

748th Supply Chain Management Group

LHE ZnNi on Landing Gear A User Perspective

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Parts on the Shelf and Contracts in Place



Agenda



- **70,000 ft Level – Overview of Challenges**
- **LHE ZnNi Partners**
- **Reasons for Change**
- **The Journey: Qualification/Implementation**
- **Summarize**
- **Questions**



LHE ZnNi - 70,000 ft Overview of Challenges



- **Feasibility – Identifying a Feasible Cd Substitute**
- **Funding – Obtaining Funding from Various Sources**
- **Partnering – Garnering Industry Support**
- **Testing – Locking Specification Requirements**
- **Coordination – Various Organizations & Industry**
 - Testing Requirements
- **Production Line Changes – Installation of Tanks**
 - Installation of 3,200 Gallon LHE ZnNi Production Line
- **Component Conversion - Cd/IVD Al to LHE ZnNi**
 - 3000+ landing gear components
- **Acceptance/Ownership – By the Overhaul Facility**
- **Industry Implementation – New Production w/LHE ZnNi**

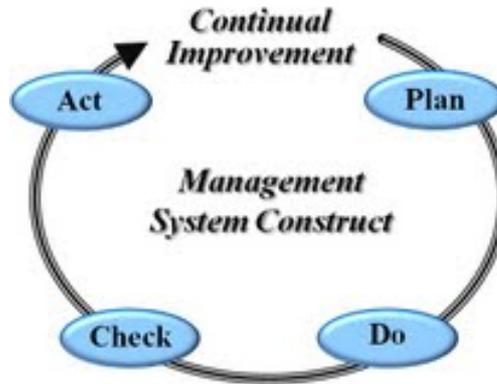
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LHE ZnNi Partners



SBIR/STTR
SMALL BUSINESS INNOVATION RESEARCH
SMALL BUSINESS TECHNOLOGY TRANSFER



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Reason for Change: Issues with Cadmium



- **Health issues**
 - Kidney & Lung damage
 - Bone embrittlement
- **Known Carcinogen**
 - (EPA 17 Chemical)
- **Possibly Leech into Ground Water during aircraft washing operations**
- **Possible Inhalation/Absorption During aircraft maintenance**
- **Cyanide Plating Bath**



Cadmium plating tank



Reason for Change: LHE ZnNi Benefits



■ LHE ZnNi

- Replaces IVD aluminum & Cadmium (Drop in replacement for Cd)
- Not affected by during high temperature event (Tested to 600 °F)
- Repairable in the field / brush plating / non toxic
- Not classified as carcinogen
- Similar corrosion protection to Cd
- More abrasion resistant then Cd



LHE ZnNi plated landing gear components

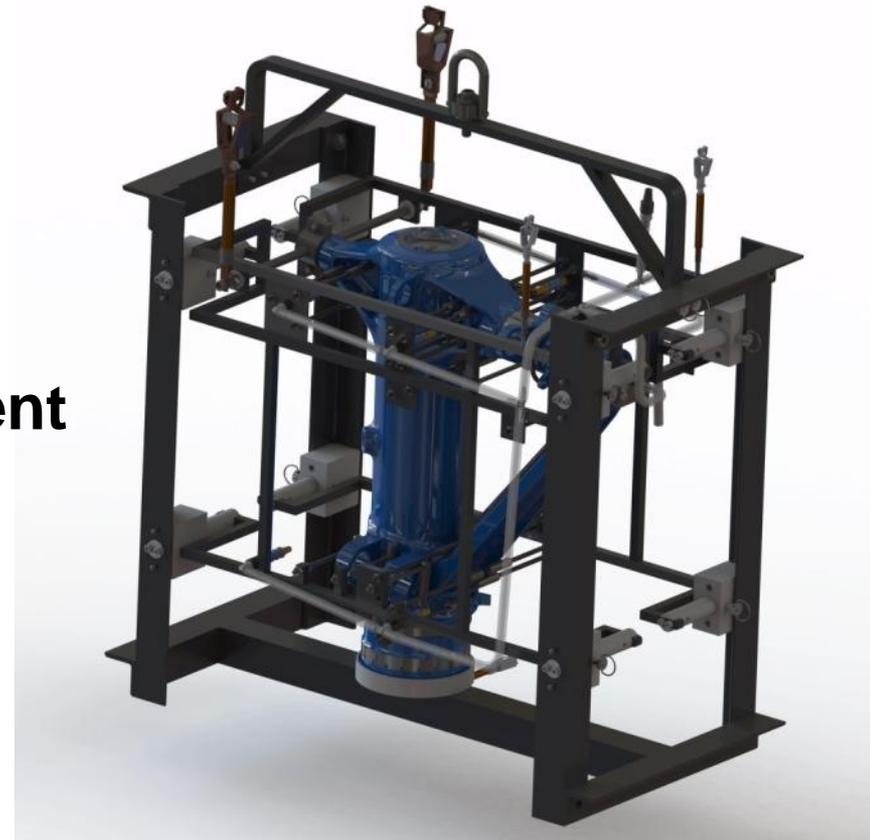
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The Journey: LHE ZnNi – SBIR Phases



