Sustainable and cost-effective stripping without compromising on performance

Sylvain Masson | Global Product Manager

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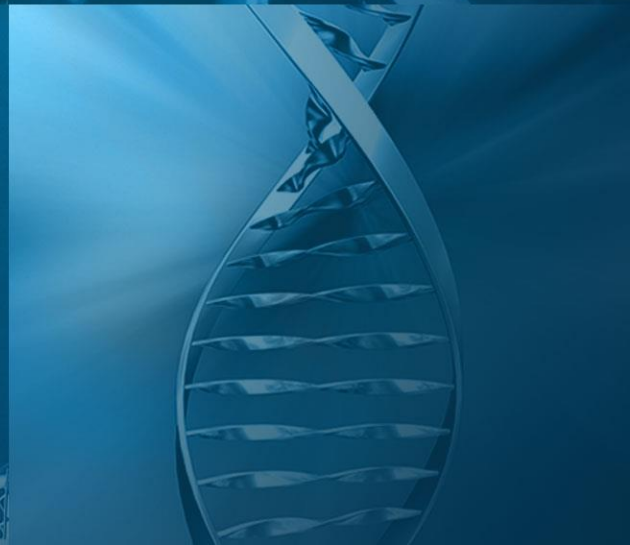
Paint removal methods



Understand existing paint removal techniques
Existing technologies limitations

Conventional mechanical

Encompassing various methods such as impact, grinding/sanding, media blasting, hydro jet

- Impossible to avoid substrate damage
- Slow and labor intensive
- Line of sight limitation
- HES risks
- Noise pollution
- Not suitable for parts reclamation

Conventional thermal

Encompassing various methods such as pyrolysis, molten salt, fluidized bed

- Weakening of metal decreasing life span
- Not suitable for tools and parts with springs and magnets
- High energy consumption
- High capital and short EQ life
- Slow processing
- Safety and fire hazards

Conventional chemical

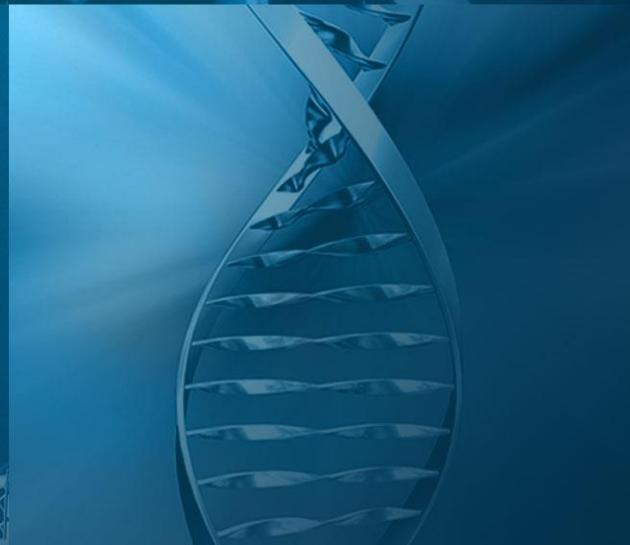
Encompassing various methods such as

- Limited substrate compatibility
- Generate large amount of waste
- Frequent make ups and inconsistent performance
- Health, environment and safety increasing issues

External outsourcing

- Large volume of paint aids mandatory to allow operation without disruption
- High cost
- Secondary operation and repairs often required

Chasing hidden costs



How much paint stripping really cost?

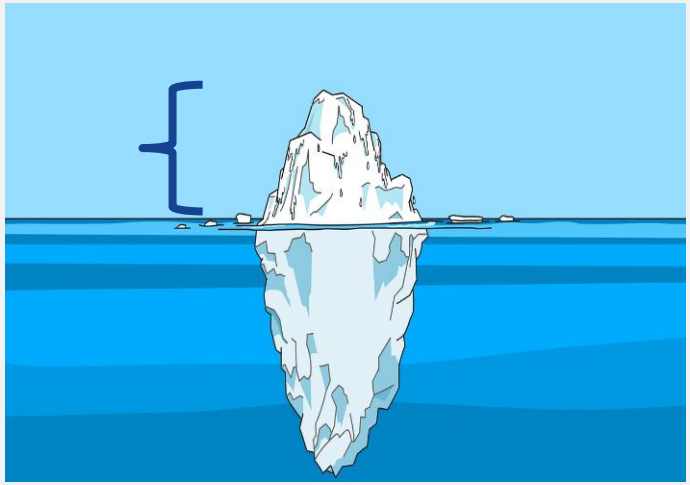
Mechanical	Thermal	Chemical	Outsourcing
			

- Regardless the chosen method, painting aids cleaning is a burden that every paint applicator must bear
- Identifying all the associated cost of such operation is not always an easy task
- If service fees or consumables are obvious, many other associated costs are often harder to see or wrongly assigned and gives an inaccurate view of the real global cost

How much paint stripping really cost?

- Direct and highly visible costs typically are:

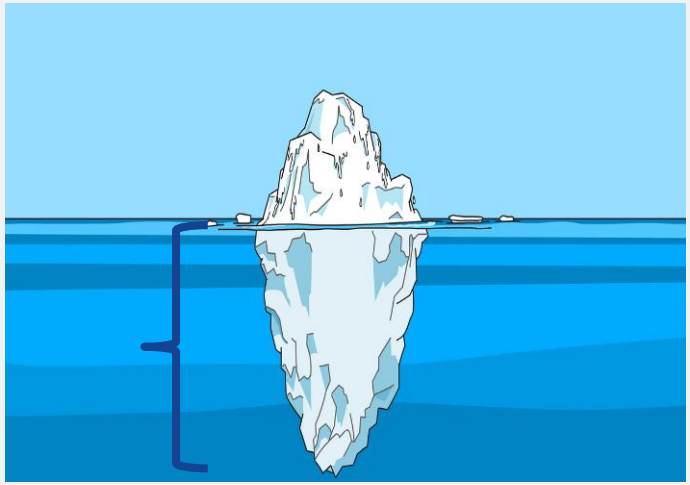
In-house operation	Out- sourcing
Energy such as gas, electricity, etc.	Service fee
Consumables such as chemistry, media for blasting, etc.	Transportation



How much paint stripping really cost?

- Other costs which could also be attributed to paint cleaning are typically:

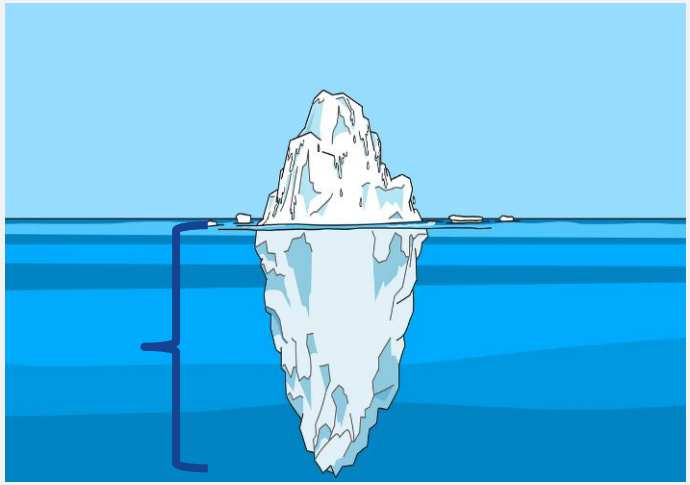
	In-house operation	Out-sourcing
Equipment depreciation	X	
Equipment maintenance	X	
Secondary cleaning	X	X
Repairs and replacement due to damages	X	X
Production paint defects due to unclean jigs and racks	X	X
Extra volume of painting aids to allow rotation	X	X



How much paint stripping really cost?

- Other costs which could also be attributed to paint cleaning are typically:

	In-house operation	Out-sourcing
Labor	X	
Waste generated	X	
Water consumption	X	X
Yield reduction due to poor continuity	X	X
Process limitation such as line of sight or substrate compatibility	X	
Paint overconsumption, etc.	X	X



How much paint stripping really cost?

It is essential to clearly identify all related paint stripping operation costs to ensure accurate comparison

The return on investment can be highly impacted by omitting to include hidden but high related costs

Utilization of a thorough comparison table will be essential

Savings may vary based on the method of choice, and typically sustainable removal processes will always provide the most efficient and cost-effective solution

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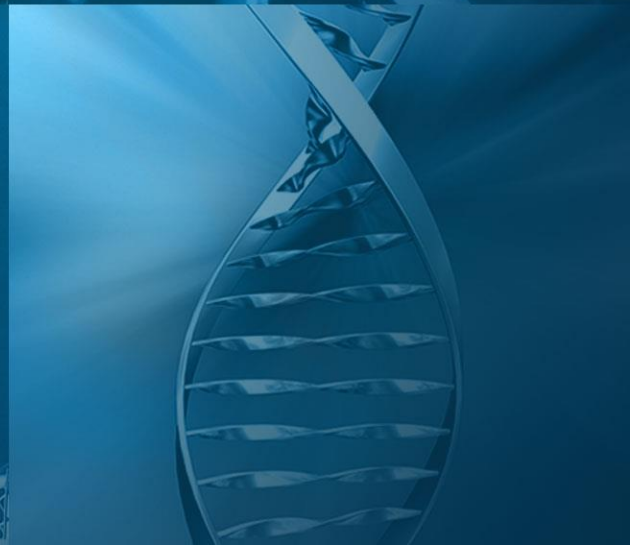
Paint Removal Cost Identificator

Production volume:	
Parts type:	

	Master Remover	Media Blast	Burn Off	Chemical	Outsource
Equipment					
Equipment life time FC					
Equipment maintenance					
Energy					
Consumable (year 1)					
Consumable					
Labor					
Initial volume (Jigs,					
Repairs					
Replacement					
Water					
Waste					
Associated reject rate					
Extra paint consumption					
Transportation					
Patrial outsource					
Secondary cleaning					
Exclusion parts (eg springs, delicate parts or could not be cleaned with current					

Sustainable paint removal

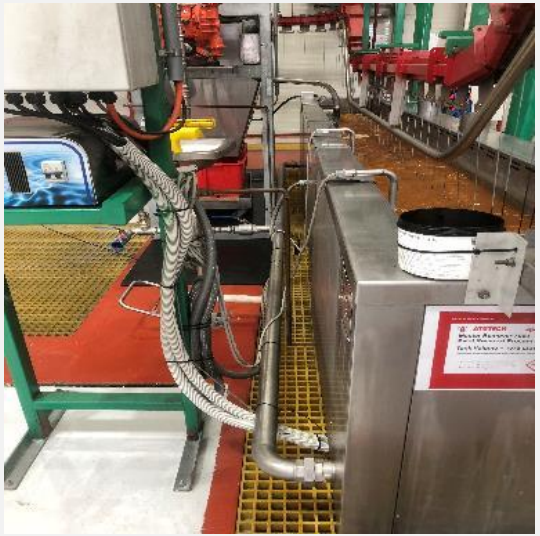


A different approach to paint removal

Sustainable stripping vs existing methods:

Mechanical

- Labor intensive
- Damages
- Etc.



