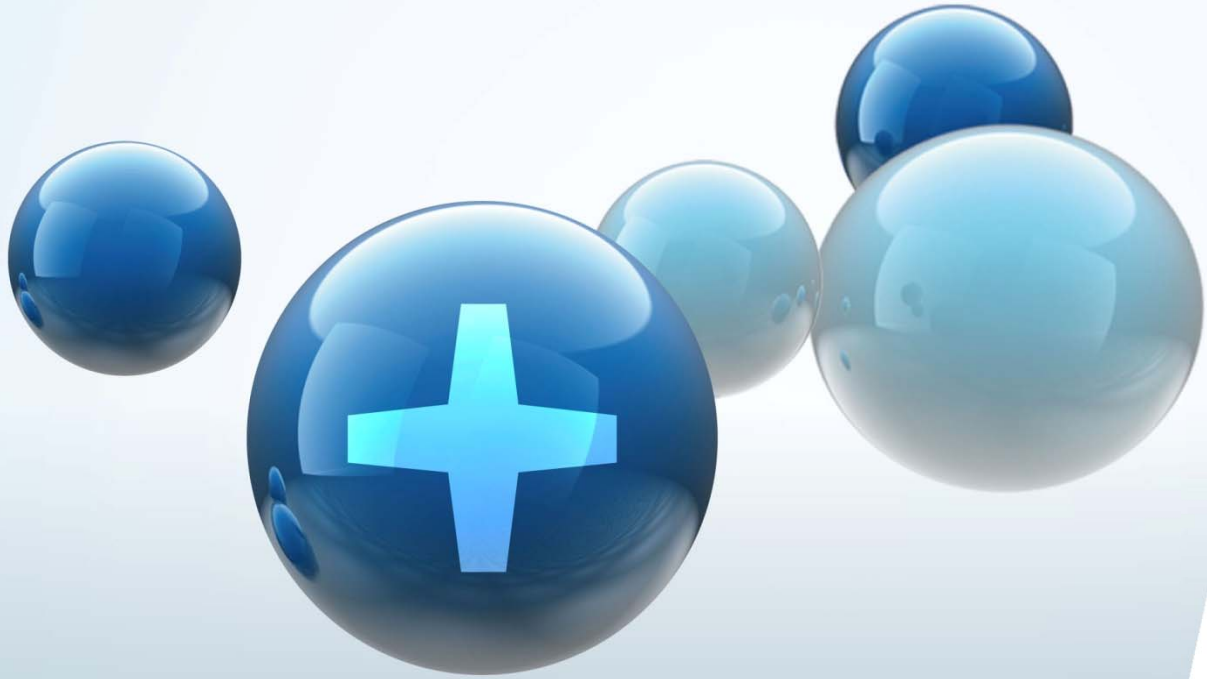
Surface Protection Design for Magnesium Components in Aircraft Cabin

Ilya Ostrovsky, Louis Verdier, Christoph Hantschel,
Miri Moskovits, Paul Lyon



Chemetall
expect more

The Chemetall Group:
At a Glance

Chemetall
expect more

- Headquarters: Frankfurt a.M. (Germany)
- Sales*: 551 million Euro (2012)
- Employees: 2,000 worldwide
- Production sites: 22 on all continents
- Subsidiaries**: more than 40 worldwide

A leading global surface treatment company

* Euro in fix exchange rate ** incl. Joint Ventures

Chemetall

- Chemetall - A leading global surface treatment company
- Experience: 30+ years of experience in surface treatment
- Enables customers' growth in all regions due to
  - global organization
  - broad market expertise
  - comprehensive technical services
  - local support
- Strong focus on the development of environmentally-sound and game-changing technologies
- Committed to highest standards of safety, health and environment
- Long-term relationship with key customers to joint success

Aero-Magnesium Group

- engineering-oriented industrial organization
- active since the mid 90's
- dedicated to the supply of a wide range of technological solutions to ensure
  - the professional use of wrought/cast magnesium alloys in aeronautics applications.
- industrial and R&D facilities in 2 sites
  - in the North of Israel and
  - in Germany.

Aero-Magnesium Group

- supplying high-end magnesium products
  - sole components
  - assemblies
- manufactured by
  - bulk machining
  - die forging
  - investment/sand casting
  - sheet forming
- operating the most recent surface finishing systems for maximum protection.

Magnesium Elektron

- dedicated service organization, specializing in the
  - development,
  - manufacture and
  - supply of magnesium products and services to technology industries worldwide.

- first processing of magnesium in 1936
- now: enviable reputation for innovation
  - due to a relentless passion to push the metallurgical boundaries of magnesium alloy technology.
- aim: to build lasting relationships with our clients
  - by working with them as partner of choice to achieve their objectives.

- Magnesium Elektron are world leaders in the development and commercialization of magnesium–zirconium alloys used in specialty areas including Aerospace.

Acknowledgements

- The presentation includes information and test results of the FP6 AEROMAG and MagForming projects which were supported by the European Commission

The Design Stages

Alloy Selection

- High-purity based magnesium alloys with tailored compositions are preferable for aerospace applications