- **LHE ZnNi SBIR AF071-320**
 - **Phase I, 14 May 2007**
 - Feasibility
 - **Phase II, 11 Aug 2008**
 - Testing and qualification
 - **Phase III, 2 Aug 2010 to Current**
 - Implementation



LHE ZnNi plating Fixture

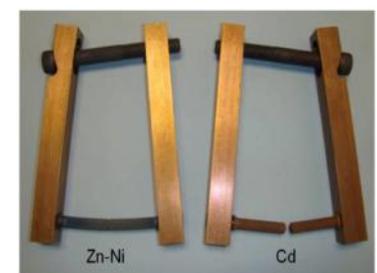
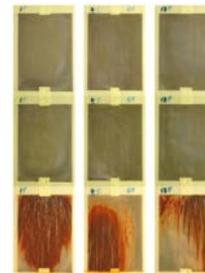
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The Journey: LHE ZnNi Qualification Testing



Test	Specification	Result
Adhesion	ASTM B571	Passed
Hydrogen Embrittlement	ASTM F519	Passed
Re-embrittlement	ASTM F519, USAF Dwg 9825019	Passed
Liquid & Solid Metal Embrittlement	ASTM F519	Passed
Fatigue	ASTM E466	Passed
Corrosion	ASTM B117	Passed
Brush Plating Process (Touch Up)	ASTM B117, ASTM B571, ASTM F519	Passed



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The Journey: LHE ZnNi Drawings



■ Process Specification

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE ON: FRACTIONS DECIMALS ANGLES .XXX .XXX .XXX	DTSMN STEVE RANSOM	DATE 12/04/30	U.S. AIR FORCE			
	CHKR RODNEY GOULD	12/05/01	TITLE Low Hydrogen Embrittlement Plating Process Specification Zinc - Nickel			
	MATL ENGR N/A		SIZE A	CAGE CODE 98747	DWG NO. 201027456	REV
	PROJ ENGR DAVE FREDERICK	12/04/30	SHEET 1 OF 23			
CURRENT CAGE CODE	A.F. AUTHENTICATION RON MONTGOMERY	12/04/30	SCALE NONE			
	RELEASE RICK HARRISON	12/05/04				

EF (MS WORD)

