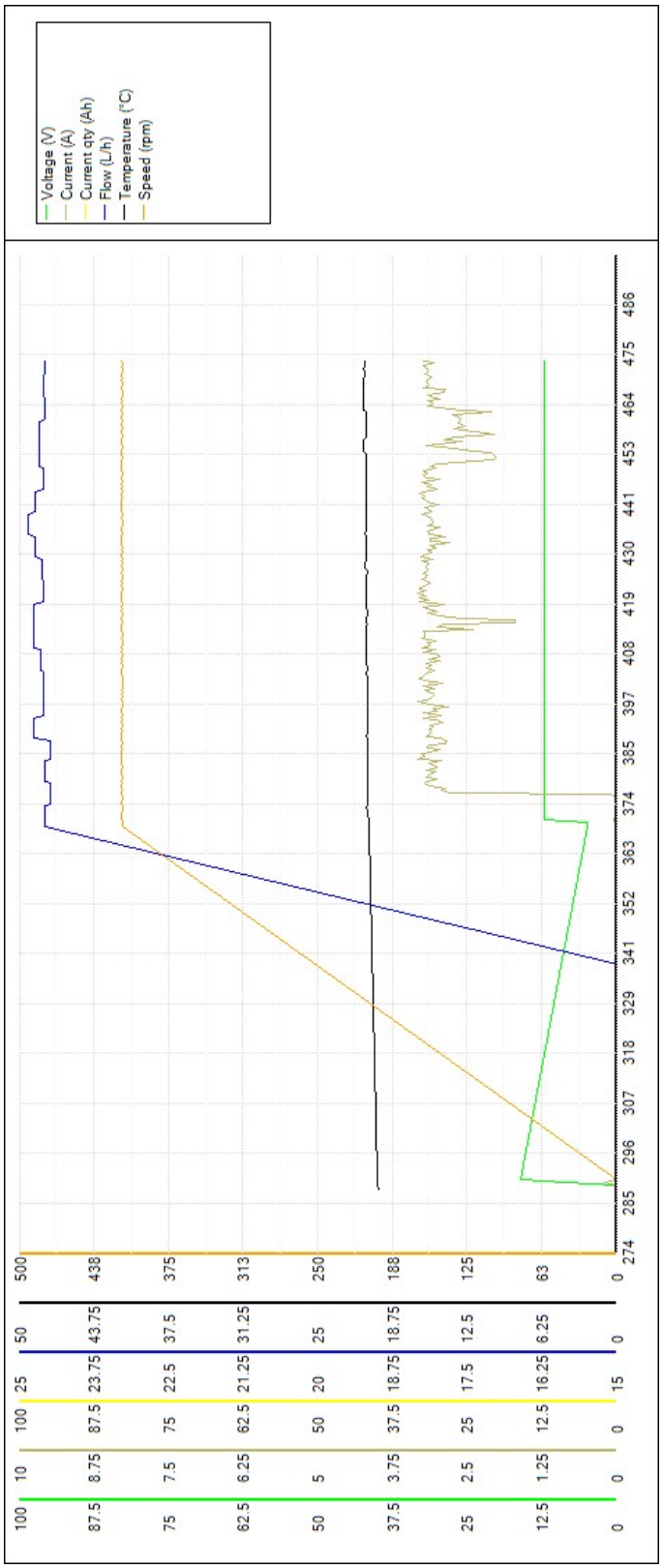
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.1 Quantity of current (mAh) :80.7 Treatment duration (min) :0:00:58	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

DALISTICK®	Treatment :	Zinc-Nickel with Dalistick tool
	Part reference :	Boeing/IBECA
	Creation date :	2/11/2019 9:29:48 AM

	Message Validate	
30	Activator XF Setting Setting Solution (None - Activator XF)	Compliant
31	Rectifier ON Setting Generation (Set point: On)	Compliant
32	Treatment Activator XF Waiting Current quantity (%) (Set point: 100)	Compliant
33	Rectifier OFF Setting Generation (Set point: Off)	Compliant
34	DKPL Dalistick tool Message Validate	Compliant
35	Stopping DKPL pump Message Validate	Compliant
36	Pump ON Setting Pumping (Set point: On)	Compliant
37	Rinsing Message Validate	Compliant
38	Wetting Message Validate	Compliant
39	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Compliant
40	Voltage setting Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	Compliant
41	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
42	Polarity setting Setting Polarity (Set point: Plating)	Compliant
43	Zinidal Aero setting Setting Solution (20160002-HE - Zinidal Aero)	Compliant
44	Rectifier ON Setting Generation (Set point: On)	Compliant
45	Zinidal Aero treatment Waiting Current quantity (%) (Set point: 100)	Compliant
46	Rectifier OFF Setting Generation (Set point: Off)	Compliant
47	Dalistick tool Message Validate	Compliant
48	Pump OFF Setting Pumping (Set point: Off)	Compliant
49	Rectifier and pump Message Validate	Compliant
50	Electrical disconnection Message Validate	Compliant
51	Rinsing Message Validate	Compliant
52	Unmasking Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/11/2019 9:29:48 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
274 285 296 307 318 329 341 352 363 374 385 397 408 419 430 441 453 464 475 486

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 9:29:48 AM

Events

Date	N°	Type	Completion
9:40:25AM	66	Step over	
9:40:25AM	66	Operating mode complete	
9:40:23AM	65	Step over	
9:40:23AM	66	Step started	Message Validate
9:40:22AM	64	Step over	
9:40:22AM	65	Step started	Control Final
9:40:20AM	64	Step started	Message Validate
9:40:20AM	63	Step over	
9:40:18AM	62	Step over	
9:40:18AM	63	Step started	Message Validate
9:40:18AM	61	Step over	
9:40:18AM	62	Step started	Message Validate
9:40:17AM	61	Step started	Message Validate
9:40:17AM	60	Step over	
9:40:16AM	60	Step started	Message Validate
9:40:16AM	59	Step over	
9:40:15AM	59	Step started	Message Validate
9:40:15AM	58	Step over	
9:40:10AM	58	Step started	Control Thickness (µm)
9:40:10AM	57	Step over	
9:40:09AM	57	Step started	Message Validate
9:40:09AM	56	Step over	
9:40:08AM	55	Step over	
9:40:08AM	56	Step started	Control Adhesion
9:40:07AM	55	Step started	Control Aspect
9:40:07AM	54	Step over	
9:40:07AM	53	Step over	
9:40:07AM	54	Step started	Message Validate
9:40:06AM	53	Step started	Message Validate
9:40:06AM	52	Step over	
9:37:54AM	51	Step over	
9:37:54AM	52	Step started	Message Validate
9:37:53AM	51	Step started	Message Validate
9:37:53AM	50	Step over	
9:37:51AM	49	Step over	
9:37:51AM	50	Step started	Message Validate
9:37:50AM	48	Step over	
9:37:50AM	49	Step started	Message Validate
9:37:49AM	48	Step started	Setting Pumping (Set point: Off)
9:37:49AM	47	Step over	
9:37:44AM	46	Step over	
9:37:44AM	47	Step started	Message Validate
9:37:43AM	46	Step started	Setting Generation (Set point: Off)
9:37:43AM	45	Step over	
9:35:59AM	44	Step over	
9:35:59AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
9:35:58AM	44	Step started	Setting Generation (Set point: On)
9:35:58AM	43	Step over	
9:35:58AM	42	Step over	
9:35:58AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
9:35:58AM	41	Step over	
9:35:58AM	42	Step started	Setting Polarity (Set point: Plating)
9:35:58AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:35:58AM	40	Step over	
9:35:58AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
9:35:58AM	39	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 9:29:48 AM

9:35:57AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:35:57AM	38	Step over	
9:34:52AM	38	Process defect: flow lower limit reached	
9:34:46AM	38	Step started	Message Validate
9:34:45AM	37	Step over	
9:34:43AM	36	Step over	
9:34:43AM	37	Step started	Message Validate
9:34:43AM	36	Process defect: flow lower limit reached	
9:34:43AM	36	Step started	Setting Pumping (Set point: On)
9:34:43AM	35	Step over	
9:34:41AM	35	Step started	Message Validate
9:34:41AM	34	Step over	
9:34:39AM	33	Step over	
9:34:39AM	34	Step started	Message Validate
9:34:39AM	32	Step over	
9:34:39AM	33	Step started	Setting Generation (Set point: Off)
9:34:38AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
9:34:38AM	31	Step over	
9:34:37AM	31	Step started	Setting Generation (Set point: On)
9:34:37AM	30	Step over	
9:34:37AM	29	Step over	
9:34:37AM	30	Step started	Setting Solution (None - Activator XF)
9:34:35AM	28	Step over	
9:34:35AM	29	Step started	Message Validate
9:34:34AM	28	Step started	Message Validate
9:34:34AM	27	Step over	
9:34:33AM	27	Step started	Message Validate
9:34:33AM	26	Step over	
9:34:31AM	26	Step started	Message Validate
9:34:31AM	25	Step over	
9:34:08AM	24	Step over	
9:34:08AM	25	Step started	Setting Surface
9:34:08AM	24	Step started	Setting Pumping (Set point: Off)
9:34:08AM	23	Step over	
9:34:04AM	23	Step started	Message Validate
9:34:04AM	22	Step over	
9:34:02AM	21	Step over	
9:34:02AM	22	Step started	Message Validate
9:34:02AM	21	Step started	Setting Pumping (Set point: On)
9:34:02AM	20	Step over	
9:33:59AM	20	Step started	Message Validate
9:33:59AM	19	Step over	
9:33:59AM	19	Step started	Message Validate
9:33:59AM	18	Step over	
9:33:59AM	17	Step over	
9:33:59AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
9:33:58AM	17	Step started	Message Validate
9:33:58AM	16	Step over	
9:33:57AM	16	Step started	Message Validate
9:33:57AM	15	Step over	
9:33:57AM	15	Step started	Message Validate
9:33:57AM	14	Step over	
9:33:55AM	14	Step started	Message Validate
9:33:55AM	13	Step over	
9:33:55AM	13	Step started	Message Validate
9:33:55AM	12	Step over	
9:33:54AM	12	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/11/2019 9:29:48 AM

9:33:54AM	11	Step over	
9:33:53AM	11	Step started	Message Validate
9:33:53AM	10	Step over	
9:33:52AM	10	Step started	Message Validate
9:33:52AM	09	Step over	
9:33:51AM	09	Step started	Message Validate
9:33:51AM	08	Step over	
9:32:20AM	08	Step started	Message Validate
9:32:20AM	07	Step over	
9:29:50AM	06	Step over	
9:29:50AM	07	Step started	Message Validate
9:29:50AM	05	Step over	
9:29:50AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:29:50AM	04	Step over	
9:29:50AM	05	Step started	Setting Polarity (Set point: Anodizing)
9:29:50AM	03	Step over	
9:29:50AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
9:29:50AM	02	Step over	
9:29:50AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
9:29:50AM	02	Step started	Setting Generation (Set point: Off)
9:29:50AM	01	Step over	
9:29:49AM	01	Step started	Setting Pumping (Set point: Off)
9:29:49AM	01	Operating mode started	Boeing/IBECA

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/19/2019 10:53:54 AM

Description

Operating mode selection

Treatment	Zinc-Nickel with Dalistick tool
Companies	UDRI - USAF
Substrate	All types of steels up to 1900 MPa
Tool type	Dalistick tool
Operating mode code	Zinidal Aero on bare or coated steel
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	Boeing/IBECA
Part designation	#48

Treatment

Surface (dm²)	0.10
Estimated duration	0.96

Electrolytes :

Electrolyte	Zinidal Aero
Lot	20160002-HE
Beaker	Zinc Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool for Zinc Nickel

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF	None	0.00	Dalistick tool for Activators
Passivateur n°3	20160001-HE	0.00	manual application

Steps

01	Pump initial setting OFF Setting Pumping (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel with Dalistick tool **Part reference :** Boeing/IBECA **Creation date :** 2/19/2019 10:53:54 AM

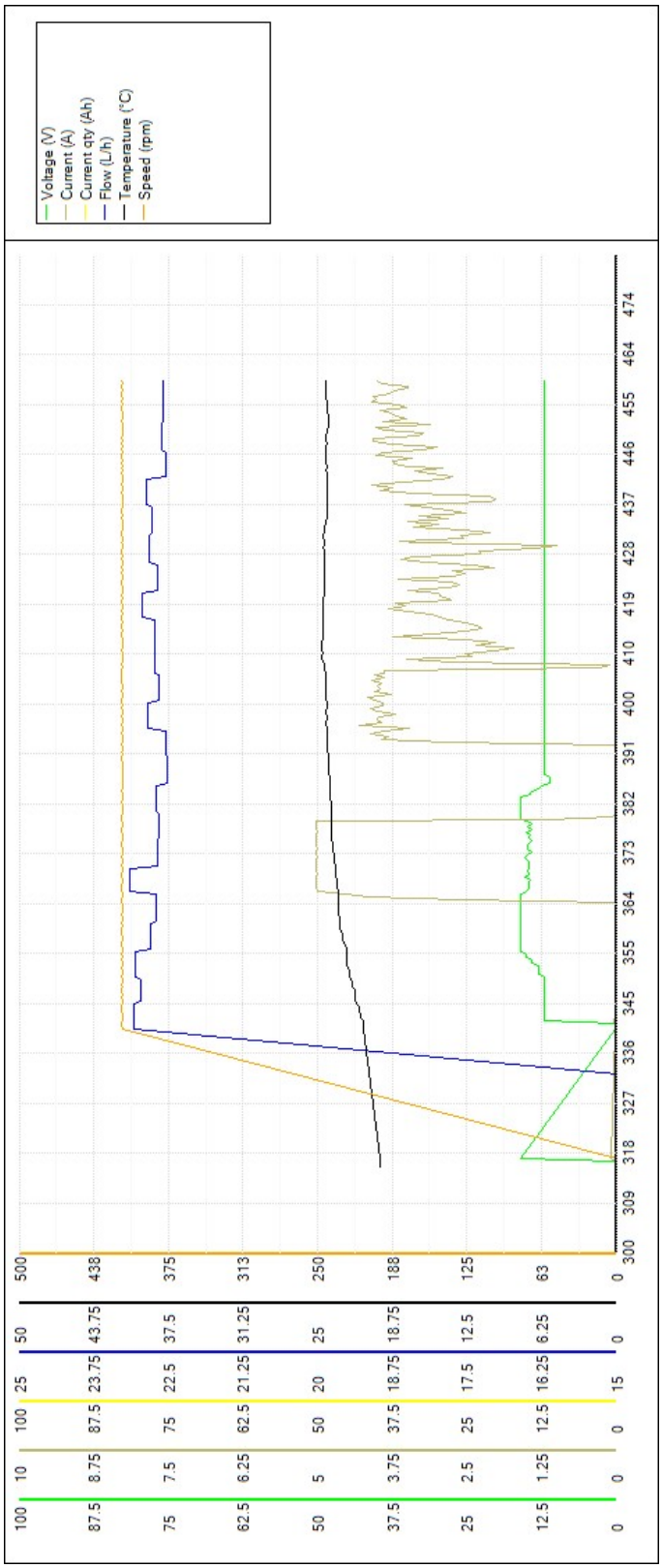
08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.1 Quantity of current (mAh) :80.04 Treatment duration (min) :0:00:58	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant
29	Information	Compliant

	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (None - Activator XF)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature stabilization	Compliant
	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (20160002-HE - Zinidal Aero)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	
52	Unmasking	Compliant
	Message Validate	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:53:54 AM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 13 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is compliant.	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Chris Venturella	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
300 309 318 327 336 345 355 364 373 382 391 400 410 419 428 437 446 455 464 474
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment :	Zinc-Nickel with Dalistick tool
Part reference :	Boeing/IBECA
Creation date :	2/19/2019 10:53:54 AM

Events

Date	N°	Type	Completion
11:07:26AM	66	Operating mode complete	
11:07:26AM	66	Step over	
11:07:22AM	66	Step started	Message Validate
11:07:22AM	65	Step over	
11:07:20AM	64	Step over	
11:07:20AM	65	Step started	Control Final
11:07:18AM	64	Step started	Message Validate
11:07:18AM	63	Step over	
11:07:16AM	63	Step started	Message Validate
11:07:16AM	62	Step over	
11:07:15AM	61	Step over	
11:07:15AM	62	Step started	Message Validate
11:07:14AM	61	Step started	Message Validate
11:07:14AM	60	Step over	
11:07:13AM	60	Step started	Message Validate
11:07:13AM	59	Step over	
11:07:11AM	59	Step started	Message Validate
11:07:11AM	58	Step over	
11:07:06AM	57	Step over	
11:07:06AM	58	Step started	Control Thickness (µm)
11:07:05AM	57	Step started	Message Validate
11:07:05AM	56	Step over	
11:07:03AM	56	Step started	Control Adhesion
11:07:03AM	55	Step over	
11:07:02AM	54	Step over	
11:07:02AM	55	Step started	Control Aspect
11:07:01AM	54	Step started	Message Validate
11:07:01AM	53	Step over	
11:06:58AM	53	Step started	Message Validate
11:06:58AM	52	Step over	
11:04:59AM	52	Process default: temperature lower limit reached	
11:04:15AM	52	Process default: temperature lower limit reached	
11:04:07AM	52	Process default: temperature lower limit reached	
11:04:07AM	52	Process default: temperature lower limit reached	
11:02:36AM	52	Process defect: temperature upper limit reached	
11:02:23AM	51	Step over	
11:02:23AM	52	Step started	Message Validate
11:02:23AM	51	Step started	Message Validate
11:02:22AM	50	Step over	
11:02:21AM	50	Step started	Message Validate
11:02:21AM	49	Step over	
11:01:57AM	49	Process defect: flow lower limit reached	
11:01:55AM	49	Process defect: flow lower limit reached	
11:01:39AM	49	Step started	Message Validate
11:01:39AM	48	Step over	
11:01:38AM	48	Step started	Setting Pumping (Set point: Off)
11:01:38AM	47	Step over	
11:01:35AM	47	Step started	Message Validate
11:01:35AM	46	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:53:54 AM

11:01:35AM	46	Step started	Setting Generation (Set point: Off)
11:01:35AM	45	Step over	
10:59:49AM	45	Process defect: temperature upper limit reached	
10:59:36AM	44	Step over	
10:59:36AM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:59:35AM	43	Step over	
10:59:35AM	44	Step started	Setting Generation (Set point: On)
10:59:35AM	42	Step over	
10:59:35AM	43	Step started	Setting Solution (20160002-HE - Zinidal Aero)
10:59:35AM	41	Step over	
10:59:35AM	42	Step started	Setting Polarity (Set point: Plating)
10:59:35AM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:59:35AM	40	Step over	
10:59:35AM	39	Step over	
10:59:35AM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:59:34AM	39	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
10:59:34AM	38	Step over	
10:59:25AM	38	Process defect: flow lower limit reached	
10:59:18AM	38	Step started	Message Validate
10:59:18AM	37	Step over	
10:59:16AM	36	Step over	
10:59:16AM	37	Step started	Message Validate
10:59:16AM	36	Process defect: flow lower limit reached	
10:59:16AM	36	Step started	Setting Pumping (Set point: On)
10:59:16AM	35	Step over	
10:59:14AM	35	Step started	Message Validate
10:59:14AM	34	Step over	
10:59:12AM	33	Step over	
10:59:12AM	34	Step started	Message Validate
10:59:12AM	33	Step started	Setting Generation (Set point: Off)
10:59:12AM	32	Step over	
10:59:11AM	31	Step over	
10:59:11AM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:59:10AM	31	Step started	Setting Generation (Set point: On)
10:59:10AM	30	Step over	
10:59:10AM	30	Step started	Setting Solution (None - Activator XF)
10:59:10AM	29	Step over	
10:59:09AM	29	Step started	Message Validate
10:59:09AM	28	Step over	
10:59:08AM	27	Step over	
10:59:08AM	28	Step started	Message Validate
10:59:07AM	26	Step over	
10:59:07AM	27	Step started	Message Validate
10:59:06AM	26	Step started	Message Validate
10:59:06AM	25	Step over	
10:54:26AM	24	Step over	
10:54:26AM	25	Step started	Setting Surface
10:54:26AM	24	Step started	Setting Pumping (Set point: Off)
10:54:25AM	23	Step over	
10:54:23AM	23	Step started	Message Validate
10:54:23AM	22	Step over	
10:54:20AM	21	Step over	
10:54:20AM	22	Step started	Message Validate
10:54:19AM	21	Step started	Setting Pumping (Set point: On)
10:54:19AM	20	Step over	
10:54:16AM	20	Step started	Message Validate
10:54:16AM	19	Step over	

DALISTICK®

Treatment : Zinc-Nickel with Dalistick tool
Part reference : Boeing/IBECA
Creation date : 2/19/2019 10:53:54 AM

10:54:13AM	19	Step started	Message Validate
10:54:13AM	18	Step over	
10:54:13AM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:54:13AM	17	Step over	
10:54:11AM	17	Step started	Message Validate
10:54:11AM	16	Step over	
10:54:09AM	16	Step started	Message Validate
10:54:08AM	15	Step over	
10:54:07AM	15	Step started	Message Validate
10:54:07AM	14	Step over	
10:54:06AM	13	Step over	
10:54:06AM	14	Step started	Message Validate
10:54:05AM	13	Step started	Message Validate
10:54:05AM	12	Step over	
10:54:03AM	11	Step over	
10:54:03AM	12	Step started	Message Validate
10:54:01AM	10	Step over	
10:54:01AM	11	Step started	Message Validate
10:54:00AM	09	Step over	
10:54:00AM	10	Step started	Message Validate
10:53:59AM	09	Step started	Message Validate
10:53:59AM	08	Step over	
10:53:57AM	07	Step over	
10:53:57AM	08	Step started	Message Validate
10:53:56AM	06	Step over	
10:53:56AM	07	Step started	Message Validate
10:53:55AM	05	Step over	
10:53:55AM	06	Step started	Setting Flow (L/h) (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:53:55AM	04	Step over	
10:53:55AM	05	Step started	Setting Polarity (Set point: Anodizing)
10:53:55AM	03	Step over	
10:53:55AM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:53:55AM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:53:55AM	02	Step over	
10:53:55AM	01	Step over	
10:53:55AM	02	Step started	Setting Generation (Set point: Off)
10:53:55AM	01	Step started	Setting Pumping (Set point: Off)
10:53:54AM	01	Operating mode started	Boeing/IBECA

Attachment No. 9 –StatisticalAnalysis Test Report for Design Of Experiment to Optimize Dalistick Zinidal Aero Brush ZnNi

Testing and Analysis for Optimizing Dalic Zinidal Aero Zinc-Nickel Brush Plating

Stephen P. Gaydos, TF and Sabyasachi (Shobbo) Basu,
TF, PhD The Boeing Company
April 8, 2019

Introduction

The following are options for test plans so that we can optimize the Dalic Zinidal Aero brush zinc-nickel (Dalic Zn-Ni) process to be a no-bake non-embrittling process for high strength steel (260 - 280 ksi UTS). Experiments were done at BR&T and UDRI (University of Dayton Research Institute) to apply Dalic Zn-Ni to high strength steel ASTM F 519 Type 1a.1 hydrogen embritlement test specimens and then carry-out an ISL (Incremental Step Load) test on the Type 1a.1 test specimens to see if they have been embrittled. The ISL process followed: 10 steps – 5% NFS / step – held for 1 hour per step followed by 10 steps – 5% NFS / step – held for 2 hour per step or until failure. A result of $\geq$ 90% NFS before failure is considered passing the test. If it fails before achieving the 90% NFS, we will record at what step the failure happened. Based on the initial experiments and on past experience, it was decided that three factors are of importance to this process and they are strike, surface prep, and activation.
A designed experiment was done to fully characterize the effects of these factors on the brush plating (with no embritlement relief baking) with the Dalic ZnNi on high strength steel.

Test Plan

The factors and levels for the test are given below

Factor Description	# Levels	Values	Comments
Strike	2	Strike or No Strike	Strike = Plate at 16V for 1 minute then finish plating at 12V. No Strike = Plate only at 12V
Surface Prep	2	Scotch Brite or Grit Blast	Use either Scotch Brite or Grit Blast to clean steel before brush plating.
Activation	2	Activation or No Activation	Activate = Apply acid anodic etch at 16V for 1 minute after abrasive cleaning and before brush plating. No Activation = Apply brush plating immediately after abrasive cleaning.
Brush Plating Site	2	BR&T and UDRI	Since brush plating is a manual operation, the test specimens will be brush plated at UDRI and BR&T to insure that results are not affected by brush plating site.

Since the number of factors is small, it was decided that full factorial (2^4) design be used with replications. Replications are important so that any unusual results from a single test run does not affect the overall results. We strongly suggest 4 replications (Total of 64 specimens, 32 at each site) but it may be okay to have only 3 replications (48 specimens, 24 at each site). But if cost is a strong factor and only 2 replications is our only option (32 specimens, 16 at each site), then we may not be able to resolve any unusual discrepancies between the replicates. The DOE was run with 48 specimens or 3 replications for each combination at each site. Each test condition was done separately and the conditions were randomized so that there is no unintentional bias affecting the results.

Three specimens at a time were sent to the testing site (IBECA) for the ISL testing. The site received specimens from BR&T and UDRI alternatively to test.

Analysis of DOE Data Collected

Data from the brush plating experiment has been collected and are given in Appendix A. As planned, there are 3 replicates for each factor combination. Note that we relabeled the values of the activation factor to reflect the process. Since the Power Supply used at BR&T (SIFCO Volts) and at UDRI (Dalicstick Amps) were different, we relabeled the Brush Plating Site with the Power Supply variable. Because, the site and the power supply used at the site are confounded, we **can't** separate the effects of the Power supply and differences in the sites. Any differences due to sites are attributed to the power supply used.