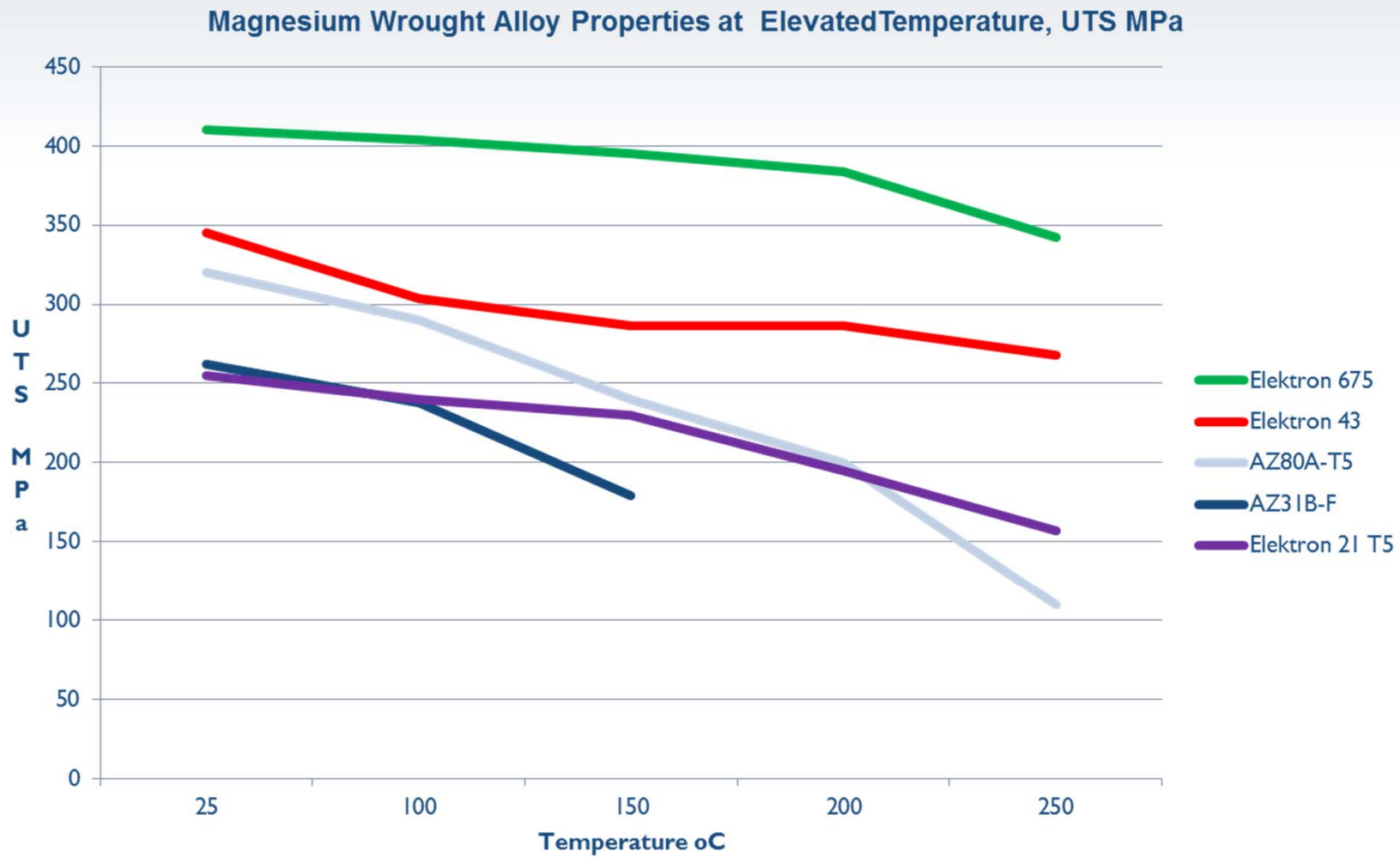
Surface Treatment Selection

- Special cleaners and deoxidizers for magnesium alloys.
- Proper combination of conductive and non-conductive coatings.

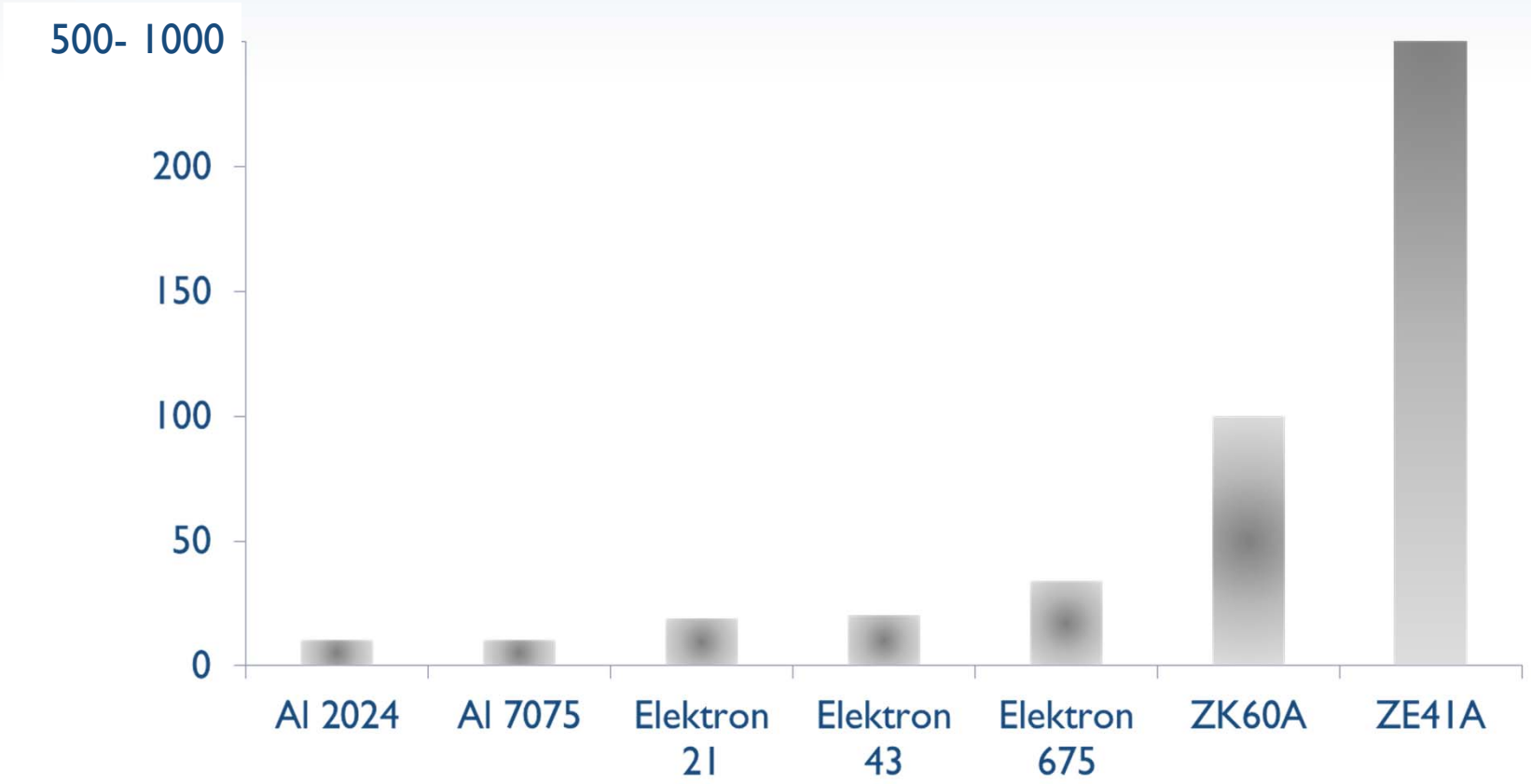
Galvanic Corrosion Protection

- Application of non-conductive coatings and sealants.