■ Source Control Dwg

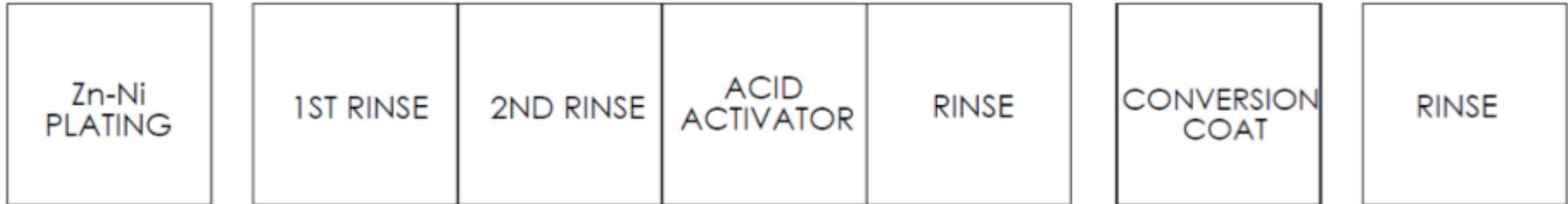
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE ON: FRACTIONS DECIMALS ANGLES .XXX .XXX .XXX	DTSMN STEVE RANSOM	DATE 12/04/16	SOURCE CONTROL DRAWING			
	CHKR RODNEY GOULD	12/05/01	U.S. AIR FORCE			
	MATL ENGR N/A		TITLE Solutions For Use In LHE Zinc - Nickel Plating On High Strength Steel Substrate (>180 KSI) Landing Gear Components			
	PROJ ENGR DAVE FREDERICK	12/04/30	SIZE A	CAGE CODE 98747	DWG NO. 201027457	REV
CURRENT CAGE CODE	A.F. AUTHENTICATION RON MONTGOMERY	12/04/30	SCALE NONE	SHEET 1 OF 15		
	RELEASE RICK HARRISON	12/05/04				

EF (MS WORD)

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The Journey: LHE ZnNi 325 Gallon Prototype Plating Process



325 gal. prototype LHE ZnNi plating tank



325 gal. prototype tri-chromium conversion coating tank

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The Journey: LHE ZnNi System Safety Evaluation



Hazard Risk Assessment Matrix Per Mil-STD 882D				
Hazard Category	1 CATASTROPHIC (Death, Total disability, \$1M, System loss, Severe environmental damage)	2 CRITICAL (Partial disability, 3 in Hospital, \$200K damage, reversible environmental damage)	3 MARGINAL (1 lost work day, \$10K damage, mitigable environmental damage)	4 NEGLIGIBLE (No lost work days, \$2K damage, minimal environmental damage)
Frequency (Probability)				
A Frequent ($>10^{-1}$)	1A	2A	3A	4A
B Probable ($10^{-1} > 10^{-2}$)	1B	2B	3B	4B
C Occasional ($10^{-2} > 10^{-3}$)	1C	2C	3C	4C
D Remote ($10^{-3} > 10^{-6}$)	1D	2D	3D	4D
E Improbable ($10^{-6} >$)	1E	2E	3E	4E

Category	Risk Acceptance Level	Category	Risk Acceptance Level
HIGH	Component Acquisition Executive	MEDIUM	Program Manager
SERIOUS	Program Executive Officer	LOW	As Directed

SSHA No.	Hazard Risk Index	Hazard Description
001	2E	Fatigue impact on component sections, due to LHE Zn-Ni plating in lieu of Cad plating.
002	3E	Adhesion failure of the LHE Zn-Ni plating increases component corrosion.
003	3E	Corrosion impact on component.
004	2E	Failure of Hydrogen to be released from component during HE relief bake
005	2E	Liquid and Solid Metal Embrittlement Failure
006	2E	Re-embrittlement from water and aqueous cleaners

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The Journey: Letter of Notification for Implementation



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS OGDEN AIR LOGISTICS CENTER (AFMC)
HILL AIR FORCE BASE, UTAH

9 November 2010

MEMORANDUM FOR DISTRIBUTION

FROM: OO-ALC/EN
6051 Gum Ln., Bldg. 1225
Hill AFB UT 84056

SUBJECT: Replacement of Cadmium (Cd) with Zinc-Nickel (ZnNi) Plating on Landing Gear