Figure 1 below gives the scatter plot of %NFS and Fracture load. Based on the data, we only analyze
%NFS as the response variable because the correlation between %NFS and Fracture Load is almost 1.

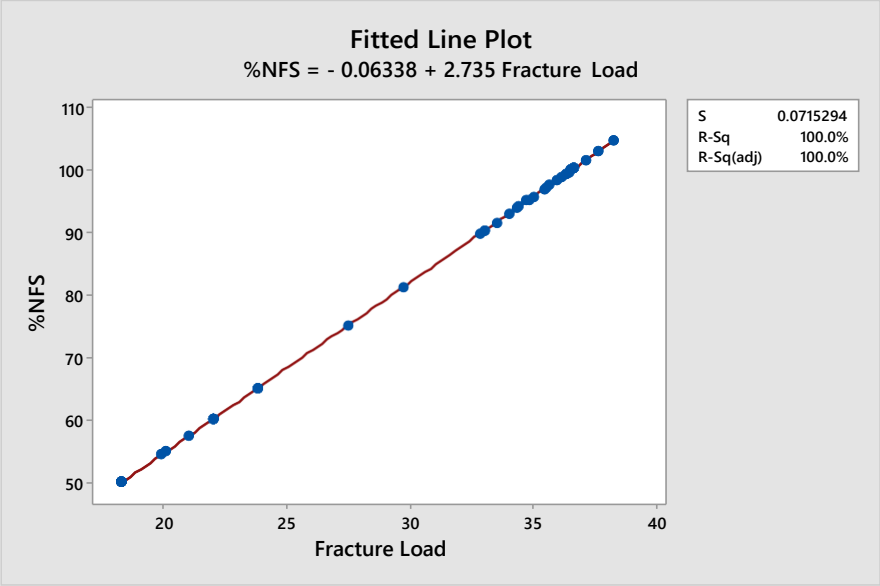


Figure 1: Scatter plot of %NFS and Fracture load along with the linear fit

Analysis of %NFS

The individual value plots for %NFS for a combination of the factors is given next in Figure 2. The individual values of %NFS are plotted for each combination of the 4 factors. This plot show the consistency of the results from one time to the next for identical combinations of settings.

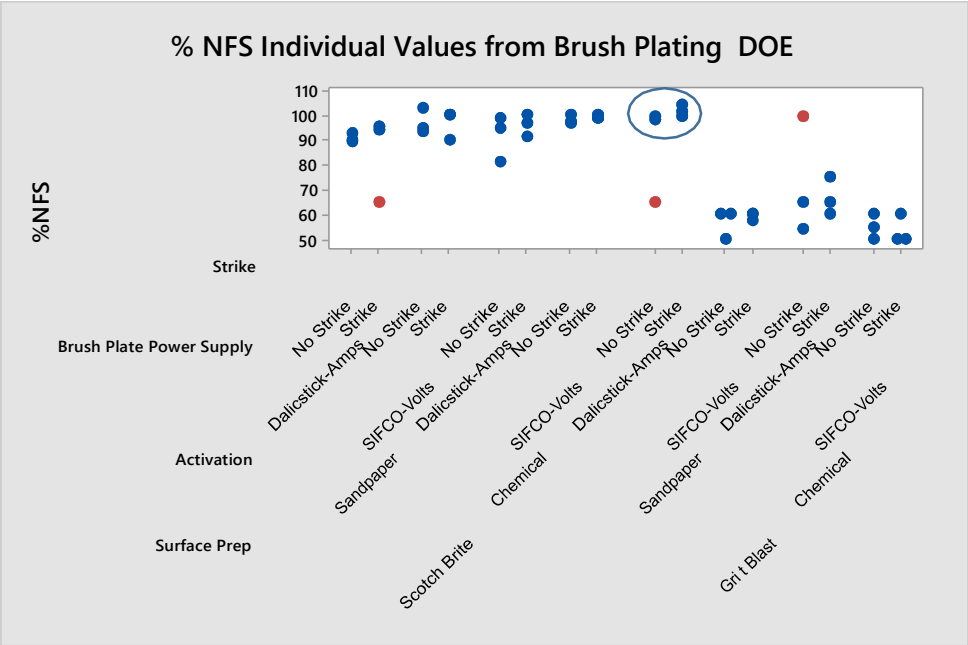


Figure 2: Individual value plots of % NFS

From the individual value plots we see the following general patterns

- Little difference in %NFS between Strike and No Strike levels
- Surface prep with Scotch Brite seems to result in higher %NFS than Grit Blast. However, the combination of Grit Blast-Chemical Activation-Dalicstick Power supply bucks the trend and have some large %NFS values. The points are circled in Figure 2.
- For a few of the factor combinations, there seems to be a lot of variability in the results. Example of these include. The unusual values are colored in Red in Figure 2.
    - No Strike – Dalicstick Amps – Chemical Activation – Grit Blast
    - No Strike – Dalicstick Amps – Sandpaper – Grit Blast
    - Strike – Dalicstick Amps – Sandpaper – Scotch Brite
- Eight %NFS values are at or above 100 with the highest value being 104.5 The combinations are given below

Specimen #	Strike	Surface Prep	Activation	Brush Plate Power Supply	Fracture Load	%NFS
48	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	38.2	104.5
20	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	37.6	102.7
38	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	37.1	101.4
17	No Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100.1
18	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100.1
44	Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.6	100.0
14	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100.0
21	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100.0

To analyze %NFS and since the maximum value is at 104.5, we decided to scale %NFS by dividing each value by 105 so that the scaled %NFS (called pNFS) is between 0 and 1. To fit a model to %NFS so that the predicted values of %NFS and its confidence bounds are between 0 and 1, we use the following transformation:

$$logitNFS = ln\left(\frac{pNFS}{1-pNFS}\right) = f(factors).$$

The individual value plots of logitNFS is given in Figure 3.

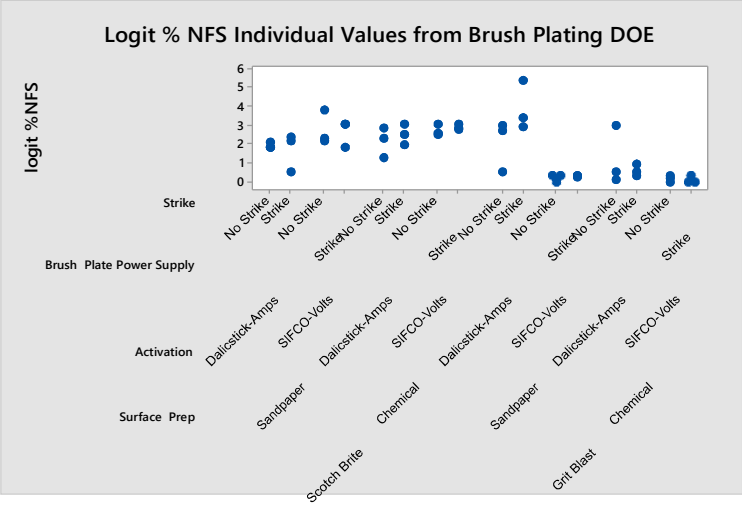


Figure 3: Individual value plots of logit % NFS

Note that in Figure 3, the unusual values of %NFS still shows as different from the other 2 of the same settings. The other observation that is slightly higher than its two other values is the largest value of
104.5. However, we don't call this data point unusual, because the other two observations had %NFS of 99,5 and 101.4.

Based on fitting all the terms in the model, the Pareto chart of the standardized effects are given in Figure 4.

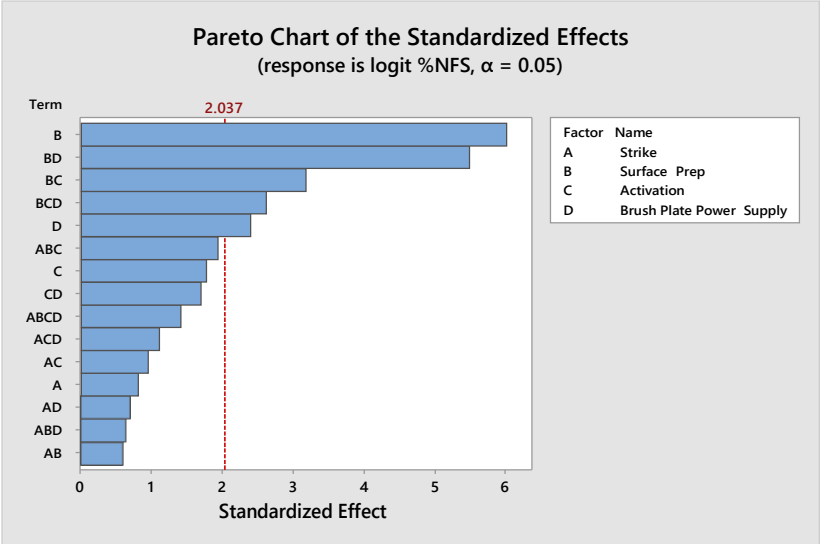


Figure 4: Pareto charts of effects of each factor and their combinations

From the Pareto chart in Figure 4 we see that Factor A (Strike/No Strike) does not have a significant effect on the results. Significance is based on the red line in the chart. A bar that goes beyond the red line is thought of as statistically significant. The main effects and the interaction plots are given next.

The main effect plots looks at the average value of the response when the level of a factor is changed from one to another. The interaction plots show the average value of the response when more than 1 factor combination changes. We display only the 2 factor interactions below in Figure 5.

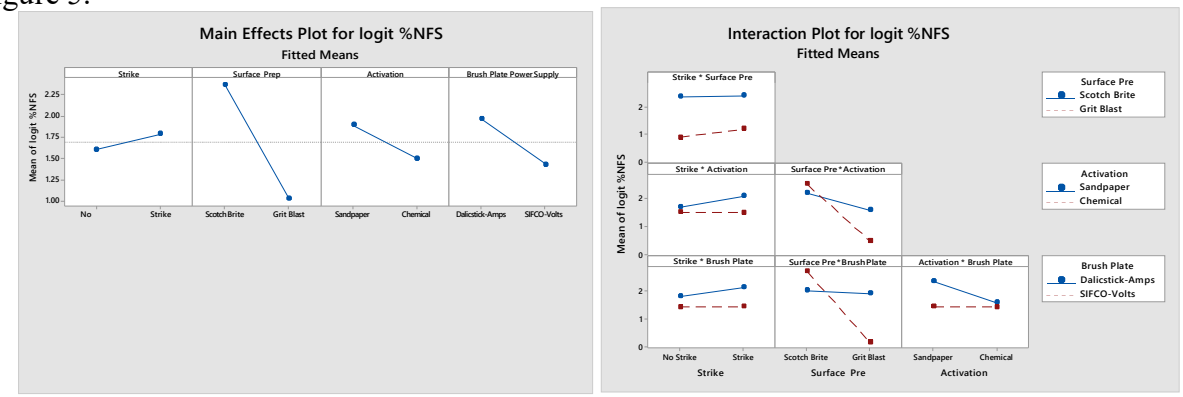


Figure 5: The Main effects and the 2-factor Interaction plots of %NFS

The main effects plots (left panel in Figure 5) show the following for each factor when averaged over all the values of the other factors:

- Strike: The %NFS increases when we Strike, but the change is not large
- Surface Prep: On average, grit blast performs much worse (lower %NFS) than scotch brite.
- Activation: Chemical activation is inferior to sandpaper activation
- Power Supply: SIFCO-Volts is inferior to Dalistick-Amps

However, the main effects plots don't tell the full story. When we study the interaction plots (right side of Figure 5) and the Pareto charts, we see that the value of %NFS can be very different depending on the combination of the variables. Here are some examples

- Looking at the Surface Prep (Factor B) and Activation (Factor C) combination (chart in position 2, 2 or middle row right) we see that for Scotch Brite surface preparation, both Sandpaper and Chemical activation perform well although the Chemical activation average value is slightly higher. However, for the Grit Blast surface prep, chemical activation performs worse than then sandpaper activation. This behavior in %NFS led to a significant BC interaction
- Looking at the Surface Prep (Factor B) and Brush Plate Power Supply (Factor D), we again see a similar patter with the Dalistick-Amps power supply having consistent values of %NFS while the SIFCO-Volts power supply performing worse for Grit Blast Surface Prep. This leads to a significant BD interaction effect.

Since many of the interaction effects are not significant, we also re-fitted the model for the logit using stepwise regression and only keeping terms that are significant at $\alpha = 0.15$. However, we included all the main effect terms in the model. The Pareto chart from this model is given in Figure 6.

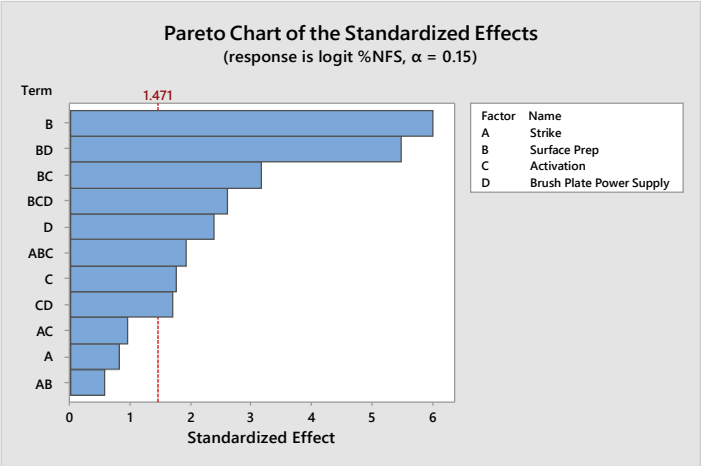


Figure 6: Pareto charts of effects for the reduced model

Note that the same terms show as being significant in this reduced model. The main effect plots and the interaction plots are given next in Figure 7.

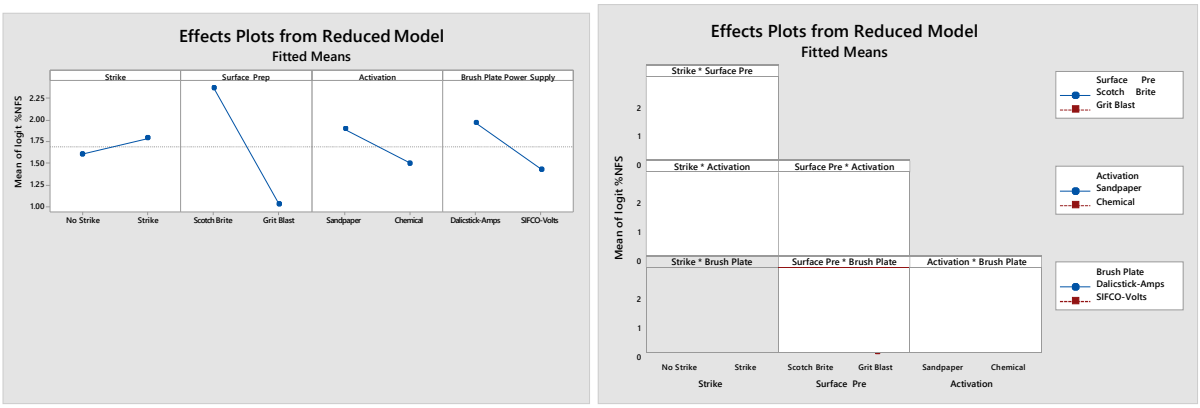


Figure 7: The Main effects and the 2-factor Interaction plots of logit %NFS from reduced model

Note that the plots and their interpretation are very similar to the full model. You will notice that the interaction plot Strike and Brush Plate Power (AD) is greyed out because that term is not in the model. The fitted model equation is

Regression Equation in Uncoded Units

logit %NFS = 1.695 + 0.091 Strike - 0.674 Surface Prep - 0.199 Activation
- 0.269 Brush Plate Power Supply + 0.065 Strike*Surface Prep
- 0.108 Strike*Activation - 0.357 Surface Prep*Activation
- 0.616 Surface Prep*Brush Plate Power Supply
+ 0.190 Activation*Brush Plate Power Supply
- 0.217 Strike*Surface Prep*Activation
+ 0.294 Surface Prep*Activation*Brush Plate Power Supply

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	11	60.7245	5.5204	9.10	0.000
Linear	4	27.5270	6.8817	11.35	0.000
Strike	1	0.3981	0.3981	0.66	0.423
Surface Prep	1	21.7729	21.7729	35.91	0.000
Activation	1	1.8924	1.8924	3.12	0.086
Brush Plate Power Supply	1	3.4636	3.4636	5.71	0.022
2-Way Interactions	5	26.8077	5.3615	8.84	0.000
Strike*Surface Prep	1	0.2051	0.2051	0.34	0.564
Strike*Activation	1	0.5563	0.5563	0.92	0.345
Surface Prep*Activation	1	6.1130	6.1130	10.08	0.003
Surface Prep*Brush Plate Power Supply	1	18.2008	18.2008	30.02	0.000
Activation*Brush Plate Power Supply	1	1.7325	1.7325	2.86	0.100
3-Way Interactions	2	6.3898	3.1949	5.27	0.010
Strike*Surface Prep*Activation	1	2.2513	2.2513	3.71	0.062
Surface Prep*Activation*Brush Plate Power Supply	1	4.1384	4.1384	6.83	0.013
Error	36	21.8272	0.6063		
Lack-of-Fit	4	2.5013	0.6253	1.04	0.404
Pure Error	32	19.3260	0.6039		
Total	47	82.5517			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.778660	73.56%	65.48%	52.99%

The R-squared is 74%, so some of the variability is not explained by the model. This inexplicable variability mostly comes from the uncertainty in the %NFS under identical conditions.

To understand which combination works we obtained the top 5 combinations, the predicted %NFS, Lower 95% Confidence Intervals and Prediction Intervals. These are given in Table 1. Note that the

$$PPffPPPPllffllPPPP\,\%llllll = 105 * \frac{pp^{llllllll}}{1 + pp^{llllllll}}$$

We multiplied by 105 to offset the scaling factor used to calculate logit value.

Table 1: The top five predicted %NFS and lower 95% confidence bounds.

				%NFS Prediction Bound		
Strike	**Surface Prep**	**Activation**	**Power Supply**	**Predicted**	**Lower 95% PI**	**Lower 95% CI**
Strike	Grit Blast	Sand Paper	Dalcstick-Amps	101.69	91.99	98.80
Strike	Scotch Brite	Chemical	SIFCO-Volts	99.55	84.81	94.97
No Strike	Scotch Brite	Sand Paper	SIFCO-Volts	98.69	82.06	93.41
No Strike	Scotch Brite	Chemical	SIFCO-Volts	97.98	80.06	92.25
Strike	Scotch Brite	Sand Paper	SIFCO-Volts	97.60	78.97	91.57

The predicted %NFS for all 5 combinations are well above 90. However, only the first option has the lower %NFS above 90. It is interesting to note that other than the first combination, the other 4 combinations are for the Power Supply SIFCO-Volts. Table 2 below gives the individual values from the DOE for each of the above combinations:

Table 2: Observed %NFS from the 5 combinations given in Table 1

Option	Factor Combination	Observed %NFS
1	Strike – Grit Blast – Sandpaper – Dalicstick_Amps	99.5, 101.4, 104.5
2	Strike – Scotch Brite – Chemical – SIFCO_Volts	98.7, 99.2, 100.0
3	No Strike – Scotch Brite – Sandpaper – SIFCO_Volts	93.7, 94.9, 102.7
4	No Strike – Scotch Brite – Chemical – SIFCO_Volts	96.8, 97.4, 100.1
5	Strike – Scotch Brite – Sandpaper – SIFCO_Volts	90.1, 100.0, 101.1

Based on the observed data and the model based on logit (%NFS), any of the top 4 combinations given in Table 2 should work. The main reason we have the 95% lower prediction limits being below 90 for options 2-4 is due to the test to test variability. Which combination works in the field will depend on the logistics. It might be worthwhile to get additional testing done on the top 4 combinations to confirm that the results are not just an artifact of the current data collection but will be consistent in the future.

Recall that in Figure 2, we saw that there were 3 combinations where one of the data points were very different from the other 2 values for the same combinations. These were

- No Strike – Dalicstick Amps – Chemical Activation – Grit Blast: % NFS values are 54.4, 65.0 and 99.8; 99.8 value will be ignored
- No Strike – Dalicstick Amps – Sandpaper – Grit Blast: %NFS values are 65.0, 98.1 and 99.8; 65.0 value will be ignored
- Strike – Dalicstick Amps – Sandpaper – Scotch Brite: %NFS values are 65.0, 94.0 and 95.6; 65.0 value will be ignored

After deleting the 3 points, we refit the data using stepwise regression keeping only the statistically significant effects and interactions. The Pareto chart from this fit is given in

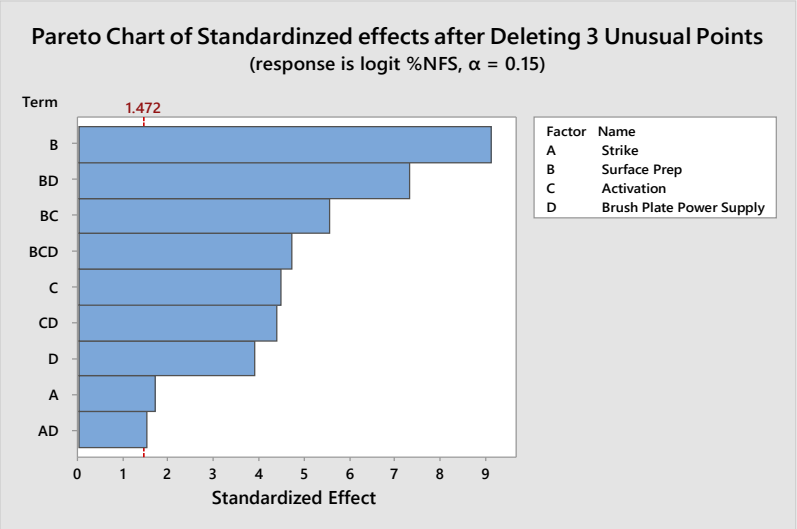


Figure 8.

Figure 8: Pareto charts of effects for the reduced model with 3 unusual data points not included

Comparing Figure 8 to Figure 6, we see that the models are very similar except that interaction AB and AC that were in the previous reduced model in not in this model, but interaction AD is not present. Also note that AB and AC the least significant terms before and AD is the least significant term in the model with deleted observations.

The main effects and the interaction plots from this model with 3 deleted points are given in Figure 9.

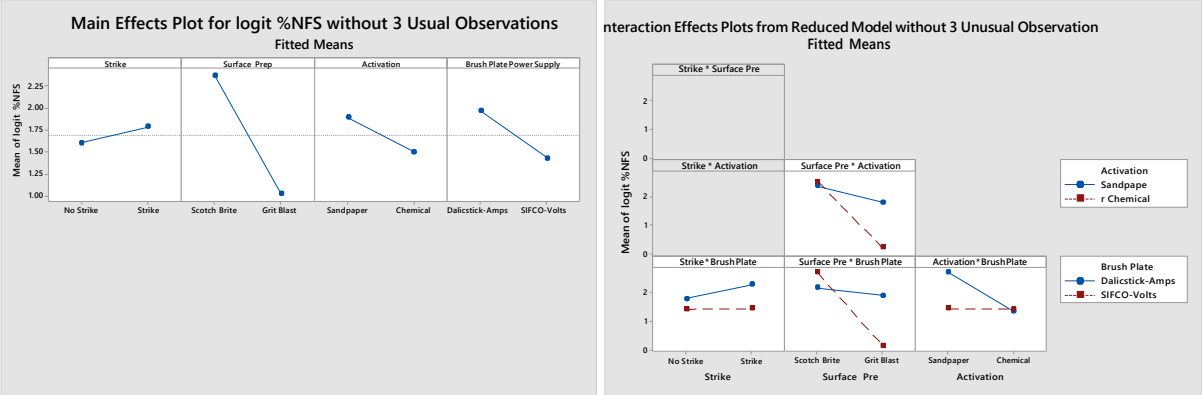


Figure 9: The Main effects and the 2-factor Interaction plots of logit %NFS from reduced model and 3 unusual observations deleted

The interpretations are similar as before except that in Figure 9 interaction plots, we have a significant Strike and Power Supply (AD) interaction as evidenced by the non-parallel nature of the two lines.

The model fit in given next

Regression Equation in Uncoded Units

logit %NFS = 1.7300 + 0.1325 Strike - 0.7150 Surface Prep - 0.3504 Activation
- 0.3035 Brush Plate Power Supply - 0.1199 Strike*Brush Plate Power Supply
- 0.4324 Surface Prep*Activation
- 0.5743 Surface Prep*Brush Plate Power Supply
+ 0.3418 Activation*Brush Plate Power Supply
+ 0.3691 Surface Prep*Activation*Brush Plate Power Supply

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	9	68.5114	7.6124	28.05	0.000
Linear	4	32.1233	8.0308	29.59	0.000
Strike	1	0.7749	0.7749	2.86	0.100
Surface Prep	1	22.5480	22.5480	83.09	0.000
Activation	1	5.4747	5.4747	20.17	0.000
Brush Plate Power Supply	1	4.1063	4.1063	15.13	0.000
2-Way Interactions	4	28.9605	7.2401	26.68	0.000
Strike*Brush Plate Power Supply	1	0.6338	0.6338	2.34	0.135
Surface Prep*Activation	1	8.3364	8.3364	30.72	0.000
Surface Prep*Brush Plate Power Supply	1	14.5476	14.5476	53.61	0.000
Activation*Brush Plate Power Supply	1	5.2100	5.2100	19.20	0.000
3-Way Interactions	1	6.0762	6.0762	22.39	0.000
Surface Prep*Activation*Brush Plate Power Supply	1	6.0762	6.0762	22.39	0.000
Error	35	9.4980	0.2714		
Lack-of-Fit	6	0.5640	0.0940	0.31	0.929
Pure Error	29	8.9340	0.3081		
Total	44	78.0094			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.520934	87.82%	84.69%	79.87%

Comparing these results to the ones with all data points, we see that the model R-sq increased from 74% to 88% and the estimate of the experimental error reduced from 0.78 to 0.52 (in the logit scale). Although the model fit is better, it is very important to understand the underlying cause of this unusual results from testing.