Extruded Alloy Properties at Temperature

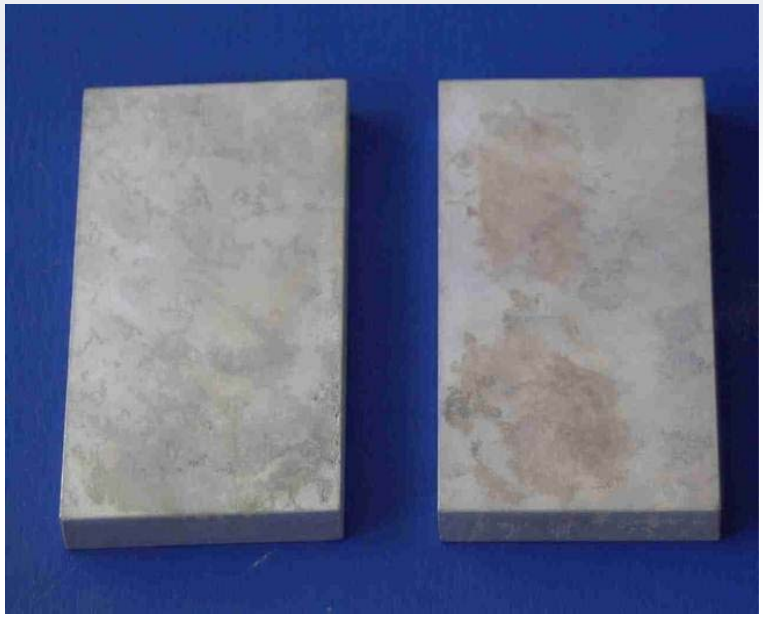


ASTM B117 Salt Spray Corrosion Rates



ASTM B117 Test Corrosion Resistance

- ZE41 – Poor corrosion performance

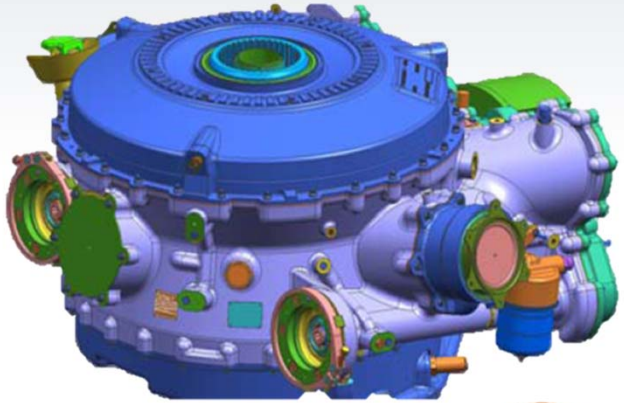


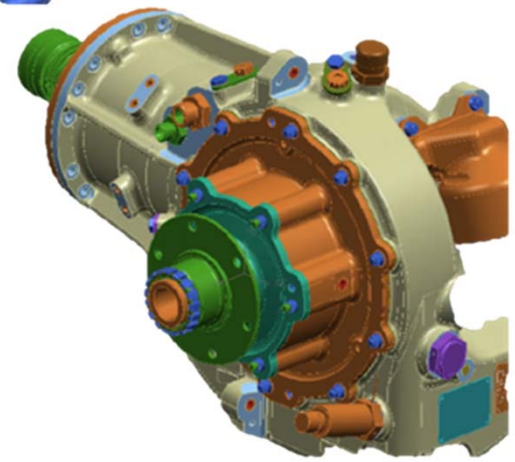
- Elektron® 21 and Elektron® 43
- Good corrosion performance

Elektron® 21 Application Example

- Light Weight (2/3 density of aluminium)
- Good Capabilities at elevated temperature
- Good Castability
- Full AMS and MMPDS specifications

Elektron® 21 Programs





"..Magnesium housings, covers, bearing retainers for weight reduction.."

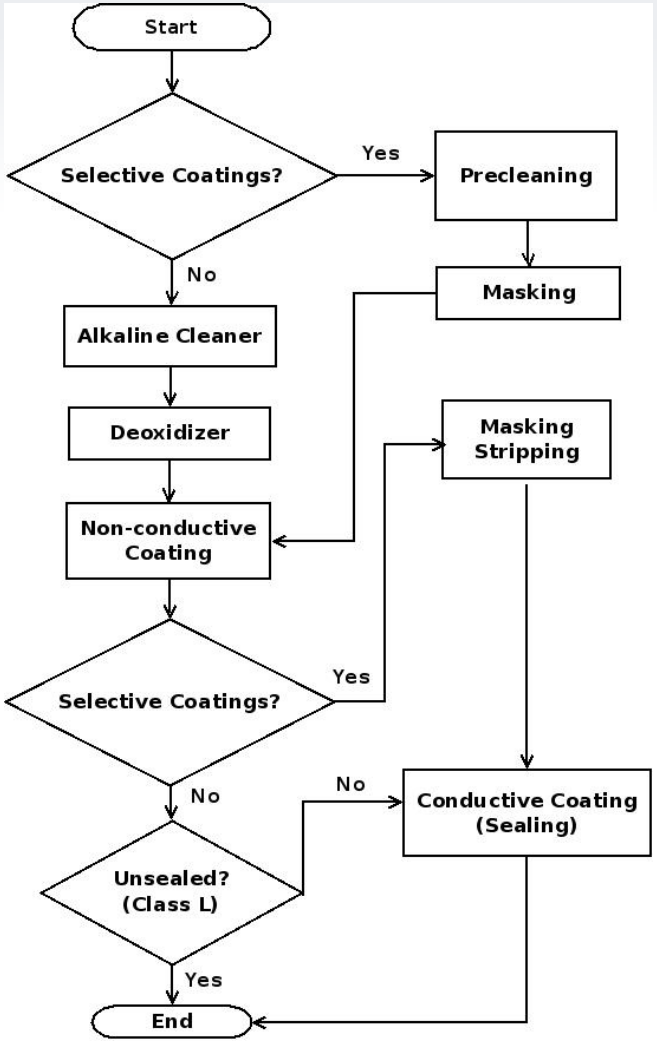
"..EV31 (Elektron® 21) chosen based on material properties , corrosion resistance (10 fold improvement cf ZE41), castability ...."

"... EV31 (Elektron® 21) and WE43 suitable. EV31 (chosen) because of better castability, reduced scrap rates, lower casting cost ...."

Ref AHS 64th Annual Forum – Montreal
Joint Boeing / Redstone Arsenal paper

Surface Treatment Selection

- Surface treatment of aerospace magnesium components is quite similar to aluminum.
- Set of the processes includes: alkaline cleaner, deoxidizer, optional desmutting, non-conductive and conductive coatings.
- The conductive coating provides also a sealing effect, when it is applied on an anodizing layer.
- All technologies are environment-friendly and do not include restricted chemical compounds.



Cleaning of Magnesium

Strong alkaline cleaners with pH higher than 11 are recommended for cleaning magnesium aerospace components:

Ardrox 6333B

- Spray cleaner, also versatile for immersion; low silicate
- Successor of Ardrox 6333A - enhanced cleaning ability, borate-free
- No etching on Magnesium

Ardrox 6378A

- Spray cleaner, also versatile for immersion;
- Successor of Ardrox 6333 - enhanced cleaning ability, borate-free
- No etching on Magnesium

Cleaners: Weight Loss Test

Type	Work conditions	Specifications	Material	Weight loss
Ardrox 6378A	20%, 60 ºC	ARP 1755A	AMS 4375	Average weight loss <0.000010
	20%, 60 ºC	ARP 1755A	AMS 4442	Average weight loss <0.000010
Ardrox 6333B	10%, 75 ºC	ARP 1755A	AMS 4375	Average weight loss <0.000010
	10%, 75 ºC	ARP 1755A	AMS 4442	Average weight loss <0.000010
	full strength	ASTM F-483	AMS 4376*	-0.04 mg/cm^2/24h
	10%	ASTM F-483	AMS 4376*	-0.01 mg/cm^2/24h

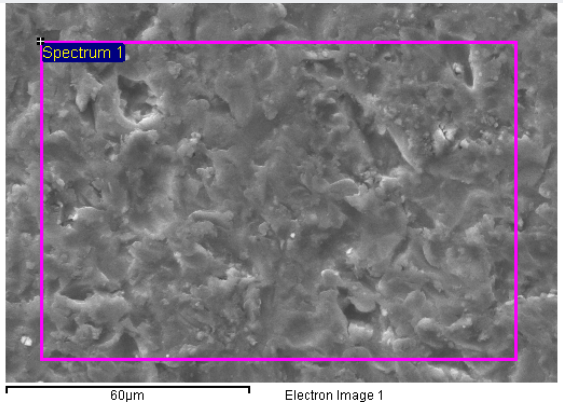
* dichromate treated in accordance with AMS 2475

Deoxidizing and desmutting

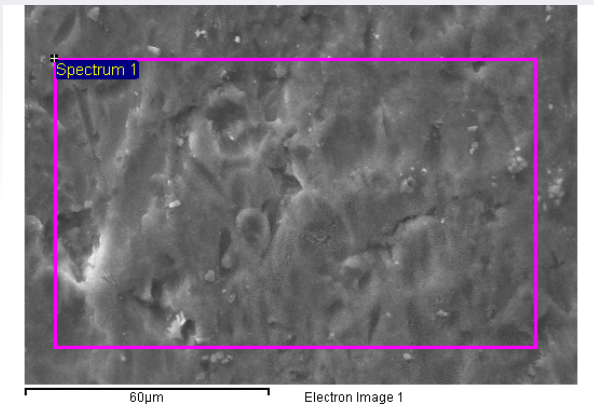
- Activate (deoxidize) magnesium surface prior to coating.
- Precise dimensions of aerospace magnesium components require a low etching rate.
- Some magnesium alloys should be desmutted after deoxidizing.