1. The purpose of this memorandum is to notify you and your applicable engineering and maintenance elements of the integration of a new corrosion preventative coating on USAF landing gear and to address concerns which may exist prior to implementation.
2. OO-ALC/GHMW, AFGLSC 417 SCMS, and commercial companies to include ES3, Boeing and Dipsol of America, have recently completed a multi-year, multi-million dollar qualification of a low hydrogen embrittling ZnNi electroplating process for corrosion prevention and control to replace Cd plating and ion vapor deposited aluminum coatings on landing gear components. The process is similar to a ZnNi plating process that has been used in the automotive industry on mild steels for many years. The main difference is that this new coating allows hydrogen embrittlement relief of high strength steels.
3. ZnNi has been thoroughly tested over the last 3-4 years and has either passed or proven itself equal to cadmium in every reasonably conceivable way. A summary of major testing:
 - Adhesion
 - Substrate Adhesion (ASTM B571)
 - Paint Adhesion (ASTM D3359)
 - Hydrogen Embrittlement (ASTM F519)
 - Re-embrittlement (ASTM F519, AF DWG# 9825019)
 - Liquid and Solid Metal Embrittlement (LME/SME), performed better at higher temps
 - Fatigue (ASTM E466), no statistical difference
 - Corrosion (ASTM B117), performed much better than Cd
 - Brush Plating for Repair of Damaged ZnNi Coatings
 - Torque Tension (statistically consistent fastener tension with a given thread torque)
4. ZnNi complies with DoD mandates to eliminate or reduce hazardous substances as defined by the EPA. The EPA has identified Cd as a particularly hazardous material (Reference <http://www.epa.gov/ttn/atw/hlthe/cadmium.html>). OSHA's National Institute for Occupational Safety and Health (NIOSH) declared it to be Immediately Dangerous to Life or Health (IDLH) in 1996 and the Agency for Toxic Substances Disease Registry (ATSDR) completed Cd's chemical toxicity profile in 1999. Cd causes problems throughout its life cycle. Not only does it pose Environmental, Safety and Health (ESH) issues in the plating plant, but it can be easily leached during aircraft wash-downs and thus contaminate ground water. Sodium Cyanide poses an additional serious exposure risk for workers in the plating shop and at the industrial wastewater treatment plant (IWTP). Many domestic and foreign military operating bases require expensive Cd-laden wastewater pre-treatment to comply with their water discharge permits. Cd is also very

expensive to dispose of if concentrations are too high for processing at the IWTP and must be disposed of as hazardous waste.

5. Implementation is planned to be a seamless form, fit, and function replacement by attrition as a preferred alternate with **no part/dash number changes**. The change will involve every landing gear managed at OO-ALC/GHMW, and it is expected to see widespread use on all military high strength steel applications in the near future. **Of particular note: there will be a visible indication to operational and maintenance units – there will be a color change in non-painted areas on steel landing gear components.** Cd with a conversion coat is a dull gold color. The ZnNi replacement will be a dull/dirty purple color.

6. A large amount of supporting data is available for review if so desired. We anticipate proceeding with implementation of this change in Jan 2011. Please address any concerns you may have prior to Jan 2011 with my focal point, Chad Hogan, Chief of USAF Landing Gear Engineering. He can be reached at DSN 777-5739 or via email at Chad.Hogan@hill.af.mil.