Based on the results from the reduced data without the three inconsistent observations, the top 6 combinations, with the top 4 have lower 95% Prediction bound at 90 or higher. These combinations are:

- Strike – Grit Blast – Sandpaper – Dalicstick_Amps: Prediction: 102.3; 95% Prediction LB: 98.1
- No Strike – Grit Blast – Sandpaper – Dalicstick_Amps: Prediction: 100.6; 95% Prediction LB: 94.0
- Strike – Scotch Brite – Chemical – SIFCO_Volts: Prediction: 98.8; 95% Prediction LB: 90.3
- No Strike – Scotch Brite – Chemical – SIFCO_Volts: Prediction: 98.7; 95% Prediction LB: 90.0
- Strike – Scotch Brite – Sandpaper – SIFCO Volts: Prediction: 98.2; 95% Prediction LB: 88.9
- No Strike – Scotch Brite – Sandpaper – SIFCO Volts: Prediction: 98.1; 95% Prediction LB: 88.5

Option	Factor Combination	Observed %NFS
1	Strike – Grit Blast – Sandpaper – Dalicstick_Amps	99.5, 101.4, 104.5
2	No Strike – Grit Blast – Sandpaper – Dalicstick_Amps	65.0, 98.1, 99.8
3	Strike – Scotch Brite – Chemical – SIFCO_Volts	98.7, 99.2, 100.0
4	No Strike – Scotch Brite – Chemical – SIFCO_Volts	96.8, 97.4, 100.1
5	Strike – Scotch Brite – Sandpaper – SIFCO Volts	90.1, 100.0 100.1
6	No Strike – Scotch Brite – Sandpaper – SIFCO_Volts	93.7, 94.9, 102.7

The observed value from the DOE for all these combinations were above 90 (except for the 1 value we deleted for combination 2). In addition, note that Strike or No Strike did not make a large difference when the other combinations are the same for the above settings. The first two have the same combinations of Surface Prep, Activation and Power Supply; so does the next two. The only difference is the Strike factor.

Comparing the top combinations from the deleted data set to the full data set, we see that 3 of the combinations are the same and they all have the predicted 95% lower bound to be above 90. The combination of No Strike – Scotch Brite – Sandpaper – SIFCO Volts is not in this list only because the lower 95% confidence bound for %NFS is 88.5 with predicted %NFS at 98.1.

We also looked at if the Time between plating and testing had an effect on the results. The time varied between 23 hours and 120 hours. Figure 10 gives these times for the combination of the factors in the test.

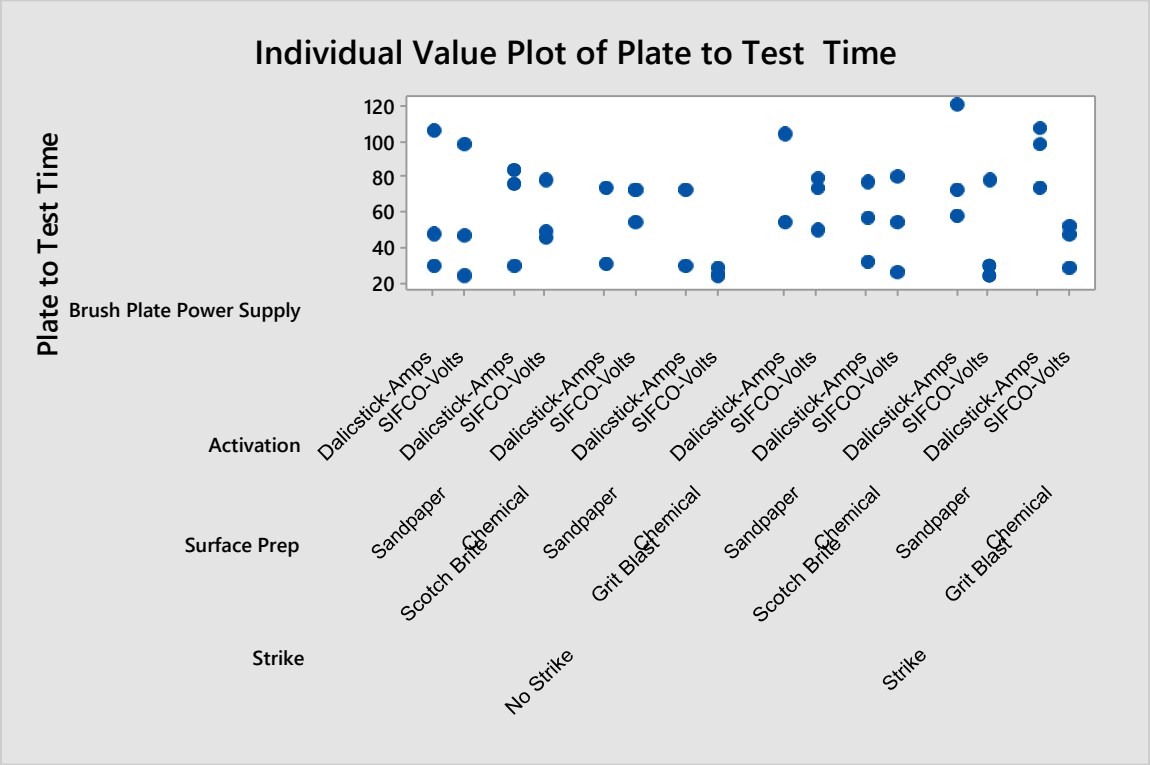


Figure 10: Time between plating and testing for different combination of test varaibles

From Figure 10 we see that there were no particular pattern indicating that the time between plating and testing was biased in any way. We also refit the model with the time between plating and testing as a covariate and found it not to be statistically significant. Hence, we conclude that time was not an important contributor to the results.

Conclusions

The DOE was performed to understand the effects of 4 factors: Strike, Surface Preparation, Activation and Brush Plate Power Supply. Here are the summary conclusions

- The experiments were run at Boeing (SIFCO – Volts) and at UDRI (Dalicstick – Amps). Since the sites and the power supply are indistinguishable, we can't separate if the effect is due to site or due to power supply. In this report, we call it a Power Supply factor.
- There is a lot of variability in the %NFS values even for the same set of conditions. In particular, there were 3 factor combinations from UDRI using the Dalicstick-Amps power supply where one value was very different from the other 2 values. Understanding why this large variability exist in the data is important.
- There are several combinations that lead to predicted
- We analyzed the data by including all 48 data points and also by excluding the 3 unusual data points. Based on all the data points, the variability in the data is large enough to have only a single combination with lower 95% predicted confidence bound be more than 100. However, without the unusual points, we see that there are many more combinations that are viable and could be more practical in practice.
- Time between plating and testing does not appear to be an important contributor within this range (between 24 and 120 hours). However, it is advisable to keep this time at a minimum.

- The factors seem to work together (positively or negatively) to produce a particular %NFS value and summarized below
    - Striking or not does not seem to have a big effect on the results, but striking may give some marginal benefit
    - Using the Dalicstick Amps power supply at UDRI seems to work only when we use Grit Blasting surface preparation with Sandpaper activation
    - Using SIFCO Volts power supply at Boeing seems to work for with Scotch Brite surface prep but for either activation (Sandpaper or Chemical) although the chemical activation works slightly better.
- More confirmatory experiments need to be performed to see which combination(s) are consistently producing %NFS above 90.

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Appendix A: Data from the Brush Plating DOE. For ease of reading they are sorted by the factors levels

Specimen #	Strike	Surface Prep	Activation	Brush Plate Power Supply	Fracture Load	% NFS	Time (Hrs) between Plating and Testing
31	No Strike	Grit Blast	Chemical	Dalicstick-Amps	19.9	54.4	28
39	No Strike	Grit Blast	Chemical	Dalicstick-Amps	23.8	65.0	72
43	No Strike	Grit Blast	Chemical	Dalicstick-Amps	36.5	99.8	30
7	No Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50.1	24
19	No Strike	Grit Blast	Chemical	SIFCO-Volts	22.0	60.0	23
22	No Strike	Grit Blast	Chemical	SIFCO-Volts	20.1	55.0	27
25	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	23.8	65.0	28
32	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	35.9	98.1	30
46	No Strike	Grit Blast	Sandpaper	Dalicstick-Amps	36.5	99.8	73
2	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	22.0	60.0	53
3	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	22.0	60.0	72
9	No Strike	Grit Blast	Sandpaper	SIFCO-Volts	18.3	50.1	71
27	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	29.7	81.2	83
37	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	34.8	95.0	28
45	No Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.3	99.2	75
6	No Strike	Scotch Brite	Chemical	SIFCO-Volts	35.4	96.8	77
17	No Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100.1	44
23	No Strike	Scotch Brite	Chemical	SIFCO-Volts	35.6	97.4	48
28	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	32.8	89.6	28
34	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	33.0	90.2	47
36	No Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	34.0	92.9	105
4	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	34.3	93.7	23
15	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	34.7	94.9	98
20	No Strike	Scotch Brite	Sandpaper	SIFCO-Volts	37.6	102.7	46
29	Strike	Grit Blast	Chemical	Dalicstick-Amps	22.0	60.0	73
30	Strike	Grit Blast	Chemical	Dalicstick-Amps	23.8	65.0	97
42	Strike	Grit Blast	Chemical	Dalicstick-Amps	27.5	75.0	107
1	Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50.0	27
8	Strike	Grit Blast	Chemical	SIFCO-Volts	18.3	50.0	47
11	Strike	Grit Blast	Chemical	SIFCO-Volts	22.0	60.1	51
33	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	36.4	99.5	71
38	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	37.1	101.4	57
48	Strike	Grit Blast	Sandpaper	Dalicstick-Amps	38.2	104.5	120
10	Strike	Grit Blast	Sandpaper	SIFCO-Volts	21.0	57.4	29
12	Strike	Grit Blast	Sandpaper	SIFCO-Volts	22.0	60.2	77
16	Strike	Grit Blast	Sandpaper	SIFCO-Volts	22.0	60.0	23
26	Strike	Scotch Brite	Chemical	Dalicstick-Amps	33.5	91.4	56
35	Strike	Scotch Brite	Chemical	Dalicstick-Amps	35.5	96.9	76
44	Strike	Scotch Brite	Chemical	Dalicstick-Amps	36.6	100.0	31
13	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.3	99.2	25
14	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.6	100.0	53
24	Strike	Scotch Brite	Chemical	SIFCO-Volts	36.1	98.7	79
40	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	34.4	94.0	53
41	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	23.8	65.0	80
47	Strike	Scotch Brite	Sandpaper	Dalicstick-Amps	35.0	95.6	103
5	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	33.0	90.1	49
18	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100.1	73
21	Strike	Scotch Brite	Sandpaper	SIFCO-Volts	36.6	100.0	78

Attachment No. 10 – DoE Confirmation Run Brush Plate Work Sheets for Application of Zinc-Nickel at BR&T (using SIFCO Equipment) and Corrdesa (using Dalistick Equipment)

Base Material:	4340 Steel - Type 1a.1	**Area**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool**	275 RPM	
Solution Supply:	Pour	**Solution**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	A-hr	Visual Test - What you are looking for:
1	Degrease	MPK or Desoclean 45				Remove Oil
2B	Deoxidize	Scotch Brite				Scotch Brite with water, rinse and dry.
3	Air Blast	Air				Remove grit blast debris or water with air nozzle
4	Mask Threads	Vinyl Cap/Tape				Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0			Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water				
7	Pre-Wet	Zinidal Aero 11040	0			
8B	No Strike					Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not bright and no burning.
10	Rinse, Demask, Rinse and Air Dry					Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3				Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 - 15 seconds to develop a dark coating color.
12	Rinse					
13	Dry					

NOTES:

Ship 1 for HE Testing within 72 hours.

TEST						
Lot #	**Specimen #**	**Date & Time Plated**		**Date &**	**Pass/Fail**	**Comments**
1.1A	SN:1.1A-32; #49	7/15/2019	8:55	7/16/2019	Fail	85% NFS (Broke at 90% NFS)
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree						

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**	
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil		
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM		
Solution Supply:	Pour	**Solution Temperature:**	RT		
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)				
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105					

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 -
12	Rinse						
13	Dry						

NOTES:					
Ship 1 for HE Testing within 72 hours.					

TEST							
Lot #	**Specimen #**	**Date & Time Plated**		**Date & Time Tested**		**Pass/Fail**	**Comments**
1.1A	SN:1.1A-39; #50	7/15/2019	9:09	7/17/2019	10:30	Fail	85% NFS. Broke going to 90% NFS.
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and
3	Air Blast	Air					Remove grit blast debris or water with air
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage Section
5A1	Pre-Wet	ACTIVATOR XF 10054	0				Pre-Wet surface.
5A2	Activate	ACTIVATOR XF 10054	16	Rev	10	0.06	Activated surface should become light grey with no black residue.
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10
12	Rinse						
13	Dry						
NOTES:							

Ship 1 for HE Testing within 72 hours.							

TEST

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-71; #51	7/15/2019	9:21	7/18/2019	9:30	Fail	85% NFS. Broke going to 90%
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**		
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil			
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM			
Solution Supply:	Pour	**Solution Temperature:**	RT			
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)					
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105						

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and dry.
3	Air Blast	Air					Remove grit blast debris or water with air
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 -
12	Rinse						
13	Dry						
NOTES:							

Ship 1 for HE Testing within 72 hours.						

TEST

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-33; #52	7/31/2019	14:10	8/1/2019	14:25	Pass	90% NFS. Broke going to 95% NFS.
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and
3	Air Blast	Air					Remove grit blast debris or water with air
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 -
12	Rinse						
13	Dry						

NOTES:						
Ship 1 for HE Testing within 72 hours.						

TEST

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-70; #53	7/31/2019	14:20	8/5/2019	8:25	Fail	85% NFS. Broke after 1 hour at
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

Base Material:	4340 Steel - Type 1a.1	**Area Plated:**	1.25 in^2	**Quantity of Test Specimens: 1**
Deposit Required:	Zinidal Aero ZnNi	**Thickness Required:**	0.5 - 0.8 mil	
Plating Tool:	Graphite FT-40 Rectangular Anode / Cotton Jacket	**Tool Speed:**	275 RPM	
Solution Supply:	Pour	**Solution Temperature:**	RT	
Notes:	Plating Formula for Zinidal Aero: A-Hr = 105 * Area (sq.in.) * Thickness (inches)			
Amp-Hr = 105 * 1.25 * 0.0008 = 0.105				

Step	Operation	Material	Volts	Polarity	Amp/sq.in.	A-hr	Visual Test - What you are looking
1	Degrease	MPK or Desoclean 45					Remove Oil
2B	Deoxidize	Scotch Brite					Scotch Brite with water, rinse and
3	Air Blast	Air					Remove grit blast debris or water with air
4	Mask Threads	Vinyl Cap/Tape					Mask threaded ends to expose 1.25 sq. in. Reduced Gage
5B	No Activate	abrasive paper					Lightly sand surface with 240 grit AlOxide abrasive paper to
6	Rinse	DI Water					
7	Pre-Wet	Zinidal Aero 11040	0				
8B	No Strike						Proceed to step 9.
9	Zn-Ni Plate	Zinidal Aero 11040	12V	Fwd	10	0.10	Start at 12 volts and maintain voltage at 12 V. Deposit should be a dull - not
10	Rinse, Demask, Rinse and Air Dry						Rinse again after demasking.
11	Conversion Coat	Passivateur No. 3					Apply Passivateur No. 3 solution. Apply solution by brushing (using soft acid brush) onto surface using very light pressure to not damage the soft conversion coating that forms, or pour on to surface using a bottle or squirt bottle or immerse in solution. Keep surface wet for 10 -
12	Rinse						
13	Dry						

NOTES:						
Ship 1 for HE Testing within 72 hours.						

TEST

Lot #	Specimen #	Date & Time Plated		Date & Time Tested		Pass/Fail	Comments
1.1A	SN:1.1A-72; #54	8/8/2019	13:45	8/12/2019	10:00	Fail	85% NFS. Broke going to 90% NFS.
Green Specialty Lot 1.1A, ASTM F 519 Type 1a.1, 90 degree notch.							

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 55
Creation date :	7/8/2019 10:01:41 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	CORRDESA/BOEING
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	CORRDESSA BOEING 55
Part designation	DORRDESA BOEING 55

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero - Dalic
Lot	p0260A
Beaker	Zinc-Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257G	1.00	Dalistick tool 20160004
Passivateur n°3	P0262	0.00	Manual application

Steps

01	Pump initial setting OFF Setting Pumping n?1 (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant

05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	Treatment :	Zinc-Nickel plating
	Part reference :	CORRDESSA BOEING 55
	Creation date :	7/8/2019 10:01:41 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature Setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping n?1 (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping n?1 (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :99.84 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant

DALISTICK®	Treatment :	Zinc-Nickel plating
	Part reference :	CORRDESSA BOEING 55
	Creation date :	7/8/2019 10:01:41 PM

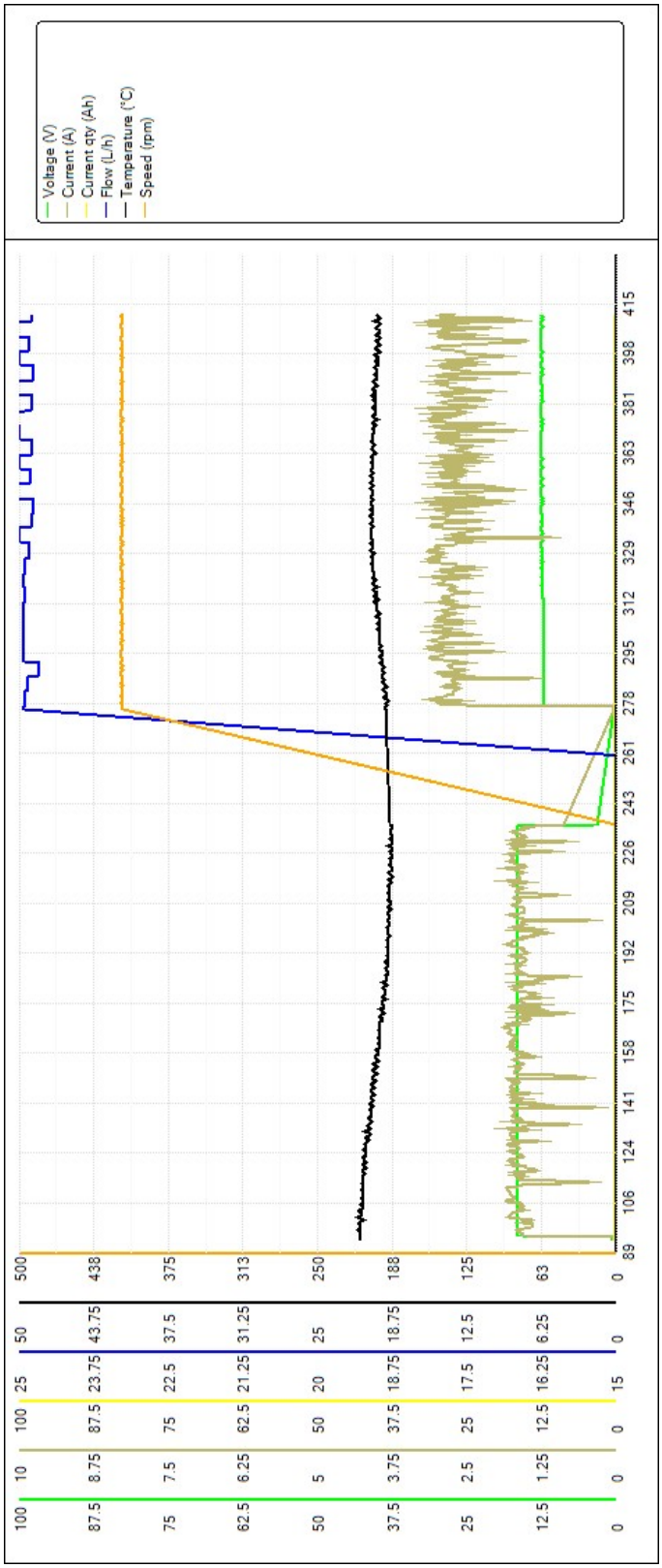
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (P0257G - Activator XF - Dalic)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping n?1 (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature Stabilization	Compliant
	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (p0260A - Zinidal Aero - Dalic)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping n?1 (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 55
Creation date :	7/8/2019 10:01:41 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant. NA	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Vivien Kibble	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
89 106 124 141 158 175 192 209 226 243 261 278 295 312 329 346 363 381 398 415
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 55
Creation date :	7/8/2019 10:01:41 PM

Events

Date	N°	Type	Completion
10:09:55PM	66	Step over	
10:09:55PM	66	Operating mode complete	
10:09:49PM	66	Step started	Message Validate
10:09:49PM	65	Step over	
10:09:48PM	64	Step over	
10:09:48PM	65	Step started	Control Final
10:09:45PM	64	Step started	Message Validate
10:09:45PM	63	Step over	
10:09:33PM	63	Step started	Message Validate
10:09:33PM	62	Step over	
10:09:27PM	62	Step started	Message Validate
10:09:27PM	61	Step over	
10:09:14PM	61	Step started	Message Validate
10:09:14PM	60	Step over	
10:09:11PM	60	Step started	Message Validate
10:09:11PM	59	Step over	
10:09:05PM	59	Step started	Message Validate
10:09:05PM	58	Step over	
10:08:59PM	58	Step started	Control Thickness (µm)
10:08:59PM	57	Step over	
10:08:56PM	57	Step started	Message Validate
10:08:56PM	56	Step over	
10:08:50PM	56	Step started	Control Adhesion
10:08:50PM	55	Step over	
10:08:50PM	54	Step over	
10:08:50PM	55	Step started	Control Aspect
10:08:50PM	53	Step over	
10:08:50PM	54	Step started	Message Validate
10:08:49PM	52	Step over	
10:08:49PM	53	Step started	Message Validate
10:08:49PM	51	Step over	
10:08:49PM	52	Step started	Message Validate
10:08:48PM	50	Step over	
10:08:48PM	51	Step started	Message Validate
10:08:47PM	49	Step over	
10:08:47PM	50	Step started	Message Validate
10:08:40PM	48	Step over	
10:08:40PM	49	Step started	Message Validate
10:08:39PM	48	Step started	Setting Pumping n?1 (Set point: Off)
10:08:39PM	47	Step over	
10:08:34PM	46	Step over	
10:08:34PM	47	Step started	Message Validate
10:08:34PM	46	Process defect: voltage high limit reached	
10:08:33PM	46	Step started	Setting Generation (Set point: Off)
10:08:33PM	45	Step over	
10:06:56PM	45	Process defect: voltage high limit reached	
10:06:19PM	44	Step over	
10:06:19PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:06:17PM	43	Step over	
10:06:17PM	44	Step started	Setting Generation (Set point: On)
10:06:17PM	43	Step started	Setting Solution (p0260A - Zinidal Aero - Dalic)
10:06:17PM	42	Step over	
10:06:17PM	42	Step started	Setting Polarity (Set point: Plating)
10:06:17PM	41	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 55
Creation date : 7/8/2019 10:01:41 PM

10:06:17PM	40	Step over	
10:06:17PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:06:17PM	39	Step over	
10:06:17PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:06:17PM	39	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:06:17PM	38	Step over	
10:06:04PM	38	Step started	Message Validate
10:06:04PM	37	Step over	
10:05:58PM	37	Process defect: flow lower limit reached	
10:05:49PM	36	Step over	
10:05:49PM	37	Step started	Message Validate
10:05:49PM	36	Process defect: flow lower limit reached	
10:05:49PM	35	Step over	
10:05:49PM	36	Step started	Setting Pumping n?1 (Set point: On)
10:05:47PM	35	Step started	Message Validate
10:05:47PM	34	Step over	
10:05:38PM	33	Step over	
10:05:38PM	34	Step started	Message Validate
10:05:38PM	33	Step started	Setting Generation (Set point: Off)
10:05:38PM	32	Step over	
10:03:17PM	31	Step over	
10:03:17PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:03:16PM	30	Step over	
10:03:16PM	31	Step started	Setting Generation (Set point: On)
10:03:15PM	29	Step over	
10:03:15PM	30	Step started	Setting Solution (P0257G - Activator XF - Dalic)
10:03:13PM	29	Step started	Message Validate
10:03:13PM	28	Step over	
10:02:50PM	28	Step started	Message Validate
10:02:49PM	27	Step over	
10:02:47PM	26	Step over	
10:02:47PM	27	Step started	Message Validate
10:02:45PM	26	Step started	Message Validate
10:02:45PM	25	Step over	
10:02:13PM	24	Step over	
10:02:13PM	25	Step started	Setting Surface
10:02:13PM	24	Step started	Setting Pumping n?1 (Set point: Off)
10:02:13PM	23	Step over	
10:02:10PM	23	Step started	Message Validate
10:02:10PM	22	Step over	
10:02:06PM	22	Step started	Message Validate
10:02:06PM	21	Step over	
10:02:06PM	21	Step started	Setting Pumping n?1 (Set point: On)
10:02:06PM	20	Step over	
10:02:05PM	20	Step started	Message Validate
10:02:04PM	19	Step over	
10:02:03PM	18	Step over	
10:02:03PM	19	Step started	Message Validate
10:02:03PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:02:03PM	17	Step over	
10:02:01PM	17	Step started	Message Validate
10:02:01PM	16	Step over	
10:01:59PM	15	Step over	
10:01:59PM	16	Step started	Message Validate
10:01:58PM	15	Step started	Message Validate
10:01:58PM	14	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 55
Creation date : 7/8/2019 10:01:41 PM