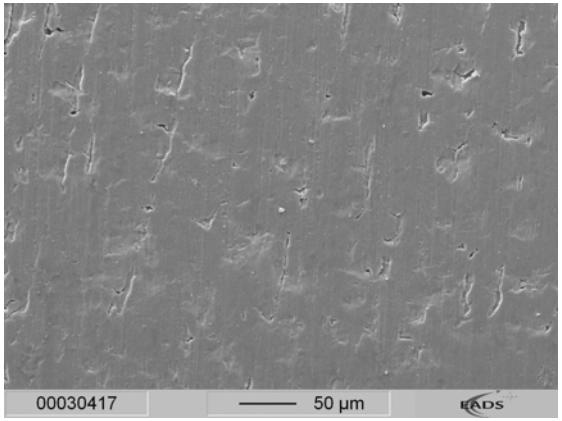
Type	Work conditions	Etching rate
Ardrox® 1277	1% (V/V), 40 ºC, 0.5 – 3 minutes	0.3 – 1.5 microns per min., depending on alloy
Ardrox® 185L	15-40% (V/V), 60-70 ºC, 10-15 minutes	No etching effect

Improvement of surface conditions in Ardrox® 1277

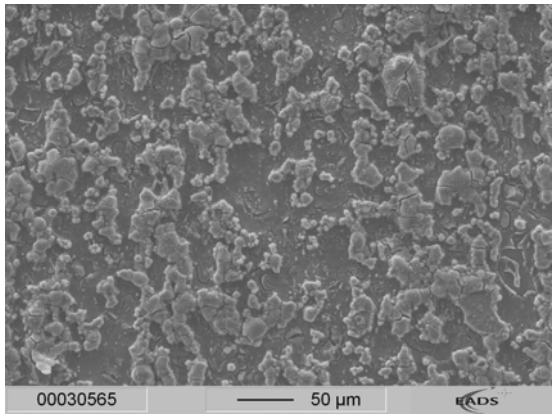


1 min





3 min



Oxsilan® MG Technology

- Non-chromate treatment
- Based on organic silicon compounds
- Fluoride-free
- Heavy metals free
- Thickness: ≤ 1 micron
- Dipping, spraying, rolling (no rinse)
- Ambient temperature process
- Offers bare corrosion protection
- Excellent paint adhesion
- Conductive coating

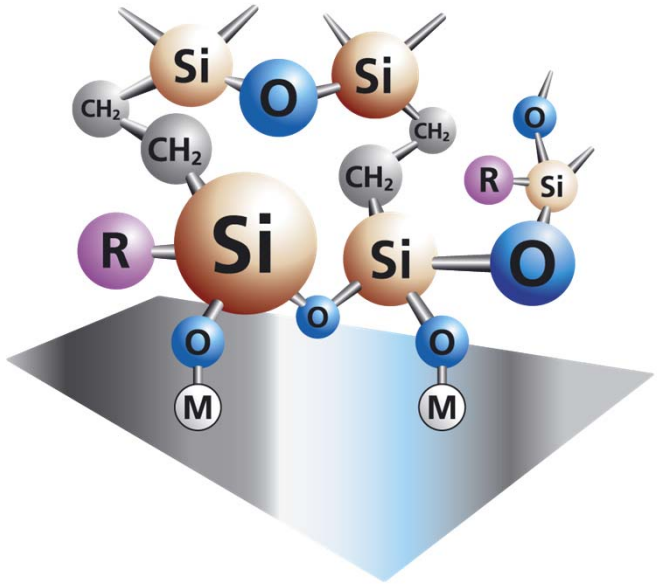
Oxsilan®

Oxsilan® MG-0611

- This coating is used as
  - stand-alone protection or
  - paint pretreatment.

- It is also used in selective coatings together with
  - anodizing
  - ceramic coatings
  - paint and powder coatings

  to build electrically conductive areas



Conductive Coating for Magnesium

- Corroded surface area

Coating/Exposure in SST	1 hour	10 hours	24 hours	48 hours
MIL-M-3171 Type VI (Dow-19)	0.03%	>50%	>50%	>50%
Chrome III (Competitor A)	0%	0.3%	1%	33%
Chrome III (Competitor B)	0%	0.1%	0.1%	10%
Oxsilan® MG-0611	0%	0%	0 – 0.03%	0.03 – 0.1%

- Remarks:
  - Test data for AZ alloys
  - All samples are with electrical resistance in accordance with MIL-DTL-5541 Class 3
  - Permanent SST in accordance with ASTM B 117

Oxsilan® MG-0611 after 48 hours of SST

- Elektron® 43

- AZ31B

Non-Conductive Coatings for Magnesium

- Electrically non-conductive coatings: major part in surface protection of magnesium components.
- Galvanic corrosion: main risk for high-purity based magnesium alloys with tailored compositions

  → very important to minimize conductive areas
- Aerospace non-conductive coating:
  - anodizing (traditional)
  - composite coating technology also possible for magnesium

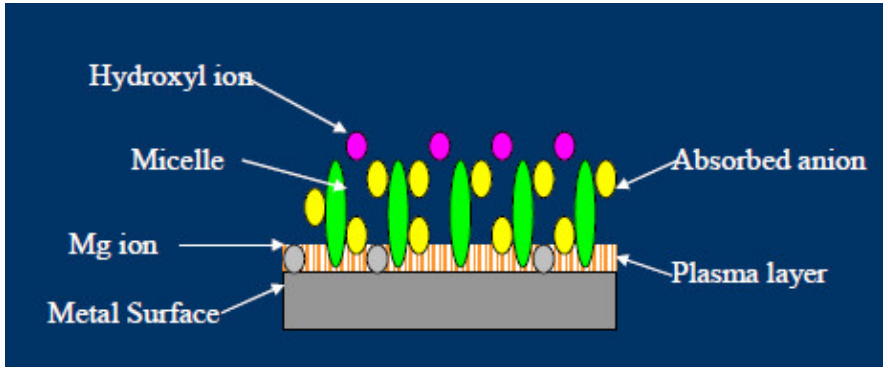
Elektron® 21 investment casting:

- Composite coating Ardrox® 1769 as main coating and Oxsilan® MG-0611 on conductive areas

Manufactured by Aero-Magnesium

Ardrox® 1770

- Aerospace anodizing for magnesium
- Environment-friendly
- Low voltage (≤ 150V)
- Smooth surface coating (equivalent to CAA)
- Offers excellent corrosion protection (equivalent to CAA)
- Top decorative coating
- Painting pretreatment process
- Thickness: 10 – 25 micron
- No reduction in fatigue resistance