- Seamless operation
- Safe to parts metallurgy
- Etc.

A different approach to paint removal

Sustainable stripping vs existing methods:

Thermal

- Ashes and dirt
- Rust
- Etc.

- Perfectly clean surface at first pass
- Keep substrate intact
- Etc.

A different approach to paint removal

Sustainable stripping vs existing methods:

Chemical

- Toxic and hazardous to the environment
- Difficult cleaning unavoidable
- Etc.

- Low VOC and low energy
- Long life to no dump solution
- Etc.

When high performance serves sustainability

Major benefits

Minimized waste, long life to no dump capability

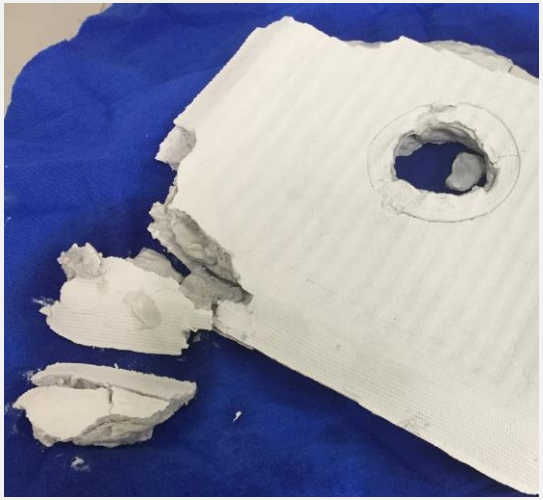
Sustainable technology will offer paint stripping preservation solution and maintain it at its optimal performance level

Long life solution will not only save make-up volumes but also the waste volumes and the labor associated with its disposal

Generating as waste almost only the volume of coating removed will dramatically reduce waste disposal cost burden

Sustainable paint removal helps to minimize waste

High filterability can make no dump become a reality



Sustainable stripping offers minimum waste, almost only coating removed from substrate

Energy consumption minimized

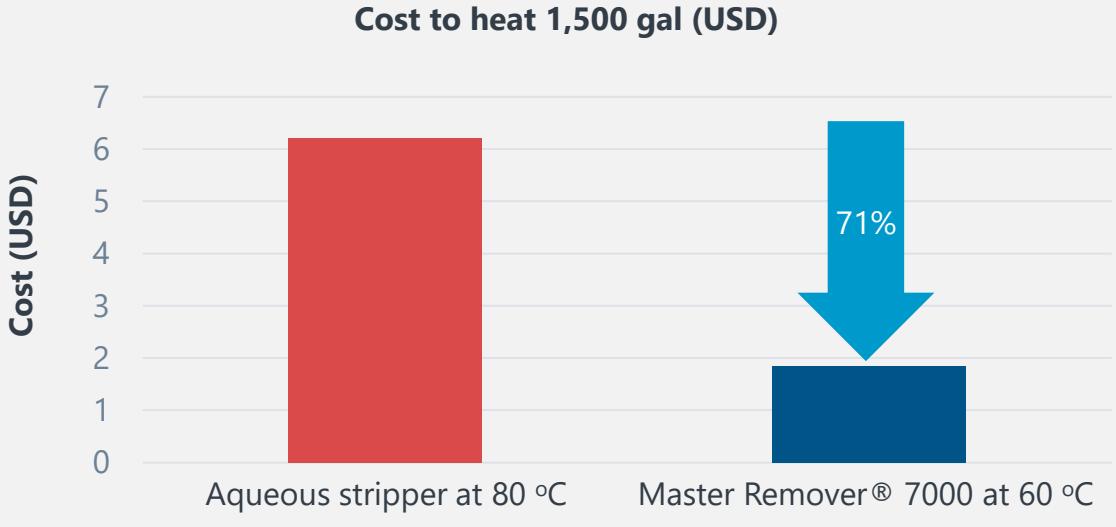
Sustainable stripping methods could offer drastically reduced energy demand

Low specific heat products will make process very energy efficient and minimize its impact burden to the painting activity

When most of the available stripping methods are considered as “money pit”, sustainable stripping is truly a new innovative way to remove paint from substrate

Sustainable paint removal helps to reduce paint aids volumes

Heating solution to operating temperature



Energy consumption minimized

Burn off oven

Energy usage: 4296 kw/day
Cost: $300.72 /day
Cost: $72,172.80 /year
CO_2 produced: 185.65 tons/year

Burn off vs. Master Remover® comparison

	Hi efficiency burn off	Master Remover® 7000
Load size	500 kg steel	500 kg steel
Oven / tank size	4 m^3	4 m^3
Cycle time	8 hours	1 hour
Heat up time	NA	12 hours
Energy per hour (operational)	203 kW/hour	6.29 kW/hour
Energy per hour (heat up)	NA	10.35 kW/hour
Loads / day	3	3
Days / year	240	240
Energy cost	$0.07 /kWh	$0.07 /kWh

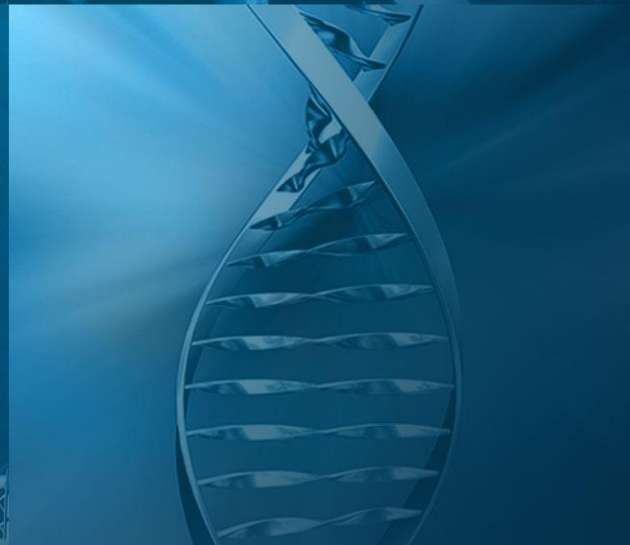
CO_2 reduction 91.2%

Master Remover® ESPRIT

Energy usage: 143kw/day
Cost: $10.01 /day
Cost: $2402.4 /year
CO_2 produced: 16.22 tons/year

When high performance serves sustainability

Other key positive impacts on productivity and control



Reject rate reduction

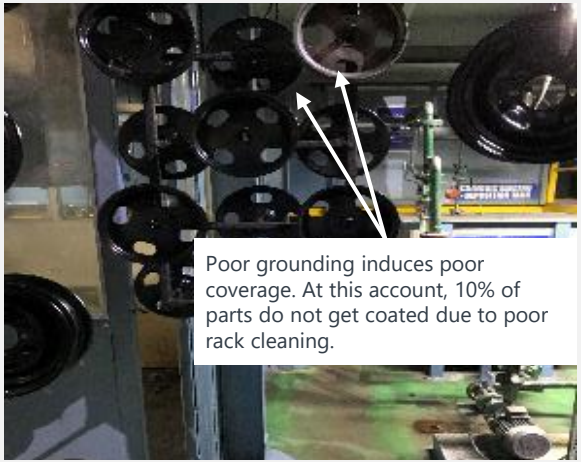
- Poor jigs and racks cleaning could have significant impact on reject rate
- Unclean racks could drag dust and dirt into paint line
- Altered geometry could lead to uneven film build and paint failure
- Altered substrate could lead to hanger rupture and subsequent line stoppage
- Sand transfer from fluidized bed can rapidly fill-up cleaner tanks and lead to major issues
- Blasting beads could prevent spring mounted jigs from functioning properly
- Poor cleaning might require extra operation, which could significantly and negatively impact production yield

Sustainable paint removal helps to reduce the reject rate

Optimized and consistent grounding

- Poor grounding will significantly diminish paint application performance
- Poor grounding will create uneven coating thickness
- Some areas could receive no paint at all
- Poor grounding can lead to extra operation to manually cover the missed areas
- Poor grounding subsequently increases paint volume needed
- Poor grounding will decrease corrosion resistance
- Coating could be more sensitive to breaking or peeling off

Sustainable paint removal improves continuity

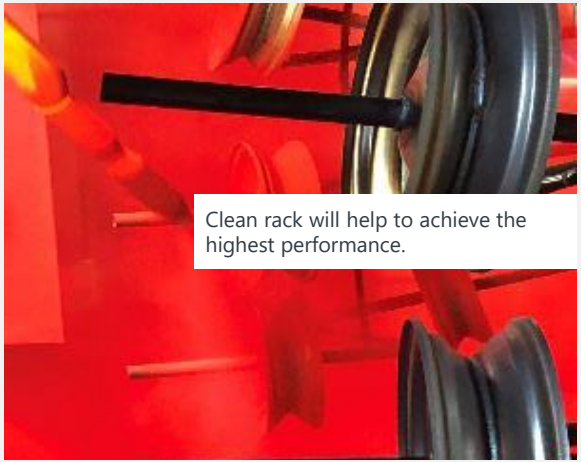


Poor grounding induces poor coverage. At this account, 10% of parts do not get coated due to poor rack cleaning.

Coverage optimized and uniform

- Optimized coverage supports better paint gloss
- Paint curing will be optimized
- Coating will subsequently be more robust
- Only minimal touch-up will be needed
- Productivity will be increased

Sustainable paint removal helps to improve quality



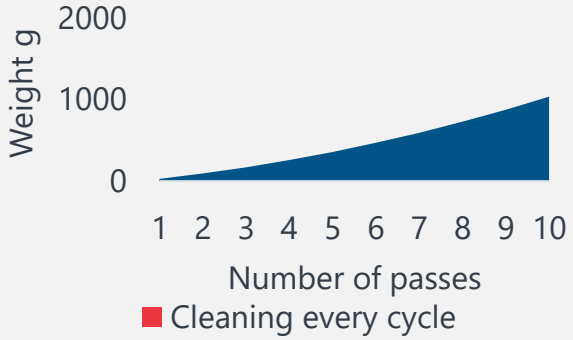
Clean rack will help to achieve the highest performance.

