Lithium-Ion Battery Manufacture

The importance of specialist contamination removal and static control for optimum, high-quality battery manufacturing outputs.

Meech

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2019

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The Performance Race

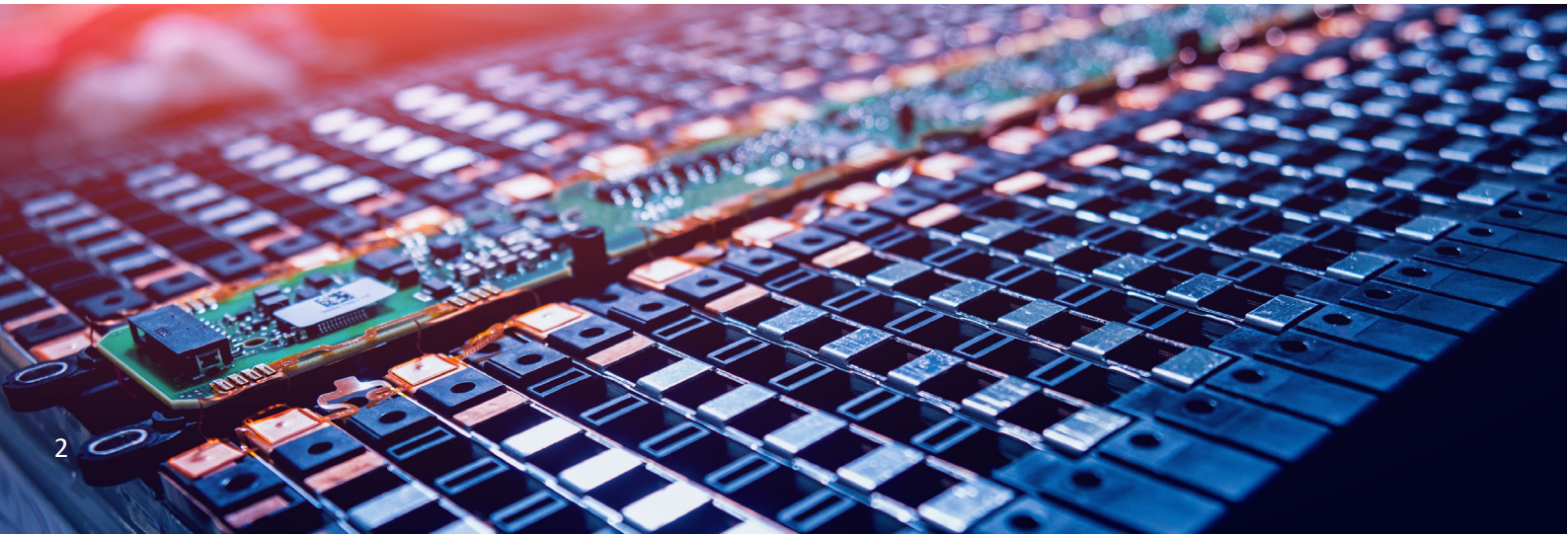
The global race for high-performance, low-cost lithium battery technology is underway, with major investments in technology and infrastructure plans.

Production giants in Asia continue to lead the race, but private equity, Government and major car brand backed investment schemes are now accelerating the advancements in battery and manufacturing process designs to deliver new local supplies in Europe and the US in particular.

By ***2030*** the global market size is expected to increase by some ***400%.***

Of that increased market size, Europe is targeting over ***30%*** of global production.

If you are designing a pilot or scaled up battery production line or have contamination or static charge related challenges, please get in touch with one of our Meech international industry experts.



Preparing for a New Industry

With the green agenda well advanced in many Western economies, the push for alternatives to traditional fossil fuel transportation is now strongly apparent. In some mature economies such as the UK, deadlines are being set to ban the sales of new petrol and diesel cars by 2030.

Making The Switch:

To make the switch to EV technology viable and attractive, there are many advancements needed. This includes infrastructure and battery capacity development for scalable, high quality supply.

Different manufacturing designs are being developed, requiring a range of specialist equipment manufacturers to produce or transform the battery components as they progress through the production cycle.

CyClean installation

Overcoming Static & Contamination

In the printing, packaging and converting industries, the issues of static and surface contamination are well understood, but in the rapidly evolving EV battery market these unforeseen issues can be greatly underestimated.

At Meech we are experienced in working with equipment manufacturers, battery designers and national research institutes to develop and test our solutions on the latest battery component technologies. We have moved and adapted quickly to collaborate with equipment and battery manufacturers in Asia and are also actively working with partners in Europe and US.

We offer specialist consultation in contamination and static charge removal from components used to assemble the highest performance battery technologies. We supply to pilot line test solutions and full scale lines and we have a high volume capacity to meet projected future demand.

Once installed, Meech technology provides a critical assurance to high volume EV battery manufacturing suppliers that their batteries are supplied with no in-built contamination or unwanted static charges. The focus is on delivering a solution which helps maximise battery production yields and overall equipment effectiveness; delivering a ***Zero Faults Forward Approach***.

The Costly Risks of Static & Contamination

Neglecting to consider static charges and surface contamination within the battery manufacturing process could lead to a number of issues:

Battery Contamination Can Lead to Soft Shortages:

Any contamination present on the battery substrate can have drastic effects on the performance of the battery. Even the slightest presence of contamination within the battery can cause soft shortages, which can lead to a drop in performance. This can significantly affect the distance range of the vehicle and therefore customer satisfaction.