10:01:56PM	14	Step started	Message Validate
10:01:56PM	13	Step over	
10:01:55PM	13	Step started	Message Validate
10:01:55PM	12	Step over	
10:01:53PM	12	Step started	Message Validate
10:01:53PM	11	Step over	
10:01:51PM	11	Step started	Message Validate
10:01:51PM	10	Step over	
10:01:50PM	10	Step started	Message Validate
10:01:50PM	09	Step over	
10:01:48PM	09	Step started	Message Validate
10:01:48PM	08	Step over	
10:01:47PM	08	Step started	Message Validate
10:01:47PM	07	Step over	
10:01:44PM	07	Step started	Message Validate
10:01:44PM	06	Step over	
10:01:44PM	06	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:01:44PM	05	Step over	
10:01:44PM	05	Step started	Setting Polarity (Set point: Anodizing)
10:01:44PM	04	Step over	
10:01:44PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:01:44PM	03	Step over	
10:01:44PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:01:44PM	02	Step over	
10:01:44PM	02	Step started	Setting Generation (Set point: Off)
10:01:44PM	01	Step over	
10:01:43PM	01	Step started	Setting Pumping n?1 (Set point: Off)
10:01:43PM	01	Operating mode started	CORRDESSA BOEING 55

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 56
Creation date :	7/8/2019 10:11:48 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	CORRDESA/BOEING
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	CORRDESSA BOEING 56
Part designation	DORRDESA BOEING 56

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero - Dalic
Lot	p0260A
Beaker	Zinc-Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257G	1.00	Dalistick tool 20160004
Passivateur n°3	P0262	0.00	Manual application

Steps

01	Pump initial setting OFF Setting Pumping n?1 (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** CORRDESSA BOEING 56 **Creation date :** 7/8/2019 10:11:48 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature Setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping n?1 (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping n?1 (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :99.84 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant

29	Information	Compliant

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 56
Creation date : 7/8/2019 10:11:48 PM

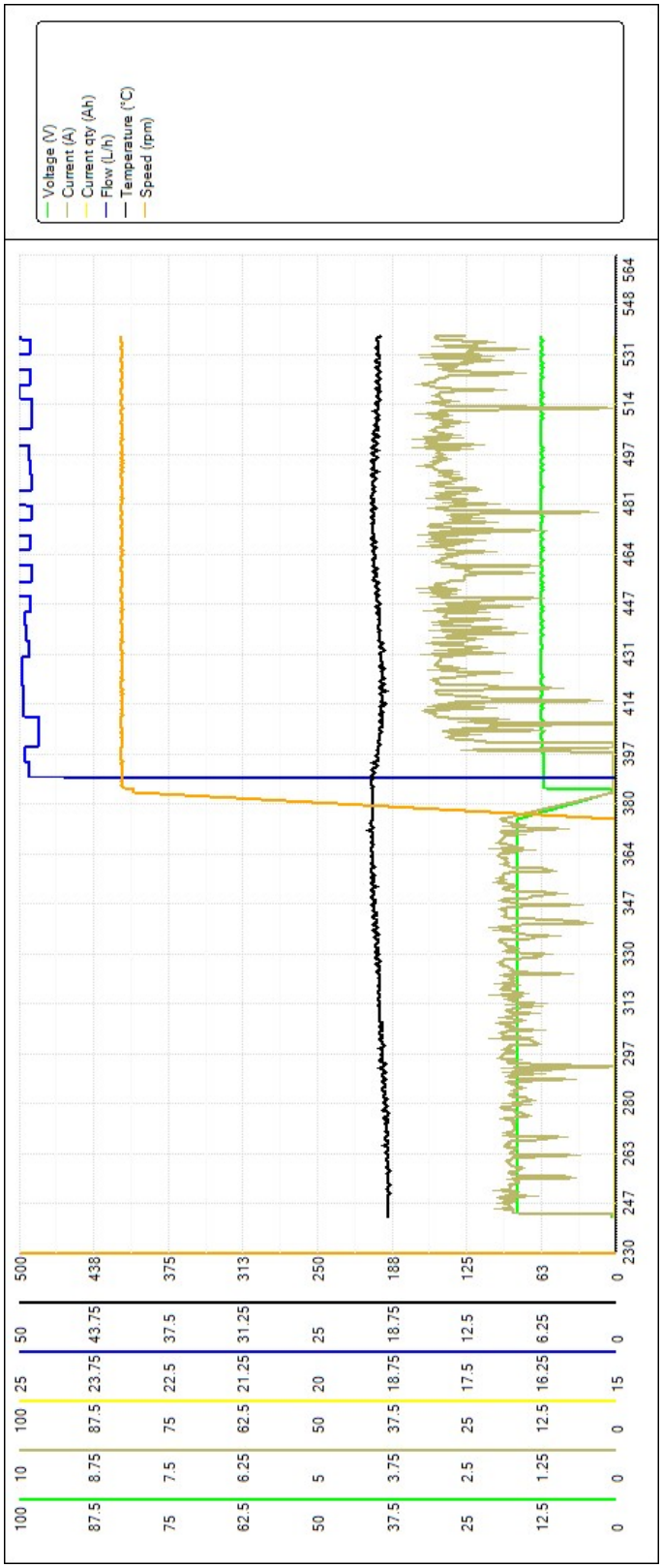
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (P0257G - Activator XF - Dalic)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping n?1 (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature Stabilization	Compliant
	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (p0260A - Zinidal Aero - Dalic)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping n?1 (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 56
Creation date :	7/8/2019 10:11:48 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant. NA\	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Vivien Kibble	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
230 247 263 280 297 313 330 347 364 380 397 414 431 447 464 481 497 514 531 548 564
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 56
Creation date : 7/8/2019 10:11:48 PM

Events

Date	N°	Type	Completion
10:21:58PM	66	Step over	
10:21:58PM	66	Operating mode complete	
10:21:57PM	65	Step over	
10:21:57PM	66	Step started	Message Validate
10:21:56PM	65	Step started	Control Final
10:21:56PM	64	Step over	
10:21:55PM	63	Step over	
10:21:55PM	64	Step started	Message Validate
10:21:54PM	62	Step over	
10:21:54PM	63	Step started	Message Validate
10:21:53PM	61	Step over	
10:21:53PM	62	Step started	Message Validate
10:21:53PM	61	Step started	Message Validate
10:21:53PM	60	Step over	
10:21:52PM	60	Step started	Message Validate
10:21:52PM	59	Step over	
10:21:51PM	59	Step started	Message Validate
10:21:51PM	58	Step over	
10:21:47PM	57	Step over	
10:21:47PM	58	Step started	Control Thickness (µm)
10:21:46PM	57	Step started	Message Validate
10:21:46PM	56	Step over	
10:21:44PM	55	Step over	
10:21:44PM	56	Step started	Control Adhesion
10:21:43PM	55	Step started	Control Aspect
10:21:43PM	54	Step over	
10:21:42PM	54	Step started	Message Validate
10:21:42PM	53	Step over	
10:21:41PM	52	Step over	
10:21:41PM	53	Step started	Message Validate
10:21:40PM	52	Step started	Message Validate
10:21:40PM	51	Step over	
10:21:37PM	51	Step started	Message Validate
10:21:37PM	50	Step over	
10:20:51PM	49	Step over	
10:20:51PM	50	Step started	Message Validate
10:20:49PM	48	Step over	
10:20:49PM	49	Step started	Message Validate
10:20:49PM	48	Step started	Setting Pumping n?1 (Set point: Off)
10:20:49PM	47	Step over	
10:20:47PM	46	Step over	
10:20:47PM	47	Step started	Message Validate
10:20:47PM	46	Process defect: voltage high limit reached	
10:20:47PM	46	Step started	Setting Generation (Set point: Off)
10:20:47PM	45	Step over	
10:18:27PM	45	Process defect: voltage high limit reached	
10:18:18PM	45	Process defect: flow high limit reached	
10:18:14PM	44	Step over	
10:18:14PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:18:13PM	43	Step over	
10:18:13PM	44	Step started	Setting Generation (Set point: On)
10:18:13PM	43	Step started	Setting Solution (p0260A - Zinidal Aero - Dalic)
10:18:13PM	42	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 56
Creation date : 7/8/2019 10:11:48 PM

10:18:12PM	41	Step over	
10:18:12PM	42	Step started	Setting Polarity (Set point: Plating)
10:18:12PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:18:12PM	40	Step over	
10:18:12PM	39	Step over	
10:18:12PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:18:12PM	38	Step over	
10:18:12PM	39	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:18:11PM	38	Step started	Message Validate
10:18:11PM	37	Step over	
10:18:09PM	36	Step over	
10:18:09PM	37	Step started	Message Validate
10:18:09PM	36	Process defect: flow high limit reached	
10:18:09PM	35	Step over	
10:18:09PM	36	Step started	Setting Pumping n?1 (Set point: On)
10:18:07PM	35	Step started	Message Validate
10:18:07PM	34	Step over	
10:18:05PM	33	Step over	
10:18:05PM	34	Step started	Message Validate
10:18:04PM	33	Step started	Setting Generation (Set point: Off)
10:18:04PM	32	Step over	
10:15:52PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:15:52PM	31	Step over	
10:15:51PM	30	Step over	
10:15:51PM	31	Step started	Setting Generation (Set point: On)
10:15:50PM	29	Step over	
10:15:50PM	30	Step started	Setting Solution (P0257G - Activator XF - Dalic)
10:15:49PM	29	Step started	Message Validate
10:15:49PM	28	Step over	
10:12:38PM	28	Step started	Message Validate
10:12:38PM	27	Step over	
10:12:35PM	26	Step over	
10:12:35PM	27	Step started	Message Validate
10:12:29PM	26	Step started	Message Validate
10:12:29PM	25	Step over	
10:12:20PM	24	Step over	
10:12:20PM	25	Step started	Setting Surface
10:12:20PM	24	Process defect: flow high limit reached	
10:12:20PM	24	Step started	Setting Pumping n?1 (Set point: Off)
10:12:20PM	23	Step over	
10:12:18PM	23	Step started	Message Validate
10:12:18PM	22	Step over	
10:12:17PM	21	Step over	
10:12:17PM	22	Step started	Message Validate
10:12:16PM	21	Process defect: flow high limit reached	
10:12:16PM	21	Step started	Setting Pumping n?1 (Set point: On)
10:12:16PM	20	Step over	
10:12:14PM	20	Step started	Message Validate
10:12:14PM	19	Step over	
10:12:13PM	19	Step started	Message Validate
10:12:13PM	18	Step over	
10:12:13PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:12:13PM	17	Step over	
10:12:10PM	17	Step started	Message Validate
10:12:10PM	16	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 56
Creation date : 7/8/2019 10:11:48 PM

10:12:09PM	15	Step over	
10:12:09PM	16	Step started	Message Validate
10:12:06PM	15	Step started	Message Validate
10:12:06PM	14	Step over	
10:12:03PM	14	Step started	Message Validate
10:12:02PM	13	Step over	
10:12:00PM	13	Step started	Message Validate
10:12:00PM	12	Step over	
10:11:58PM	12	Step started	Message Validate
10:11:58PM	11	Step over	
10:11:57PM	11	Step started	Message Validate
10:11:57PM	10	Step over	
10:11:54PM	10	Step started	Message Validate
10:11:54PM	09	Step over	
10:11:53PM	09	Step started	Message Validate
10:11:53PM	08	Step over	
10:11:51PM	08	Step started	Message Validate
10:11:51PM	07	Step over	
10:11:50PM	06	Step over	
10:11:50PM	07	Step started	Message Validate
10:11:50PM	05	Step over	
10:11:50PM	06	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:11:49PM	05	Step started	Setting Polarity (Set point: Anodizing)
10:11:49PM	04	Step over	
10:11:49PM	03	Step over	
10:11:49PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:11:49PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:11:49PM	02	Step over	
10:11:49PM	01	Step over	
10:11:49PM	02	Step started	Setting Generation (Set point: Off)
10:11:49PM	01	Step started	Setting Pumping n?1 (Set point: Off)
10:11:49PM	01	Operating mode started	CORRDESSA BOEING 56

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 57
Creation date :	7/8/2019 10:22:12 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	CORRDESA/BOEING
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	CORRDESSA BOEING 57
Part designation	DORRDESA BOEING 57

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero - Dalic
Lot	p0260A
Beaker	Zinc-Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257G	1.00	Dalistick tool 20160004
Passivateur n°3	P0262	0.00	Manual application

Steps

01	Pump initial setting OFF Setting Pumping n?1 (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** CORRDESSA BOEING 57 **Creation date :** 7/8/2019 10:22:12 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature Setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping n?1 (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping n?1 (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :99.84 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant

29	Information	Compliant

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 57
Creation date : 7/8/2019 10:22:12 PM

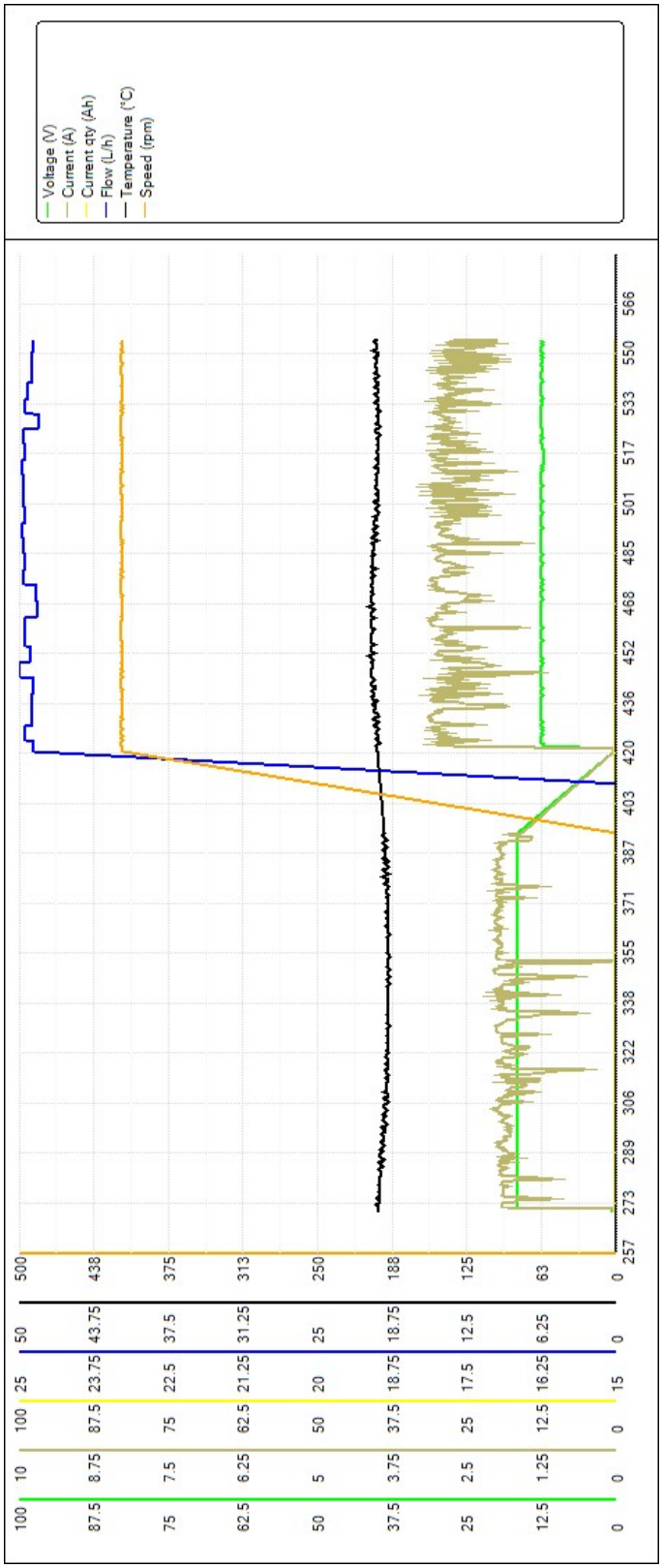
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (P0257G - Activator XF - Dalic)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Compliant
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping n?1 (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature Stabilization	Compliant
	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (p0260A - Zinidal Aero - Dalic)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping n?1 (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	CORRDESSA BOEING 57
Creation date :	7/8/2019 10:22:12 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant. NA	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Vivien Kibble	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
257 273 289 306 322 338 355 371 387 403 420 436 452 468 485 501 517 533 550 566
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 57
Creation date : 7/8/2019 10:22:12 PM

Events

Date	N°	Type	Completion
10:32:08PM	66	Step over	
10:32:08PM	66	Operating mode complete	
10:32:07PM	66	Step started	Message Validate
10:32:07PM	65	Step over	
10:32:07PM	65	Step started	Control Final
10:32:07PM	64	Step over	
10:32:06PM	64	Step started	Message Validate
10:32:06PM	63	Step over	
10:32:06PM	63	Step started	Message Validate
10:32:06PM	62	Step over	
10:32:05PM	62	Step started	Message Validate
10:32:05PM	61	Step over	
10:32:04PM	61	Step started	Message Validate
10:32:04PM	60	Step over	
10:32:02PM	60	Step started	Message Validate
10:32:02PM	59	Step over	
10:32:01PM	59	Step started	Message Validate
10:32:01PM	58	Step over	
10:31:57PM	57	Step over	
10:31:57PM	58	Step started	Control Thickness (µm)
10:31:56PM	56	Step over	
10:31:56PM	57	Step started	Message Validate
10:31:55PM	55	Step over	
10:31:55PM	56	Step started	Control Adhesion
10:31:55PM	54	Step over	
10:31:55PM	55	Step started	Control Aspect
10:31:54PM	53	Step over	
10:31:54PM	54	Step started	Message Validate
10:31:53PM	53	Step started	Message Validate
10:31:53PM	52	Step over	
10:31:41PM	52	Step started	Message Validate
10:31:40PM	51	Step over	
10:31:38PM	51	Step started	Message Validate
10:31:38PM	50	Step over	
10:31:37PM	50	Step started	Message Validate
10:31:37PM	49	Step over	
10:31:30PM	48	Step over	
10:31:30PM	49	Step started	Message Validate
10:31:30PM	48	Step started	Setting Pumping n?1 (Set point: Off)
10:31:30PM	47	Step over	
10:31:28PM	46	Step over	
10:31:28PM	47	Step started	Message Validate
10:31:28PM	46	Process defect: voltage high limit reached	
10:31:27PM	46	Step started	Setting Generation (Set point: Off)
10:31:27PM	45	Step over	
10:30:53PM	45	Process defect: voltage high limit reached	
10:30:47PM	45	Process defect: voltage high limit reached	
10:29:16PM	45	Process defect: voltage high limit reached	
10:29:14PM	44	Step over	
10:29:14PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
10:29:13PM	44	Step started	Setting Generation (Set point: On)
10:29:13PM	43	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 57
Creation date : 7/8/2019 10:22:12 PM

10:29:13PM	42	Step over	
10:29:13PM	43	Step started	Setting Solution (p0260A - Zinidal Aero - Dalic)
10:29:13PM	42	Step started	Setting Polarity (Set point: Plating)
10:29:13PM	41	Step over	
10:29:13PM	40	Step over	
10:29:13PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:29:13PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
10:29:13PM	39	Step over	
10:29:12PM	39	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:29:12PM	38	Step over	
10:29:02PM	38	Process defect: flow lower limit reached	
10:28:54PM	38	Step started	Message Validate
10:28:54PM	37	Step over	
10:28:52PM	37	Step started	Message Validate
10:28:52PM	36	Step over	
10:28:52PM	36	Process defect: flow lower limit reached	
10:28:52PM	35	Step over	
10:28:52PM	36	Step started	Setting Pumping n?1 (Set point: On)
10:28:51PM	35	Step started	Message Validate
10:28:51PM	34	Step over	
10:28:47PM	33	Step over	
10:28:47PM	34	Step started	Message Validate
10:28:47PM	33	Step started	Setting Generation (Set point: Off)
10:28:47PM	32	Step over	
10:26:45PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
10:26:45PM	31	Step over	
10:26:43PM	30	Step over	
10:26:43PM	31	Step started	Setting Generation (Set point: On)
10:26:43PM	29	Step over	
10:26:43PM	30	Step started	Setting Solution (P0257G - Activator XF - Dalic)
10:26:39PM	29	Step started	Message Validate
10:26:39PM	28	Step over	
10:22:45PM	28	Step started	Message Validate
10:22:45PM	27	Step over	
10:22:42PM	26	Step over	
10:22:42PM	27	Step started	Message Validate
10:22:41PM	26	Step started	Message Validate
10:22:41PM	25	Step over	
10:22:34PM	24	Step over	
10:22:34PM	25	Step started	Setting Surface
10:22:34PM	24	Step started	Setting Pumping n?1 (Set point: Off)
10:22:34PM	23	Step over	
10:22:32PM	23	Step started	Message Validate
10:22:32PM	22	Step over	
10:22:31PM	21	Step over	
10:22:31PM	22	Step started	Message Validate
10:22:30PM	21	Step started	Setting Pumping n?1 (Set point: On)
10:22:30PM	20	Step over	
10:22:28PM	19	Step over	
10:22:28PM	20	Step started	Message Validate
10:22:27PM	19	Step started	Message Validate
10:22:27PM	18	Step over	
10:22:27PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
10:22:27PM	17	Step over	
10:22:25PM	17	Step started	Message Validate

10:22:25PM	16	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : CORRDESSA BOEING 57
Creation date : 7/8/2019 10:22:12 PM

10:22:23PM	15	Step over	
10:22:23PM	16	Step started	Message Validate
10:22:21PM	14	Step over	
10:22:21PM	15	Step started	Message Validate
10:22:20PM	13	Step over	
10:22:20PM	14	Step started	Message Validate
10:22:20PM	12	Step over	
10:22:20PM	13	Step started	Message Validate
10:22:19PM	12	Step started	Message Validate
10:22:19PM	11	Step over	
10:22:18PM	11	Step started	Message Validate
10:22:18PM	10	Step over	
10:22:17PM	10	Step started	Message Validate
10:22:17PM	09	Step over	
10:22:16PM	08	Step over	
10:22:16PM	09	Step started	Message Validate
10:22:15PM	07	Step over	
10:22:15PM	08	Step started	Message Validate
10:22:14PM	07	Step started	Message Validate
10:22:14PM	06	Step over	
10:22:14PM	06	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
10:22:14PM	05	Step over	
10:22:14PM	04	Step over	
10:22:14PM	05	Step started	Setting Polarity (Set point: Anodizing)
10:22:13PM	03	Step over	
10:22:13PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
10:22:13PM	02	Step over	
10:22:13PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
10:22:13PM	01	Step over	
10:22:13PM	02	Step started	Setting Generation (Set point: Off)
10:22:13PM	01	Step started	Setting Pumping n?1 (Set point: Off)
10:22:13PM	01	Operating mode started	CORRDESSA BOEING 57

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	58
Creation date :	7/22/2019 8:24:19 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	CORRDESA/BOEING
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	58
Part designation	58

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero - Dalic
Lot	P0257E
Beaker	Zinc-Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257G	1.00	Dalistick tool 20160004
Passivateur n°3	P0262	0.00	Manual application

Steps

01	Pump initial setting OFF Setting Pumping n?1 (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** 58 **Creation date :** 7/22/2019 8:24:19 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature Setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping n?1 (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping n?1 (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :99.84 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Passed

29	Information	Passed

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	58
Creation date :	7/22/2019 8:24:19 PM

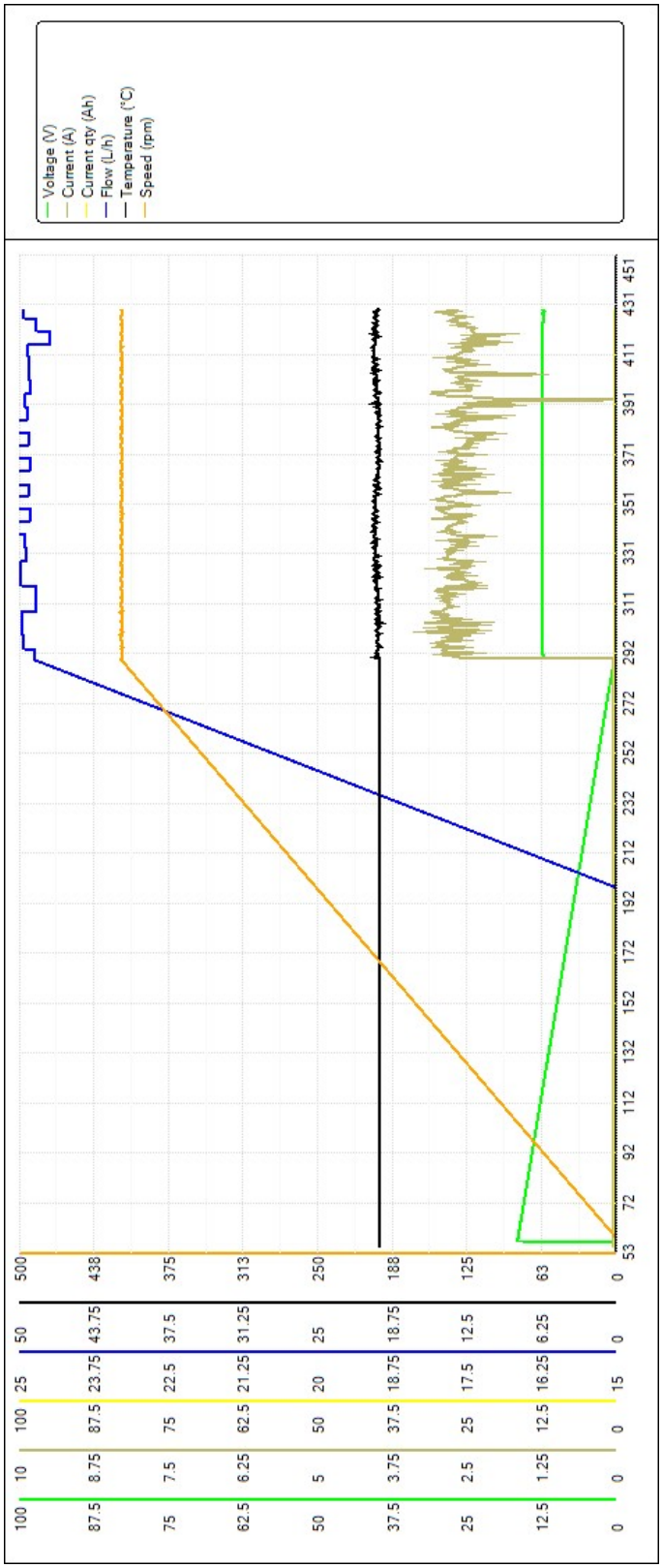
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (P0257G - Activator XF - Dalic)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Passed
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Compliant
	Message Validate	
35	Stopping DKPL pump	Compliant
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping n?1 (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature Stabilization	Compliant
	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (P0257E - Zinidal Aero - Dalic)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping n?1 (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	58
Creation date :	7/22/2019 8:24:19 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant. nz	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Vivien Kibble	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0
53 72 92 112 132 152 172 192 212 232 252 272 292 311 331 351 371 391 411 431 451