Paint consumption reduced

- Unclean paint tooling significantly increases paint consumption
- Small metal chair which needs 6 dag/unit would then require 8 dag/unit, almost 35% unnecessary extra consumption
- Hook coating weight will very rapidly increase when not cleaned regularly
- An unstripped 1-meter hook can represent up to an extra 4.3 kg of paint every 10 cycles
- Extra paint accumulated will be 100% waste with no possibility of reclaiming, increasing operating costs

Paint volume after 10 passes (g)

Paint weight (g) on 1 m long hook



Sustainable paint removal reduces paint consumption

Jig and rack handling

- Aggressive stripping methods create irreversible damage to substrate:
  - Heavy gauge steel will be needed to prevent part racking/fixturing to fail
  - Frequent replacement will be necessary
- Secondary operation almost unavoidable:
  - Geometry re-alignment
  - Welds repairs
  - Magnet replacement
  - Seals repairs
  - Parts replacements, such as springs, etc.
  - Cleaning of ashes, flakes, dirt, etc.

Sustainable paint removal helps to reduce paint aids volumes

Sustainable stripping will preserve metallurgy for optimal tooling usage.

Jig and rack volumes need

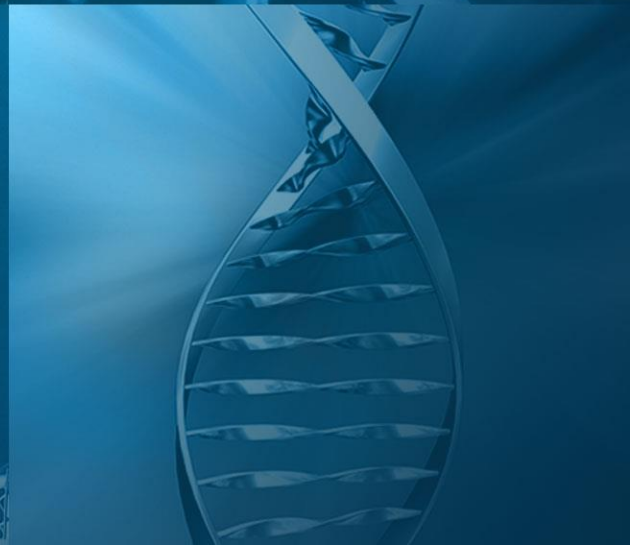
- Significant extra jigs and racks volume is typically needed for:
  - Rotation due to slow in-house processes
  - Rotation to contractor when outsourced
  - Routine replacement
  - Rotation due to repair time or additional cleaning
- Unavoidable damage will make replacement a necessity
- Smaller tools, springs which could not be processed with traditional stripping method, are just disposed and considered as consumable

Sustainable paint removal helps reduce paint aids volumes

Sustainable stripping will preserve metallurgy for optimal tooling usage.

Simplicity of implementation and operation

Choosing the right equipment



Selection of the right equipment design

- It is essential to select the right design to meet the highest sustainability standards
- In-house stripping implementation could be simple and easy
- Pre-assembled, optimized installation are available
- Ready to use paint removal systems could rapidly be installed to save money at the same time of improving working environment and performances
- It will then ensure optimal performance:
  - Fast coating removal
  - Low energy demand
  - Minimal waste generation

Sustainable in-house stripping can be fast and easy to implement

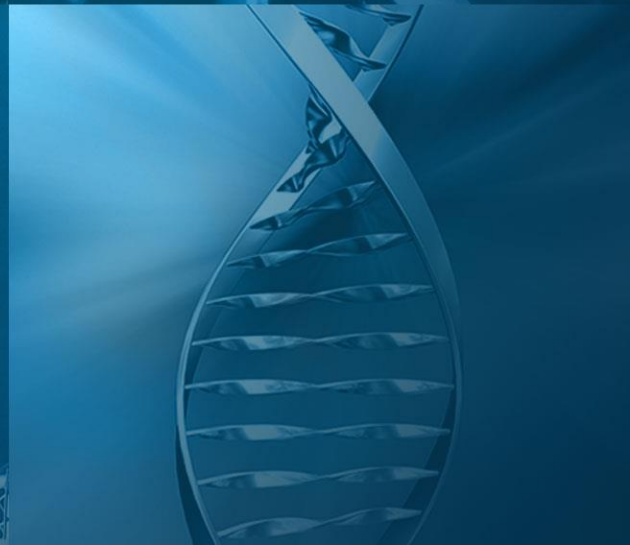
Simple to use and easy to control

Quick and easy controls

- Rapid and easy activity level check will make sure the process always functions optimally
- Minimum water and additives required for simple and easy replenishment
- Easy visual control to maximize process simplicity of use

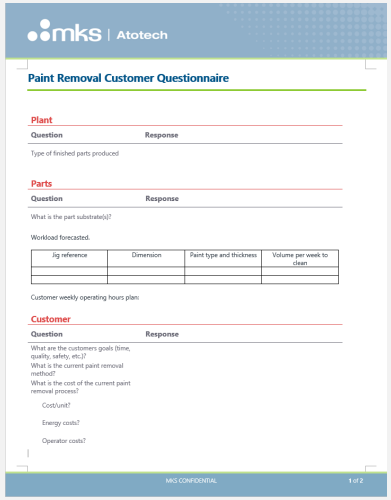
Minimum to seamless operation that can save man-months

Sustainable paint removal implementation in 7 easy steps



7 easy steps to sustainable paint removal

- Identification of the need
- Identification of actual stripping cost (including hidden)
- Target definition / KPI
- Paint removal evaluation
- Commitment to the project
- Equipment design
- Equipment fabrication and installation
- Start-up, commissioning



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Paint Removal Customer Questionnaire

Plant

Question	Response
Type of finished parts produced	

Parts

Question	Response
What is the part substrate(s)?	

Workload forecasted.

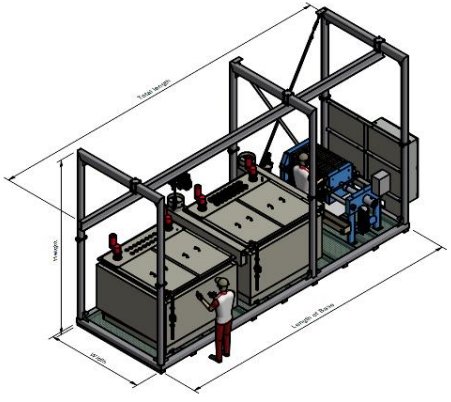
Jig reference	Dimension	Paint type and thickness	Volume per week to clean

Customer weekly operating hours plan:

Customer

Question	Response
What are the customers goals (time, quality, safety, etc.)?	
What is the current paint removal method?	
What is the cost of the current paint removal process?	
Cost/unit?	
Energy costs?	
Operator costs?	

MKS CONFIDENTIAL 1 of 2



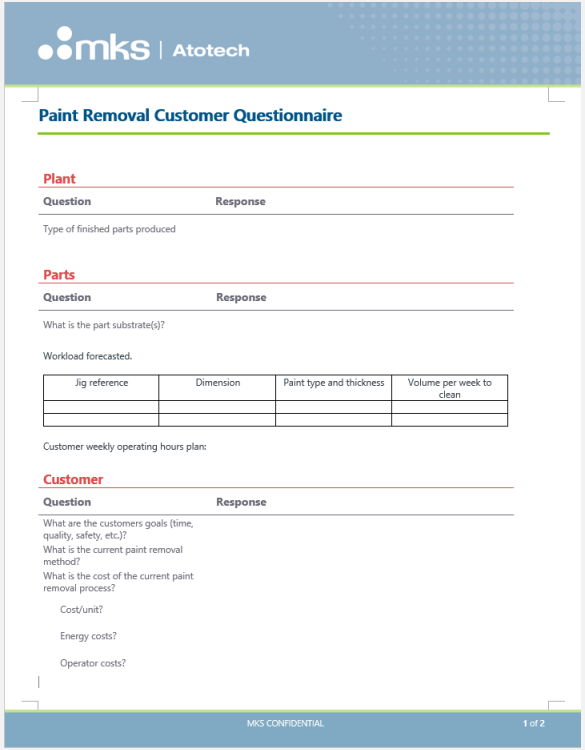
#1 Identification of the need

Sustainable stripping is offering new opportunities which did not exist before. Therefore, we clearly need to define the needs specific to each applicators

Need for parts reclamation
- Substrate (light metal, ferrous metal, mixed metal)
- Geometries
- Types of paints to be removed
- Volumes

Fixtures / paint aids cleaning
- Substrates (light metal, ferrous metal, mixed metal)
- Types of paints to be removed
- Desired frequency of cleaning

Define KPI
- Cost reduction
- Waste reduction
- Energy reduction



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What is the cost of the current paint removal process?	
Cost/unit?	
Energy costs?	
Operator costs?	

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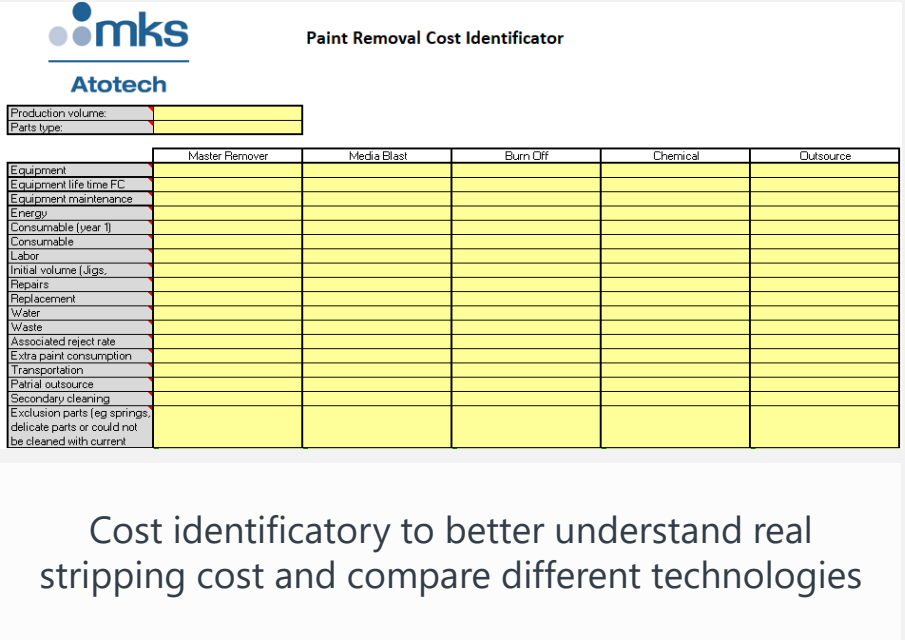
#2 Identification of the total cost of stripping