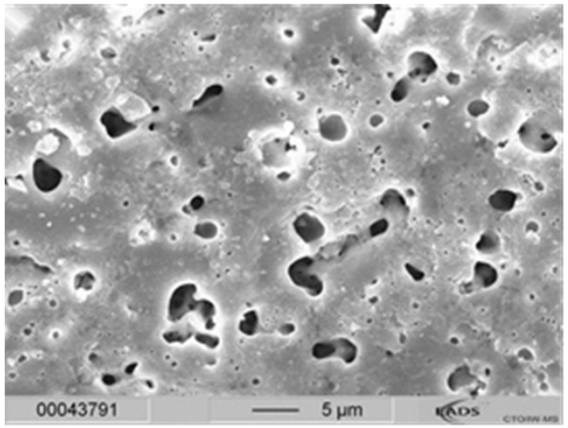


Plasma-Gel Anodizing Ardrox® 1770

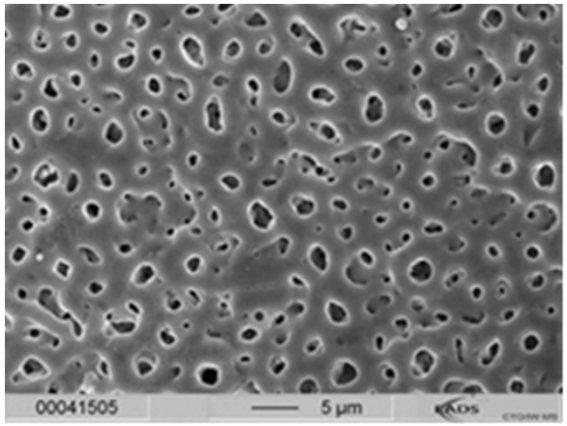
PGA Ardrox® 1770

- fatigue test ✓
- dynamic load test ✓
- approval as main coating on aerospace components (i.e. rudder pedals, axes) ✓
- low porosity →high corrosion resistance

  (comparable to aerospace anodizing technologies for aluminium)



Ardrox® 1770 on AZ31B sheet



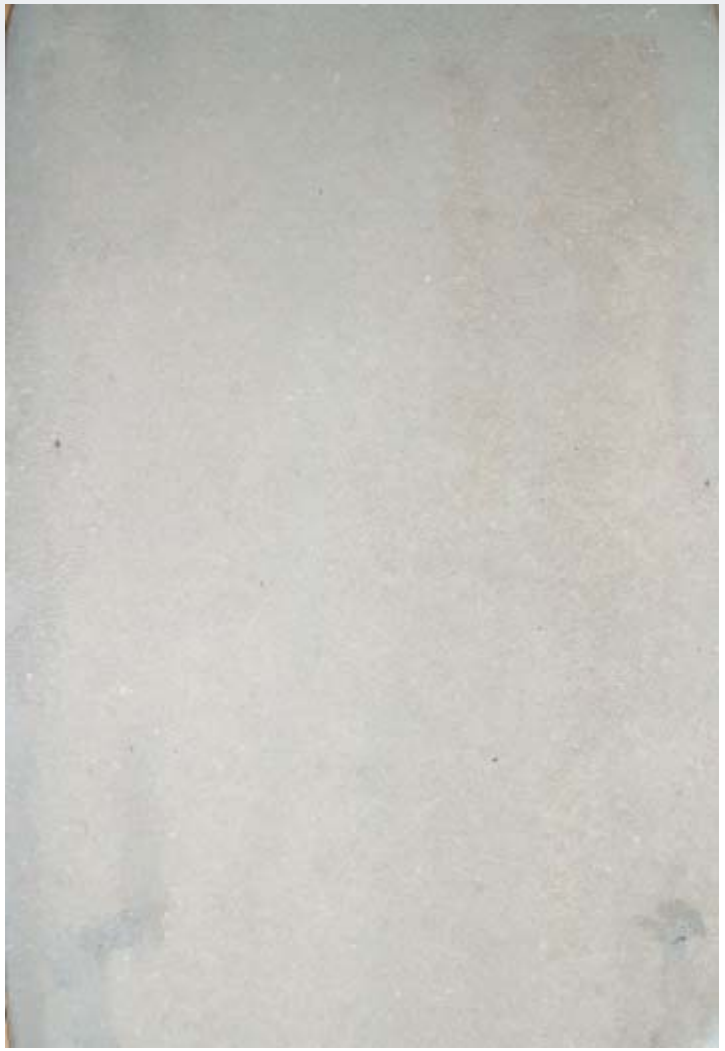
Other commercial anodizing process on AZ31B sheet

Ardrox® 1770: Appearance

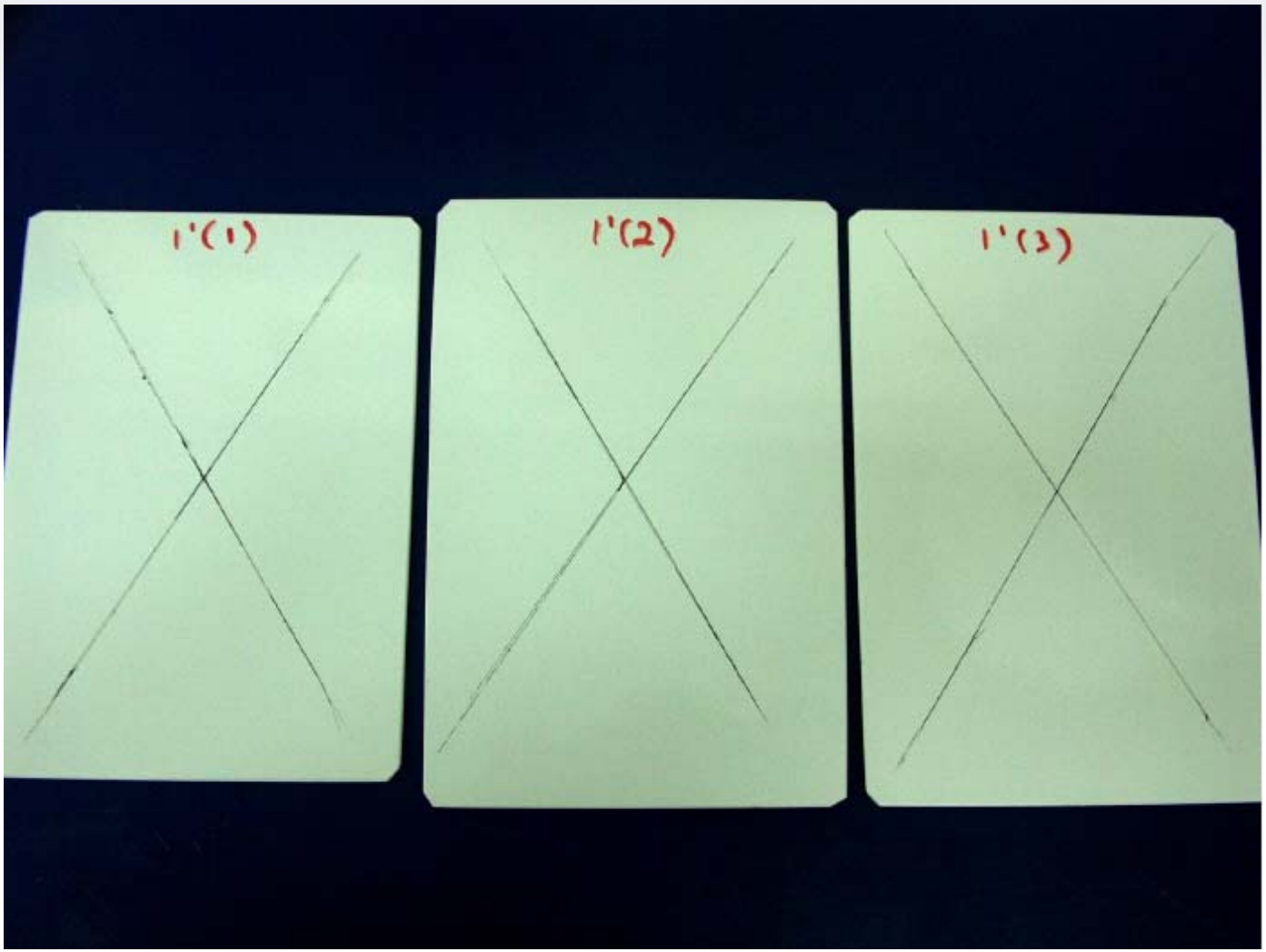
- AZ31B
- Voltage: 120V
- Thickness: 18-20 micron
- Coating: 8 minutes