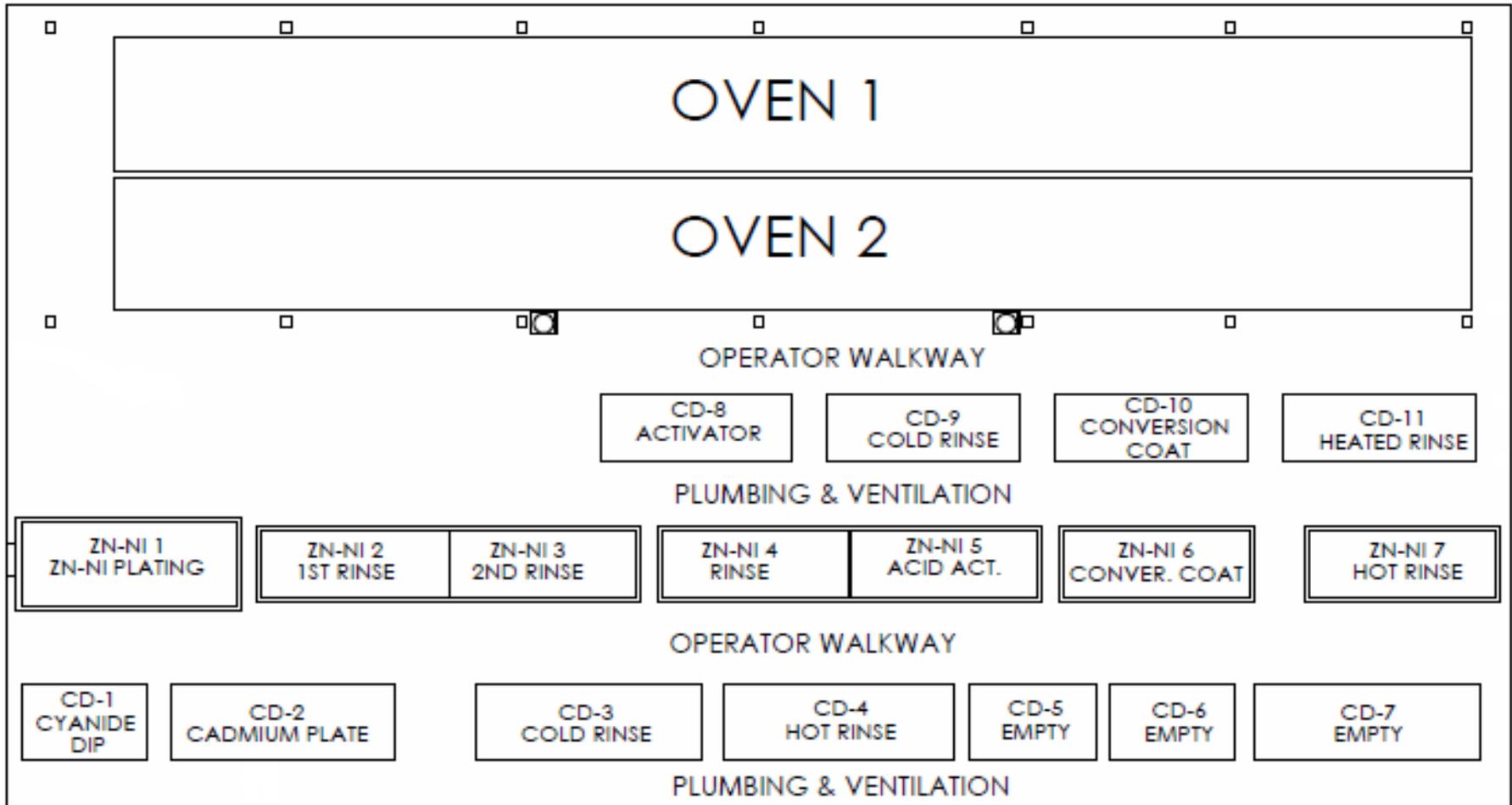
ANGIE L. TYMOFICHUK, SES, DAF
Director, Engineering and Technical
Management Directorate

cc:
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HQ AFMC/A4
OO-ALC/CC
AAC/EN
AEDC/EN
AFFTC/CZ
AFGLSC/EN
AFNWC/EN
AFRL/XP
ASC/EN
ESC/EN
OC-ALC/EN
WR-ALC/EN
OO-ALC/GH
309 MXW/EN

DISTRIBUTION: (listed on next page)



The Journey: USAF LHE ZnNi Plating Line Installation



LHE ZnNi and cadmium plating line schematic

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The Journey: LHE ZnNi Prototype Plating Line Installation