- Equipment capital and depreciation
- Maintenance
- Operating costs
- Consumable
- Labor
- Production yield loss
- Scrap cost
- Fixture volumes (initial invest + routine repairs and replacement)



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Paint Removal Cost Identificator

Production volume:	
Parts type:	

	Master Remover	Media Blast	Burn Off	Chemical	Outsource
Equipment					
Equipment life time FC					
Equipment maintenance					
Energy					
Consumable (year 1)					
Consumable					
Labor					
Initial volume (Jigs,					
Repairs					
Replacement					
Water					
Waste					
Associated reject rate					
Extra paint consumption					
Transportation					
Patrial outsource					
Secondary cleaning					
Exclusion parts (eg springs, delicate parts or could not be cleaned with current					

Cost identificatory to better understand real stripping cost and compare different technologies

#3 Target definition

- Strip time
- Frequencies
- Waste target
- Application mode
  - In-line vs. offline
  - Spray vs. immersion
- Costs
- Floor space

#4 Paint removal evaluation

Select representative sample
- Parts or jigs with similar coating weight than the intend to be stripped

Screen processes

Evaluate the different paint types

Evaluate application mode
- In-line vs. offline
- Spray vs. immersion

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#5 Project commitment

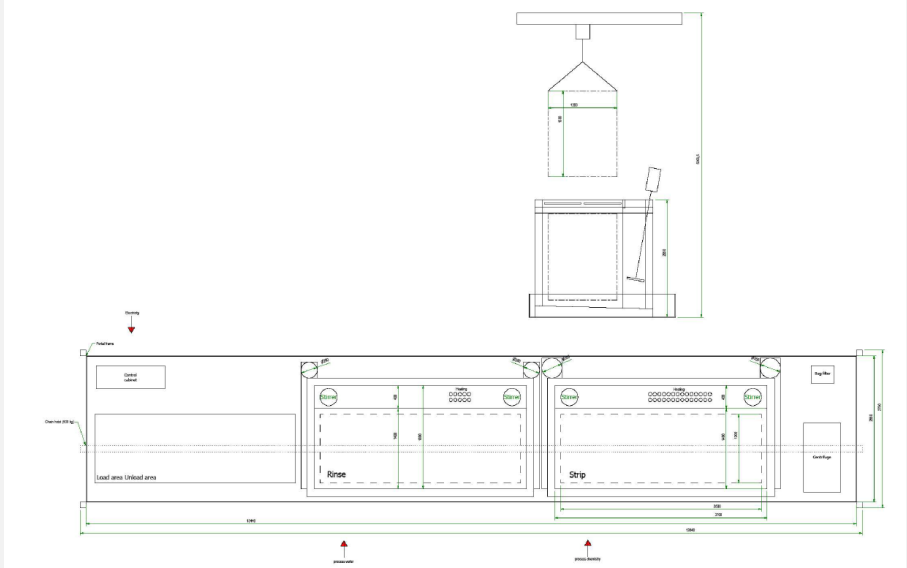
Implement NDA

Sign letter of intent

Define scope of cooperation

#6 Equipment design, fabrication and installation

- Spray / immersion mode
- In-line / offline
- Size capacity
- Define specs and material
- Floor space available
- Functional testing
- Assembly on site
- Connection to amenities and ventilation

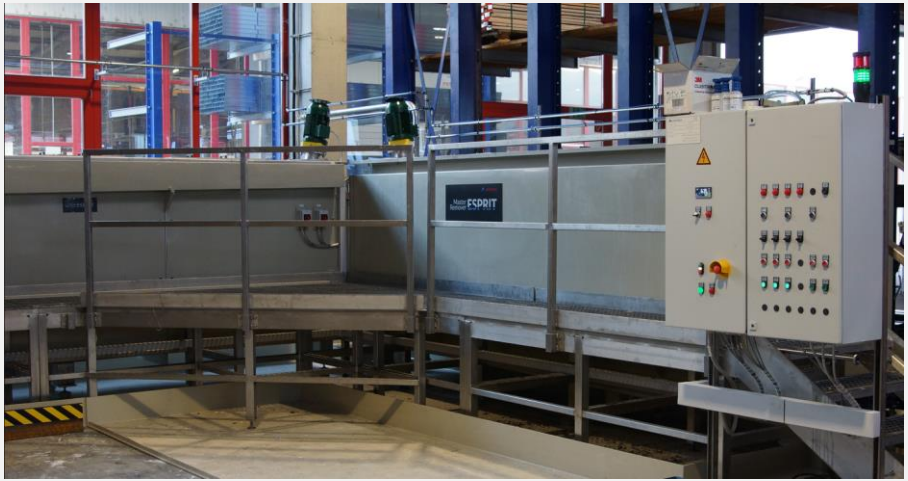


#7 Sustainable paint removal startup

Start up support

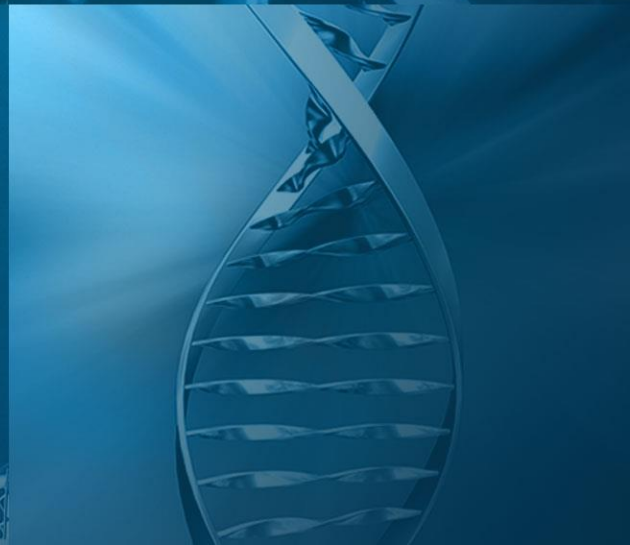
Operators training

Process optimization



When high performance serves sustainability

Case study



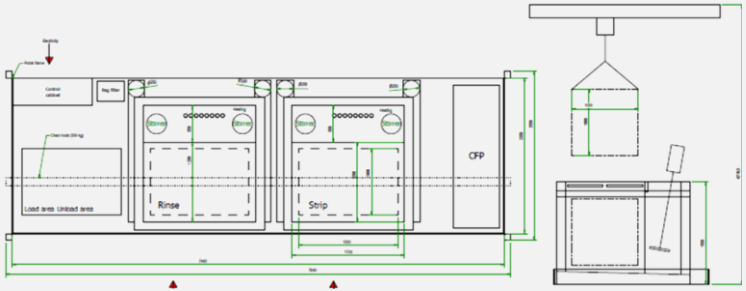
EV OEM application
Battery painting fixtures

Master Remover® processes are the ideal solution for applicators seeking a sustainable alternative:

- Preserve substrate
- Long life to no dump
- Low waste
- Low water consumption

Master Remover® processes free of regulated substances and associated hazards

Turnkey approach with Master Remover® ESPRIT



1x pass rack before

1x pass rack after

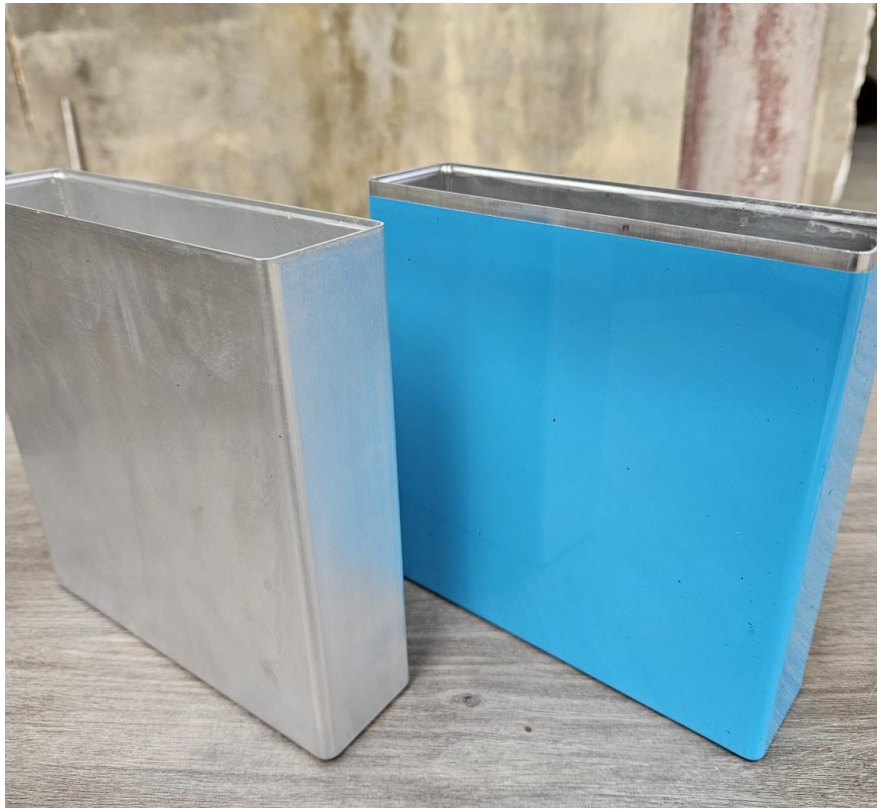
EV battery modules

Battery box reclamation

Master Remover® processes can easily remove flame retardant and dielectric paint without any etch and alteration of substrate

Master Remover® processes free of regulated substances and associated hazards

Turnkey approach with Master Remover® ESPRIT



EV cooling trays

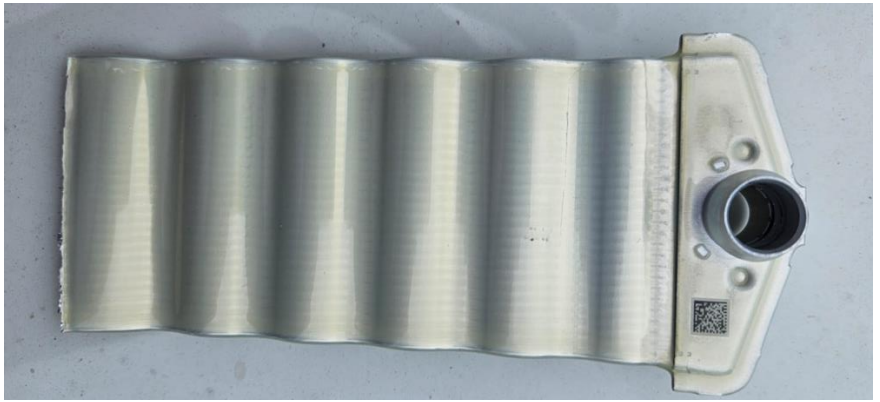
Cooling trays reclamation

Master Remover® processes can easily remove flame retardant and dielectric paint without any etch and alteration of substrate

