

# TripleHard Chromium Coating

Osmo Jahkola

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BAuA, Dortmund

**SQRQC**

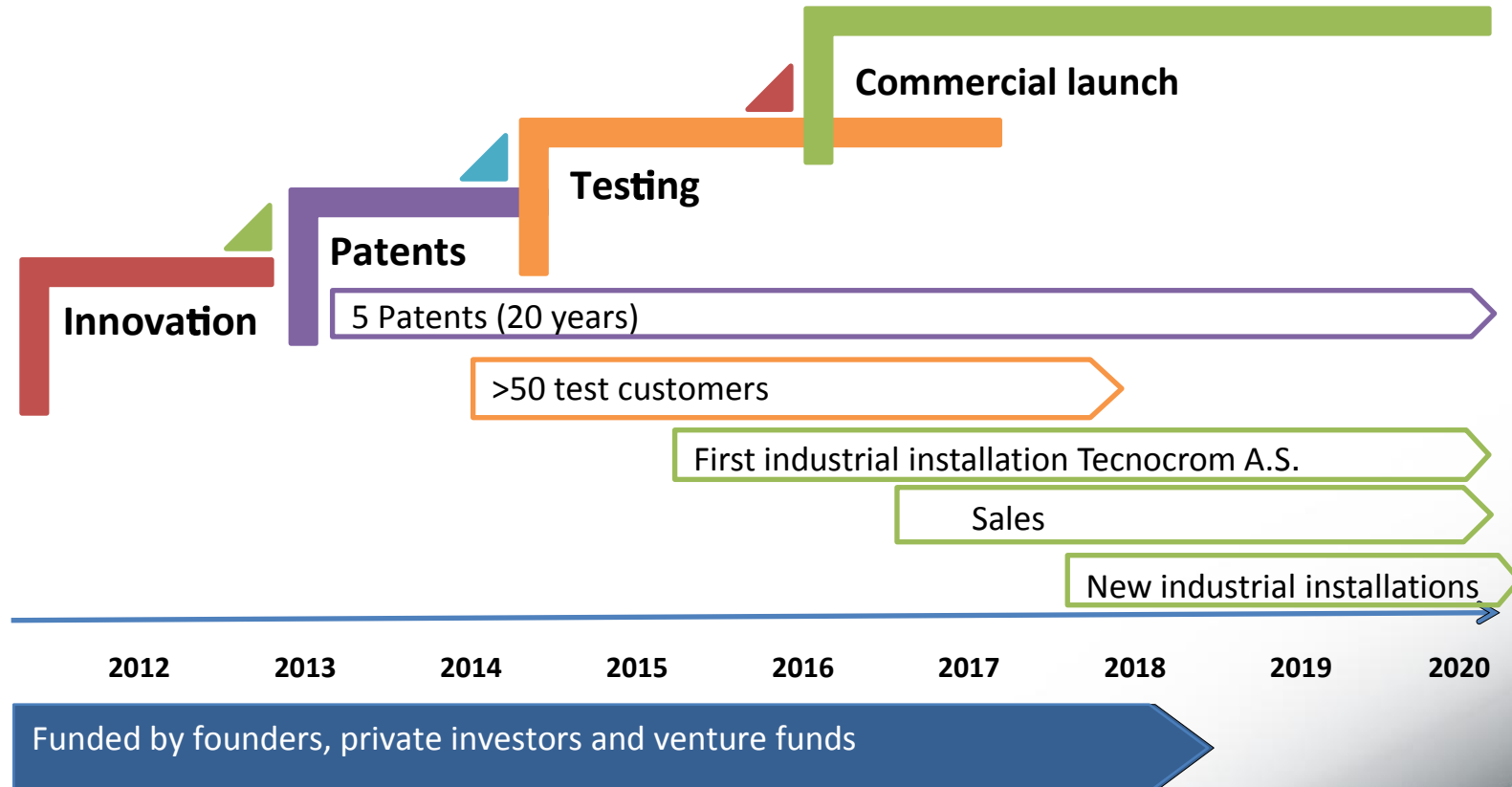
# Savroc Ltd



- Technology provider of tough and safe TripleHard® chrome based coatings
- TripleHard® is patented worldwide.
- Best ever tested hard chromium technology
- Founded in 2012
- Based in Kuopio, Finland