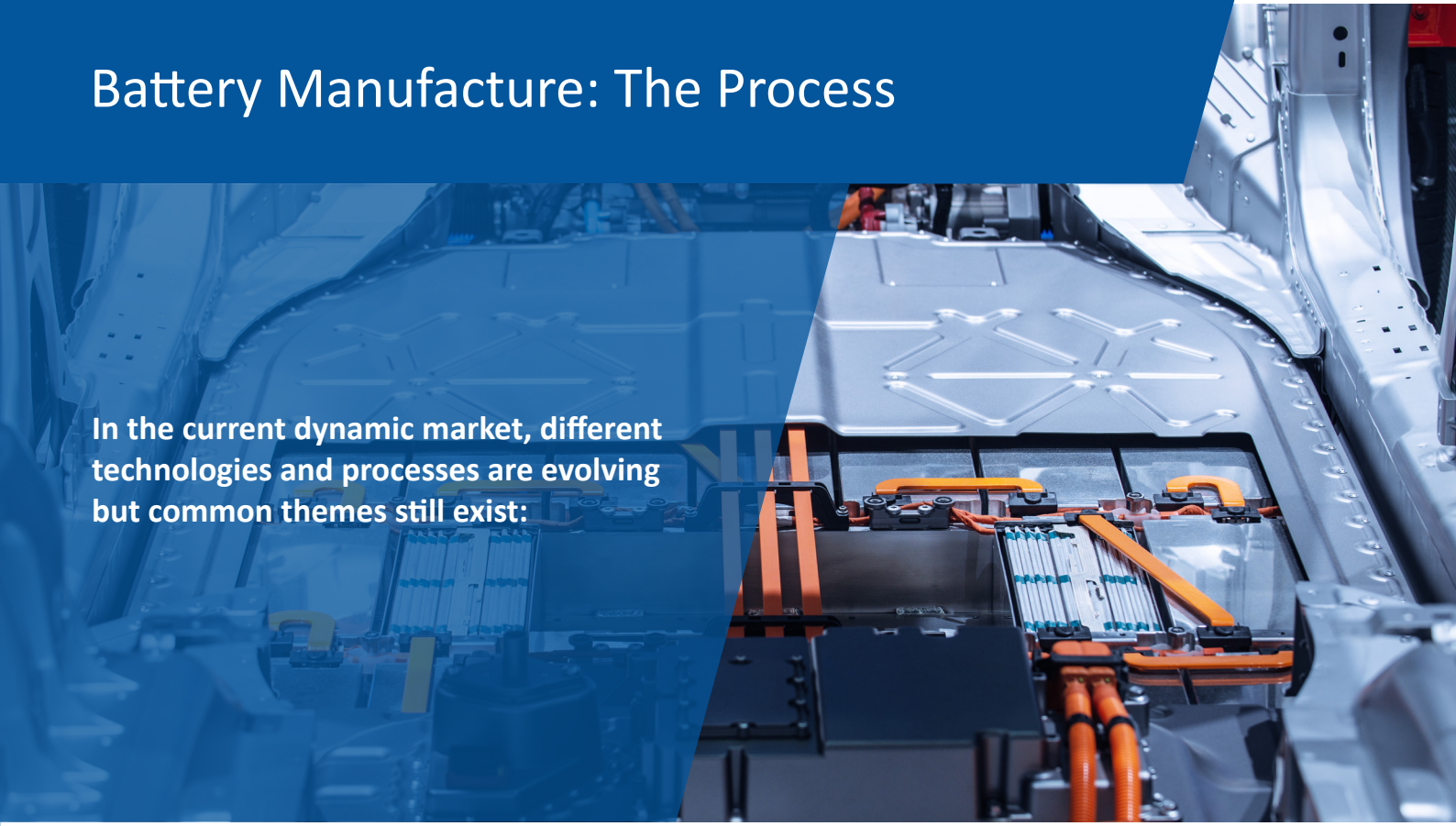
Poor Quality Leads to Rejections:

In the automotive industry, both OEM and end-customers expect the best, aligning with the high price-point of an EV purchase. Manufacturers cannot afford to release sub-standard parts to the production line and risk both product failure and customer satisfaction.

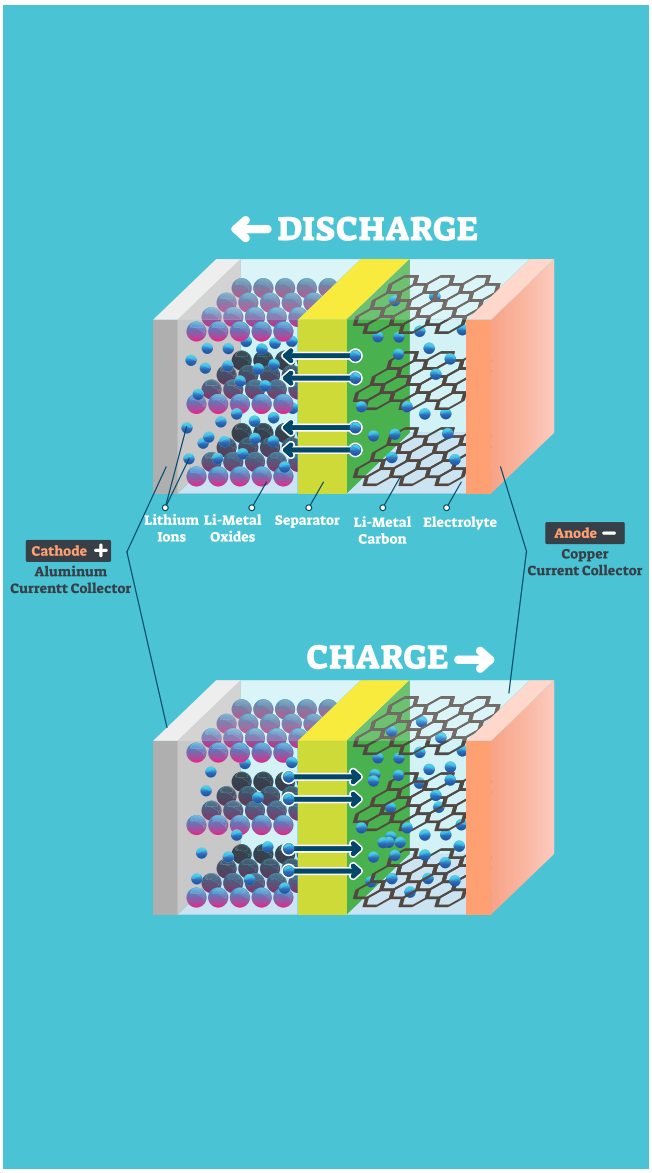
Battery Rejections Leads to Reduced Profits:

The energy used in producing a battery is around 50x the capacity of the battery itself. Battery manufacture is a costly business and any rejections can significantly affect the profit margins. As issues can rarely be detected before the end-of-line soak-testing, it is imperative that preventative action be taken throughout the manufacturing process.