Master Remover® processes free of regulated substances and associated hazards

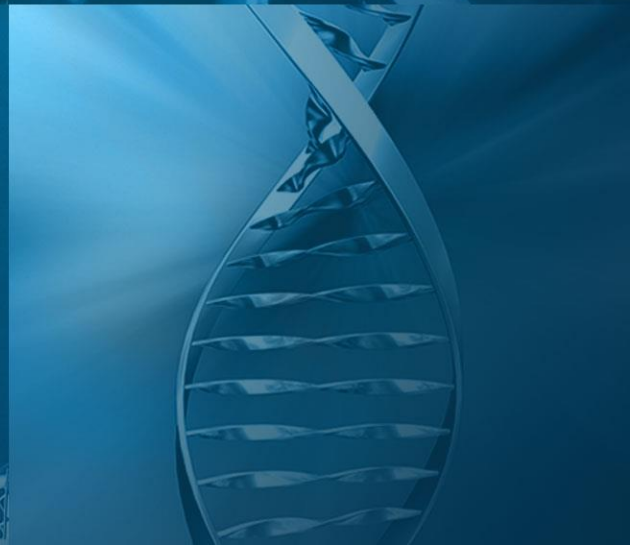
Turnkey approach with Master Remover® ESPRIT

Without alteration of substrate unique identification QR code still readable after reclamation



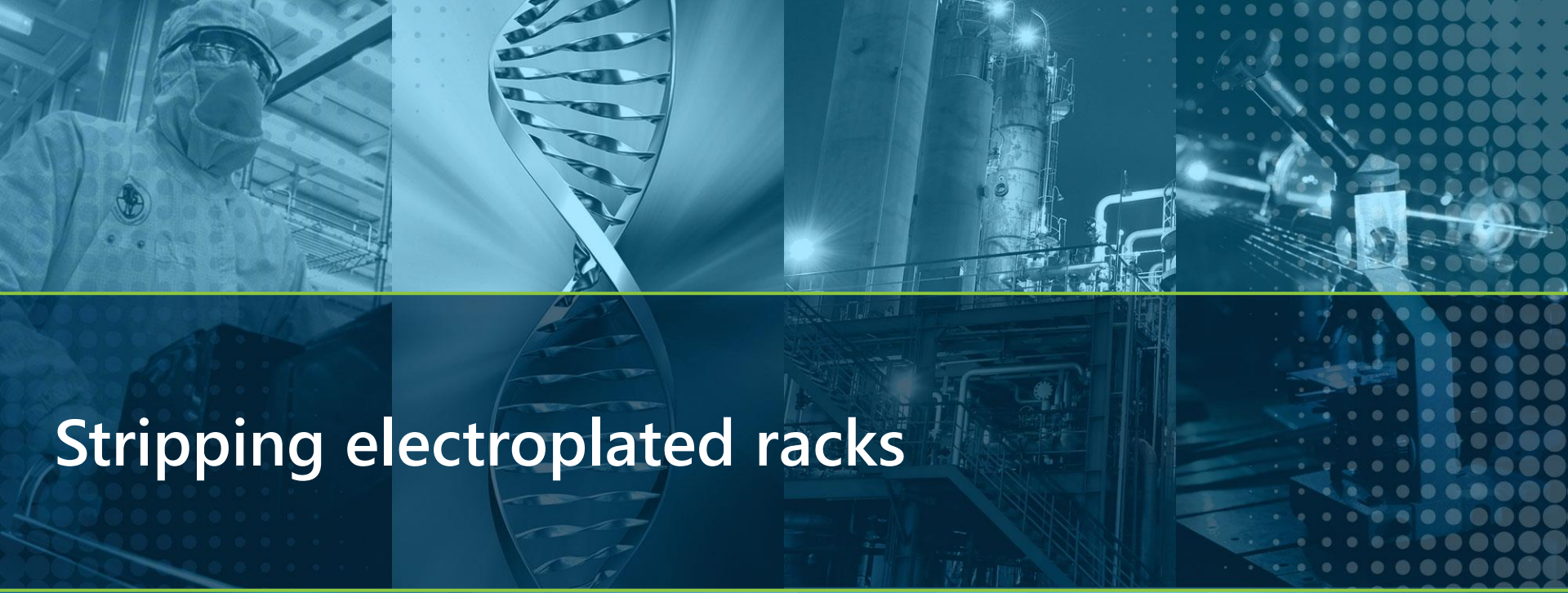
When high performance serves sustainability

Sustainable paint removal



In-line hook cleaning at architectural AI industry

!	Poor tooling cleaning can have many negative impacts on painting operation and rapidly drive cost up
!	To get accurate global cost view sometimes requires to investigate hidden areas
↗	Sustainable paint stripping can efficiently support process optimization
↗	Technologies have evolved and stride towards sustainability
↗	Change to superior solution can really be easy and fast to implement
↗	No need to compromise between high performance and low running cost anymore



Stripping electroplated racks

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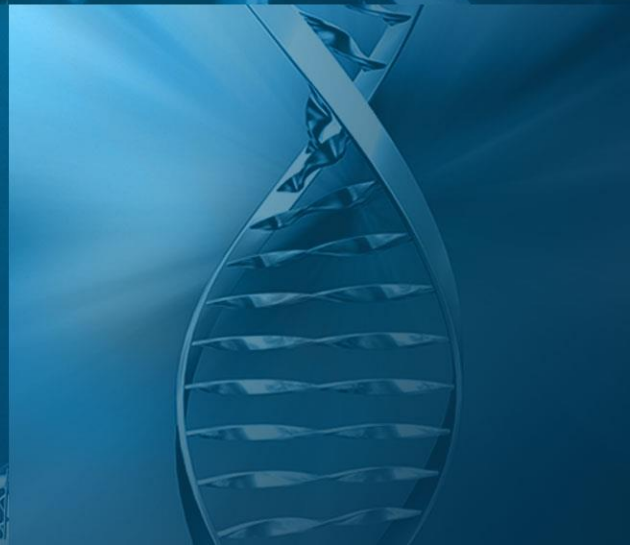
Introduction



Introduction
Rack stripping

To ensure the best plating performance of parts the associated racks must be kept in good condition. This includes removing deposits plated on them during the process.

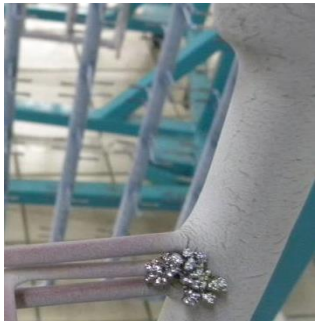
Rack stripping is commonly included at the end of the process sequence for industrial plating lines to ensure racks are optimized for the next plating cycle

After the racks are stripped there should be:

- No metallic deposits left on the rack tips
  - Preferably also none on the plastic insulation
  - To avoid plating quality and plating thickness issues
- No passivation of the rack tips
  - To avoid localized current loss, skip or reduced plating

Introduction
Main requirements

To ensure racks are in the best condition to give the best performance during the next plating cycle the rack stripping typically requires:



- Fast stripping
  - Typically, within 15 minutes
- Multiple metal stripping capability
  - Typically, Cr on Ni on Cu layers
- No attack of the rack tips
  - Typically, stainless steel substrates
- No degradation of the plastic insulation
- Easy process control
- Minimal environmental impact

Introduction
Mechanical

Advantages
Non-etching
No hydrogen embrittlement
Dry
No cathodes & wiring

Disadvantages
Slow
Labor intensive
Fiddly for small parts
Damage to rack tips & coating
Metallic dust & particles
Disposal of metallic waste

Typical hand and electric tools for mechanically removing plated deposits from racks

Introduction
Chemical (immersion)

Advantages
Simple processing
No cathodes or wiring
Suitable for complicated geometries

Disadvantages
Slow
Highly hazardous chemicals
Toxic fumes generated
Short bath lifetimes
High waste output
Expensive disposal costs

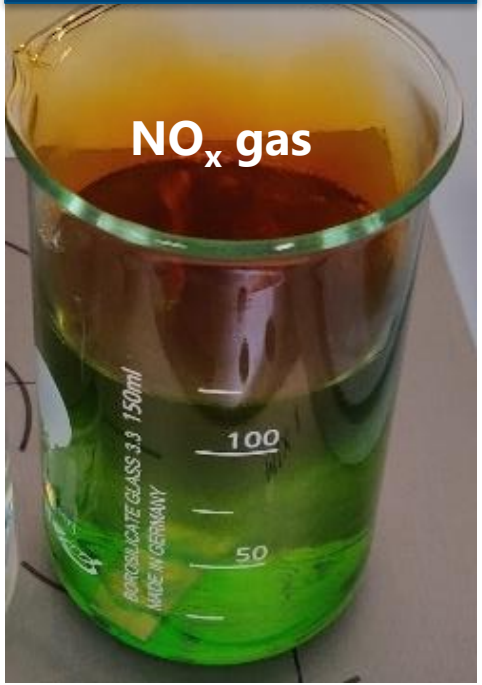
Common chemicals
Nitric acid
Halides
Strong oxidizers

Introduction
Chemical stripping – issues with nitric acid

Nitric acid reacts strongly during stripping.