Ardrox® 1770: Salt Spray Test

- Material: AZ31B
- Thickness: 10-12 microns
- Bare Corrosion Test in accordance with MIL-A-8625
- After 336 hours in the salt fog

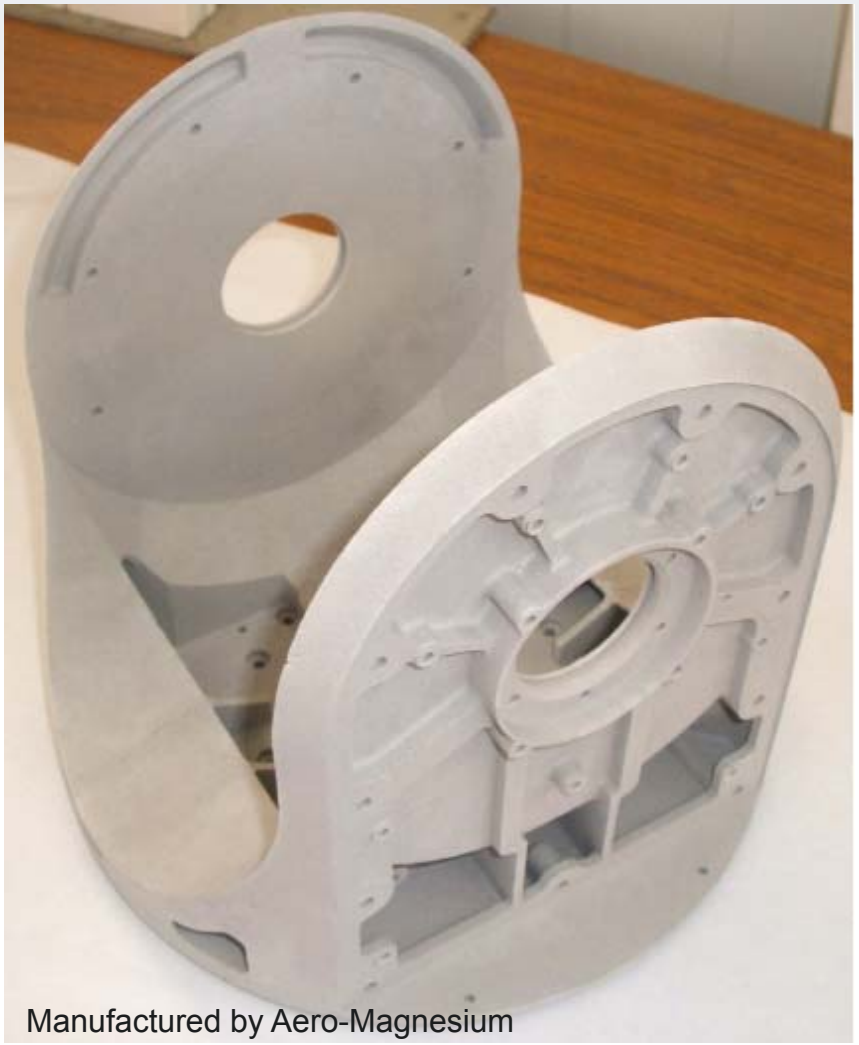


Ardrox® 1770 with Paint: 2000 hours SST



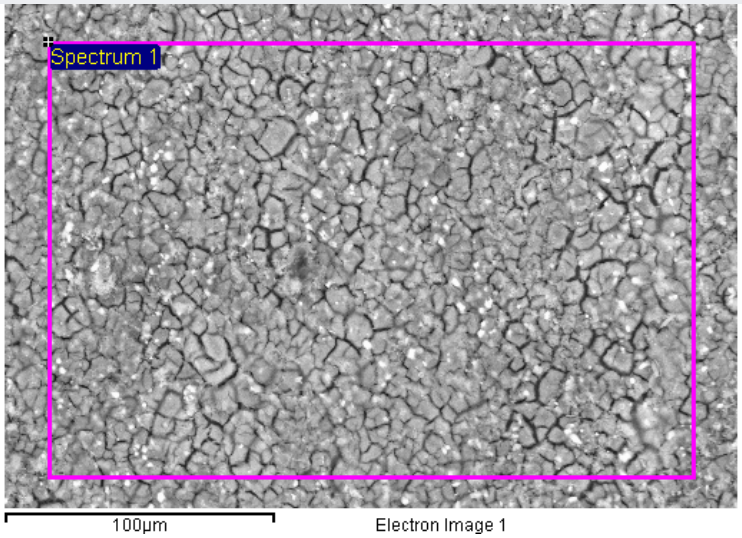
Ardrox® 1770: Coating of Complex Shapes

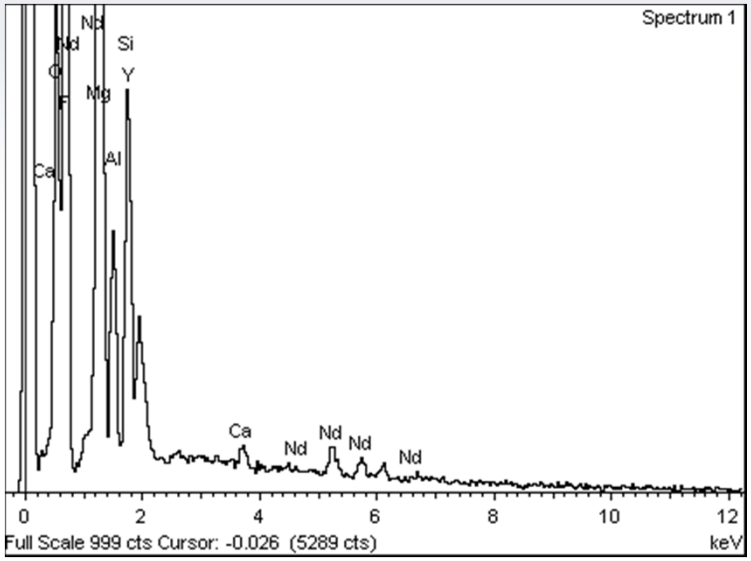
- AZ91E:
  - investment casting
  - complementary machining
  - anodizing/selective coating



Manufactured by Aero-Magnesium

What Is „Composite Coating“?





- The morphology of the coating layer and an example of its composition on magnesium.