Battery Manufacture: The Process



In the current dynamic market, different technologies and processes are evolving but common themes still exist:



Anode and Cathode:

An Anode is the negative or reducing electrode that releases electrons to the external circuit and oxidizes during an electrochemical reaction. The Cathode is the positive or oxidizing electrode that acquires electrons from the external circuit and is reduced during the electrochemical reaction.

Separator:

The separator is a porous membrane which is placed between electrodes of opposite polarity. It is permeable to ionic flow but crucially prevents electric contact of the electrodes.

To produce these (even in different designs), a number of common process stages are required. If there are any stages where even a trace amount of contamination becomes embedded in the layers, or uneven charges on the separator film lead to material burns or material flow issues, the down stream output could be severely affected leading to damage, rejects, loss of charge or critical failure.

Battery Manufacture: The Environment

With high quality and sensitive materials being used in the latest high-performance battery designs, the manufacturing environment is very important and must be carefully considered.

Temperature & Humidity:

The manufacturing environment has to be maintained at ultra low humidity and at a constant temperature.

Equipment has to be designed and tested to operate in this environment.

Lithium is extremely sensitive to even the smallest amounts of moisture in the air and temperature inconsistencies in production. The slightest exposure leads to reduced performance and impacts the product life of lithium-ion batteries.

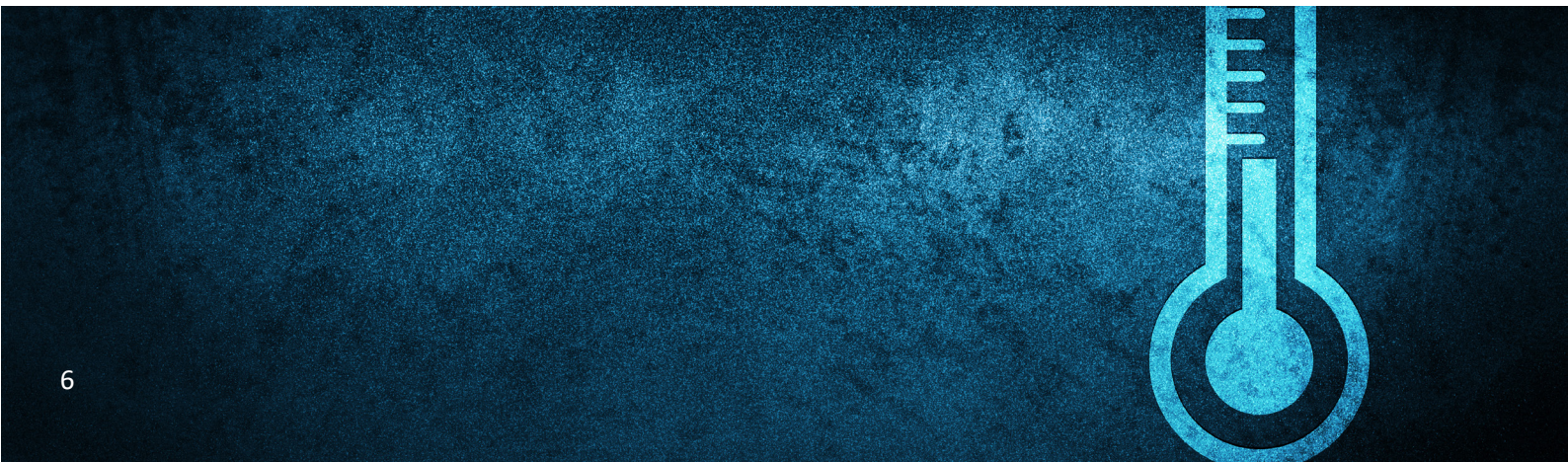
Room temperature should typically be maintained at the recommended levels of around 25°C (77°F), with a tolerance of +/(-) 2°C (36°F), along with low dew points in the range of <1%.

Air:

The air change rate in the production room should typically be 20 to 50 air changes per hour, while maintaining minimum fresh air introduction for positive room pressure and essential ventilation for operators.

Tried & Tested For Assurance:

We understand these crucial requirements and have tested our equipment in dry rooms and dry test chambers. Our product designs have been adapted to eliminate potential premature wear items such as belts and pulleys and replace them with direct drive motors. Drawing from our expertise and core competencies, Meech offers a tailored range of solutions to remove static charges and contamination in order to deliver a zero faults forward approach at each application stage.



Highly Controlled Operating Needs

We appreciate that the battery manufacturing industry must pay careful attention to certain criteria in order to achieve profitability and efficiency. This is where Meech static control and contamination removal equipment plays a vital supporting role:

Energy:

The energy ratio of producing a storage cell is approximately 50:1, meaning high yields are critical. Each step of the manufacturing process must be critically examined for any production quality risks.

Capacity:

It is essential that the final battery delivers its quoted KWh output. Any process risks which could prevent this need to be carefully managed. These include contamination and static control in various key stages of production.

Environmental Hazards:

There must be no fire hazards present within the manufacturing process which could cause any harm, including those related to static charges.

High Performance Levels:

Production quality must remain consistently high to achieve the best yield and quality results in order to meet production targets and exceed customer satisfaction.

Reduced Down-Time:

Installing the correct contamination removal and static control equipment helps to optimise the process flow and minimise downtime risks for high scale production.

Specialised Support:

In this dynamic and competitive industry, it is important to work with specialised suppliers in areas of strategic importance. This will help to achieve optimum output, gaining an advantage over competitors.

Meech Applications: Achieving Excellence

We have identified critical key stages in the production process where contamination and uncontrolled static charges can result in battery performance or production process failures:

1. Pre-Coating

Maintain the coating quality and layer thickness by removing surface contamination on the base material.

2. Coating Roller Cleaning

Prevent compromising the coating accuracy by removing contamination on the roller.

3. Pre-Calendering

Remove loose coating material and contamination from the drying process to maintain the coating tolerance.