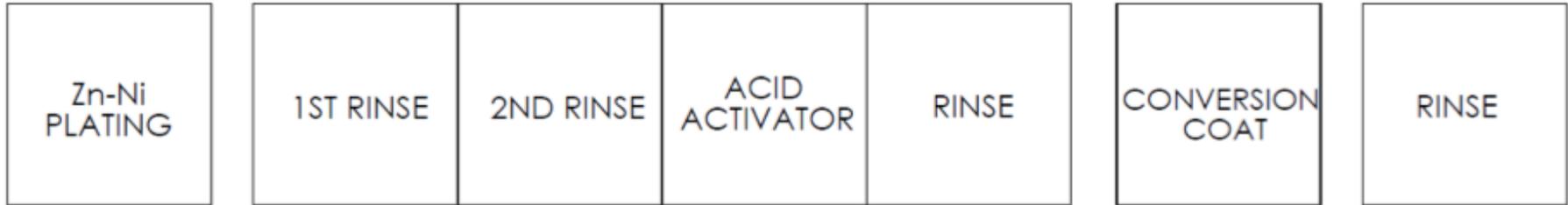


LHE ZnNi site preparation for installation

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The Journey: LHE ZnNi 3200 gallon Prototype Plating Line



**IZ-C17+ LHE ZnNi plating line Fully Operational
May 2013**

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The Journey: Master Process Order (MPO)



MASTER PROCESS ORDER		1. PAGE 1 of 5 PAGES		
2. TITLE Zinc-Nickel Plating		3. M.P.O. NUMBER ZN01 (draft)		
4. TYPE, MODEL, SERIES		5. USING ORGANIZATION		6. DATE EFFECTIVE
7. PART NUMBER AND AFSC N/A	8. REFERENCED PUBLICATIONS N/A	9. DATE RESCINDED		
10. NAME OF ASSIGNED AND PROJECT NUMBER N/A				
11. INSTRUCTIONS				
<p>Section Main This process order is organized in sections. Additional sections may be added by Process Engineering as necessary. The production shops will be notified of any changes or additions.</p> <p>SECTIONS: 1. Main 2. Safety 3. Zinc Nickel Plating 4. Zinc Nickel Brush Plating 5. Compressed Air Cleanliness Check</p>				
12. INITIATED BY POSITION	POSITION	ORGANIZATION	PHONE	DATE
13. APPROVED BY	POSITION	ORGANIZATION	PHONE	DATE

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The Journey: Process Order Template



PROCESS ORDER		PAGE 1 of 5 PAGES
PART CLASSIFICATION NLG - Axle	P.O. NUMBER	VERSION
M.P.O. NAME Zn-Ni Planting	SUBMIT DATE 14-Sept-2010	EXPIRATION DATE
PART NUMBER	SPECIFICATION Zn-Ni Plate	TECH ORDER [24-Sep-2002 (CH 6 , 31-Aug-2009)]

Main Image

NLG Axle



Section Main

Task 1

TECHNICAL ORDER DATA REFERENCE:

This Process Order is in accordance with **T.O.** If the current TO is different, please notify process engineers before processing the part.

Task 2

Reference the Zn-Ni Plating Master Process Order (MPO) for general information.

PROCESS ORDER		PAGE 2 of 5 PAGES
PART CLASSIFICATION ... - NLG - Axle	P.O. NUMBER	VERSION

Task 3

PPE and Safety: Wear correct Personal Protective Equipment (PPE) and abide by current safety requirements as discussed in the main section of the Zn-Ni Plating Master Process Order.

Task 4

Data Table

Note

To see the Data Table Image look in the "Attachments" Menu.

Attachments: Table: NLG Axle
Picture: NLG Axle Fixture Assembly

Task 5

Plating Setup

Task 5.1

Install Internal Anode

Task 5.2

Install Grounding Collar in the center of journal 1 (see image):

Attachments: Image: NLG Axle Grounding Collar

Note

To see the NLG Axle Grounding Collar Image look in the "Attachments" Menu.

Task 5.3

Mask all surfaces chrome plated or HVOF coated. If there are any journals NOT Chrome, Nickel Plated or HVOF coated, initiate an AFMC Form 202 to allow Zn-Ni on the bare journals. Grounding collar shall also be masked.