Composite Coating Ardrox® 1769

- Visible non-chromate conversion coating for magnesium

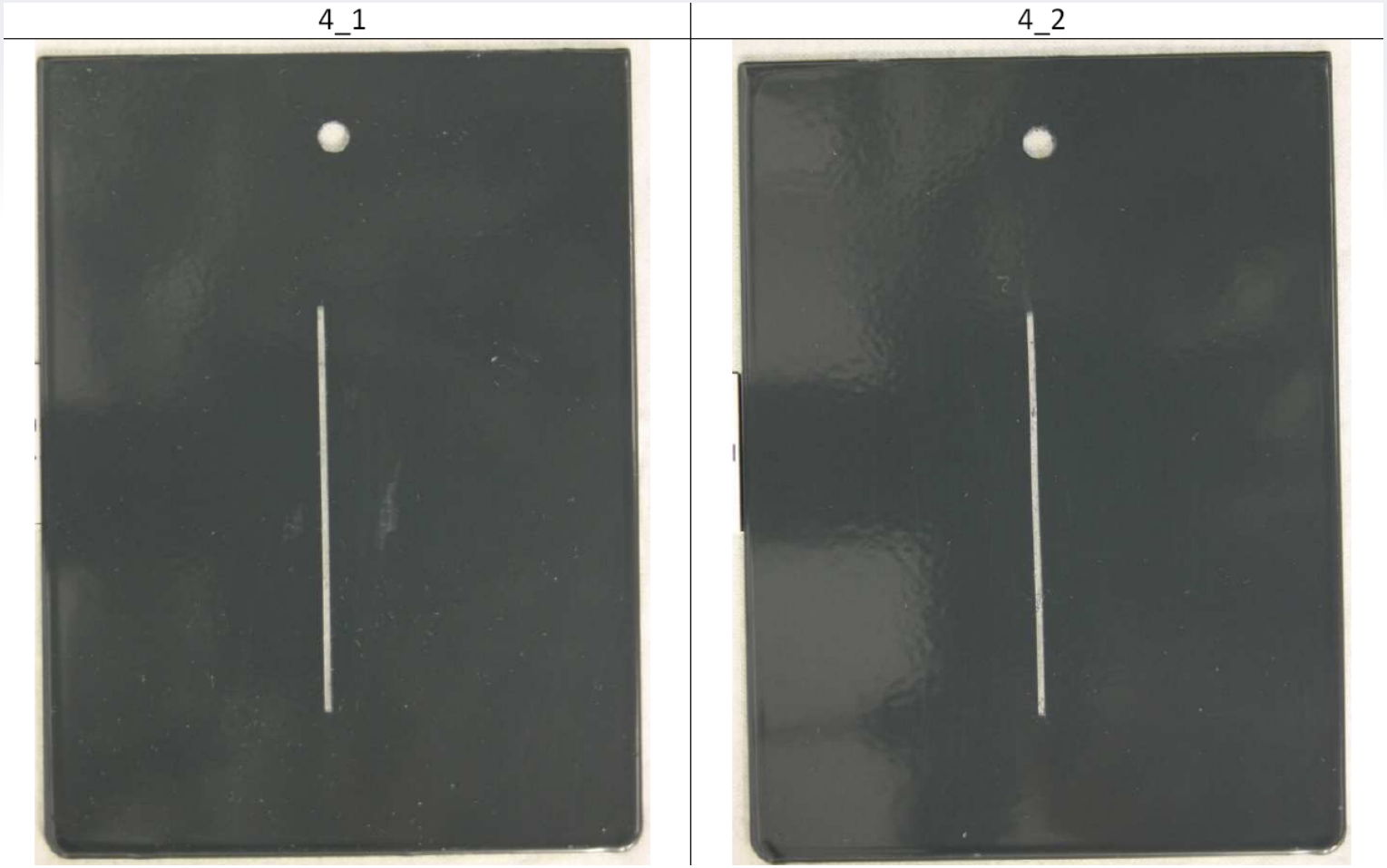
- Applicable on Elektron® 43, Elektron ® 21, Elektron ® 675, Elektron® WE43, Elektron® WE54, MnE21 as well as AZ, AM, AE and other magnesium alloys

- Fields of application:
  - Paint, powder coating, E-coat and PTFE coating pretreatment
  - Forming pretreatment
  - Adhesive bonding pretreatment
  - Stand-alone corrosion protection (when sealed)
  - Flammability protection

Ardrox® 1769: Forming Pretreatment

- Technology Demonstrator in FP6 MagForming

Ardrox® 1769: SST results



Substrate: AZ91D Thixomolded
Powder Coating
ASTM B117: 1520 hours

Ardrox® 1769: Flammability Protection

- Results of tests at Airbus Deutschland (during FP6 AEROMAG) on limited number of specimens.
- Recent large scale tests results will presented by Airbus

Magnesium alloy	*Surface conditions*	*Time to ignition (sec)*	*Burning time (sec)*
AZ31	Cleaned only	92	490
AZ31	Cleaned and coated	283	44
AZ61	Cleaned only	88	704
AZ61	Cleaned and coated	512	50

Paint Adhesion Tests

Process	Substrate	Cr loaded primer		
		Gt dry	Gt wet	Blistering
Ardrox 1769 Class L	Elektron 675	0	0	4(s2)
Ardrox 1769 Class S	AZ31	0	0	4(s1)
	AZ61	0	0	2(s1)
	Elektron 675	0	0	1(s2)
	WE43	0	2	5(s1)
	Elektron 21	0	0	5(s2)
Ardrox 1770 Class L	AZ31	0	NA	NA
	AZ61	0	NA	NA
	WE43	0	NA	NA
Ardrox 1770 Class S	AZ31	0	0	0
	AZ61	0	0	0
	WE43	0	0	0
	Elektron 21	0	0	0

Wet adhesion on anodizing layer in accordance with Fed. Std. 141

Selective Coatings

Process

- masking conductive areas
- anodizing or composite coating
- stripping the masking
- immersion in Oxsilan® MG-0611 solution

After immersion

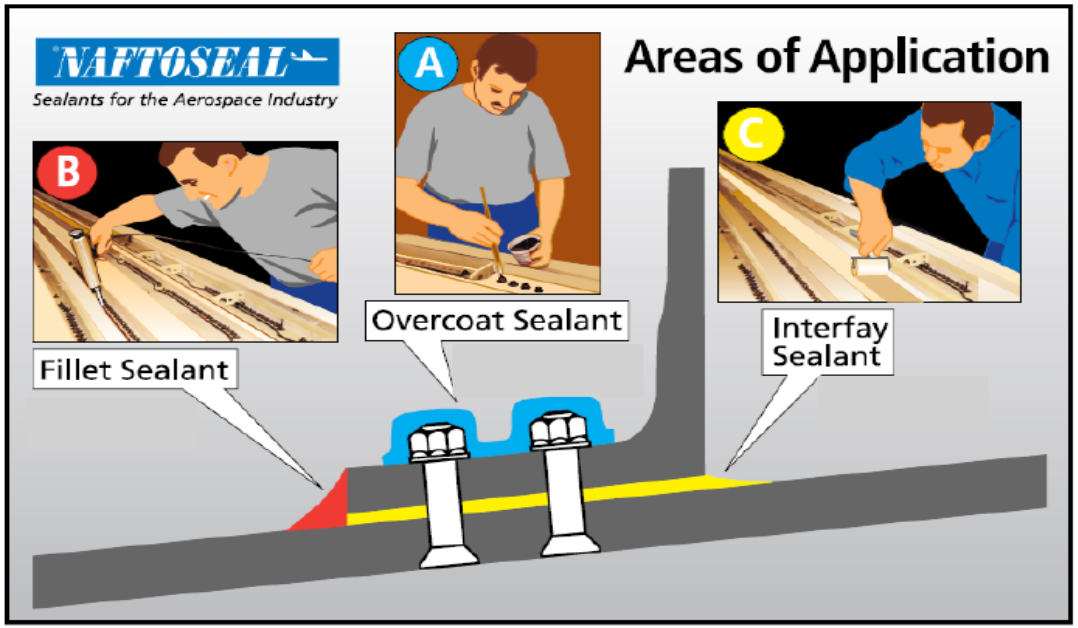
- non-conductive coating is sealed
- previously masked areas have coating which is
  - protective
  - electrically conductive