4. Post Slitting

The slitting process creates small and large contamination particles which could lead to future electrical shortages and expensive rejects, therefore cleaning is very important. Toxic dust generation is also highly likely at this stage.

5. Post Cutting / Stamping / Laser Cutting of Electrodes

Stamping and cutting produces high risk contamination particles and removal at this stage is critical.

6. Cleaning & Static Control on the Separator Film

The separator film is very sensitive to static charges; attracting contamination and potentially leading to material damage. Static control and surface cleaning is recommended.

To combat these specific challenges, we have developed a

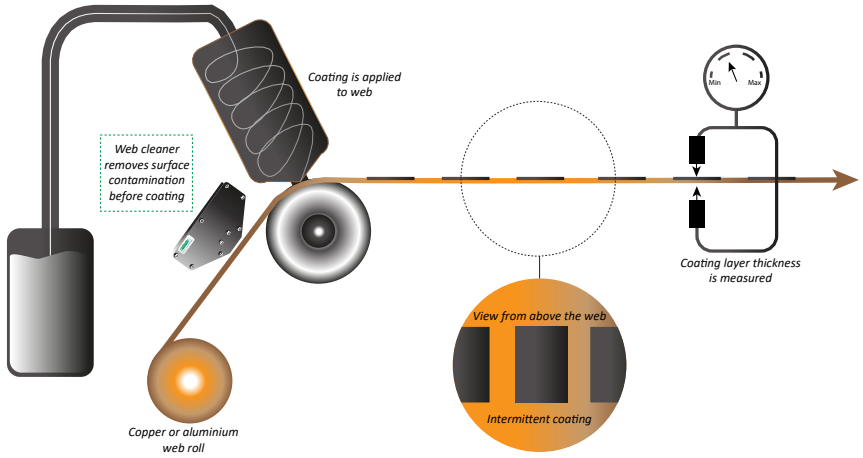
- Zero Faults Forward

approach for both battery pilot lines and scaled-up battery production processes.

Zero Faults Forward:

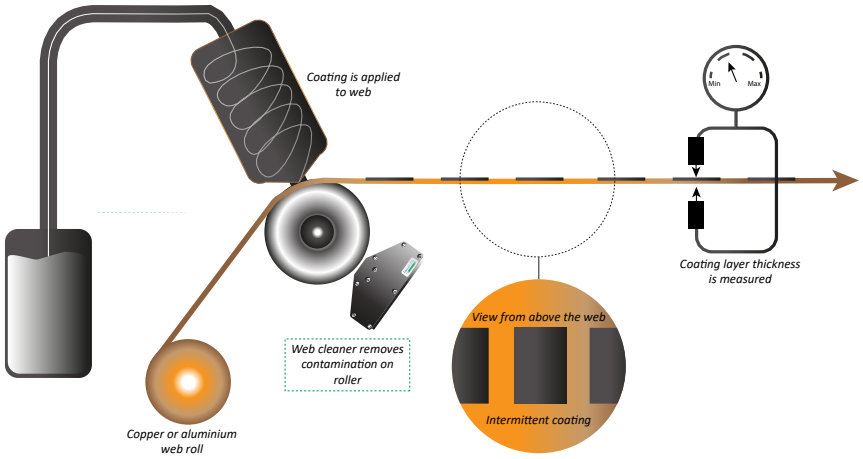
1. Pre-Coating:

The accuracy and quality of the coated web is essential to maintain a uniformed structure within the the EV battery. Any contamination within the coating affects the performance within the structural layers and is carried forward into the final construction. Prior to the coating stage of the copper/aluminium web, a cleaning process is needed to remove surface contamination. Depending on type of contamination and sensitivity of coating material and tension, Meech can recommend a range of web cleaning solutions without compromising on performance.



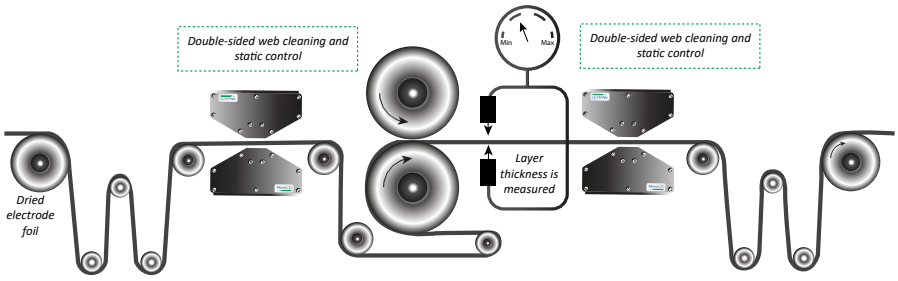
2. Coating Roller Cleaning:

Another contamination risk area in the coating process is the roller itself which very accurately positions the web to maintain accurate coating. We can offer either our non-contact CyClean-R which is ideal for use directly on a roller, or our contact brush RoClean. These will effectively clean the roller of any contamination to ensure critical coating consistency.



3. Pre-Calendering:

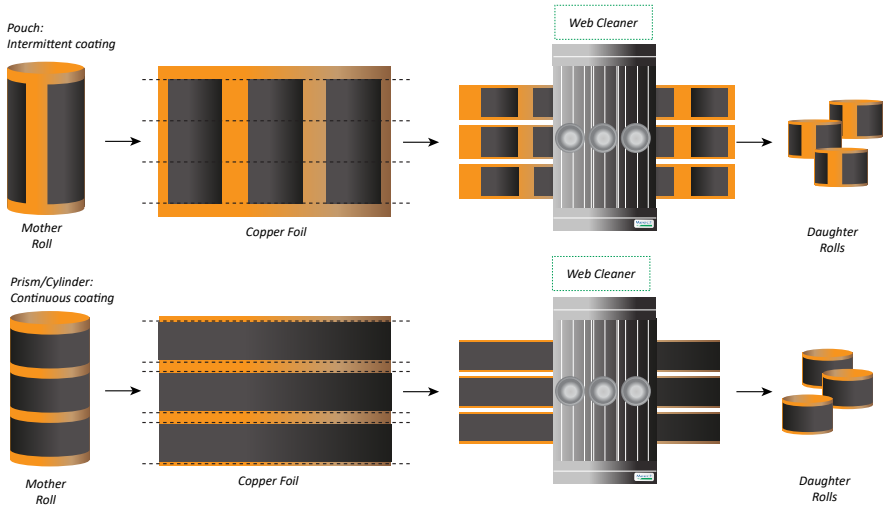
During this stage, the web and coating layers are compressed together to the exact required thickness which also activates the coating on the web itself. Cleaning the web prior to this critical stage prevents contamination being trapped between the layers which could result in the coating layer being out of tolerence.