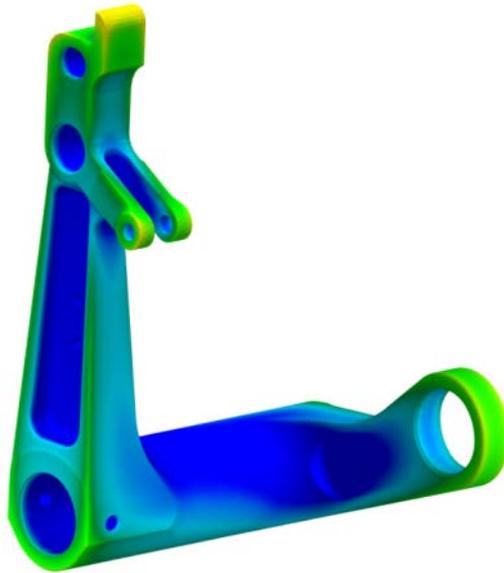
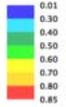
Attachments: Image: NLG Axle Masked Areas

Note

To see the NLG Axle Masked Areas Image look in the "Attachments" Menu.



The Journey: LHE ZnNi Conformal Anodes



**LHE ZnNi plating
without conformal
anode**



**LHE ZnNi plating
conformal anode**

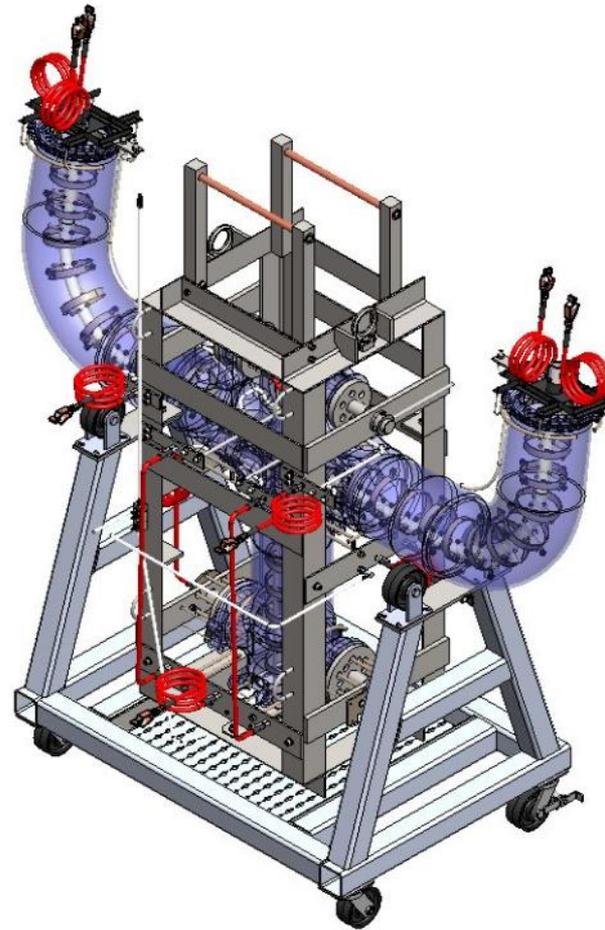


**LHE ZnNi plating
conformal anode**

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The Journey: LHE ZnNi Conformal Anodes



MLG bogie of installation stand

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The Journey: LHE ZnNi Conformal Anodes



NLG drag brace plating process

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The Journey: LHE ZnNi Conformal Anodes