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 58
Creation date : 7/22/2019 8:24:19 PM

Events

Date	N°	Type	Completion
8:31:55PM	66	Operating mode complete	
8:31:55PM	66	Step over	
8:31:54PM	66	Step started	Message Validate
8:31:54PM	65	Step over	
8:31:53PM	65	Step started	Control Final
8:31:53PM	64	Step over	
8:31:53PM	64	Step started	Message Validate
8:31:53PM	63	Step over	
8:31:52PM	63	Step started	Message Validate
8:31:52PM	62	Step over	
8:31:52PM	62	Step started	Message Validate
8:31:52PM	61	Step over	
8:31:51PM	61	Step started	Message Validate
8:31:51PM	60	Step over	
8:31:51PM	60	Step started	Message Validate
8:31:51PM	59	Step over	
8:31:50PM	59	Step started	Message Validate
8:31:50PM	58	Step over	
8:31:43PM	58	Step started	Control Thickness (µm)
8:31:43PM	57	Step over	
8:31:41PM	57	Step started	Message Validate
8:31:41PM	56	Step over	
8:31:39PM	55	Step over	
8:31:39PM	56	Step started	Control Adhesion
8:31:38PM	54	Step over	
8:31:38PM	55	Step started	Control Aspect
8:31:38PM	54	Step started	Message Validate
8:31:38PM	53	Step over	
8:31:37PM	52	Step over	
8:31:37PM	53	Step started	Message Validate
8:31:36PM	52	Step started	Message Validate
8:31:36PM	51	Step over	
8:31:35PM	51	Step started	Message Validate
8:31:35PM	50	Step over	
8:31:33PM	49	Step over	
8:31:33PM	50	Step started	Message Validate
8:31:32PM	48	Step over	
8:31:32PM	49	Step started	Message Validate
8:31:32PM	48	Step started	Setting Pumping n?1 (Set point: Off)
8:31:32PM	47	Step over	
8:31:30PM	46	Step over	
8:31:30PM	47	Step started	Message Validate
8:31:30PM	46	Step started	Setting Generation (Set point: Off)
8:31:30PM	45	Step over	
8:31:24PM	45	Process defect: voltage high limit reached	
8:29:12PM	45	Process defect: voltage high limit reached	
8:29:10PM	44	Step over	
8:29:10PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
8:29:09PM	44	Step started	Setting Generation (Set point: On)
8:29:09PM	43	Step over	
8:29:09PM	42	Step over	
8:29:09PM	43	Step started	Setting Solution (P0257E - Zinidal Aero - Dalic)
8:29:08PM	42	Step started	Setting Polarity (Set point: Plating)
8:29:08PM	41	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 58
Creation date : 7/22/2019 8:24:19 PM

8:29:08PM	40	Step over	
8:29:08PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:29:08PM	39	Step over	
8:29:08PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
8:29:08PM	39	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:29:08PM	38	Step over	
8:28:44PM	38	Step started	Message Validate
8:28:44PM	37	Step over	
8:28:43PM	37	Process defect: flow high limit reached	
8:28:43PM	37	Process defect: flow high limit reached	
8:28:23PM	37	Process defect: flow high limit reached	
8:28:18PM	37	Process defect: flow high limit reached	
8:27:57PM	37	Process defect: flow high limit reached	
8:27:57PM	37	Process defect: flow high limit reached	
8:25:30PM	37	Process defect: flow high limit reached	
8:25:22PM	36	Step over	
8:25:22PM	37	Step started	Message Validate
8:25:22PM	36	Process defect: flow high limit reached	
8:25:22PM	35	Step over	
8:25:22PM	36	Step started	Setting Pumping n?1 (Set point: On)
8:25:21PM	35	Step started	Message Validate
8:25:21PM	34	Step over	
8:25:19PM	33	Step over	
8:25:19PM	34	Step started	Message Validate
8:25:19PM	33	Step started	Setting Generation (Set point: Off)
8:25:18PM	32	Step over	
8:25:16PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
8:25:16PM	31	Step over	
8:25:15PM	31	Step started	Setting Generation (Set point: On)
8:25:15PM	30	Step over	
8:25:15PM	29	Step over	
8:25:15PM	30	Step started	Setting Solution (P0257G - Activator XF - Dalic)
8:25:13PM	29	Step started	Message Validate
8:25:13PM	28	Step over	
8:25:10PM	28	Step started	Message Validate
8:25:10PM	27	Step over	
8:25:07PM	26	Step over	
8:25:07PM	27	Step started	Message Validate
8:25:06PM	26	Step started	Message Validate
8:25:06PM	25	Step over	
8:24:56PM	25	Step started	Setting Surface
8:24:56PM	24	Step over	
8:24:56PM	24	Process defect: flow high limit reached	
8:24:56PM	24	Step started	Setting Pumping n?1 (Set point: Off)
8:24:56PM	23	Step over	
8:24:53PM	22	Step over	
8:24:53PM	23	Step started	Message Validate
8:24:52PM	21	Step over	

8:24:52PM	22	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 58
Creation date : 7/22/2019 8:24:19 PM

8:24:52PM	21	Process defect: flow high limit reached	
8:24:52PM	21	Step started	Setting Pumping n?1 (Set point: On)
8:24:52PM	20	Step over	
8:24:51PM	20	Step started	Message Validate
8:24:51PM	19	Step over	
8:24:51PM	19	Step started	Message Validate
8:24:51PM	18	Step over	
8:24:51PM	17	Step over	
8:24:51PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:24:50PM	17	Step started	Message Validate
8:24:50PM	16	Step over	
8:24:50PM	16	Step started	Message Validate
8:24:50PM	15	Step over	
8:24:49PM	14	Step over	
8:24:49PM	15	Step started	Message Validate
8:24:49PM	14	Step started	Message Validate
8:24:49PM	13	Step over	
8:24:48PM	13	Step started	Message Validate
8:24:48PM	12	Step over	
8:24:48PM	12	Step started	Message Validate
8:24:48PM	11	Step over	
8:24:47PM	11	Step started	Message Validate
8:24:47PM	10	Step over	
8:24:47PM	09	Step over	
8:24:47PM	10	Step started	Message Validate
8:24:43PM	09	Step started	Message Validate
8:24:43PM	08	Step over	
8:24:23PM	07	Step over	
8:24:23PM	08	Step started	Message Validate
8:24:21PM	06	Step over	
8:24:21PM	07	Step started	Message Validate
8:24:21PM	05	Step over	
8:24:21PM	06	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:24:21PM	04	Step over	
8:24:21PM	05	Step started	Setting Polarity (Set point: Anodizing)
8:24:20PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:24:20PM	03	Step over	
8:24:20PM	02	Step over	
8:24:20PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
8:24:20PM	02	Step started	Setting Generation (Set point: Off)
8:24:20PM	01	Step over	
8:24:20PM	01	Step started	Setting Pumping n?1 (Set point: Off)
8:24:20PM	01	Operating mode started	58

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	59
Creation date :	7/22/2019 8:32:06 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	CORRDESA/BOEING
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	59
Part designation	59

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero - Dalic
Lot	P0257E
Beaker	Zinc-Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257G	1.00	Dalistick tool 20160004
Passivateur n°3	P0262	0.00	Manual application

Steps

01	Pump initial setting OFF Setting Pumping n?1 (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** 59 **Creation date :** 7/22/2019 8:32:06 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature Setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping n?1 (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping n?1 (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :99.84 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Passed

29	Information	Passed

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	59
Creation date :	7/22/2019 8:32:06 PM

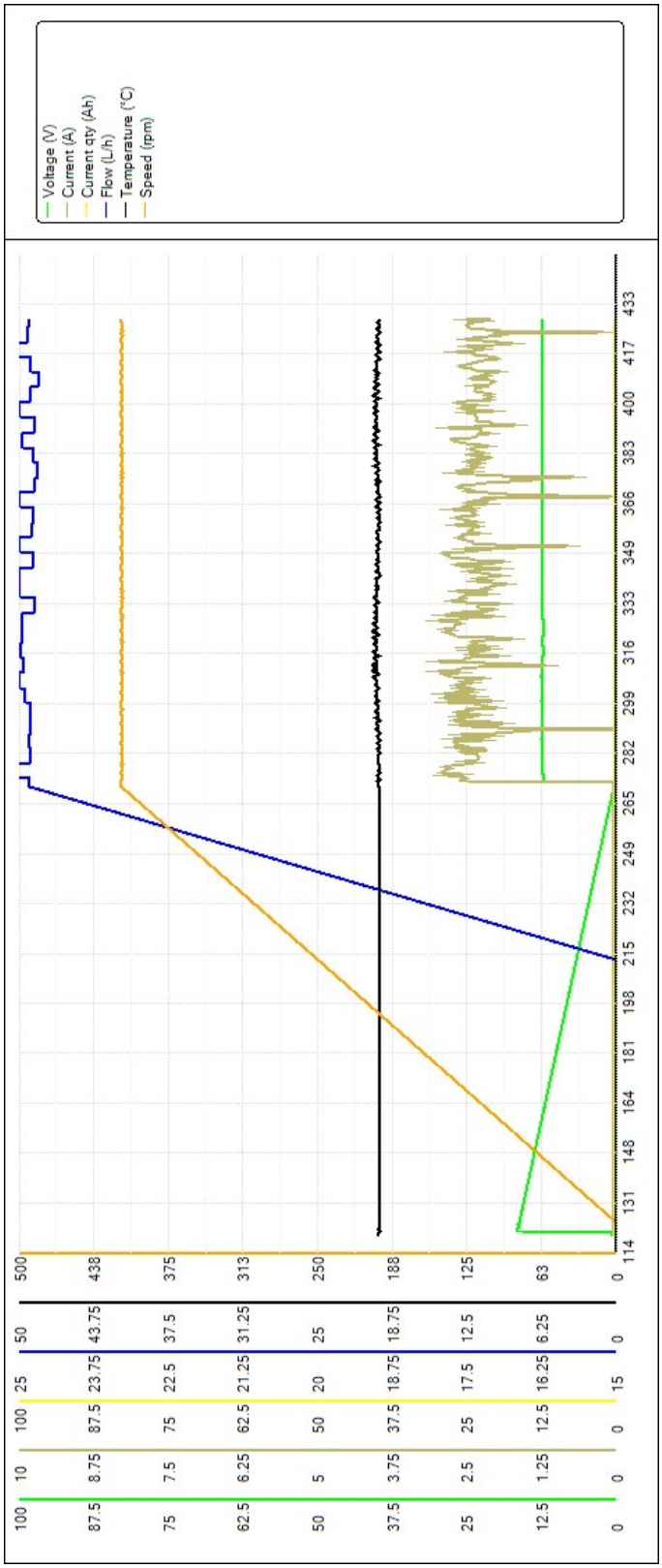
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (P0257G - Activator XF - Dalic)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Passed
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Passed
	Message Validate	
35	Stopping DKPL pump	Passed
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping n?1 (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature Stabilization	Compliant
	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (P0257E - Zinidal Aero - Dalic)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping n?1 (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	59
Creation date :	7/22/2019 8:32:06 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant. na	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Vivien Kibble	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
114 131 148 164 181 198 215 232 249 265 282 299 316 333 349 366 383 400 417 433
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 59
Creation date : 7/22/2019 8:32:06 PM

Events

Date	N°	Type	Completion
8:39:30PM	66	Operating mode complete	
8:39:30PM	66	Step over	
8:39:29PM	66	Step started	Message Validate
8:39:29PM	65	Step over	
8:39:29PM	65	Step started	Control Final
8:39:29PM	64	Step over	
8:39:28PM	64	Step started	Message Validate
8:39:28PM	63	Step over	
8:39:27PM	63	Step started	Message Validate
8:39:27PM	62	Step over	
8:39:27PM	62	Step started	Message Validate
8:39:27PM	61	Step over	
8:39:26PM	61	Step started	Message Validate
8:39:26PM	60	Step over	
8:39:26PM	60	Step started	Message Validate
8:39:26PM	59	Step over	
8:39:25PM	59	Step started	Message Validate
8:39:25PM	58	Step over	
8:39:22PM	58	Step started	Control Thickness (µm)
8:39:22PM	57	Step over	
8:39:21PM	57	Step started	Message Validate
8:39:21PM	56	Step over	
8:39:20PM	56	Step started	Control Adhesion
8:39:20PM	55	Step over	
8:39:20PM	55	Step started	Control Aspect
8:39:20PM	54	Step over	
8:39:19PM	54	Step started	Message Validate
8:39:19PM	53	Step over	
8:39:18PM	53	Step started	Message Validate
8:39:18PM	52	Step over	
8:39:18PM	52	Step started	Message Validate
8:39:18PM	51	Step over	
8:39:18PM	51	Step started	Message Validate
8:39:18PM	50	Step over	
8:39:17PM	50	Step started	Message Validate
8:39:17PM	49	Step over	
8:39:17PM	49	Step started	Message Validate
8:39:17PM	48	Step over	
8:39:17PM	48	Step started	Setting Pumping n?1 (Set point: Off)
8:39:17PM	47	Step over	
8:39:16PM	47	Step started	Message Validate
8:39:16PM	46	Step over	
8:39:16PM	46	Process defect: voltage high limit reached	
8:39:15PM	46	Step started	Setting Generation (Set point: Off)
8:39:15PM	45	Step over	
8:37:34PM	45	Process defect: voltage high limit reached	
8:37:28PM	45	Process defect: voltage high limit reached	
8:37:25PM	45	Process defect: voltage high limit reached	
8:37:22PM	45	Process defect: voltage high limit reached	
8:36:42PM	45	Process defect: voltage high limit reached	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 59
Creation date : 7/22/2019 8:32:06 PM

8:36:39PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
8:36:39PM	44	Step over	
8:36:37PM	44	Step started	Setting Generation (Set point: On)
8:36:37PM	43	Step over	
8:36:37PM	43	Step started	Setting Solution (P0257E - Zinidal Aero - Dalic)
8:36:37PM	42	Step over	
8:36:37PM	42	Step started	Setting Polarity (Set point: Plating)
8:36:37PM	41	Step over	
8:36:37PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:36:37PM	40	Step over	
8:36:37PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
8:36:37PM	39	Step over	
8:36:37PM	39	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:36:37PM	38	Step over	
8:36:08PM	38	Step started	Message Validate
8:36:07PM	37	Step over	
8:34:16PM	37	Step started	Message Validate
8:34:16PM	36	Step over	
8:34:16PM	36	Step started	Setting Pumping n?1 (Set point: On)
8:34:16PM	35	Step over	
8:34:13PM	35	Step started	Message Validate
8:34:13PM	34	Step over	
8:34:11PM	34	Step started	Message Validate
8:34:11PM	33	Step over	
8:34:10PM	33	Process defect: voltage high limit reached	
8:34:10PM	33	Step started	Setting Generation (Set point: Off)
8:34:10PM	32	Step over	
8:34:09PM	32	Process defect: voltage high limit reached	
8:34:07PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
8:34:07PM	31	Step over	
8:34:06PM	31	Step started	Setting Generation (Set point: On)
8:34:06PM	30	Step over	
8:34:06PM	30	Step started	Setting Solution (P0257G - Activator XF - Dalic)
8:34:06PM	29	Step over	
8:34:05PM	29	Step started	Message Validate
8:34:05PM	28	Step over	
8:34:03PM	28	Step started	Message Validate
8:34:03PM	27	Step over	
8:34:02PM	27	Step started	Message Validate
8:34:02PM	26	Step over	
8:34:00PM	26	Step started	Message Validate
8:34:00PM	25	Step over	
8:33:44PM	25	Step started	Setting Surface
8:33:44PM	24	Step over	
8:33:43PM	24	Step started	Setting Pumping n?1 (Set point: Off)
8:33:43PM	23	Step over	
8:33:42PM	23	Step started	Message Validate
8:33:42PM	22	Step over	
8:33:12PM	22	Process defect: flow high limit reached	
8:33:12PM	22	Process defect: flow high limit reached	
8:32:18PM	22	Step started	Message Validate
8:32:18PM	21	Step over	
8:32:18PM	21	Step started	Setting Pumping n?1 (Set point: On)
8:32:18PM	20	Step over	

8:32:17PM	20	Step started	Message Validate

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 59
Creation date : 7/22/2019 8:32:06 PM

8:32:17PM	19	Step over	
8:32:16PM	19	Step started	Message Validate
8:32:16PM	18	Step over	
8:32:16PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:32:16PM	17	Step over	
8:32:14PM	17	Step started	Message Validate
8:32:14PM	16	Step over	
8:32:13PM	16	Step started	Message Validate
8:32:13PM	15	Step over	
8:32:12PM	15	Step started	Message Validate
8:32:12PM	14	Step over	
8:32:12PM	14	Step started	Message Validate
8:32:12PM	13	Step over	
8:32:11PM	13	Step started	Message Validate
8:32:11PM	12	Step over	
8:32:11PM	12	Step started	Message Validate
8:32:11PM	11	Step over	
8:32:10PM	11	Step started	Message Validate
8:32:10PM	10	Step over	
8:32:10PM	10	Step started	Message Validate
8:32:10PM	09	Step over	
8:32:10PM	09	Step started	Message Validate
8:32:10PM	08	Step over	
8:32:09PM	08	Step started	Message Validate
8:32:09PM	07	Step over	
8:32:07PM	07	Step started	Message Validate
8:32:07PM	06	Step over	
8:32:07PM	06	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:32:07PM	05	Step over	
8:32:07PM	05	Step started	Setting Polarity (Set point: Anodizing)
8:32:07PM	04	Step over	
8:32:07PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:32:07PM	03	Step over	
8:32:07PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
8:32:07PM	02	Step over	
8:32:07PM	02	Step started	Setting Generation (Set point: Off)
8:32:07PM	01	Step over	
8:32:06PM	01	Step started	Setting Pumping n?1 (Set point: Off)
8:32:06PM	01	Operating mode started	59

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	60
Creation date :	7/22/2019 8:39:42 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	CORRDESA/BOEING
Operating mode designati	Zinidal AERO with Activator XF surface preparation

Part

Part reference	60
Part designation	60

Treatment

Surface (dm²)	0.12
Estimated duration	1.20

Electrolytes :

Electrolyte	Zinidal Aero - Dalic
Lot	P0257E
Beaker	Zinc-Nickel unit
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	13.00
Min. allowable thickness	8.00
Max. allowable thickness (	18.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257G	1.00	Dalistick tool 20160004
Passivateur n°3	P0262	0.00	Manual application

Steps

01	Pump initial setting OFF Setting Pumping n?1 (Set point: Off)	Compliant
02	Rectifier initial setting Setting Generation (Set point: Off)	Compliant
03	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)	Compliant
04	Current setting Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	Compliant
05	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
06	Flow setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
07	Information Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** 60 **Creation date :** 7/22/2019 8:39:42 PM

08	Safety equipments Message Validate	Compliant
09	Rectifier and Pump Message Validate	Compliant
10	DKPL pump Message Validate	Compliant
11	Tubes connection on DKPL pump Message Validate	Compliant
12	Bonnet change for Activator XF Message Validate	Compliant
13	Filling Activator XF Message Validate	Compliant
14	Electrical connections DKPL Message Validate	Compliant
15	Tubes connection on D2020 station Message Validate	Compliant
16	Bonnet change for Zinidal Aero Message Validate	Compliant
17	Filling Zinidal Aero Message Validate	Compliant
18	Temperature Setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
19	Electrical connections D2020 Message Validate	Compliant
20	Degreasing Message Validate	Compliant
21	Pump ON Setting Pumping n?1 (Set point: On)	Compliant
22	Pump activated Message Validate	Compliant
23	Masking Message Validate	Compliant
24	Pump OFF Setting Pumping n?1 (Set point: Off)	Compliant
25	Area setting Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :99.84 Treatment duration (min) :0:01:12	Compliant
26	DKPL pump activation Message Validate	Compliant
27	Electrical connection with the part Message Validate	Compliant
28	Wetting Message Validate	Compliant

29	Information	Compliant

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 60
Creation date : 7/22/2019 8:39:42 PM

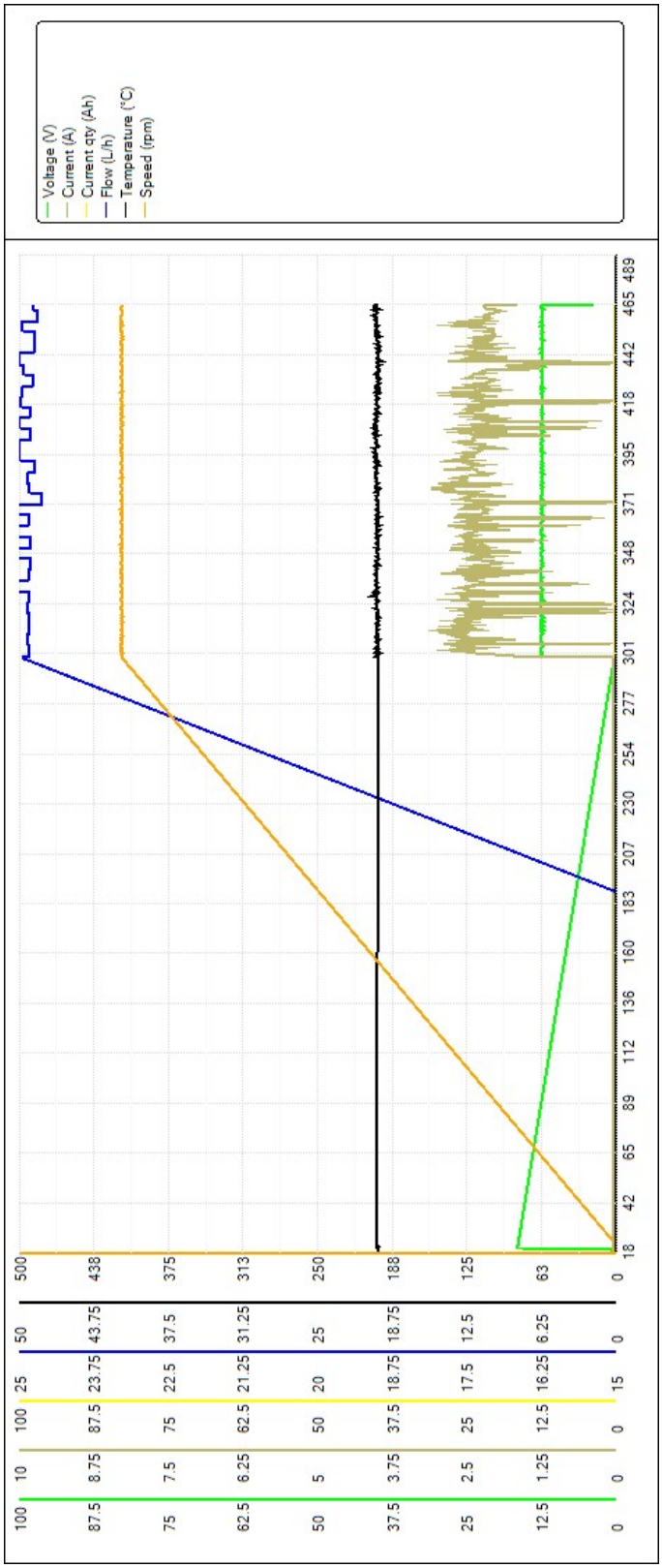
	Message Validate	
30	Activator XF Setting	Compliant
	Setting Solution (P0257G - Activator XF - Dalic)	
31	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
32	Treatment Activator XF	Passed
	Waiting Current quantity (%) (Set point: 100)	
33	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
34	DKPL Dalistick tool	Passed
	Message Validate	
35	Stopping DKPL pump	Passed
	Message Validate	
36	Pump ON	Compliant
	Setting Pumping n?1 (Set point: On)	
37	Rinsing	Compliant
	Message Validate	
38	Wetting	Compliant
	Message Validate	
39	Temperature Stabilization	Compliant
	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	
40	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)	
41	Current setting	Compliant
	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)	
42	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
43	Zinidal Aero setting	Compliant
	Setting Solution (P0257E - Zinidal Aero - Dalic)	
44	Rectifier ON	Compliant
	Setting Generation (Set point: On)	
45	Zinidal Aero treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
46	Rectifier OFF	Compliant
	Setting Generation (Set point: Off)	
47	Dalistick tool	Compliant
	Message Validate	
48	Pump OFF	Compliant
	Setting Pumping n?1 (Set point: Off)	
49	Rectifier and pump	Compliant
	Message Validate	
50	Electrical disconnection	Compliant
	Message Validate	
51	Rinsing	Compliant
	Message Validate	