- NOx gas generated
  - Acute toxicity
  - Skin corrosion / irritation
  - Serious eye damage
  - Line needs to be well ventilated
  - Damage to equipment
  - Attack of racks
  - Local bans
  - Handling risk for staff

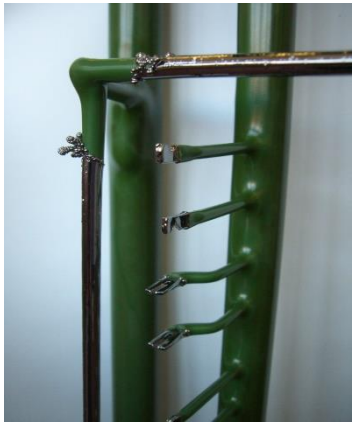
- Bath lifetime short
  - Bath quickly saturated with metals
  - Stripping rate significantly drops
  - High frequency of make-ups

Fresh make-up	During stripping
	

Electrolytic rack stripping
Ammonium nitrate based rack stripper

- Currently the most used electrolytic rack strippers are ammonium nitrate based processes
- They have the following advantages / disadvantages:

Advantages	Disadvantages
Ease of use • Simple analysis • 2 components and pH control	Based on ammonium nitrate • Supply & storage strictly controlled • Potential explosive nature of ammonium nitrate • Major source of nitrogen that can pollute rivers & lakes that can lead to eutrophication
Suitable for stainless steel rack tips • Series 304 & 316	High sludge generation
No harsh chemicals used • No cyanide or fluoride • No highly concentrated nitric acid	Wastewater treatment complicated by highly complexing ammonium and/or amines
Fast and efficient • Perfect for automatic lines	
Decades of industrial experience	



Electrolytic rack stripping
New rack stripper development

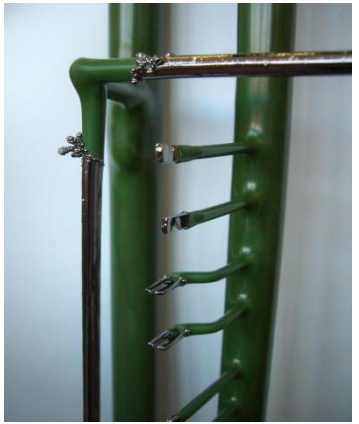
- A new electrolytic rack stripping process was developed that incorporates the benefits of conventional electrolytic rack strippers but without the issues of ammonium nitrate or amines.

UniStrip® Rackstrip AF

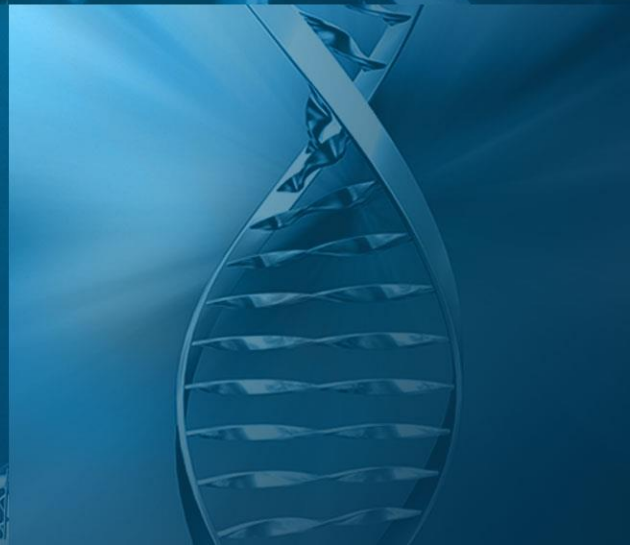
Electrolytic rack stripping
UniStrip® Rackstrip

- UniStrip® Rackstrip AF
- It has the following advantages / disadvantages:

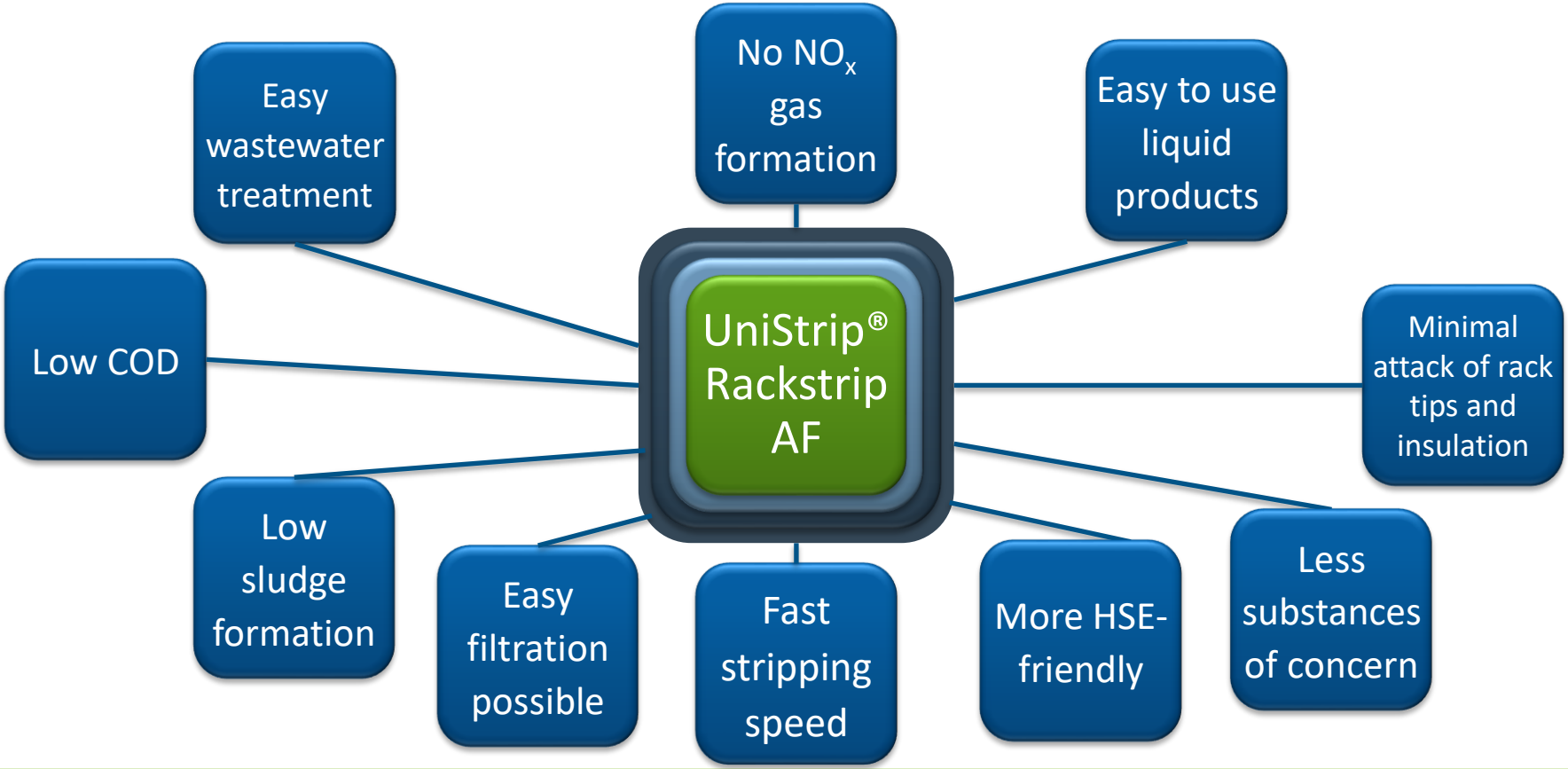
Advantages	Disadvantages
Ease of use • Simple analysis • 2 components and pH control	More complicated setup • Rectifier • Bus bars • Cathodes • Bath agitation
Suitable for stainless steel rack tips • Series 301, 304 & 316	Added electricity costs
No harsh chemicals used • No cyanide or fluoride • No highly concentrated nitric acid	Regular cathode maintenance
Fast and efficient • Perfect for automatic lines	
No NO_x gas generated	



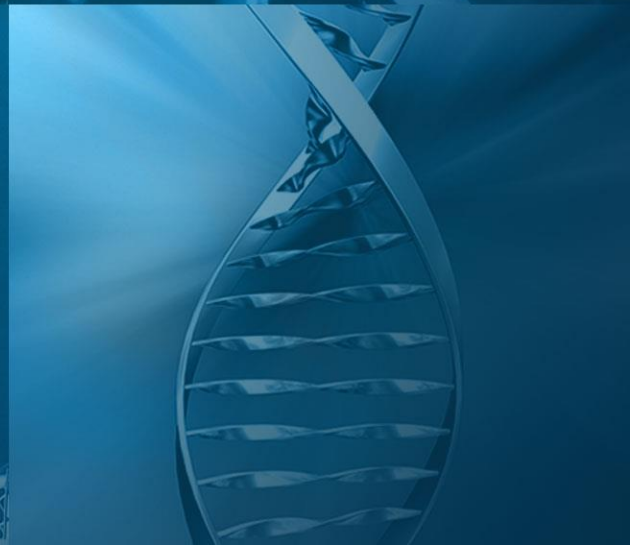
Process features



UniStrip® Rackstrip AF
In a nutshell



Setup



- The tank must be thoroughly clean before performing the make-up of UniStrip® Rackstrip AF
  - To avoid contamination
    - Especially of nitric acid, amines and ammonia

Component	Amount	Units
DI water	750	ml/l
UNISTRIP RACKSTRIP AF M	250	ml/l

- The tank must have good agitation
  - Air agitation is preferred
  - A mechanical stirrer or circulation pump can also be used, although not usually as effective

Setup
Working parameters

Parameter	Setpoint	Range	Units
UNISTRIP RACKSTRIP AF M	250	225 - 300	ml/l
UNISTRIP RACKSTRIP AF C	215	165 - 265	ml/l
Temperature	35	25 – 50	°C
pH	6.0	5.5 – 6.2	
Current density	50 - 70	20 - 100	A/dm^2
Cathode material	Stainless steel (series 304 or 316)		
Cathode/Anode ratio	50:1		
Voltage	7 - 10	<12	V
Agitation	Air agitation preferred		

Maintenance
Bath maintenance

To ensure the best operation of the UniStrip® Rackstrip AF process the following actions need to be carried out:

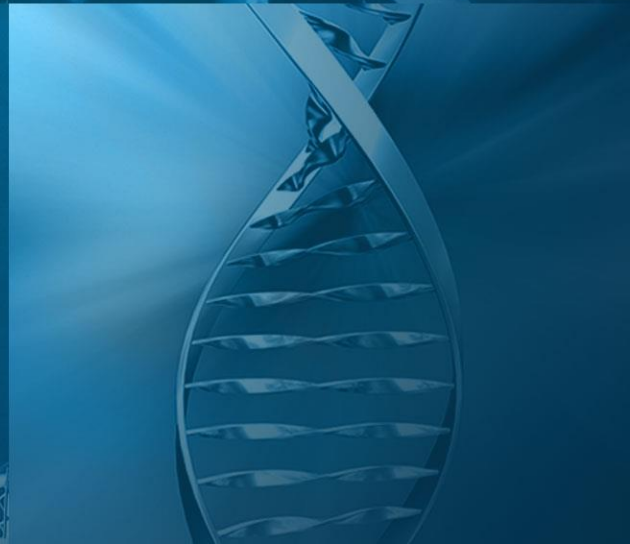
- Determination of the optimal voltage, Amps and exposure time
  - Set the parameters accordingly
- Good working solution agitation (air agitation preferred)
  - To ensure the bath is homogenous
  - To minimize rack tip attack
  - To improve rack tip stripping
- pH measurement and control
- Regularly check the stripping rate
- Regularly check and clean the cathodes
- Regularly analyse the bath
  - Replenish the bath with UNISTRIP RACKSTRIP AF C
- Removal of metal sludge generated