** All drawings show a CyClean-R profile. This is for illustrative purposes only. The web cleaner and position most suitable for your process will depend on certain factors of your application.*

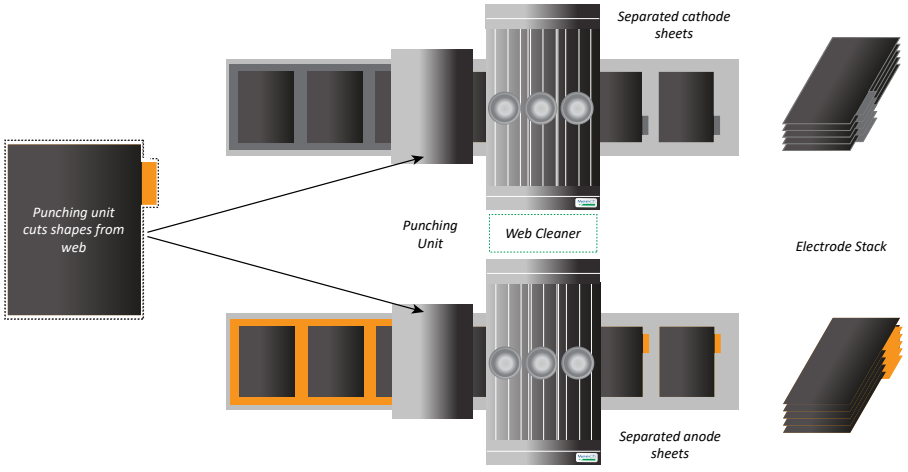
4. Post Slitting:

The slitting process creates a lot of debris made up of both the base and coating materials. This is a high contamination risk stage where cleaning is imperative to avoid the risk of future electrical shortages and expensive rejects. The use of a web cleaner at this stage ensures that the particles are removed from the surface and filtered away from the operating atmosphere to avoid re-contamination. Depending on the process and materials, contamination can be bonded or un-bonded, requiring careful analysis to choose the optimum contact or non-contact cleaning solution. Slitting dust is highly likely in this area and as the coating materials may have toxic content, special consideration is needed. Meech will also review this application in detail to determine the best method of contamination filtration and retention with our specified air handling unit (AHU).



5. Post Electrode Cutting:

Similar to the post-slitting stage, during electrode cutting, particles and debris contaminate the web. In order to minimise this, a web cleaner to clean the surface of the substrate will help to ensure there are no electrical shortage risks. The same considerations apply around toxic dust removal and entrapment in order to respect the cleanroom environment and operator safety.

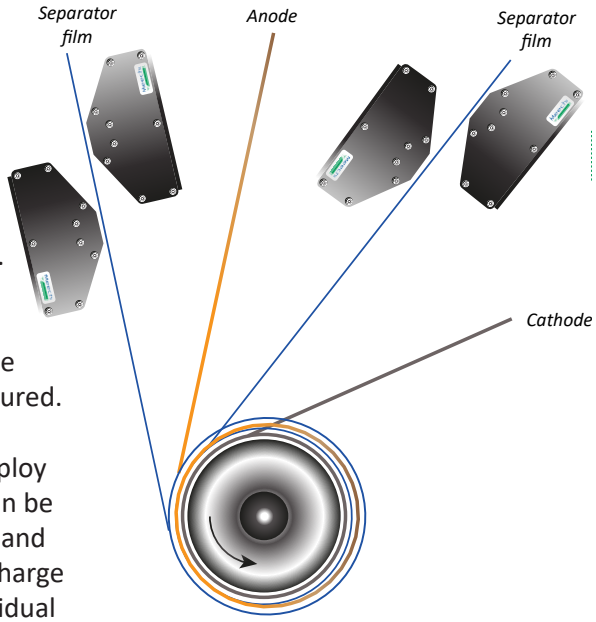


** All drawings show a CyClean-R profile. This is for illustrative purposes only. The web cleaner and position most suitable for your process will depend on certain factors of your application.*

6. Cleaning & Static Control on the Separator Film

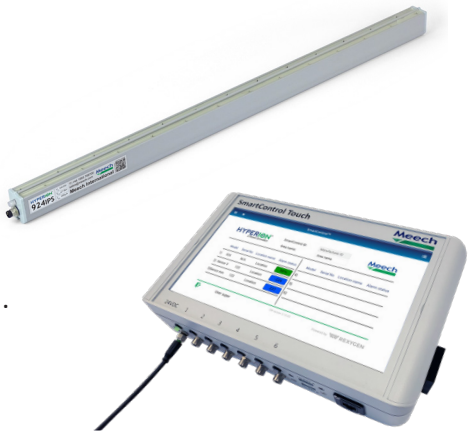
This porous membrane has to be placed between electrodes of opposite polarity and it is permeable to ionic flow, but crucially prevents electrical contact of the electrodes. The separator film is very sensitive to static charge created by friction, winding and unwinding throughout the transfer processes.

Static charges generated on insulative materials such as the separator film attract ambient particles adding to contamination risk problems. More crucially, charges generated can be high and if not carefully controlled can lead to small sparks resulting in small dendritic burns in the material. While not immediately obvious, these can lead to a loss in insulative properties and create shortages in the battery cell itself. In soak tests or in final vehicle use these would show up as a loss of capacity or even over-heating problems.