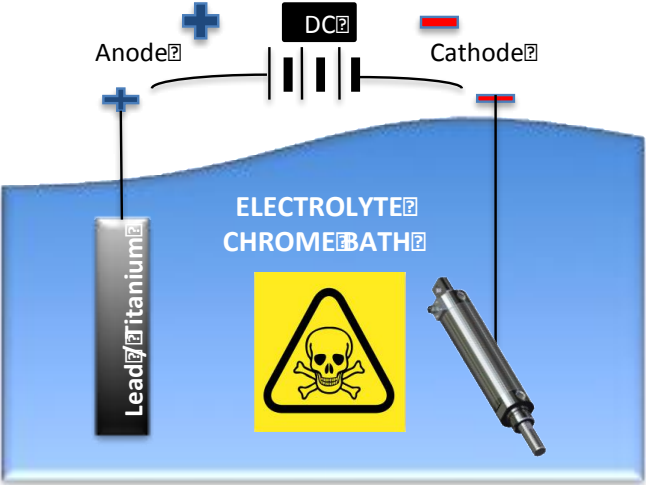


# From Lab to Industrial Implementation

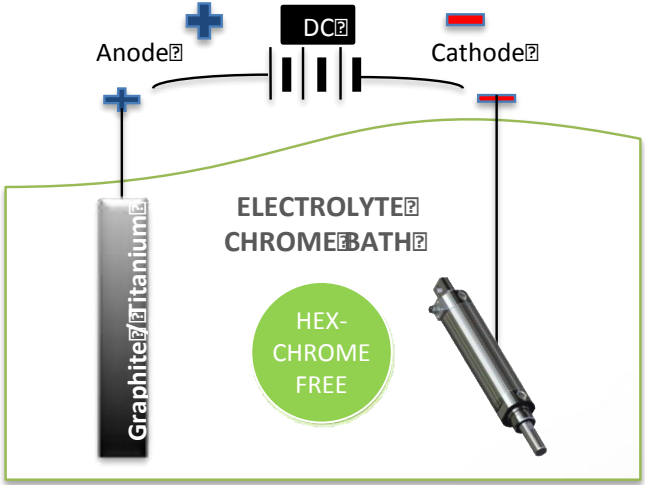


# Chrome Plating Process

## Traditional coating method



## Savroc's coating method



# Technical Benefits

Test	TripleHard	HCr	Electroless nickel	Electroless nickel + thermal treatment 400C
Taber wear index CS10, 1 kg	1	2	16	9
Hardness (HV 0,05)	1500- 1800	1000	600	900
Adhesion (Daimler Benz/ Rockwell C)	+++	++	+++	++
Bending test (Adhesion)	++	+	+	+
Corrosion NSS EN ISO 9227	+++	-	++	+
POR - Wear (PinOnRod), 500 g, 15 min [ $\mu\text{m}$ ]	3	5	15	10
POR - Friction (PinOnRod)	0,12	0,45	-	-

# Financial Benefits



- Better wear resistance
  - Longer lifetime - higher production output
- Excellent corrosion resistance - cheaper base material
- Lower current density – lower electricity consumption
- Lower friction
  - Less force – less compressed air - smaller actuator
- Thinner coating - less material
- Less waste – less disposal fees
- Much less exhaust air - cheaper air ventilation system
- REACH compliant- no authorization fees