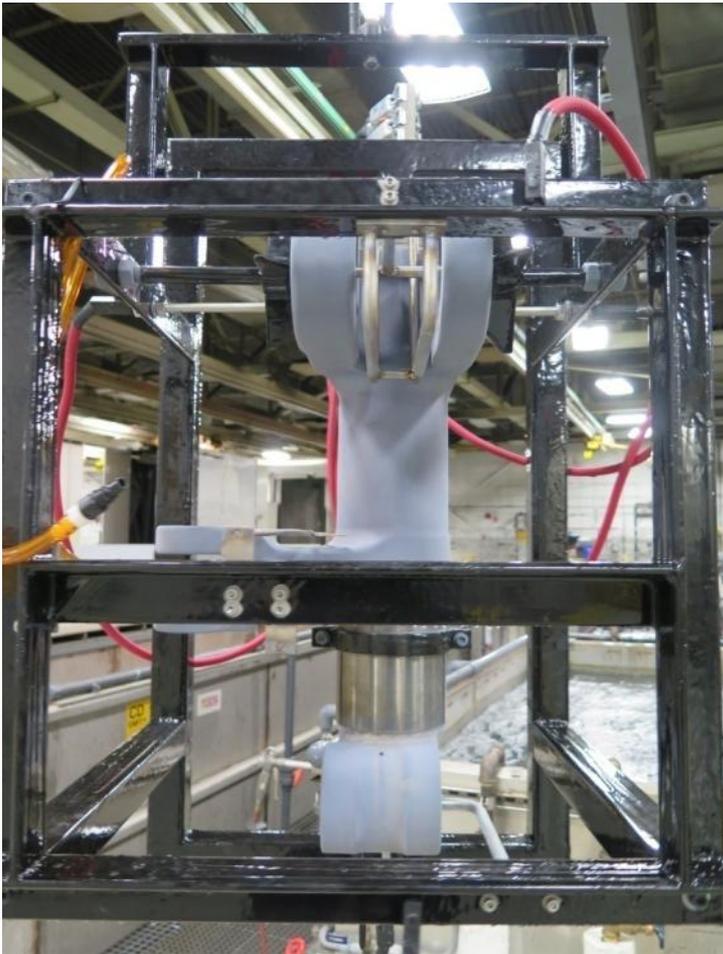


NLG piston after plating in fixture

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The Journey: LHE ZnNi Conformal Anodes



MLG trunnion spindle after plating in fixture

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The Journey: Field Corrosion Test El Segundo, CA, Corrosion Site



**Parts plated without
conformal anodes at
corrosion test site
for 3.9 Years**



Cadmium

LHE ZnNi

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The Journey: LHE ZnNi Commercialization & Implementation



- **ES3 and USAF involved other commercial companies**
- **19 Commercial facilities have adopted the LHE ZnNi plating process and installed plating lines**
- **10 Additional facilities are currently installing plating lines**



LHE ZnNi Commercial Facilities



Company	Location
Hi-Tech Mtl Finishing	Denton, TX
DCI-Aerotech	Detroit, MI
Courter Hall	Garland, TX
Southwest United	Tulsa, OK
Omni Metal Finishing	Fountain Valley, CA
Anoplate	Syracuse, NY
Tech Metals	Dayton, OH
Art Brass Aerospace	Seattle, WA
QC Plating	Ontario, CA
Metal Surfaces, Inc	Bell Gardens, CA
California Technical Plating	San Fernando, CA
Moog Aircraft	Torrance, CA
Heroux Devtek	Longueuil, QE, CA
Fitz Aerospace	N. Richland Hills, TX
Hartwell Mfg	Cucamonga, CA

Company	Location
ES3	Warner Robins, AL
Curtiss-Wright	Shelby, NC
UTAS	Oakville, ON, CA
Boeing Company	Portland, OR
Installing Plating Lines	
Ripak Aerospace	W. Babylon, NY
Alcoa Fastening Systems	Torrance, CA
Bristol Industries	Brea, CA
Embee	Santa Ana, CA
Electrolurgy	Irvine, CA
Reid Metal Finishing	Santa Ana, CA
Central Metal Finishing	N. Andover, MA
QC Plating	Ontario, CA
SW United-Canada	Brampton, ON, CA
NAVAIR	Jacksonville, FL

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Summary: LHE ZnNi - 70,000 ft Overview of Challenges



- **Feasibility – Identifying a Feasible Cd Substitute**
- **Funding – Obtaining Funding from Various Sources**
- **Partnering – Garnering Industry Support**
- **Testing – Locking Specification Requirements**
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Questions



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748th Supply Chain Management Group



*The Supply Chain Delivers ...
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