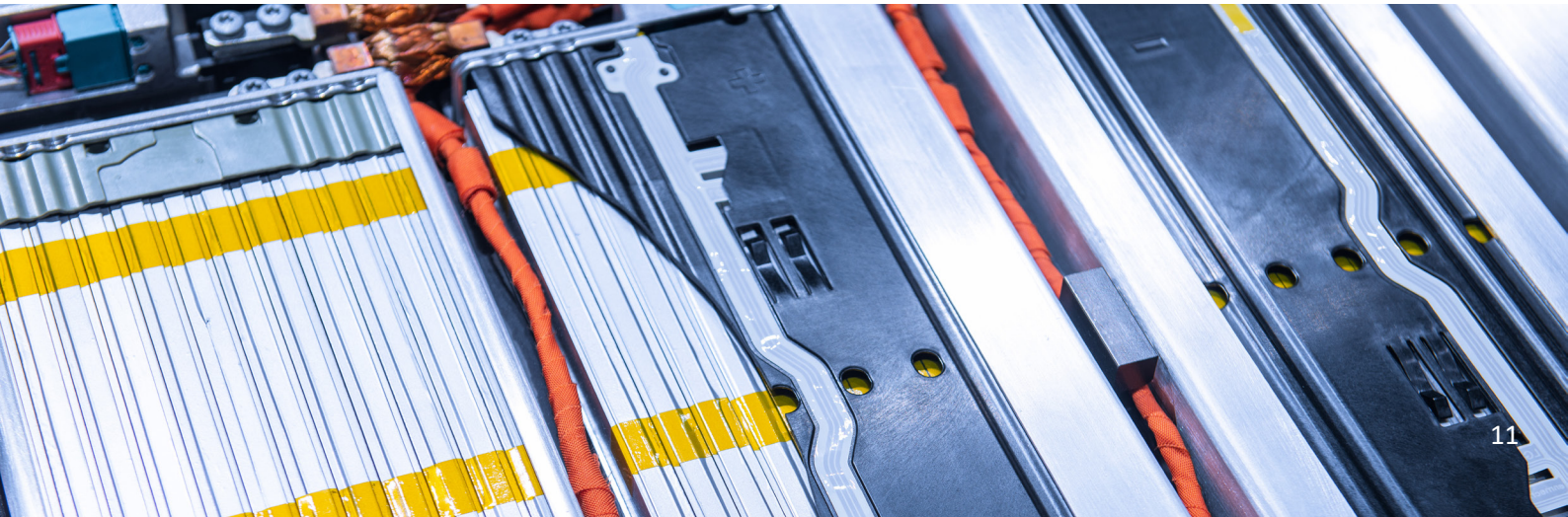


We suggest a number of solutions for the best results. Throughout the separator film transfer, ionisation bars should be located close to the film where charges are measured.

The Meech solution is to employ close range DC bars which can be tuned to match the material and application to ensure rapid charge decay times and minimal residual charges are achieved. The levels of charge will depend on a number of factors and if application speeds vary then ionisation bars can be paired with voltage sensors for continuous feedback control. Prior to winding, surface cleaning of the substrate is also recommended to prevent contamination becoming trapped within the battery film wind. This static charge management can also be monitored using a Meech SmartControl™ solution.



** This drawing shows a CyClean-R profile, Hyperion™ 924IPSv2 ionisation bar and SmartControl™. These are or illustrative purposes only. The web cleaner and ionisation bar position most suitable for your process will depend on certain factors of your application.*



Solutions For Battery Manufacture

We have identified the importance of eliminating contamination and removing static charges within the battery manufacturing and assembly processes and we have pinpointed the areas where such technology is applicable.

Meech offers a dedicated approach to surface contamination and static charge removal with a range of solutions, tailored to the battery manufacturing industry, which can be matched to the material, process and contamination type.

Specialised Service

At Meech, we understand the importance of getting to know your process. This allows us to consider the materials employed and identify likely surface contamination issues or static charge build up.

We also need to understand the environment, including the space requirements and limitations to ensure our equipment is suitably adapted in order to meet your needs.

Meech RoClean™ Contact Web Cleaner

Providing The Full Solution

When exploring surface cleaning options, contamination types will be studied to determine whether it is, for example dry, wet, bonded, semi-bonded, sensitive to friction or toxic in nature. This again, will allow us to recommend the most suitable Meech cleaning system that will deliver the best results.

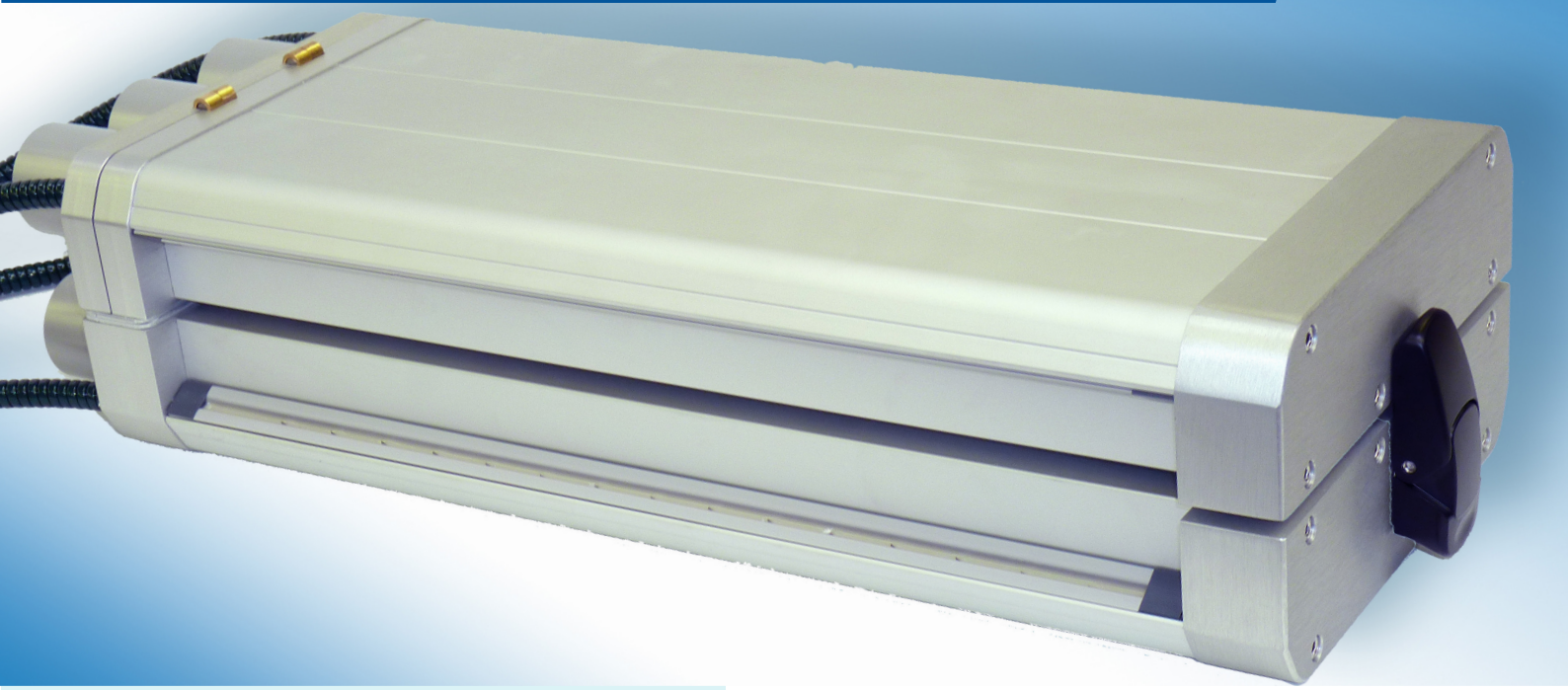
Our support consultants share our knowledge openly, however we are used to working under NDAs for maximum protection of our customers designs and special requirements.