# TripleHard Coatings

**3 different coatings**

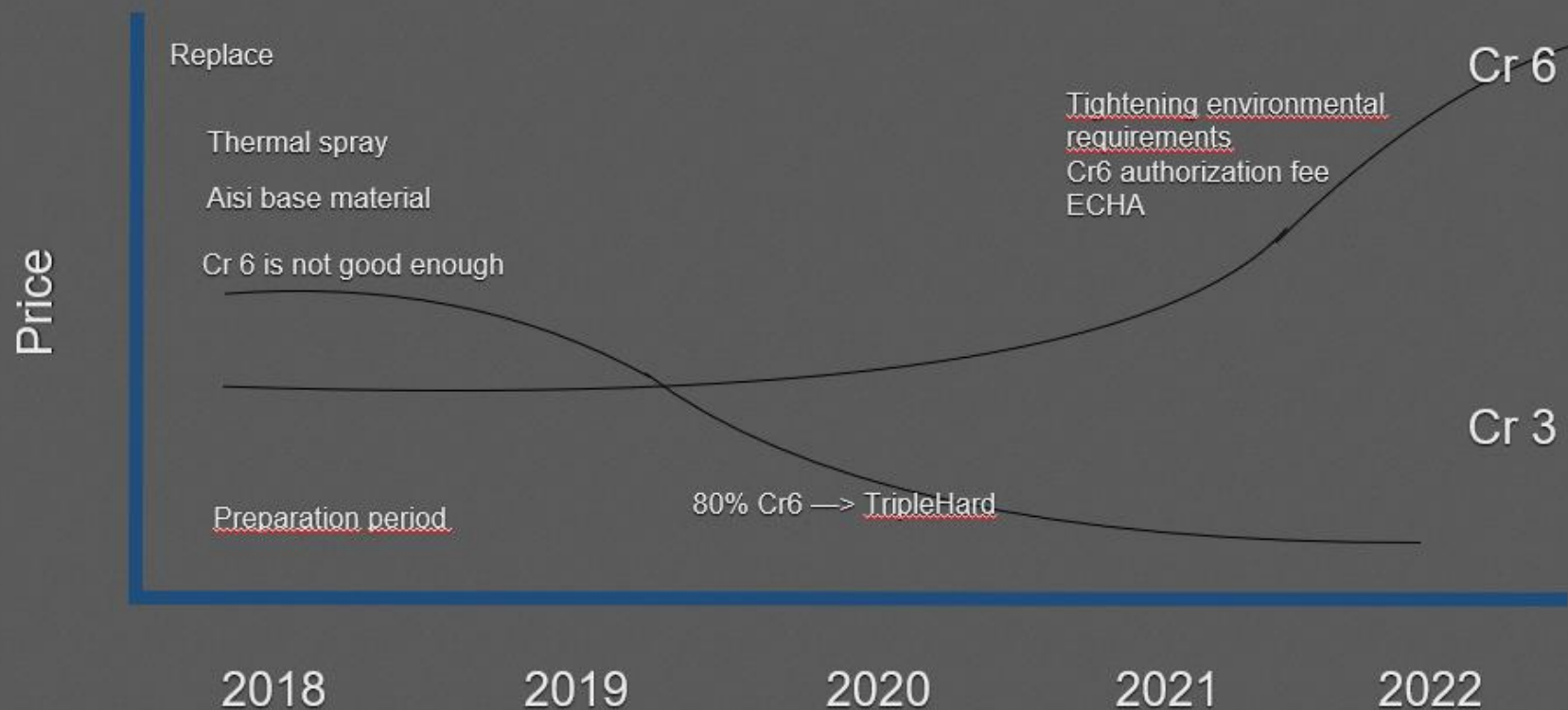
**No thickness limitation**

**Tested up to 100  $\mu\text{m}$**

**Micro fissures**

	NIP + CR	NI + CR	CR ONLY
<u>NI THICKNESS</u>	2 - 30 $\mu\text{m}$	1-3 $\mu\text{m}$	-
<u>CR THICKNESS</u>	5 - 100 $\mu\text{m}$	5 - 100 $\mu\text{m}$	5 - 100 $\mu\text{m}$
FISSURES	MICRO	MICRO	MICRO
HARDNESS	1700 Hv	1 700 Hv	1700 Hv
CORROSION	1000	>240	200
<u>TABER WEAR INDEX</u>	1,03	1,03	1,03

# Chemistry price



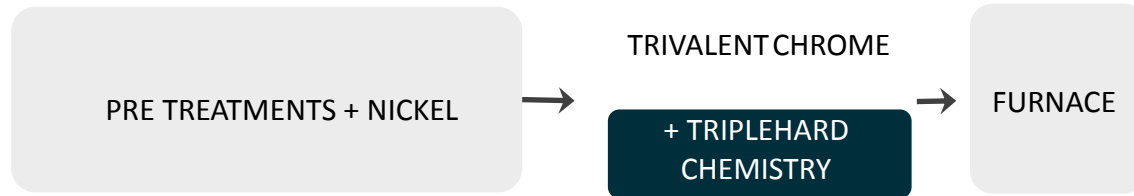


# Case Examples and Applications

**SQVRQC**

# Integrating TripleHard® Technology in an Existing SAVROC Plating Line – Case Tecnocrom Industrial S.A.

- TripleHard® technology was integrated into Tecnocrom's existing electroplating line.
- One additional plating tank for TripleHard chemistry was required.
- Process has been running over 3 years from now