Maintenance
pH control

- The pH should be maintained within the range of 5.5 – 6.5. During normal operation, the pH increases slightly. If the pH strays outside the normal range this can affect the tip attack and metal sequestration.

pH < 5	pH range 5 - 7	pH > 7
Stripping rate increases but stainless-steel tips will be attacked	Ideal operating range	Stripping rate decreases Precipitation of metals possible Passivation of racks possible
Add NaOH		Add acetic acid

Benefits of UniStrip® Rackstrip AF



Process benchmarking
Comparison to nitric acid

- UniStrip® Rackstrip AF uses electricity to power the stripping of copper and nickel instead of the strong oxidizing chemistry of nitric acid.
  - The effect is better performance with less wastewater issues, equipment attack and less waste

Parameter	Nitric acid	AF	Difference	Units
Make-up	500	250	50% less	ml/l
Cu strip rate	12	12	-	µm/min
Ni strip rate	5	10	100% faster	µm/min
S/steel attack	<0.05	<0.05	-	µm/min
Optimal pH	<1	6.0	More neutral	
Ammonia	0	0	-	%
Nitrate	40	4	90% less	%
COD	-	57	Higher	g O_2/l
NO_x formation	YES	NO	100% less	

Benefits of UniStrip® Rackstrip AF

Benchmarking with ammonium nitrate based electrolytic stripper

UniStrip® Rackstrip AF has the same technical performance as ammonium nitrate based processes, but with added environmental benefits

Parameter	Amm. Nitrate	AF	Difference	Units
Make-up	250	250	-	ml/l
Cu strip rate	12	12	-	µm/min
Ni strip rate	11	10	-	µm/min
S/steel attack	<0.05	<0.05	-	µm/min
Optimal pH	6.5	6.0	Slightly lower	
Ammonia	100	0	100% less	%
Nitrate	100	87	13% less	%
COD	117	57	49% less	g O_2/l

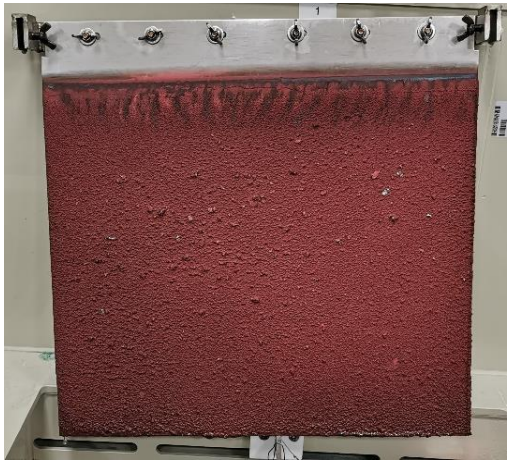
Benefits of UniStrip® Rackstrip AF

Copper plate-out

With AF when stripping racks from POP plating lines

Copper plates-out onto the cathodes

- This minimizes the amount of Cu in the AF bath
  - Ni is also removed from the bath by co-deposition
- Helps reduce the total amount of metals in the AF bath
  - Increases the lifetime of the bath
  - Reduces voluminous hydroxide/oxide sludge generation
- Reduces the amount of Ni salts collecting on the cathodes
  - Minimizes resistance increase of cathodes



Benefits of UniStrip® Rackstrip AF
Sludge

The UniStrip® Rackstrip AF process generates less sludge than ammonia based strippers

- Less frequent sludge removal required
  - Reduced effort and down time
  - Reduced industrial waste costs
  - Reduced bath loss
- UniStrip® Rackstrip AF has an ammonium nitrate-free formulation
- Enables the use of common filter technologies
  - Simple filter presses can be used with no potential risk of explosion
  - More efficient sludge processing
    - Reducing disposal costs

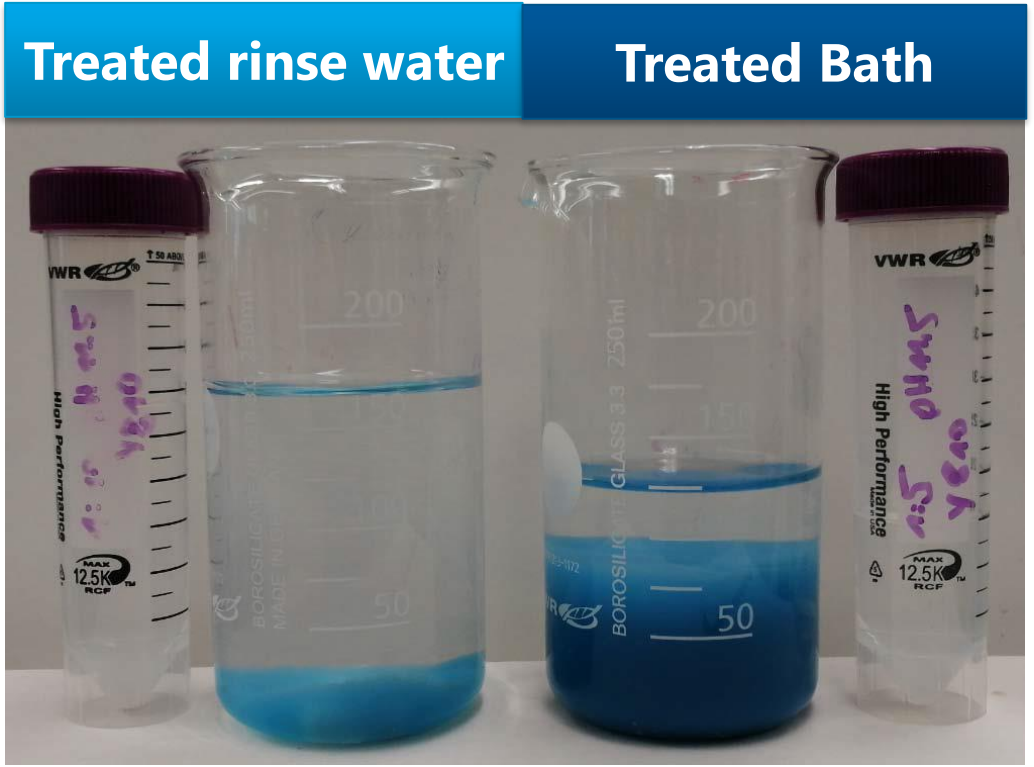
TechCenter tank after 8 months

Benefits of UniStrip® Rackstrip AF

Simple wastewater treatment

As UniStrip® Rackstrip AF doesn't contain ammonia or hard chelators it is easier to waste treat than ammonia containing electrolytic strippers.

- Wastewater treatment of UniStrip® Rackstrip AF bath concentrates:
  - 1:5 dilution
  - pH adjustment to 11.5 with NaOH
  - Addition of simple flocculation agents like $CaCl_2$ and/or $Ca(OH)_2$ speeds up flocculation
- No need for complex breaking chemicals
  - Like Sediganth C



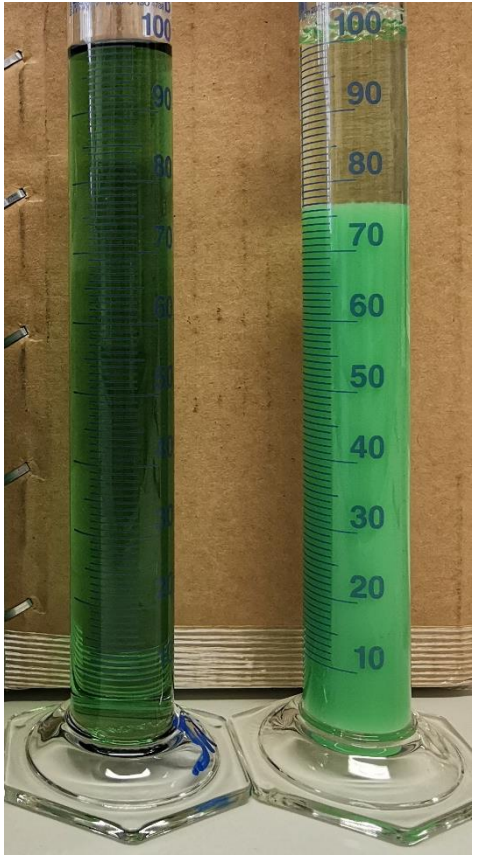
Benefits of UniStrip® Rackstrip AF

Metal contamination treatment

As UniStrip® Rackstrip AF is ammonia and amine-free the complexing of the metals is less strong

This enables simpler wastewater treatment, but also enables a simple and cost-effective way to treat the AF bath for metal contamination

- Pump the bath into a reaction vessel
- Increase the pH to ≈10.5 with a solution of NaOH
- Let the sludge settle into a sediment at the bottom of the vessel
- Pump out the upper (clear) portion of the treated bath into the AF tank
- Process the sedimentation through a filter press and recover the liquid to use in the AF tank
- Make an addition of UNISTRIP RACKSTRIP AF M and water to replace the missing volume
- Adjust the AF bath pH to 6 using Nitric Acid (or in combination with acetic acid)



Benefits of UniStrip® Rackstrip AF

Enabling use of filter press for sludge

Sludge from UniStrip® Rackstrip AF and metal contamination treatments can be filtered using standard filter presses

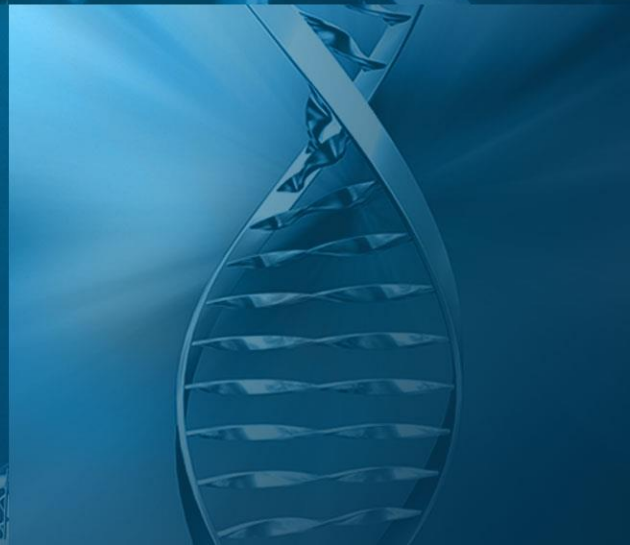
In this case:

- 2,850 liters of UniStrip® Rackstrip AF bath
- With a 20.9 g/l Ni content
- Generated 600 kg of sludge
  - Containing ≈60 kg Ni
- Only lost 9% of the bath
  - ≈250 liters

Treated bath

Filter cake

Annualized Savings



Annualized savings
Introduction

The UniStrip® Rackstrip AF process has several benefits over nitric acid for stripping racks and these can all result in cost savings as well as technical or environmental benefits.