Separate from the surface cleaning solutions on the different webs, Meech also specialises in ionisation bars for the separator film. Our specialists will evaluate the winding, unwinding and travel process of the film to identify where static build up needs to be managed.

Uniquely, Meech offers a single source of solutions for both contamination removal and static charge control in the EV battery market.

This makes us an ideal partner for your battery manufacture project.

Engineered Solutions for Battery Manufacture:
CyClean™ Non-Contact Web Cleaner

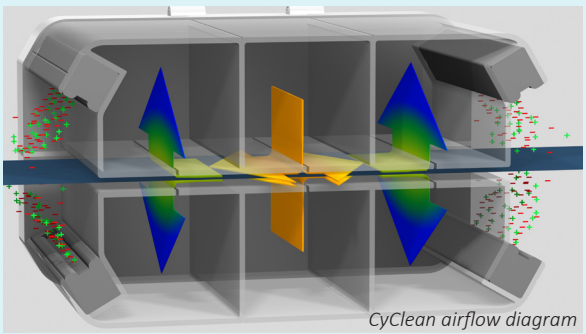


Product Overview:

The Meech CyClean has been designed in response to the demand for a compact, high performance, non-contact web cleaning system. Through the application of advanced computational fluid dynamics, Meech has optimised the cleaning efficiency of CyClean to remove and extract contamination to as low as 1 micron.

A CyClean system comprises three main components; the cleaning head, active static control and an Air Handling Unit (AHUv3) – with an optional upgrade to improve the capturing and retention of toxic battery coating dust.

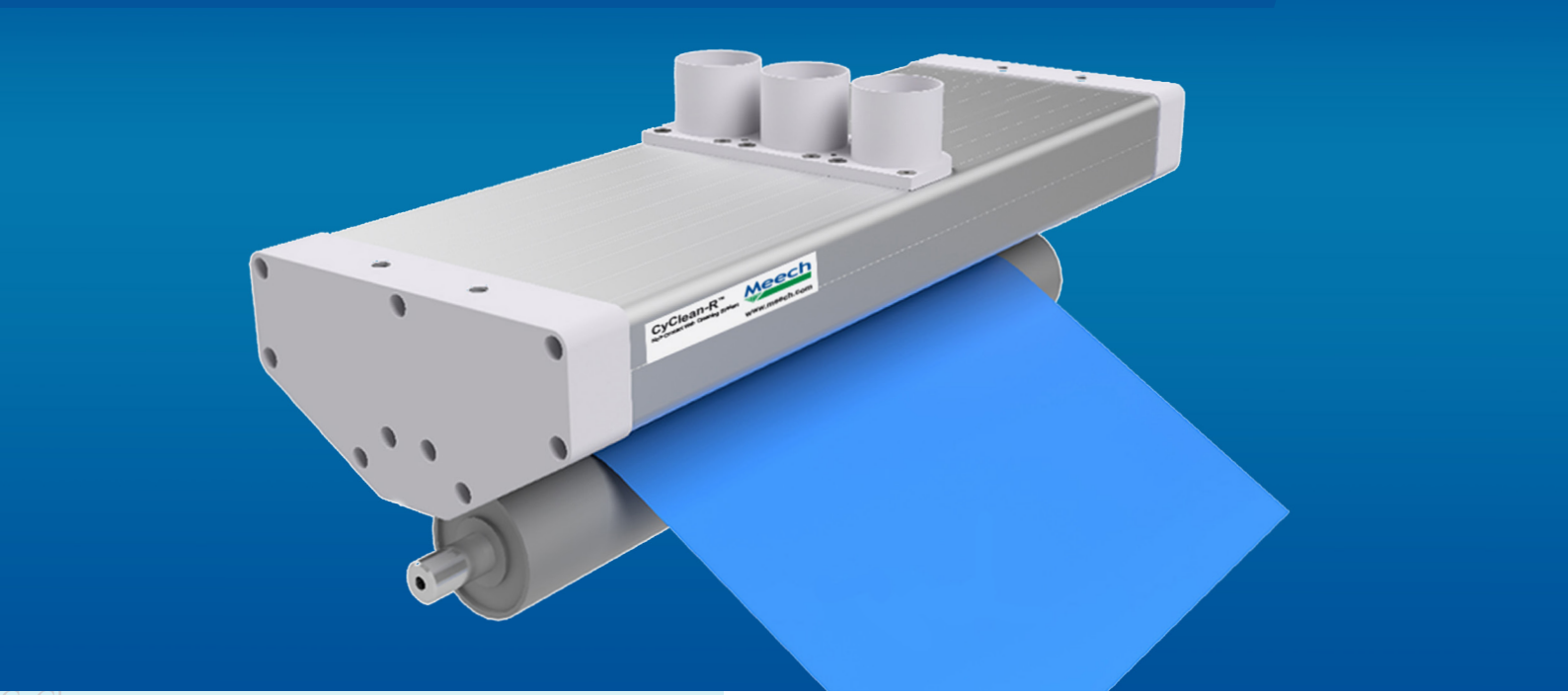
The system is available with a manual or a pneumatic opening option and can clean webs up to 3000mm. The double-sided non-contact cleaning head has been designed to provide excellent contamination removal, whilst minimising any risk of web recontamination.