# TripleHard Mining – Excellent Corrosion Resistance

- Comparison with Cr6 and TripleHard
- Cr6: Base material AISI 329 and 20MnV6
- TripleHard 20MnV6 normal carbon steel
- Very demanding environment in an Australia mine
- Salt and elevated temperature

# 20MnV6 + Cr6

- After 2 months
- 20MnV6 base material
- Easy to see a lot of rust

Need to change the  
cylinder



# Aisi 329 + Cr6 mining

- After 4 months
- Aisi base material
- Easy to see rust

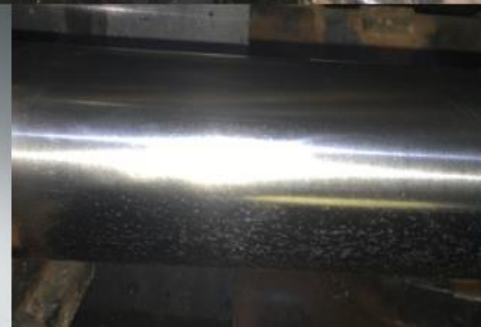
Even AISI base material rod is rusty. Need to change the cylinder



# 20MnV6 + TripleHard

- After 6 months
- Normal steel base material
- NO RUST

TripleHard performs much better than Cr6 with AISI base material



# Examples of Industrial Applications

Automotive brake systems



Cylinders



Valve components



Pistons



Shock absorbers



Shotgun barrels and Grenade mortars



# Proof of Technology



Application	Tests	Status
Hydraulic cylinders	Corrosion, wear, sealing, bending, variety of testing	Life time tests passed In production
Valve components (ball, seal rings, cylinder rods and tubes)	Wear, Sealing properties, corrosion	Field operational tests passed In production
Gun barrels	Shooting tests, Corrosion, wear, thermal shocks	Shooting tests passed
Linkage pins	Galling resistance	Tests passed
Automotive brake parts	Wear, Corrosion	Tests passed
Shock absorbers	Corrosion, wear, bending, cracking	Tests running
Wear parts	Wear resistance	Field test passed In production



# Support Slides

Test Results

**SQRQC**

## TripleHard® Wear Testing



### Objective:

To measure the Taber wear index (TWI) on a panel provided by Savroc Ltd.

### Conclusion:

The average TWI (over 9x1000 cycles) for the TripleHard® coating was 1.03 mg loss/1000 cycles.

### Test Parameters:

Abradent: CS-10 wheels

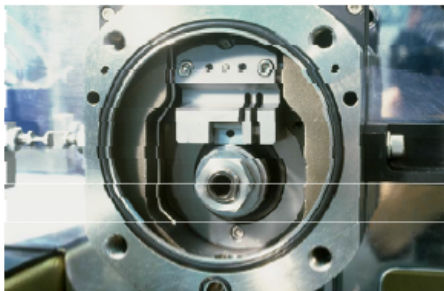
Load: 1000 grams

Refacing: 50 cycles with S-11 refacing discs between every 1000 cycles

### Results:

Run No.	Cycles	Before Weight (g)	After Weight (g)	Loss (mg)
1*	1000	160.5142	160.5120	2.2
2	1000	160.5120	160.5106	1.4
3	1000	160.5106	160.5096	1.0
4*	1000	160.5096	160.5072	2.4
5	1000	160.5072	160.5058	1.4
6	1000	160.5058	160.5050	0.8
7	1000	160.5050	160.5039	1.1
8	1000	160.5039	160.5031	0.8
9	1000	160.5031	160.5019	1.2
10	1000	160.5019	160.5013	0.6
11	1000	160.5013	160.5003	1.0
Average				1.03