We have used a typical POP rack stripping bath and process to compare the 2 processes

Parameter	Value	Units
Tank size	4,000	litres
Rack throughput	3	/hour
	15,840	/year
Metal stripped	128	g/rack

Annualized savings

Basic parameters used for both strippers

Nitric acid	Value	Units
Strip time $_{immersion}$	15	Minutes
Nitric acid content	50	% v/v
Make-ups	6	/year
CO_2 due to NO_x	8	kg/rack

UniStrip® Rackstrip AF	Value	Units
Strip time $_{electrolysis}$	11	Minutes
UniStrip AF M make-up	25	% v/v
Make-ups	0	/year
Metal treatment	1	/year
UniStrip AF C dosing	730	ml/kAh
Acetic acid dosing	300	ml/kAh
Current	600	A
Voltage	8	V
Bath temperature	35	°C
Heat up frequency	1	/week

Annualized savings
Chemical additions

The UniStrip® Rackstrip AF process requires significantly less chemistry to operate the process over a year.

- Mainly due to utilizing electricity as the main driver for metal stripping, not strong chemical attack
- Annual chemical additions are:

Nitric acid	**17,040**	**kg/year**

UniStrip Rackstrip AF	**2,479**	**kg/year**

- Meaning:
  - Less additions and handling
  - Less shipping
  - Less storage
  - Less packaging waste

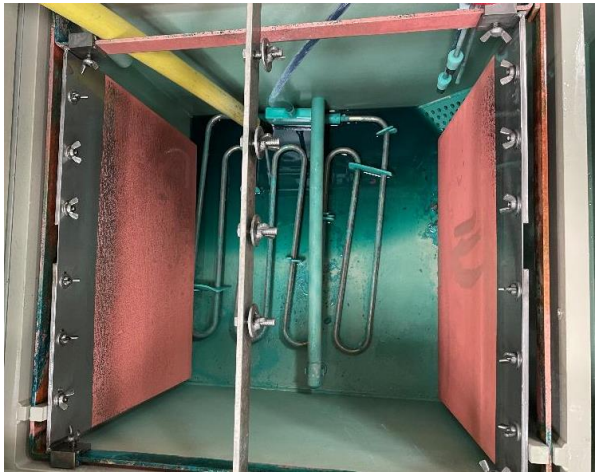
>14.5 tonnes less chemistry

>85% less chemistry

Annualized savings
Sludge generation – UniStrip® Rackstrip AF

The UniStrip® Rackstrip AF process plates-out most of the metals stripped creating a greatly reduced amount of voluminous hydroxide sludge

UniStrip® Rackstrip AF	Value	Units
Metal treatment	1	/year
Sludge / treatment	1	Tonne
Plate-out sludge	256	g/rack
Annual Plate-out sludge	4	Tonnes
Annual sludge	**5**	**Tonnes**



- Due to these more dense forms of precipitating the stripped metals the sludge generated is only **5 Tonnes a year**

Annualized savings
Sludge generation

The UniStrip® Rackstrip AF process generates significantly less sludge over the year compared to nitric acid stripping.

- Mainly due to plate-out of the metals on the cathodes and not voluminous hydroxides of metals during waste water treatment
- Annual sludge generation is:

Nitric acid	**24**	**Tonnes/year**

UniStrip Rackstrip AF	**5**	**Tonnes/year**

19 tonnes less sludge

79% less sludge

Savings against ammonium nitrate electrolytic processes

Savings
Sludge / tank maintenance

Tank maintenance is easier with UniStrip® Rackstrip AF

- Significantly less sludge generated
- Easy rinsing of tank walls with pressure washer
- Significant reduction in sludge removal frequency

Reduced in-tank sludge formation

Ammonium nitrate 150kg in 3 weeks

UniStrip® Rackstrip AF 25kg in 7 weeks

Savings

Basis for typical POP rack stripping operation savings calculations

To calculate the typical savings of using UniStrip® Rackstrip AF vs BR details from a customer that used both processes were compiled and compared

Parameter	Value
Tank size (l)	4,000
Stripping time (mins)	7
Current (A)	1,200
Cathode Area (dm^2)	550
Days / week	5
Hours / day	16
Average kAh/h	0.6

Savings
In-tank and Cathode sludge formation

- Sludge is generated from 3 main sources
  - In-tank during stripping and subsequent chemical reactions
  - Due to deposits on cathodes that are manually removed
  - For UniStrip® Rackstrip AF during Ni precipitation treatment
- These are common frequencies for sludge collection:

Maintenance	Amm. NO_3	AF
Sludge removal frequency	14 days	6 months
(bath solution loss)	4%	-
Ni precipitation	-	Annually
(bath solution loss)	-	10%
Cathode cleaning	14 days	14 days

Savings
Sludge reduction savings

- Less metal salts formed by the AF process reduces sludge significantly
  - Reducing the frequency of sludge removal and the associated maintenance time
  - Saving money on sludge disposal by more than half

	Annual sludge (kg)		
Sludge type	**Amm. NO_3**	**AF**	**Difference**
In-tank	2,400	171	**-93%**
Cathode	120	600	**+400%**
Ni treatment	-	406	**+**
TOTAL	**2,520**	**1,177**	**-53%**

≈50% less sludge generated by UniStrip® Rackstrip AF

Savings
Chemistry additions

UniStrip Rackstrip AF C was designed to be the only additive product required for day-to-day bath maintenance

UniStrip Rackstrip AF M is only used for make-ups and for large bath additions after metal contamination treatment

- UniStrip Rackstrip AF C was formulated to be as concentrated as possible
  - This helps to minimize dosing amounts required
- This is in addition to having lower chemical additions required due to sludge formation and subsequent replenishment
- All of this leads to reduced chemical additions
  - Less shipping of chemistry, saving costs and CO_2 footprint
  - Less warehouse space required

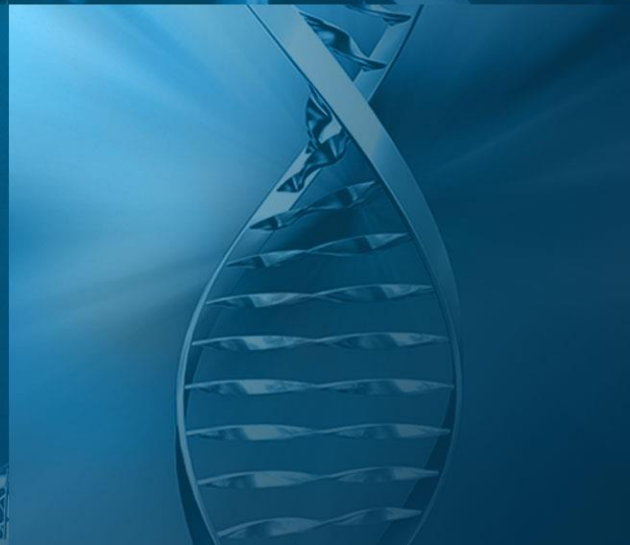
Savings
Chemistry consumption

- Reduced dosing requirements, high product concentrations and lower bath loss corrections significantly reduce the chemicals additions required
  - Saving money, shipping and storage

	Annual Chemistry (kg)				
Addition	**Add^{v} 1**	**Add^{v} 2**	**AF C**	**AF M**	**Difference**
Dosing	4,062	508	2,555	-	**-44%**
Corrections	812	-	-	143	**-82%**
TOTAL	**5,382**		**2,698**		**-50%**

≈50% less chemical consumption for UniStrip® Rackstrip AF

Summary

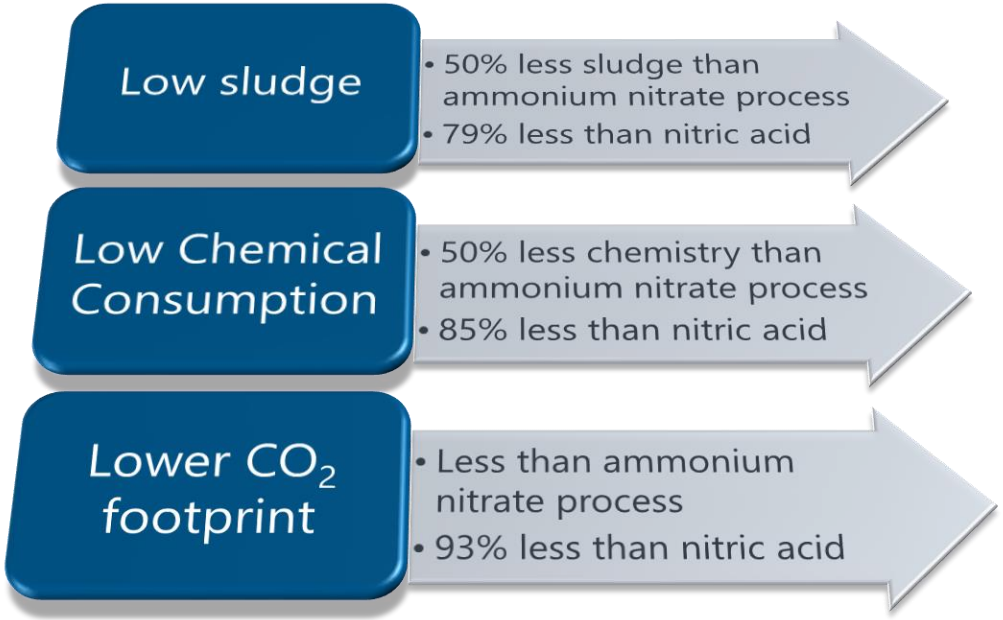


Summary

UniStrip® Rackstrip AF is a highly effective and fast electrolytic rack stripper that is a low environmental impact alternative to ammonium nitrate and nitric acid processes:

Also has the added benefits:

- Less hazardous chemistry
- Fewer chemical additions
- Low sludge generation
- Lower CO_2 footprint



Thank you!

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Janów Podlaski Castle, Poland