52	Unmasking Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	60
Creation date :	7/22/2019 8:39:42 PM

53	Rinsing Message Validate	Compliant
54	Drying Message Validate	Compliant
55	Visual inspection Control Aspect	Compliant
56	Adhesion test Control Adhesion	Compliant
57	Degreasing Message Validate	Compliant
58	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 13 Lower tolerance (µm) : 8 Upper tolerance (µm) : 18 The thickness is not compliant. na	Compliant
59	Finish Message Validate	Compliant
60	Filling Passivateur n°3 Message Validate	Compliant
61	Passivateur n°3 application Message Validate	Compliant
62	Rinsing Message Validate	Compliant
63	Drying Message Validate	Compliant
64	Information Message Validate	Compliant
65	Final control Control Final **Comments** Vivien Kibble	Compliant
66	Cleaning information Message Validate	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
500 438 375 313 250 188 125 63 0
18 42 65 89 112 136 160 183 207 230 254 277 301 324 348 371 395 418 442 465 489
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 60
Creation date : 7/22/2019 8:39:42 PM

Events

Date	N°	Type	Completion
8:47:47PM	66	Operating mode complete	
8:47:47PM	66	Step over	
8:47:46PM	66	Step started	Message Validate
8:47:46PM	65	Step over	
8:47:46PM	65	Step started	Control Final
8:47:46PM	64	Step over	
8:47:45PM	64	Step started	Message Validate
8:47:45PM	63	Step over	
8:47:45PM	63	Step started	Message Validate
8:47:45PM	62	Step over	
8:47:44PM	62	Step started	Message Validate
8:47:44PM	61	Step over	
8:47:44PM	61	Step started	Message Validate
8:47:44PM	60	Step over	
8:47:43PM	60	Step started	Message Validate
8:47:43PM	59	Step over	
8:47:42PM	59	Step started	Message Validate
8:47:42PM	58	Step over	
8:47:39PM	58	Step started	Control Thickness (µm)
8:47:39PM	57	Step over	
8:47:38PM	57	Step started	Message Validate
8:47:38PM	56	Step over	
8:47:34PM	56	Step started	Control Adhesion
8:47:34PM	55	Step over	
8:47:33PM	55	Step started	Control Aspect
8:47:33PM	54	Step over	
8:47:32PM	54	Step started	Message Validate
8:47:32PM	53	Step over	
8:47:32PM	53	Step started	Message Validate
8:47:32PM	52	Step over	
8:47:31PM	52	Step started	Message Validate
8:47:31PM	51	Step over	
8:47:31PM	51	Step started	Message Validate
8:47:31PM	50	Step over	
8:47:30PM	50	Step started	Message Validate
8:47:30PM	49	Step over	
8:47:30PM	49	Step started	Message Validate
8:47:30PM	48	Step over	
8:47:30PM	48	Step started	Setting Pumping n?1 (Set point: Off)
8:47:30PM	47	Step over	
8:47:28PM	47	Step started	Message Validate
8:47:28PM	46	Step over	
8:47:28PM	46	Step started	Setting Generation (Set point: Off)
8:47:27PM	45	Step over	
8:47:19PM	45	Communication error	Dalipump
8:47:19PM	45	Communication error	Dalipump
8:44:42PM	45	Step started	Waiting Current quantity (%) (Set point: 100)
8:44:42PM	44	Step over	
8:44:40PM	44	Step started	Setting Generation (Set point: On)
8:44:40PM	43	Step over	
8:44:40PM	43	Step started	Setting Solution (P0257E - Zinidal Aero - Dalic)
8:44:40PM	42	Step over	
8:44:40PM	42	Step started	Setting Polarity (Set point: Plating)
8:44:40PM	41	Step over	
8:44:40PM	41	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:44:40PM	40	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 60
Creation date : 7/22/2019 8:39:42 PM

8:44:40PM	40	Step started	Setting Voltage (V) (Set point: 12 ; Mini: 1 ; Maxi: 12.2)
8:44:40PM	39	Step over	
8:44:40PM	39	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:44:40PM	38	Step over	
8:40:28PM	38	Step started	Message Validate
8:40:28PM	37	Step over	
8:40:13PM	37	Process defect: flow lower limit reached	
8:40:08PM	37	Step started	Message Validate
8:40:08PM	36	Step over	
8:40:08PM	36	Process defect: flow lower limit reached	
8:40:08PM	36	Step started	Setting Pumping n?1 (Set point: On)
8:40:08PM	35	Step over	
8:40:07PM	35	Step started	Message Validate
8:40:07PM	34	Step over	
8:40:05PM	34	Step started	Message Validate
8:40:05PM	33	Step over	
8:40:05PM	33	Process defect: voltage high limit reached	
8:40:05PM	33	Step started	Setting Generation (Set point: Off)
8:40:05PM	32	Step over	
8:40:04PM	32	Process defect: voltage high limit reached	
8:40:03PM	32	Step started	Waiting Current quantity (%) (Set point: 100)
8:40:03PM	31	Step over	
8:40:01PM	31	Step started	Setting Generation (Set point: On)
8:40:01PM	30	Step over	
8:40:01PM	30	Step started	Setting Solution (P0257G - Activator XF - Dalic)
8:40:01PM	29	Step over	
8:40:01PM	29	Step started	Message Validate
8:40:01PM	28	Step over	
8:40:00PM	28	Step started	Message Validate
8:40:00PM	27	Step over	
8:39:59PM	27	Step started	Message Validate
8:39:59PM	26	Step over	
8:39:59PM	26	Step started	Message Validate
8:39:59PM	25	Step over	
8:39:53PM	25	Step started	Setting Surface
8:39:53PM	24	Step over	
8:39:53PM	24	Step started	Setting Pumping n?1 (Set point: Off)
8:39:53PM	23	Step over	
8:39:51PM	23	Step started	Message Validate
8:39:51PM	22	Step over	
8:39:51PM	22	Step started	Message Validate
8:39:51PM	21	Step over	
8:39:51PM	21	Step started	Setting Pumping n?1 (Set point: On)
8:39:51PM	20	Step over	
8:39:50PM	20	Step started	Message Validate
8:39:50PM	19	Step over	
8:39:50PM	19	Step started	Message Validate
8:39:50PM	18	Step over	
8:39:50PM	18	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:39:50PM	17	Step over	
8:39:49PM	17	Step started	Message Validate
8:39:49PM	16	Step over	
8:39:49PM	16	Step started	Message Validate

8:39:49PM	15	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : 60
Creation date : 7/22/2019 8:39:42 PM

8:39:48PM	15	Step started	Message Validate
8:39:48PM	14	Step over	
8:39:48PM	14	Step started	Message Validate
8:39:48PM	13	Step over	
8:39:47PM	13	Step started	Message Validate
8:39:47PM	12	Step over	
8:39:47PM	12	Step started	Message Validate
8:39:47PM	11	Step over	
8:39:46PM	11	Step started	Message Validate
8:39:46PM	10	Step over	
8:39:46PM	10	Step started	Message Validate
8:39:46PM	09	Step over	
8:39:45PM	09	Step started	Message Validate
8:39:45PM	08	Step over	
8:39:45PM	08	Step started	Message Validate
8:39:45PM	07	Step over	
8:39:43PM	07	Step started	Message Validate
8:39:43PM	06	Step over	
8:39:43PM	06	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:39:43PM	05	Step over	
8:39:43PM	05	Step started	Setting Polarity (Set point: Anodizing)
8:39:43PM	04	Step over	
8:39:43PM	04	Step started	Setting Current (A) (Set point: 5 ; Mini: 0 ; Maxi: 5.2)
8:39:43PM	03	Step over	
8:39:43PM	03	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 16.2)
8:39:43PM	02	Step over	
8:39:42PM	02	Step started	Setting Generation (Set point: Off)
8:39:42PM	01	Step over	
8:39:42PM	01	Step started	Setting Pumping n?1 (Set point: Off)
8:39:42PM	01	Operating mode started	60

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Boeing ZnNi 61
Creation date :	8/5/2019 8:46:27 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	Corrdesa/Boeing -Sifco 6V
Operating mode designati	Zinc-Nickel treatment according to the SETI report

Part

Part reference	Boeing ZnNi 61
Part designation	Boeing ZnNi 61

Treatment

Surface (dm²)	0.12
Estimated duration	0.55

Electrolytes :

Electrolyte	Zinc-Nickel LHE 4018 - Sifco
Lot	P0138D
Beaker	Electrolyte bottle + Cap
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	12.00
Min. allowable thickness	7.00
Max. allowable thickness (	17.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257J	1.00	Dalistick tool 20160004

Steps

01	Rectifier setting Setting Generation (Set point: Off)	Compliant
02	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
03	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
04	Flow 1 setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
05	Flow 2 setting Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
06	Switch ON the Dalistick station Message Validate	Compliant
07	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
08	Degreasing Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Boeing ZnNi 61
Creation date :	8/5/2019 8:46:27 PM

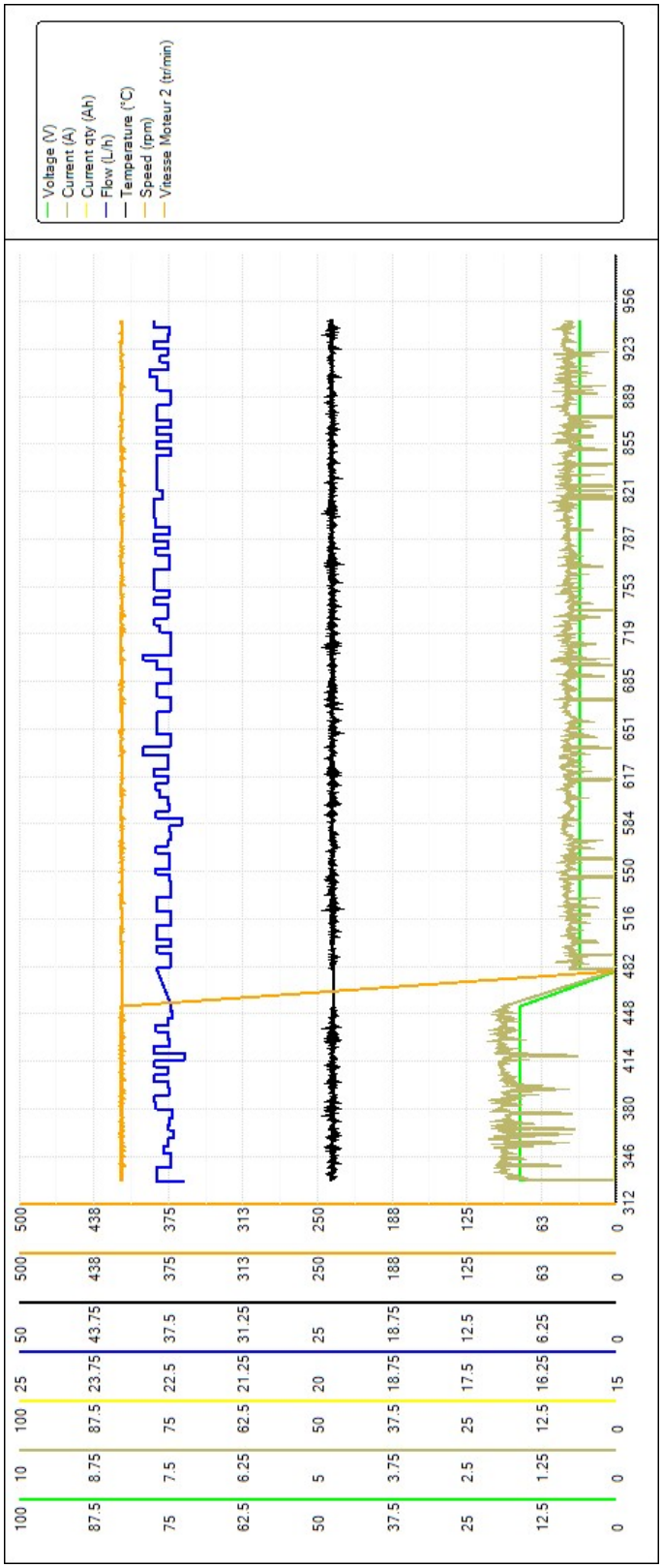
09	Masking Message Validate	Compliant
10	Surface Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :92.16 Treatment duration (min) :0:00:33	Compliant
11	Pump 2 setting Setting Pumping n?1 (Set point: On)	Compliant
12	Pump 2 activated Message Validate	Compliant
13	Rectifier connection Message Validate	Compliant
14	Wetting Message Validate	Compliant
15	Current activation Message Validate	Compliant
16	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)	Compliant
17	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
18	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
19	Electrolyte setting Setting Solution (P0257J - Activator XF - Dalic)	Compliant
20	Rectifier setting Setting Generation (Set point: On)	Compliant
21	Activator treatment Waiting Current quantity (%) (Set point: 100)	Compliant
22	Rectifier setting Setting Generation (Set point: Off)	Compliant
23	Activator treatment complete Message Validate	Compliant
24	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
25	Rinsing Message Validate	Compliant
26	Pump 1 setting Setting Pumping n?1 (Set point: On)	Compliant
27	Pump 1 activated Message Validate	Compliant
28	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Passed
29	Rectifier connection Message Validate	Compliant

30	Wetting	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Boeing ZnNi 61
Creation date :	8/5/2019 8:46:27 PM

	Message Validate	
31	Voltage setting	Compliant
	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)	
32	Current setting	Compliant
	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	
33	Polarity setting	Compliant
	Setting Polarity (Set point: Plating)	
34	Electrolyte setting	Compliant
	Setting Solution (P0138D - Zinc-Nickel LHE 4018 - Sifco)	
35	Rectifier setting	Compliant
	Setting Generation (Set point: On)	
36	Zinc-Nickel plating treatment	Compliant
	Waiting Current quantity (%) (Set point: 100)	
37	Rectifier setting	Compliant
	Setting Generation (Set point: Off)	
38	Zinc-Nickel plating treatment complete	Compliant
	Message Validate	
39	Pump 1 setting	Compliant
	Setting Pumping n?1 (Set point: Off)	
40	Rinsing	Compliant
	Message Validate	
41	Visual inspection	Compliant
	Control Aspect	
42	Adhesion test	Compliant
	Control Adhesion	
43	Thickness control	Compliant
	Control Thickness (µm)	
	Comments Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 12 Lower tolerance (µm) : 7 Upper tolerance (µm) : 17 The thickness is not compliant. dfsg	
44	Final control	Compliant
	Control Final	
	Comments Vivien Kibble	


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
Vitesse Moteur 2 (tr/min)
312 346 380 414 448 482 516 550 584 617 651 685 719 753 787 821 855 889 923 956
500 438 375 313 250 188 125 63 0
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Boeing ZnNi 61
Creation date : 8/5/2019 8:46:27 PM

Events

Date	N°	Type	Completion
9:02:23PM	44	Step over	
9:02:23PM	44	Operating mode complete	
9:02:22PM	44	Step started	Control Final
9:02:22PM	43	Step over	
9:02:16PM	42	Step over	
9:02:16PM	43	Step started	Control Thickness (µm)
9:02:16PM	42	Step started	Control Adhesion
9:02:16PM	41	Step over	
9:02:15PM	41	Step started	Control Aspect
9:02:15PM	40	Step over	
9:02:15PM	39	Step over	
9:02:15PM	40	Step started	Message Validate
9:02:15PM	38	Step over	
9:02:15PM	39	Step started	Setting Pumping n?1 (Set point: Off)
9:02:10PM	37	Step over	
9:02:10PM	38	Step started	Message Validate
9:02:10PM	36	Step over	
9:02:10PM	37	Step started	Setting Generation (Set point: Off)
8:54:27PM	35	Step over	
8:54:27PM	36	Step started	Waiting Current quantity (%) (Set point: 100)
8:54:26PM	34	Step over	
8:54:26PM	35	Step started	Setting Generation (Set point: On)
8:54:26PM	33	Step over	
8:54:26PM	34	Step started	Setting Solution (P0138D - Zinc-Nickel LHE 4018 - Sifco)
8:54:26PM	32	Step over	
8:54:26PM	33	Step started	Setting Polarity (Set point: Plating)
8:54:25PM	31	Step over	
8:54:25PM	32	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
8:54:25PM	30	Step over	
8:54:25PM	31	Step started	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)
8:54:23PM	29	Step over	
8:54:23PM	30	Step started	Message Validate
8:54:21PM	29	Step started	Message Validate
8:54:21PM	28	Step over	
8:54:14PM	27	Step over	
8:54:14PM	28	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
8:54:10PM	26	Step over	
8:54:10PM	27	Step started	Message Validate
8:54:10PM	26	Step started	Setting Pumping n?1 (Set point: On)
8:54:10PM	25	Step over	
8:54:05PM	24	Step over	
8:54:05PM	25	Step started	Message Validate
8:54:05PM	23	Step over	
8:54:05PM	24	Step started	Setting Pumping n?2 (Set point: Off)
8:54:01PM	23	Step started	Message Validate
8:54:01PM	22	Step over	
8:54:01PM	21	Step over	
8:54:01PM	22	Step started	Setting Generation (Set point: Off)
8:51:57PM	21	Step started	Waiting Current quantity (%) (Set point: 100)
8:51:57PM	20	Step over	
8:51:56PM	20	Step started	Setting Generation (Set point: On)
8:51:56PM	19	Step over	
8:51:56PM	18	Step over	
8:51:56PM	19	Step started	Setting Solution (P0257J - Activator XF - Dalic)
8:51:56PM	17	Step over	
8:51:56PM	18	Step started	Setting Polarity (Set point: Anodizing)

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Boeing ZnNi 61
Creation date : 8/5/2019 8:46:27 PM

8:51:56PM	16	Step over	
8:51:56PM	17	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
8:51:55PM	15	Step over	
8:51:55PM	16	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)
8:51:54PM	15	Step started	Message Validate
8:51:54PM	14	Step over	
8:51:50PM	13	Step over	
8:51:50PM	14	Step started	Message Validate
8:51:48PM	12	Step over	
8:51:48PM	13	Step started	Message Validate
8:46:52PM	11	Step over	
8:46:52PM	12	Step started	Message Validate
8:46:52PM	11	Step started	Setting Pumping n?1 (Set point: On)
8:46:52PM	10	Step over	
8:46:31PM	09	Step over	
8:46:31PM	10	Step started	Setting Surface
8:46:30PM	08	Step over	
8:46:30PM	09	Step started	Message Validate
8:46:30PM	07	Step over	
8:46:30PM	08	Step started	Message Validate
8:46:30PM	07	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:46:30PM	06	Step over	
8:46:28PM	06	Step started	Message Validate
8:46:28PM	05	Step over	
8:46:28PM	05	Step started	Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:46:28PM	04	Step over	
8:46:28PM	03	Step over	
8:46:28PM	04	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:46:28PM	03	Step started	Setting Pumping n?2 (Set point: Off)
8:46:28PM	02	Step over	
8:46:27PM	02	Step started	Setting Pumping n?1 (Set point: Off)
8:46:27PM	01	Step over	
8:46:27PM	01	Step started	Setting Generation (Set point: Off)
8:46:27PM	01	Operating mode started	Boeing ZnNi 61

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Boeing ZnNi 62
Creation date : 8/5/2019 9:02:35 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	Corrdesa/Boeing -Sifco 6V
Operating mode designati	Zinc-Nickel treatment according to the SETI report

Part

Part reference	Boeing ZnNi 62
Part designation	Boeing ZnNi 62

Treatment

Surface (dm²)	0.12
Estimated duration	0.55

Electrolytes :

Electrolyte	Zinc-Nickel LHE 4018 - Sifco
Lot	P0138D
Beaker	Electrolyte bottle + Cap
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	12.00
Min. allowable thickness	7.00
Max. allowable thickness (	17.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257J	1.00	Dalistick tool 20160004

Steps

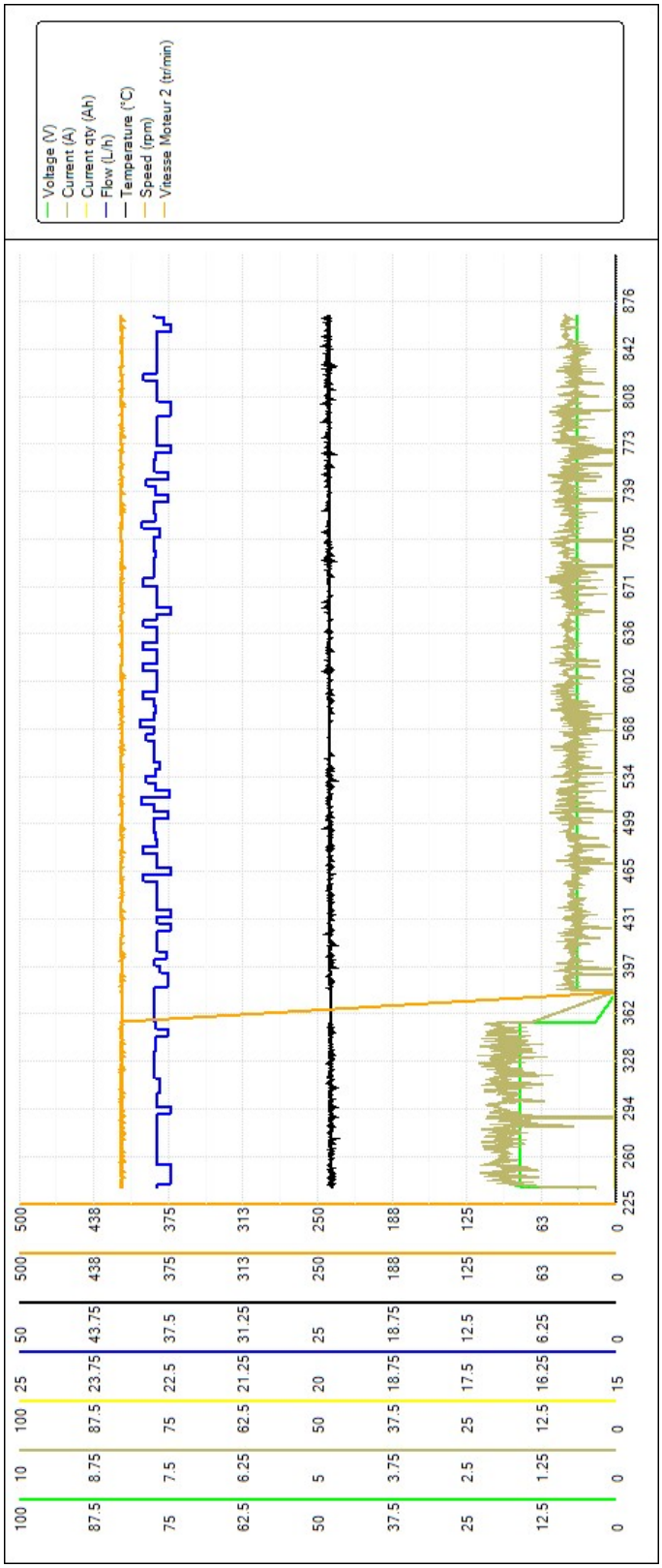
01	Rectifier setting Setting Generation (Set point: Off)	Compliant
02	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
03	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
04	Flow 1 setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
05	Flow 2 setting Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
06	Switch ON the Dalistick station Message Validate	Compliant
07	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
08	Degreasing Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** Boeing ZnNi 62 **Creation date :** 8/5/2019 9:02:35 PM

09	Masking Message Validate	Compliant
10	Surface Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :92.16 Treatment duration (min) :0:00:33	Compliant
11	Pump 2 setting Setting Pumping n?1 (Set point: On)	Compliant
12	Pump 2 activated Message Validate	Compliant
13	Rectifier connection Message Validate	Compliant
14	Wetting Message Validate	Compliant
15	Current activation Message Validate	Compliant
16	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)	Compliant
17	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
18	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
19	Electrolyte setting Setting Solution (P0257J - Activator XF - Dalic)	Compliant
20	Rectifier setting Setting Generation (Set point: On)	Compliant
21	Activator treatment Waiting Current quantity (%) (Set point: 100)	Compliant
22	Rectifier setting Setting Generation (Set point: Off)	Compliant
23	Activator treatment complete Message Validate	Compliant
24	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
25	Rinsing Message Validate	Compliant
26	Pump 1 setting Setting Pumping n?1 (Set point: On)	Compliant
27	Pump 1 activated Message Validate	Compliant
28	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Passed
29	Rectifier connection Message Validate	Compliant
30	Wetting	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** Boeing ZnNi 62 **Creation date :** 8/5/2019 9:02:35 PM

	Message Validate	
31	Voltage setting Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)	Compliant
32	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
33	Polarity setting Setting Polarity (Set point: Plating)	Compliant
34	Electrolyte setting Setting Solution (P0138D - Zinc-Nickel LHE 4018 - Sifco)	Compliant
35	Rectifier setting Setting Generation (Set point: On)	Compliant
36	Zinc-Nickel plating treatment Waiting Current quantity (%) (Set point: 100)	Compliant
37	Rectifier setting Setting Generation (Set point: Off)	Compliant
38	Zinc-Nickel plating treatment complete Message Validate	Compliant
39	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
40	Rinsing Message Validate	Compliant
41	Visual inspection Control Aspect	Compliant
42	Adhesion test Control Adhesion	Compliant
43	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 12 Lower tolerance (µm) : 7 Upper tolerance (µm) : 17 The thickness is not compliant. dsd	Compliant
44	Final control Control Final **Comments** Vivien Kibble	Compliant


Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
Vitesse Moteur 2 (tr/min)
225 260 294 328 362 397 431 465 499 534 568 602 636 671 705 739 773 808 842 876
500 438 375 313 250 188 125 63 0
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Boeing ZnNi 62
Creation date : 8/5/2019 9:02:35 PM

Events

Date	N°	Type	Completion
9:17:12PM	44	Operating mode complete	
9:17:12PM	44	Step over	
9:17:11PM	44	Step started	Control Final
9:17:11PM	43	Step over	
9:17:08PM	42	Step over	
9:17:08PM	43	Step started	Control Thickness (µm)
9:17:08PM	41	Step over	
9:17:08PM	42	Step started	Control Adhesion
9:17:05PM	40	Step over	
9:17:05PM	41	Step started	Control Aspect
9:17:05PM	39	Step over	
9:17:05PM	40	Step started	Message Validate
9:17:04PM	38	Step over	
9:17:04PM	39	Step started	Setting Pumping n?1 (Set point: Off)
9:17:03PM	37	Step over	
9:17:03PM	38	Step started	Message Validate
9:17:03PM	36	Step over	
9:17:03PM	37	Step started	Setting Generation (Set point: Off)
9:08:55PM	35	Step over	
9:08:55PM	36	Step started	Waiting Current quantity (%) (Set point: 100)
9:08:54PM	35	Step started	Setting Generation (Set point: On)
9:08:54PM	34	Step over	
9:08:54PM	34	Step started	Setting Solution (P0138D - Zinc-Nickel LHE 4018 - Sifco)
9:08:54PM	33	Step over	
9:08:54PM	32	Step over	
9:08:54PM	33	Step started	Setting Polarity (Set point: Plating)
9:08:54PM	31	Step over	
9:08:54PM	32	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
9:08:54PM	30	Step over	
9:08:54PM	31	Step started	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)
9:08:39PM	29	Step over	
9:08:39PM	30	Step started	Message Validate
9:08:38PM	29	Step started	Message Validate
9:08:38PM	28	Step over	
9:08:36PM	27	Step over	
9:08:36PM	28	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:08:35PM	26	Step over	
9:08:35PM	27	Step started	Message Validate
9:08:35PM	26	Step started	Setting Pumping n?1 (Set point: On)
9:08:35PM	25	Step over	
9:08:34PM	25	Step started	Message Validate
9:08:34PM	24	Step over	
9:08:34PM	23	Step over	
9:08:34PM	24	Step started	Setting Pumping n?2 (Set point: Off)
9:08:33PM	23	Step started	Message Validate
9:08:33PM	22	Step over	
9:08:33PM	21	Step over	
9:08:33PM	22	Step started	Setting Generation (Set point: Off)
9:06:34PM	21	Step started	Waiting Current quantity (%) (Set point: 100)
9:06:34PM	20	Step over	
9:06:33PM	20	Step started	Setting Generation (Set point: On)
9:06:33PM	19	Step over	
9:06:33PM	18	Step over	
9:06:33PM	19	Step started	Setting Solution (P0257J - Activator XF - Dalic)
9:06:33PM	18	Step started	Setting Polarity (Set point: Anodizing)
9:06:33PM	17	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Boeing ZnNi 62
Creation date : 8/5/2019 9:02:35 PM

9:06:33PM	16	Step over	
9:06:33PM	17	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
9:06:32PM	15	Step over	
9:06:32PM	16	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)
9:06:31PM	15	Step started	Message Validate
9:06:31PM	14	Step over	
9:06:30PM	13	Step over	
9:06:30PM	14	Step started	Message Validate
9:06:29PM	13	Step started	Message Validate
9:06:29PM	12	Step over	
9:02:56PM	12	Process defect: flow lower limit reached	
9:02:56PM	12	Process defect: flow lower limit reached	
9:02:46PM	11	Step over	
9:02:46PM	12	Step started	Message Validate
9:02:46PM	11	Step started	Setting Pumping n?1 (Set point: On)
9:02:46PM	10	Step over	
9:02:40PM	10	Step started	Setting Surface
9:02:40PM	09	Step over	
9:02:39PM	09	Step started	Message Validate
9:02:39PM	08	Step over	
9:02:38PM	08	Step started	Message Validate
9:02:38PM	07	Step over	
9:02:38PM	07	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
9:02:38PM	06	Step over	
9:02:37PM	05	Step over	
9:02:37PM	06	Step started	Message Validate
9:02:36PM	04	Step over	
9:02:36PM	05	Step started	Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:02:36PM	03	Step over	
9:02:36PM	04	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:02:36PM	02	Step over	
9:02:36PM	03	Step started	Setting Pumping n?2 (Set point: Off)
9:02:36PM	01	Step over	
9:02:36PM	02	Step started	Setting Pumping n?1 (Set point: Off)
9:02:36PM	01	Step started	Setting Generation (Set point: Off)
9:02:36PM	01	Operating mode started	Boeing ZnNi 62

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Boeing ZnNi 63
Creation date :	8/5/2019 9:17:21 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	Corrdesa/Boeing -Sifco 6V
Operating mode designati	Zinc-Nickel treatment according to the SETI report

Part

Part reference	Boeing ZnNi 63
Part designation	Boeing ZnNi 63

Treatment

Surface (dm²)	0.12
Estimated duration	0.55

Electrolytes :

Electrolyte	Zinc-Nickel LHE 4018 - Sifco
Lot	P0138D
Beaker	Electrolyte bottle + Cap
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	12.00
Min. allowable thickness	7.00
Max. allowable thickness (	17.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	P0257J	1.00	Dalistick tool 20160004

Steps

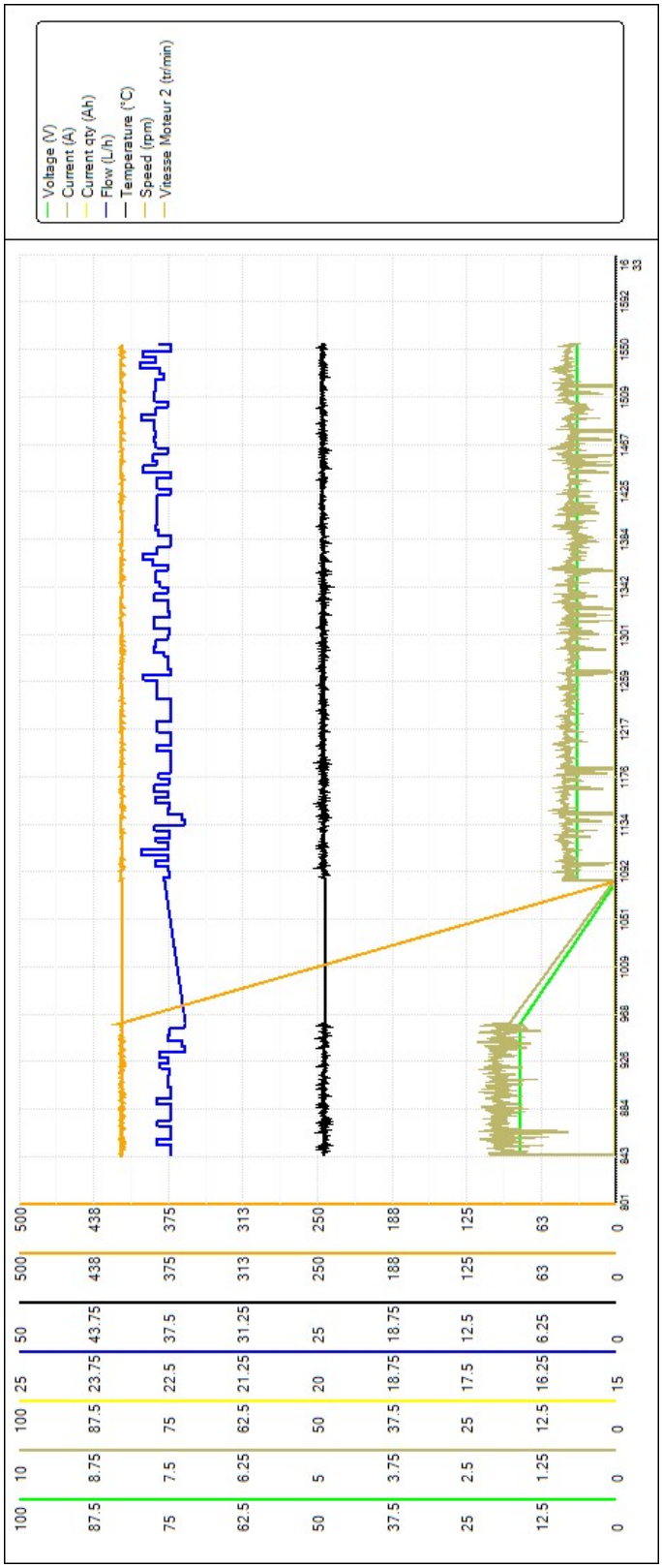
01	Rectifier setting Setting Generation (Set point: Off)	Compliant
02	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
03	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
04	Flow 1 setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
05	Flow 2 setting Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
06	Switch ON the Dalistick station Message Validate	Compliant
07	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
08	Degreasing Message Validate	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** Boeing ZnNi 63 **Creation date :** 8/5/2019 9:17:21 PM

09	Masking Message Validate	Compliant
10	Surface Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :92.16 Treatment duration (min) :0:00:33	Compliant
11	Pump 2 setting Setting Pumping n?1 (Set point: On)	Compliant
12	Pump 2 activated Message Validate	Compliant
13	Rectifier connection Message Validate	Compliant
14	Wetting Message Validate	Compliant
15	Current activation Message Validate	Compliant
16	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)	Compliant
17	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
18	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
19	Electrolyte setting Setting Solution (P0257J - Activator XF - Dalic)	Compliant
20	Rectifier setting Setting Generation (Set point: On)	Compliant
21	Activator treatment Waiting Current quantity (%) (Set point: 100)	Compliant
22	Rectifier setting Setting Generation (Set point: Off)	Compliant
23	Activator treatment complete Message Validate	Compliant
24	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
25	Rinsing Message Validate	Compliant
26	Pump 1 setting Setting Pumping n?1 (Set point: On)	Compliant
27	Pump 1 activated Message Validate	Compliant
28	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Passed
29	Rectifier connection Message Validate	Compliant
30	Wetting	Compliant

DALISTICK®	**Treatment :** Zinc-Nickel plating **Part reference :** Boeing ZnNi 63 **Creation date :** 8/5/2019 9:17:21 PM

	Message Validate	
31	Voltage setting Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)	Compliant
32	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
33	Polarity setting Setting Polarity (Set point: Plating)	Compliant
34	Electrolyte setting Setting Solution (P0138D - Zinc-Nickel LHE 4018 - Sifco)	Compliant
35	Rectifier setting Setting Generation (Set point: On)	Compliant
36	Zinc-Nickel plating treatment Waiting Current quantity (%) (Set point: 100)	Compliant
37	Rectifier setting Setting Generation (Set point: Off)	Compliant
38	Zinc-Nickel plating treatment complete Message Validate	Compliant
39	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
40	Rinsing Message Validate	Compliant
41	Visual inspection Control Aspect	Compliant
42	Adhesion test Control Adhesion	Compliant
43	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 12 Lower tolerance (µm) : 7 Upper tolerance (µm) : 17 The thickness is not compliant. dsrth	Compliant
44	Final control Control Final **Comments** Vivien Kibble	Compliant



DISTRIBUTION STATEMENT A: Approved for Public Release; AFLCMC-2021-0001, 7 Jan 21.

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Boeing ZnNi 63
Creation date :	8/5/2019 9:17:21 PM

Events

Date	N°	Type	Completion
9:43:25PM	44	Operating mode complete	
9:43:25PM	44	Step over	
9:43:25PM	43	Step over	
9:43:25PM	44	Step started	Control Final
9:43:22PM	42	Step over	
9:43:22PM	43	Step started	Control Thickness (µm)
9:43:21PM	41	Step over	
9:43:21PM	42	Step started	Control Adhesion
9:43:21PM	40	Step over	
9:43:21PM	41	Step started	Control Aspect
9:43:20PM	39	Step over	
9:43:20PM	40	Step started	Message Validate
9:43:20PM	39	Step started	Setting Pumping n?1 (Set point: Off)
9:43:20PM	38	Step over	
9:43:18PM	37	Step over	
9:43:18PM	38	Step started	Message Validate
9:43:18PM	36	Step over	
9:43:18PM	37	Step started	Setting Generation (Set point: Off)
9:35:27PM	36	Step started	Waiting Current quantity (%) (Set point: 100)
9:35:27PM	35	Step over	
9:35:26PM	35	Step started	Setting Generation (Set point: On)
9:35:26PM	34	Step over	
9:35:26PM	34	Step started	Setting Solution (P0138D - Zinc-Nickel LHE 4018 - Sifco)
9:35:26PM	33	Step over	
9:35:26PM	33	Step started	Setting Polarity (Set point: Plating)
9:35:26PM	32	Step over	
9:35:26PM	31	Step over	
9:35:26PM	32	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
9:35:25PM	30	Step over	
9:35:25PM	31	Step started	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)
9:35:24PM	29	Step over	
9:35:24PM	30	Step started	Message Validate
9:35:24PM	28	Step over	
9:35:24PM	29	Step started	Message Validate
9:35:22PM	27	Step over	
9:35:22PM	28	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
9:34:48PM	27	Process defect: flow lower limit reached	
9:34:48PM	27	Process defect: flow lower limit reached	
9:34:38PM	26	Step over	
9:34:38PM	27	Step started	Message Validate
9:34:38PM	26	Step started	Setting Pumping n?1 (Set point: On)
9:34:38PM	25	Step over	
9:33:29PM	24	Step over	
9:33:29PM	25	Step started	Message Validate
9:33:29PM	24	Step started	Setting Pumping n?2 (Set point: Off)
9:33:29PM	23	Step over	
9:33:22PM	23	Step started	Message Validate
9:33:22PM	22	Step over	
9:33:22PM	21	Step over	
9:33:22PM	22	Step started	Setting Generation (Set point: Off)
9:31:26PM	21	Step started	Waiting Current quantity (%) (Set point: 100)
9:31:26PM	20	Step over	
9:31:25PM	20	Step started	Setting Generation (Set point: On)

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9:31:25PM	19	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Boeing ZnNi 63
Creation date : 8/5/2019 9:17:21 PM

9:31:25PM	18	Step over	
9:31:25PM	19	Step started	Setting Solution (P0257J - Activator XF - Dalic)
9:31:25PM	18	Step started	Setting Polarity (Set point: Anodizing)
9:31:25PM	17	Step over	
9:31:24PM	17	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
9:31:24PM	16	Step over	
9:31:24PM	16	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)
9:31:24PM	15	Step over	
9:31:23PM	14	Step over	
9:31:23PM	15	Step started	Message Validate
9:30:47PM	13	Step over	
9:30:47PM	14	Step started	Message Validate
9:30:45PM	12	Step over	
9:30:45PM	13	Step started	Message Validate
9:30:32PM	12	Step started	Message Validate
9:30:32PM	11	Step over	
9:30:32PM	10	Step over	
9:30:32PM	11	Step started	Setting Pumping n?1 (Set point: On)
9:30:26PM	09	Step over	
9:30:26PM	10	Step started	Setting Surface
9:30:26PM	08	Step over	
9:30:26PM	09	Step started	Message Validate
9:30:24PM	07	Step over	
9:30:24PM	08	Step started	Message Validate
9:30:24PM	07	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
9:30:24PM	06	Step over	
9:17:23PM	06	Step started	Message Validate
9:17:23PM	05	Step over	
9:17:22PM	05	Step started	Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:17:22PM	04	Step over	
9:17:22PM	03	Step over	
9:17:22PM	04	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
9:17:22PM	02	Step over	
9:17:22PM	03	Step started	Setting Pumping n?2 (Set point: Off)
9:17:22PM	01	Step over	
9:17:22PM	02	Step started	Setting Pumping n?1 (Set point: Off)
9:17:22PM	01	Step started	Setting Generation (Set point: Off)
9:17:22PM	01	Operating mode started	Boeing ZnNi 63

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DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 64
Creation date :	8/12/2019 7:38:04 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	Corrdesa/Boeing -Sifco 6V
Operating mode designati	Zinc-Nickel treatment according to the SETI report

Part

Part reference	Sample 64
Part designation	Sample 64

Treatment

Surface (dm²)	0.12
Estimated duration	0.55

Electrolytes :

Electrolyte	Zinc-Nickel LHE 4018 - Sifco
Lot	P0260A
Beaker	Electrolyte bottle + Cap
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	12.00
Min. allowable thickness	7.00
Max. allowable thickness (	17.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	000000	0.00	Manual application

Steps

01	Rectifier setting Setting Generation (Set point: Off)	Compliant
02	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
03	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
04	Flow 1 setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
05	Flow 2 setting Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
06	Switch ON the Dalistick station Message Validate	Compliant
07	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant

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08	Degreasing Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 64
Creation date :	8/12/2019 7:38:04 PM

09	Masking Message Validate	Compliant
10	Surface Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :92.16 Treatment duration (min) :0:00:33	Compliant
11	Pump 2 setting Setting Pumping n?1 (Set point: On)	Compliant
12	Pump 2 activated Message Validate	Compliant
13	Rectifier connection Message Validate	Compliant
14	Wetting Message Validate	Compliant
15	Current activation Message Validate	Compliant
16	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)	Compliant
17	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
18	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
19	Electrolyte setting Setting Solution (000000 - Activator XF - Dalic)	Compliant
20	Rectifier setting Setting Generation (Set point: On)	Compliant
21	Activator treatment Waiting Current quantity (%) (Set point: 100)	Compliant
22	Rectifier setting Setting Generation (Set point: Off)	Compliant
23	Activator treatment complete Message Validate	Compliant
24	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
25	Rinsing Message Validate	Compliant
26	Pump 1 setting Setting Pumping n?1 (Set point: On)	Compliant
27	Pump 1 activated Message Validate	Compliant
28	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Passed

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29	Rectifier connection Message Validate	Compliant
30	Wetting	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 64
Creation date :	8/12/2019 7:38:04 PM

	Message Validate	
31	Voltage setting Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)	Compliant
32	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
33	Polarity setting Setting Polarity (Set point: Plating)	Compliant
34	Electrolyte setting Setting Solution (P0260A - Zinc-Nickel LHE 4018 - Sifco)	Compliant
35	Rectifier setting Setting Generation (Set point: On)	Compliant
36	Zinc-Nickel plating treatment Waiting Current quantity (%) (Set point: 100)	Compliant
37	Rectifier setting Setting Generation (Set point: Off)	Compliant
38	Zinc-Nickel plating treatment complete Message Validate	Compliant
39	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
40	Rinsing Message Validate	Compliant
41	Visual inspection Control Aspect	Compliant
42	Adhesion test Control Adhesion	Compliant
43	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 12 Lower tolerance (µm) : 7 Upper tolerance (µm) : 17 The thickness is not compliant. Note that this process did not use XF	Compliant
44	Final control Control Final **Comments** Vivien Kibble	Compliant

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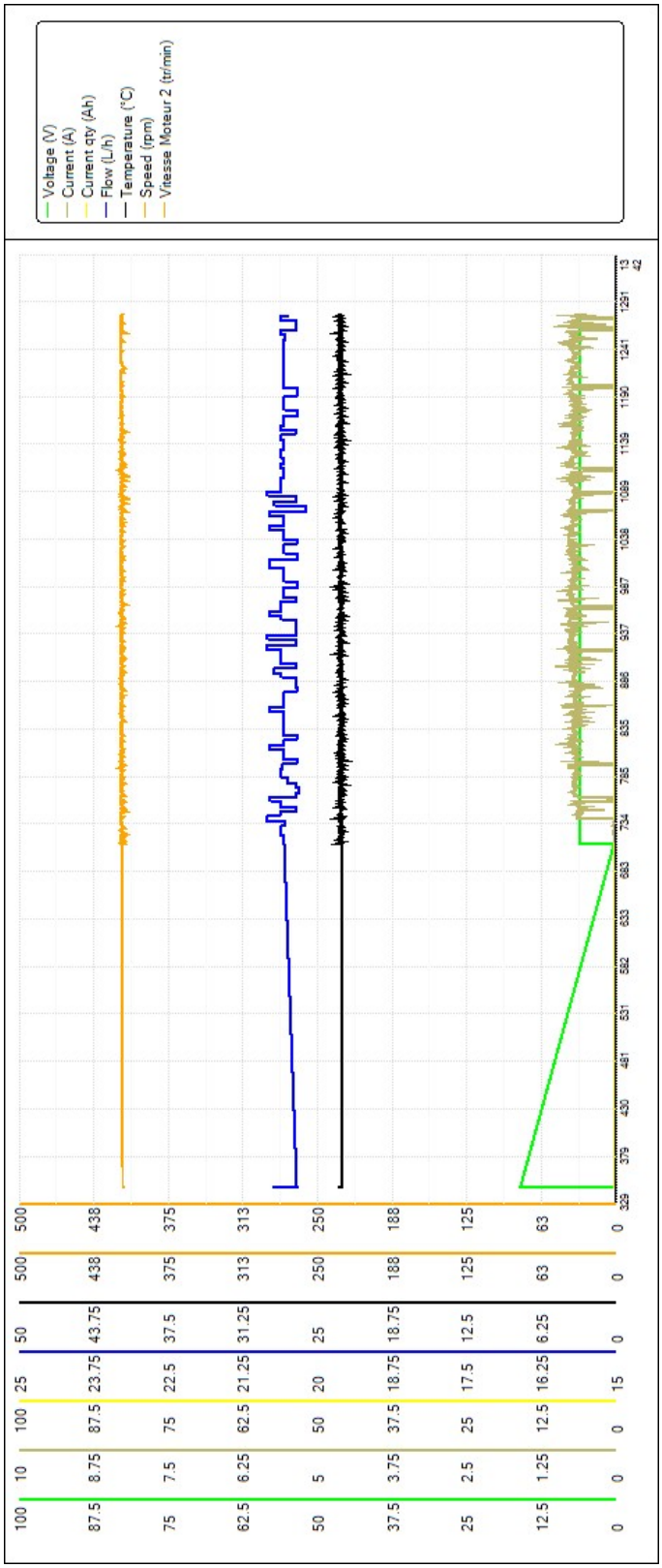

Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
Vitesse Moteur 2 (tr/min)

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Sample 64
Creation date : 8/12/2019 7:38:04 PM

Events

Date	N°	Type	Completion
8:02:16PM	44	Operating mode complete	
8:02:16PM	44	Step over	
8:02:16PM	43	Step over	
8:02:16PM	44	Step started	Control Final
8:01:53PM	43	Step started	Control Thickness (µm)
8:01:53PM	42	Step over	
8:01:53PM	41	Step over	
8:01:53PM	42	Step started	Control Adhesion
8:01:52PM	40	Step over	
8:01:52PM	41	Step started	Control Aspect
7:59:32PM	40	Step started	Message Validate
7:59:32PM	39	Step over	
7:59:32PM	38	Step over	
7:59:32PM	39	Step started	Setting Pumping n?1 (Set point: Off)
7:59:24PM	37	Step over	
7:59:24PM	38	Step started	Message Validate
7:59:24PM	37	Step started	Setting Generation (Set point: Off)
7:59:23PM	36	Step over	
7:49:59PM	35	Step over	
7:49:59PM	36	Step started	Waiting Current quantity (%) (Set point: 100)
7:49:58PM	34	Step over	
7:49:58PM	35	Step started	Setting Generation (Set point: On)
7:49:58PM	33	Step over	
7:49:58PM	34	Step started	Setting Solution (P0260A - Zinc-Nickel LHE 4018 - Sifco)
7:49:58PM	33	Step started	Setting Polarity (Set point: Plating)
7:49:58PM	32	Step over	
7:49:58PM	31	Step over	
7:49:58PM	32	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
7:49:58PM	30	Step over	
7:49:58PM	31	Step started	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)
7:49:45PM	29	Step over	
7:49:45PM	30	Step started	Message Validate
7:49:44PM	29	Step started	Message Validate
7:49:44PM	28	Step over	
7:49:42PM	28	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
7:49:42PM	27	Step over	
7:43:59PM	27	Step started	Message Validate
7:43:59PM	26	Step over	
7:43:59PM	25	Step over	
7:43:59PM	26	Step started	Setting Pumping n?1 (Set point: On)
7:43:57PM	24	Step over	
7:43:57PM	25	Step started	Message Validate
7:43:57PM	23	Step over	
7:43:57PM	24	Step started	Setting Pumping n?2 (Set point: Off)
7:43:54PM	22	Step over	
7:43:54PM	23	Step started	Message Validate
7:43:53PM	21	Step over	
7:43:53PM	22	Step started	Setting Generation (Set point: Off)
7:43:53PM	20	Step over	
7:43:53PM	21	Step started	Waiting Current quantity (%) (Set point: 100)
7:43:51PM	19	Step over	
7:43:51PM	20	Step started	Setting Generation (Set point: On)
7:43:51PM	18	Step over	
7:43:51PM	19	Step started	Setting Solution (000000 - Activator XF - Dalic)
7:43:51PM	17	Step over	
7:43:51PM	18	Step started	Setting Polarity (Set point: Anodizing)

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Sample 64
Creation date : 8/12/2019 7:38:04 PM