Sealing of Dissimilar Joints and Inserts

Chemetall
expect more

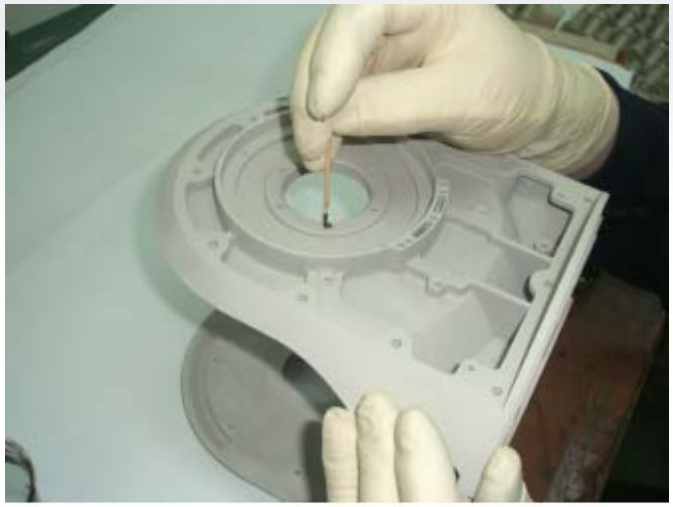
Naftoseal® polysulfide sealants

- proven solution for galvanic corrosion protection of magnesium
- for sealing
  - rivets
  - bolts
  - stainless steel inserts
  - Heli-Coils®
  - titanium and bronze bushings with Mg

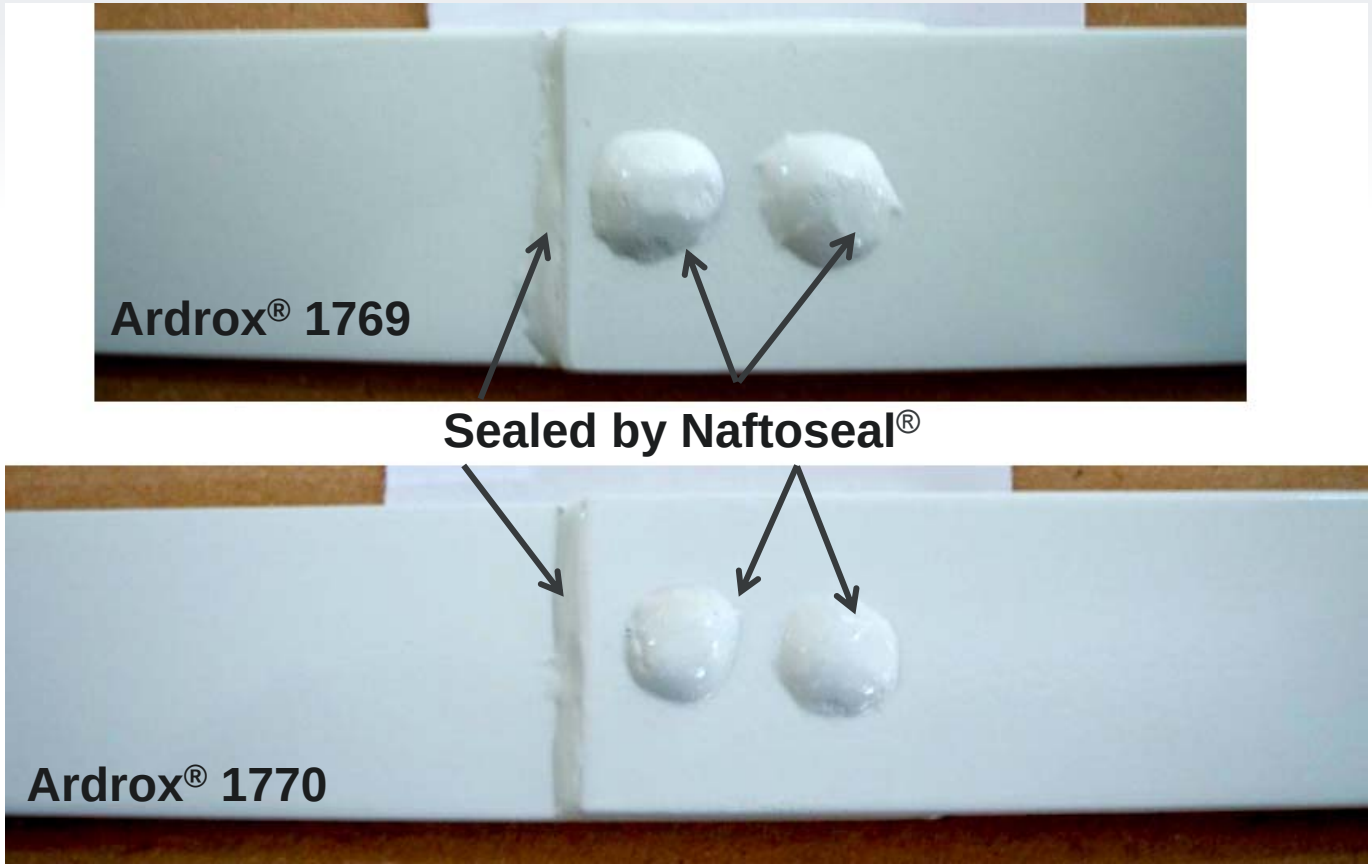


Naftoseal® : Wet Assembling of Heli-Coils®

Chemetall
expect more



Naftoseal®: Protection of Riveted Structures



After 2000 hours in Salt Spray Test (ASTM B117)

Naftoseal®: Protection of Dissimilar Joints

- Stainless steel bolts, Heli-Coils® and inserts in AZ31 magnesium components
- Sealed by Naftoseal®
- After cycling salt spray in accordance with MIL-STD-810

Chemetall
expect more

Examples of Magnesium Aeronautic Components

Magnesium Rudder Brake Pedal

Ardrox 1770® Class L and paint

Magnesium Seat Components (Helicopter)

- Ardrox® 1770 Class S, sealed by Oxsilan® MG-0611
- Utilization without paint
- In air since 2005 (2000-2005 with predecessor ARDROX® 1770)

(Courtesy of Golan Industries)

Magnesium Rudder Pedal Arm

- Main coating: Ardrox® 1770 Class S
- Ardrox® 1770 Class L as PTFE pretreatment
- Oxsilan® MG-0611 on precise areas
- Naftoseal® protects the riveting
- Status: TRL 6

(Manufactured by Aero-Magnesium)

G-150 Service Door Inner Panel

- Super plastic forming of AZ31B
- Technology Demonstrator in MagForming
- Pretreated by Ardrox® 1769
- Status: TRL6

Thank you very much for your attention!

Chemetall GmbH
Trakehner Straße 3
60487 Frankfurt am Main
Germany

T +49 69 7165 0
F +49 69 7165 3018
surfacetreatment@chemetall.com
www.chemetall.com

Chemetall GmbH
ilya.ostrovsky@chemetall.com
christoph.hantschel@chemetall.com
louis.verdier@chemetall.com

Magnesium Elektron
paul.lyon@magnesium-elektron.com

Aero-Magnesium Limited (A.C.S.)
miri.moskovits@aero-magnesium.com

Expect more
Solutions for Aerospace

Chemetall
expect more