## BOR Scuffing Test

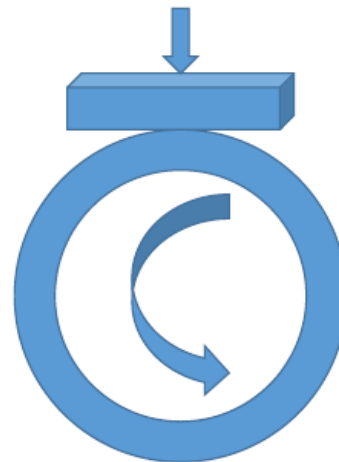


- Block (bearing) – 8620 carburized
- Ring (pin) – Trivalent Cr
- Grease lubricated – **marginal lube**
- Room temperature
- Step loading (50 lbf – 1275 lbf)
- Constant velocity – 100 rpm (0.18 m/s)



**Marginal Grease Lubrication**

Ring (pin)	Block (bearing)
Hard Cr (Baseline)	8620
Trivalent Cr	8620



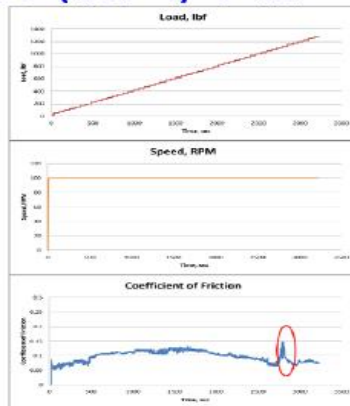
# BOR Wear Test Results

Hard Cr Plated rings were prepared using the traditional process and tested as a comparative baseline to Savroc's TripleHard plating.

The 'spike' in friction shown below for the Hard Cr sample is due to galling (i.e., metal-to-metal adhesion). The Savroc plating did not exhibit any galling up to the maximum loading of 1275 lb force. The estimated contact stress at this maximum loading is  $\sim 850$  MPa.

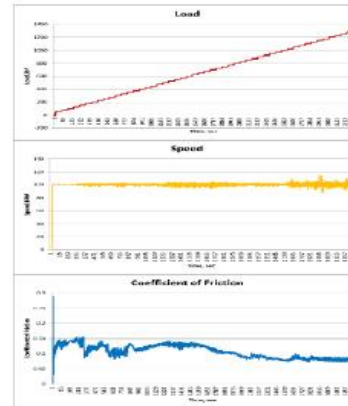
## BOR Test Results – Hard Cr (baseline) vs. steel

- Grease lubricated – **marginal lube**
- Grease: Cat multi-purpose grease
- Scuffing load: initiation at 1125 lbf?



## BOR Test Results – Trivalent Cr vs. steel

- Grease lubricated – **marginal lube**
- Grease: Cat multi-purpose grease
- Final load: No scuffing up to 1275 lbf
- Contact pressure:  $\sim 850$  MPa

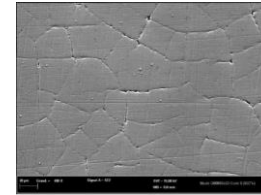


# Hardness\*

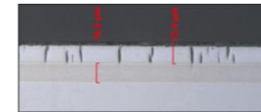
- TripleHard coating has a hardness up to 1800 HV.
- The hardness of the coating isn't affected by high temperatures and the structure stays stable.

## Hardness measurement of Savroc TripleHard

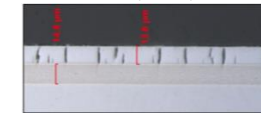
	Base	After thermal shock at 400°C	After thermal shock at 600°C
Average thickness of Cr layer	13,4 µm	13,6 µm	13,5 µm
Average thickness of Ni/P layer	14,5 µm	14,8 µm	14,7 µm
Hardness Cr	1884 HV (30g)	1780 HV (30g)	1798 HV (30g)
Hardness Ni/P	705 HV (30g)	715 HV (30g)	726 HV (30g)
Hardness of substrate	195 HV (200g)	194 HV (200g)	201 HV (200g)



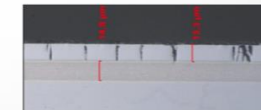
Microcrack pattern after thermal shock test at 600° C (400x)



Base (500x)



After 400° C (500x)



After 600° C (500x)

# THANK YOU!

osmo.jahkola@savroc.com