7:43:51PM	16	Step over	
7:43:51PM	17	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
7:43:51PM	15	Step over	
7:43:51PM	16	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)
7:43:49PM	14	Step over	
7:43:49PM	15	Step started	Message Validate
7:43:47PM	14	Step started	Message Validate
7:43:47PM	13	Step over	
7:43:44PM	12	Step over	
7:43:44PM	13	Step started	Message Validate
7:43:18PM	12	Step started	Message Validate
7:43:18PM	11	Step over	
7:43:17PM	10	Step over	
7:43:17PM	11	Step started	Setting Pumping n?1 (Set point: On)
7:38:28PM	10	Step started	Setting Surface
7:38:28PM	09	Step over	
7:38:26PM	08	Step over	
7:38:26PM	09	Step started	Message Validate
7:38:17PM	07	Step over	
7:38:17PM	08	Step started	Message Validate
7:38:17PM	07	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
7:38:17PM	06	Step over	
7:38:12PM	06	Powering	
7:38:08PM	05	Step over	
7:38:08PM	06	Step started	Message Validate
7:38:08PM	05	Step started	Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)
7:38:08PM	04	Step over	
7:38:08PM	03	Step over	
7:38:08PM	04	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
7:38:08PM	02	Step over	
7:38:08PM	03	Step started	Setting Pumping n?2 (Set point: Off)
7:38:08PM	02	Step started	Setting Pumping n?1 (Set point: Off)
7:38:08PM	01	Step over	
7:38:07PM	01	Step started	Setting Generation (Set point: Off)
7:38:07PM	01	Operating mode started	Sample 64

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 65
Creation date :	8/12/2019 8:02:32 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	Corrdesa/Boeing -Sifco 6V
Operating mode designati	Zinc-Nickel treatment according to the SETI report

Part

Part reference	Sample 65
Part designation	Sample 65

Treatment

Surface (dm²)	0.12
Estimated duration	0.55

Electrolytes :

Electrolyte	Zinc-Nickel LHE 4018 - Sifco
Lot	P0260A
Beaker	Electrolyte bottle + Cap
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	12.00
Min. allowable thickness	7.00
Max. allowable thickness (	17.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	000000	0.00	Manual application

Steps

01	Rectifier setting Setting Generation (Set point: Off)	Compliant
02	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
03	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
04	Flow 1 setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
05	Flow 2 setting Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
06	Switch ON the Dalistick station Message Validate	Compliant
07	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant
08	Degreasing Message Validate	Compliant

DALISTICK®

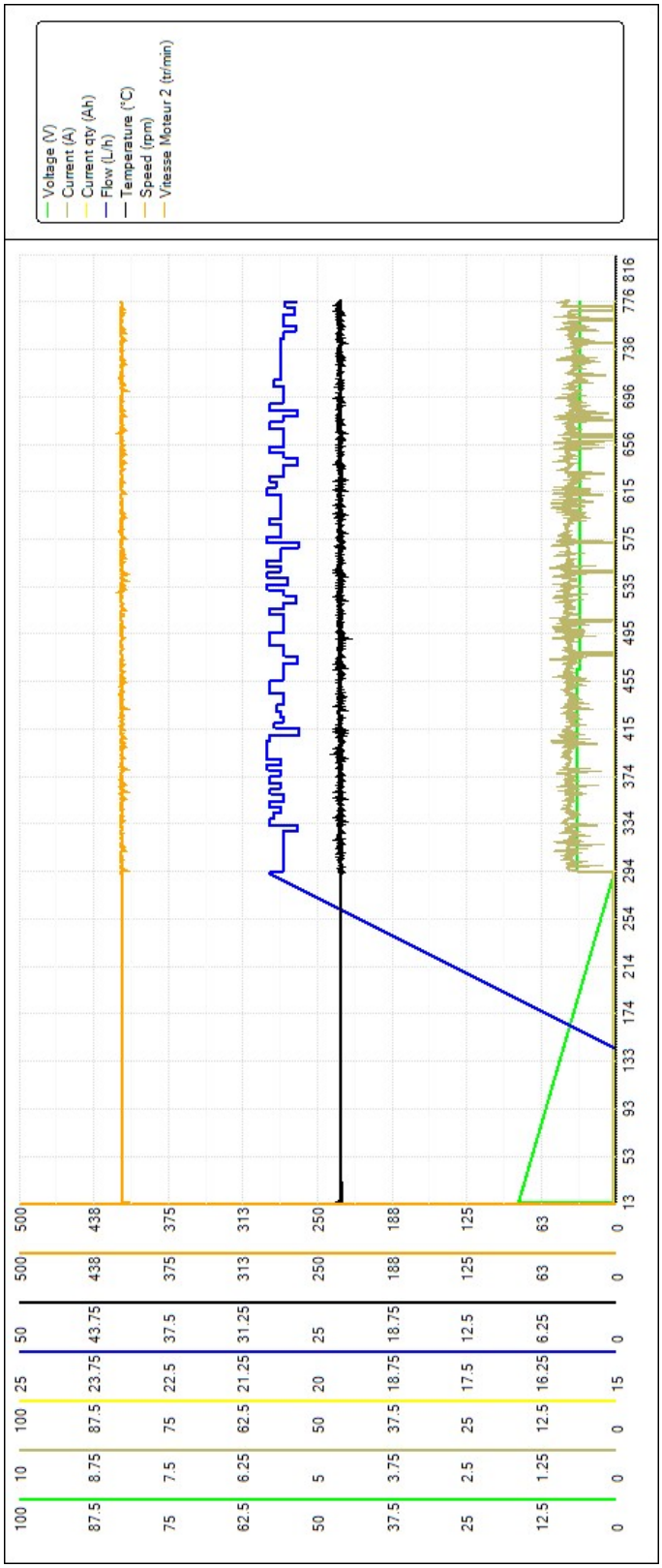
Treatment : Zinc-Nickel plating
Part reference : Sample 65
Creation date : 8/12/2019 8:02:32 PM

09	Masking Message Validate	Compliant
10	Surface Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :92.16 Treatment duration (min) :0:00:33	Compliant
11	Pump 2 setting Setting Pumping n?1 (Set point: On)	Compliant
12	Pump 2 activated Message Validate	Compliant
13	Rectifier connection Message Validate	Compliant
14	Wetting Message Validate	Compliant
15	Current activation Message Validate	Compliant
16	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)	Compliant
17	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
18	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
19	Electrolyte setting Setting Solution (000000 - Activator XF - Dalic)	Compliant
20	Rectifier setting Setting Generation (Set point: On)	Compliant
21	Activator treatment Waiting Current quantity (%) (Set point: 100)	Compliant
22	Rectifier setting Setting Generation (Set point: Off)	Compliant
23	Activator treatment complete Message Validate	Compliant
24	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
25	Rinsing Message Validate	Compliant
26	Pump 1 setting Setting Pumping n?1 (Set point: On)	Compliant
27	Pump 1 activated Message Validate	Compliant
28	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Passed
29	Rectifier connection Message Validate	Compliant
30	Wetting	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 65
Creation date :	8/12/2019 8:02:32 PM

	Message Validate	
31	Voltage setting Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)	Compliant
32	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
33	Polarity setting Setting Polarity (Set point: Plating)	Compliant
34	Electrolyte setting Setting Solution (P0260A - Zinc-Nickel LHE 4018 - Sifco)	Compliant
35	Rectifier setting Setting Generation (Set point: On)	Compliant
36	Zinc-Nickel plating treatment Waiting Current quantity (%) (Set point: 100)	Compliant
37	Rectifier setting Setting Generation (Set point: Off)	Compliant
38	Zinc-Nickel plating treatment complete Message Validate	Compliant
39	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
40	Rinsing Message Validate	Compliant
41	Visual inspection Control Aspect	Compliant
42	Adhesion test Control Adhesion	Compliant
43	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 12 Lower tolerance (µm) : 7 Upper tolerance (µm) : 17 The thickness is not compliant. Note no Activator XF was used in this process	Compliant
44	Final control Control Final **Comments** Vivien Kibble	Compliant



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DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 65
Creation date :	8/12/2019 8:02:32 PM

Events

Date	N°	Type	Completion
8:21:08PM	44	Operating mode complete	
8:21:08PM	44	Step over	
8:21:07PM	44	Step started	Control Final
8:21:07PM	43	Step over	
8:20:44PM	42	Step over	
8:20:44PM	43	Step started	Control Thickness (µm)
8:20:44PM	41	Step over	
8:20:44PM	42	Step started	Control Adhesion
8:20:43PM	40	Step over	
8:20:43PM	41	Step started	Control Aspect
8:15:35PM	39	Step over	
8:15:35PM	40	Step started	Message Validate
8:15:35PM	38	Step over	
8:15:35PM	39	Step started	Setting Pumping n?1 (Set point: Off)
8:15:30PM	37	Step over	
8:15:30PM	38	Step started	Message Validate
8:15:30PM	36	Step over	
8:15:30PM	37	Step started	Setting Generation (Set point: Off)
8:07:26PM	35	Step over	
8:07:26PM	36	Step started	Waiting Current quantity (%) (Set point: 100)
8:07:25PM	35	Step started	Setting Generation (Set point: On)
8:07:25PM	34	Step over	
8:07:25PM	33	Step over	
8:07:25PM	34	Step started	Setting Solution (P0260A - Zinc-Nickel LHE 4018 - Sifco)
8:07:24PM	32	Step over	
8:07:24PM	33	Step started	Setting Polarity (Set point: Plating)
8:07:24PM	31	Step over	
8:07:24PM	32	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
8:07:24PM	30	Step over	
8:07:24PM	31	Step started	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)
8:07:04PM	29	Step over	
8:07:04PM	30	Step started	Message Validate
8:07:01PM	29	Step started	Message Validate
8:07:00PM	28	Step over	
8:03:01PM	28	Process defect: flow lower limit reached	
8:02:53PM	27	Step over	
8:02:53PM	28	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
8:02:52PM	27	Process defect: flow lower limit reached	
8:02:51PM	27	Step started	Message Validate
8:02:51PM	26	Step over	
8:02:51PM	26	Step started	Setting Pumping n?1 (Set point: On)
8:02:51PM	25	Step over	
8:02:50PM	24	Step over	
8:02:50PM	25	Step started	Message Validate
8:02:49PM	23	Step over	
8:02:49PM	24	Step started	Setting Pumping n?2 (Set point: Off)
8:02:48PM	23	Step started	Message Validate
8:02:48PM	22	Step over	
8:02:48PM	21	Step over	
8:02:48PM	22	Step started	Setting Generation (Set point: Off)
8:02:47PM	20	Step over	
8:02:47PM	21	Step started	Waiting Current quantity (%) (Set point: 100)
8:02:46PM	19	Step over	

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8:02:46PM	20	Step started	Setting Generation (Set point: On)

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Sample 65
Creation date : 8/12/2019 8:02:32 PM

8:02:46PM	18	Step over	
8:02:46PM	19	Step started	Setting Solution (000000 - Activator XF - Dalic)
8:02:46PM	18	Step started	Setting Polarity (Set point: Anodizing)
8:02:46PM	17	Step over	
8:02:46PM	16	Step over	
8:02:46PM	17	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
8:02:45PM	15	Step over	
8:02:45PM	16	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)
8:02:45PM	14	Step over	
8:02:45PM	15	Step started	Message Validate
8:02:44PM	14	Step started	Message Validate
8:02:44PM	13	Step over	
8:02:43PM	12	Step over	
8:02:43PM	13	Step started	Message Validate
8:02:42PM	11	Step over	
8:02:42PM	12	Step started	Message Validate
8:02:42PM	10	Step over	
8:02:42PM	11	Step started	Setting Pumping n?1 (Set point: On)
8:02:36PM	09	Step over	
8:02:36PM	10	Step started	Setting Surface
8:02:36PM	09	Step started	Message Validate
8:02:36PM	08	Step over	
8:02:35PM	08	Step started	Message Validate
8:02:35PM	07	Step over	
8:02:35PM	07	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:02:35PM	06	Step over	
8:02:33PM	05	Step over	
8:02:33PM	06	Step started	Message Validate
8:02:33PM	04	Step over	
8:02:33PM	05	Step started	Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:02:33PM	04	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:02:33PM	03	Step over	
8:02:33PM	02	Step over	
8:02:33PM	03	Step started	Setting Pumping n?2 (Set point: Off)
8:02:33PM	01	Step over	
8:02:33PM	02	Step started	Setting Pumping n?1 (Set point: Off)
8:02:33PM	01	Step started	Setting Generation (Set point: Off)
8:02:32PM	01	Operating mode started	Sample 65

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DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 66
Creation date :	8/12/2019 8:21:18 PM

Description

Operating mode selection

Treatment	Zinc-Nickel plating
Companies	
Substrate	High strength steel
Tool type	Dalistick tool
Operating mode code	Corrdesa/Boeing -Sifco 6V
Operating mode designati	Zinc-Nickel treatment according to the SETI report

Part

Part reference	Sample 66
Part designation	Sample 66

Treatment

Surface (dm²)	0.12
Estimated duration	0.55

Electrolytes :

Electrolyte	Zinc-Nickel LHE 4018 - Sifco
Lot	P0260A
Beaker	Electrolyte bottle + Cap
Initial volume	1.00
Total current quantity (mA	0.06
Thickness	12.00
Min. allowable thickness	7.00
Max. allowable thickness (	17.00
Outil Dalistick	Dalistick tool 20140014

Secondary electrolytes

Electrolyte	Lot electrolyte	Thickness	Stick
Activator XF - Dalic	000000	0.00	Manual application

Steps

01	Rectifier setting Setting Generation (Set point: Off)	Compliant
02	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
03	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
04	Flow 1 setting Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
05	Flow 2 setting Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)	Compliant
06	Switch ON the Dalistick station Message Validate	Compliant
07	Temperature setting Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)	Compliant

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08	Degreasing Message Validate	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 66
Creation date :	8/12/2019 8:21:18 PM

09	Masking Message Validate	Compliant
10	Surface Setting Surface **Comments** Total area to be treated (dm²) :0.12 Quantity of current (mAh) :92.16 Treatment duration (min) :0:00:33	Compliant
11	Pump 2 setting Setting Pumping n?1 (Set point: On)	Compliant
12	Pump 2 activated Message Validate	Compliant
13	Rectifier connection Message Validate	Compliant
14	Wetting Message Validate	Compliant
15	Current activation Message Validate	Compliant
16	Voltage setting Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)	Compliant
17	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
18	Polarity setting Setting Polarity (Set point: Anodizing)	Compliant
19	Electrolyte setting Setting Solution (000000 - Activator XF - Dalic)	Compliant
20	Rectifier setting Setting Generation (Set point: On)	Compliant
21	Activator treatment Waiting Current quantity (%) (Set point: 100)	Compliant
22	Rectifier setting Setting Generation (Set point: Off)	Compliant
23	Activator treatment complete Message Validate	Compliant
24	Pump 2 setting Setting Pumping n?2 (Set point: Off)	Compliant
25	Rinsing Message Validate	Compliant
26	Pump 1 setting Setting Pumping n?1 (Set point: On)	Compliant
27	Pump 1 activated Message Validate	Compliant
28	Temperature stabilization Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)	Passed
29	Rectifier connection	Compliant

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	Message Validate	
30	Wetting	Compliant

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 66
Creation date :	8/12/2019 8:21:18 PM

	Message Validate	
31	Voltage setting Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)	Compliant
32	Current setting Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)	Compliant
33	Polarity setting Setting Polarity (Set point: Plating)	Compliant
34	Electrolyte setting Setting Solution (P0260A - Zinc-Nickel LHE 4018 - Sifco)	Compliant
35	Rectifier setting Setting Generation (Set point: On)	Compliant
36	Zinc-Nickel plating treatment Waiting Current quantity (%) (Set point: 100)	Compliant
37	Rectifier setting Setting Generation (Set point: Off)	Compliant
38	Zinc-Nickel plating treatment complete Message Validate	Compliant
39	Pump 1 setting Setting Pumping n?1 (Set point: Off)	Compliant
40	Rinsing Message Validate	Compliant
41	Visual inspection Control Aspect	Compliant
42	Adhesion test Control Adhesion	Compliant
43	Thickness control Control Thickness (µm) **Comments** Minimum (µm) : 0 Maximum (µm) : 0 Average (µm) : 0 Standard deviation (µm) : 0 Average required (µm) : 12 Lower tolerance (µm) : 7 Upper tolerance (µm) : 17 The thickness is not compliant. Note Activator XF was not used in this process	Compliant
44	Final control Control Final **Comments** Vivien Kibble	Compliant

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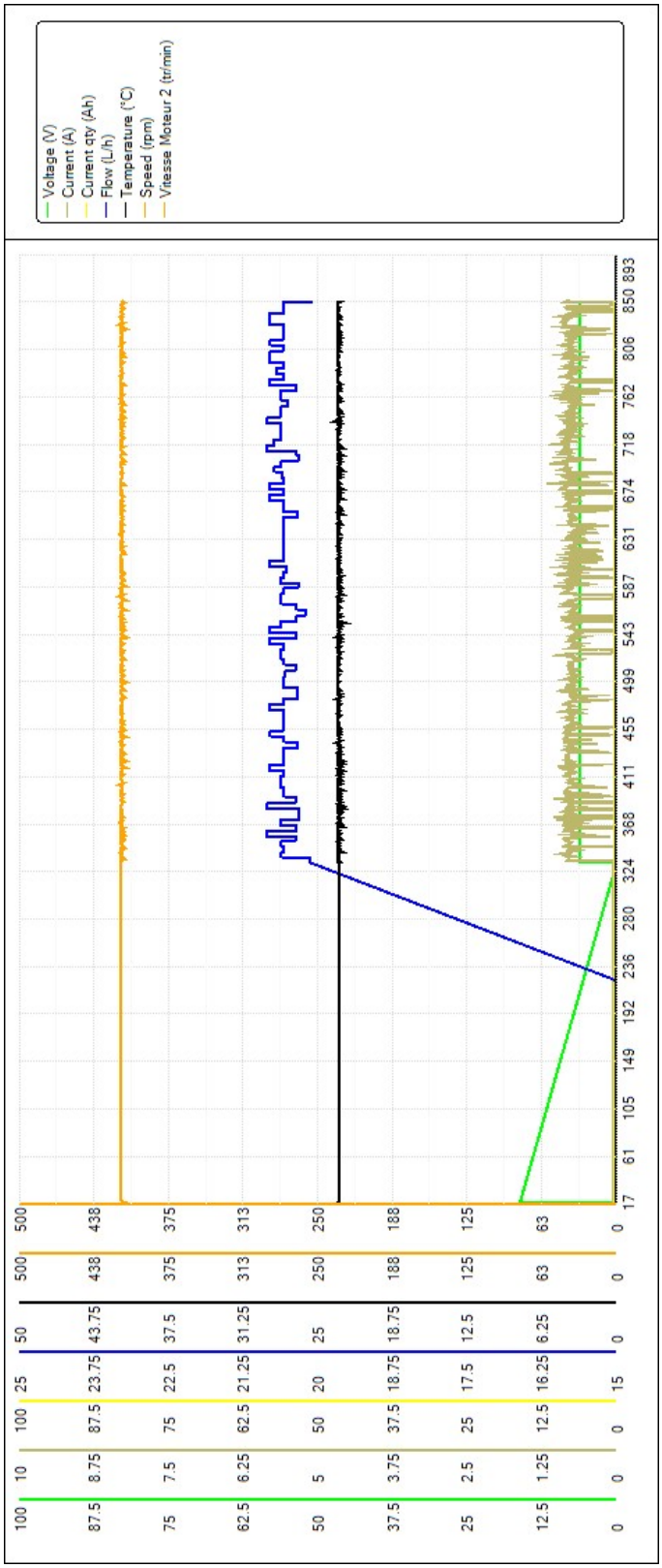
Voltage (V)
Current (A)
Current qty (Ah)
Flow (L/h)
Temperature (°C)
Speed (rpm)
Vitesse Moteur 2 (tr/min)
17 61 105 149 192 236 280 324 368 411 455 499 543 587 631 674 718 762 806 850 893
500 438 375 313 250 188 125 63 0
500 438 375 313 250 188 125 63 0
50 43.75 37.5 31.25 25 18.75 12.5 6.25 0
25 23.75 22.5 21.25 20 18.75 17.5 16.25 15
100 87.5 75 62.5 50 37.5 25 12.5 0
10 8.75 7.5 6.25 5 3.75 2.5 1.25 0
100 87.5 75 62.5 50 37.5 25 12.5 0

DALISTICK®

Treatment :	Zinc-Nickel plating
Part reference :	Sample 66
Creation date :	8/12/2019 8:21:18 PM

Events

Date	N°	Type	Completion
10:03:38PM	44	Operating mode complete	
10:03:38PM	44	Step over	
10:03:38PM	43	Step over	
10:03:38PM	44	Step started	Control Final
10:03:10PM	43	Step started	Control Thickness (µm)
10:03:10PM	42	Step over	
10:03:10PM	41	Step over	
10:03:10PM	42	Step started	Control Adhesion
9:21:23PM	41	Process defect: temperature set point reaching timeout	
8:35:36PM	40	Step over	
8:35:36PM	41	Step started	Control Aspect
8:35:34PM	39	Step over	
8:35:34PM	40	Step started	Message Validate
8:35:34PM	38	Step over	
8:35:34PM	39	Step started	Setting Pumping n?1 (Set point: Off)
8:35:30PM	37	Step over	
8:35:30PM	38	Step started	Message Validate
8:35:30PM	36	Step over	
8:35:30PM	37	Step started	Setting Generation (Set point: Off)
8:26:52PM	35	Step over	
8:26:52PM	36	Step started	Waiting Current quantity (%) (Set point: 100)
8:26:50PM	34	Step over	
8:26:50PM	35	Step started	Setting Generation (Set point: On)
8:26:50PM	33	Step over	
8:26:50PM	34	Step started	Setting Solution (P0260A - Zinc-Nickel LHE 4018 - Sifco)
8:26:50PM	32	Step over	
8:26:50PM	33	Step started	Setting Polarity (Set point: Plating)
8:26:50PM	32	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
8:26:50PM	31	Step over	
8:26:50PM	30	Step over	
8:26:50PM	31	Step started	Setting Voltage (V) (Set point: 6 ; Mini: 5 ; Maxi: 7)
8:26:47PM	30	Step started	Message Validate
8:26:47PM	29	Step over	
8:26:47PM	29	Step started	Message Validate
8:26:47PM	28	Step over	
8:26:45PM	28	Step started	Waiting Temperature (°C) (Mini: 18 ; Maxi: 22)
8:26:45PM	27	Step over	
8:21:50PM	27	Process defect: flow lower limit reached	
8:21:42PM	27	Process defect: flow lower limit reached	
8:21:42PM	27	Step started	Message Validate
8:21:42PM	26	Step over	
8:21:41PM	26	Step started	Setting Pumping n?1 (Set point: On)
8:21:41PM	25	Step over	
8:21:40PM	24	Step over	
8:21:40PM	25	Step started	Message Validate
8:21:40PM	24	Step started	Setting Pumping n?2 (Set point: Off)
8:21:40PM	23	Step over	
8:21:39PM	22	Step over	
8:21:39PM	23	Step started	Message Validate
8:21:38PM	21	Step over	
8:21:38PM	22	Step started	Setting Generation (Set point: Off)
8:21:38PM	21	Step started	Waiting Current quantity (%) (Set point: 100)
8:21:38PM	20	Step over	

DALISTICK®

Treatment : Zinc-Nickel plating
Part reference : Sample 66
Creation date : 8/12/2019 8:21:18 PM

8:21:36PM	20	Step started	Setting Generation (Set point: On)
8:21:36PM	19	Step over	
8:21:36PM	18	Step over	
8:21:36PM	19	Step started	Setting Solution (000000 - Activator XF - Dalic)
8:21:36PM	18	Step started	Setting Polarity (Set point: Anodizing)
8:21:36PM	17	Step over	
8:21:36PM	16	Step over	
8:21:36PM	17	Step started	Setting Current (A) (Set point: 10 ; Mini: 0 ; Maxi: 10)
8:21:36PM	15	Step over	
8:21:36PM	16	Step started	Setting Voltage (V) (Set point: 16 ; Mini: 2 ; Maxi: 17)
8:21:35PM	14	Step over	
8:21:35PM	15	Step started	Message Validate
8:21:35PM	13	Step over	
8:21:35PM	14	Step started	Message Validate
8:21:34PM	13	Step started	Message Validate
8:21:34PM	12	Step over	
8:21:32PM	11	Step over	
8:21:32PM	12	Step started	Message Validate
8:21:32PM	10	Step over	
8:21:32PM	11	Step started	Setting Pumping n?1 (Set point: On)
8:21:27PM	09	Step over	
8:21:27PM	10	Step started	Setting Surface
8:21:25PM	08	Step over	
8:21:25PM	09	Step started	Message Validate
8:21:23PM	07	Step over	
8:21:23PM	08	Step started	Message Validate
8:21:23PM	06	Step over	
8:21:23PM	07	Step started	Setting Temperature (°C) (Set point: 20 ; Mini: 18 ; Maxi: 22)
8:21:19PM	06	Step started	Message Validate
8:21:19PM	05	Step over	
8:21:19PM	05	Step started	Setting Flow (L/h) n?2 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:21:19PM	04	Step over	
8:21:19PM	04	Step started	Setting Flow (L/h) n?1 (Set point: 24 ; Mini: 20 ; Maxi: 25)
8:21:19PM	03	Step over	
8:21:19PM	02	Step over	
8:21:19PM	03	Step started	Setting Pumping n?2 (Set point: Off)
8:21:19PM	01	Step over	
8:21:19PM	02	Step started	Setting Pumping n?1 (Set point: Off)
8:21:19PM	01	Step started	Setting Generation (Set point: Off)
8:21:18PM	01	Operating mode started	Sample 66