CyClean airflow diagram

Feature	Benefit
Non-contact cleaning head	Eliminates risk of marking or damaging the battery substrate or coating surface. No interference with web tension or web tracking.
Compact design	Flexible positioning and easy installation.
Integrated static control (optional)	Neutralises static charges to optimise cleaning performance and help to prevent re-contamination of the substrate.
Unique 'fixed ports' system	The ducting connections to the cleaning head remain stationary, resulting in easier installation and reduced wear and tear.
Air balancing via compatible Meech AHU	Allows complete control of the bias between positive and vacuum air flows.
Automatic vacuum pressure control	Automatically monitors and refines the vacuum flow to ensure optimum cleaning performance is maintained.
High quality hinged 'clam shell' design	Allows the unit to open for easy threading of the battery web substrate.
No consumable items	Lower operating costs and minimised downtime.
Quiet operation	Can be installed in enclosed battery production areas with no health and safety issues for operators due to noise.
Optional toxic dust removal AHU upgrade	Range of enhanced AHU features which improve the entrapment of toxic and potentially hazardous battery coating dust and prevents recontamination when removing filter bags.

Engineered Solutions for Battery Manufacture:
CyClean-R™ Non-Contact Web Cleaner

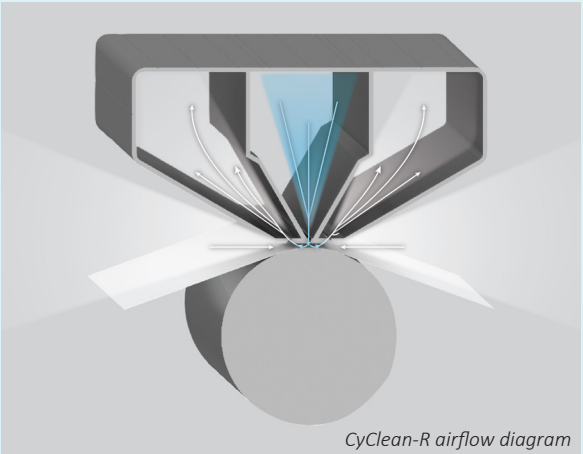


Product Overview:

Based on the popular cleaning technology of the Cyclean, CyClean-R is designed for high-performance contamination removal from low-tension web applications.

The CyClean-R is available in a fixed, manual or pneumatic option, and is offered as a single-sided cleaning system, with double-sided cleaning configurations available as an option. It utilises the proven CyClean cleaning philosophy of advanced computational fluid dynamics and bypasses the challenge of low-tension webs by cleaning the web directly on a roller.

CyClean-R is supplied with the latest Hyperion™ model 924IPSv2 DC type static control bars, to maximise the cleaning performance.



CyClean-R airflow diagram

Feature	Benefit
Cleans positioned over a guide roller	Avoids battery web tension challenge for some more sensitive substrate material designs. Enables effective cleaning without any detrimental impact on the material structure.
Unique, focussed air flow design	Air is directed onto the substrate surface at a focussed point, at extremely high velocity. This enhances the cleaning performance without stressing the material.
Integrated static control (optional)	Neutralises static charges to optimise cleaning performance and help prevent re-contamination of the substrate.
Robust structure and design	Options to clean very wide battery web widths – up to 9000mm widths.
Unique 'fixed ports' system	The ducting connections to the cleaning head remain stationary, resulting in easier installation and reduced wear and tear.
Air balancing via compatible Meech AHU	Allows complete control of the bias between positive and vacuum air flows.
Automatic vacuum pressure control	Automatically monitors and refines the vacuum flow to ensure optimum cleaning performance is maintained.
High quality, hinged 'clam shell' design	Allows unit to open for easy threading of battery web substrate.
Quiet operation	Can be installed in enclosed battery production areas with no H&S issues for operators due to noise.
Optional toxic dust removal AHU upgrade	Range of enhanced AHU features which improve the entrapment of toxic and potentially hazardous battery coating dust and prevents recontamination when removing the filter bags.

Engineered Solutions for Battery Manufacture:
RoClean™ Contact Brush Web Cleaner

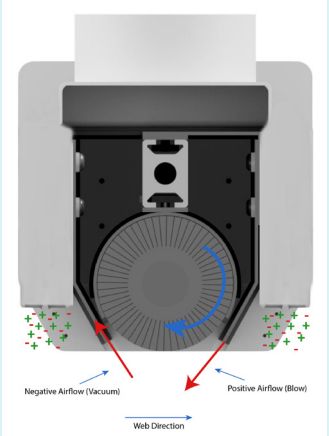
Product Overview:

Unlike other brush cleaning web cleaners on market, RoClean combines dynamic air flow and rotating brush technology. The battery web passes through an ionisation cloud on entrance and exit, while the brushes rotates in the opposite direction to the web for thorough disruption of any challenging contamination particles. Contaminants are drawn into the vacuum chamber. The positive air flow not only disrupts contamination on the web, it also ensures that any contamination left on the brush is also moved to vacuum chamber.

Height adjustable, long-life brush ensures the correct pressure can be delivered, relative to the substrate sensitivity and/or the type of contamination.

Meech AHUs ensure that the air balance is maintained in order to perfectly control the accuracy of the air pressure and vacuum.

A direct drive motor is used rather than a belt drive to minimise the risks of belt wear in a battery dry room environment which could potentially lead to contamination within the critical cleanroom application.



RoClean working diagram

Feature	Benefit
Specially adapted brush cleaning design for battery web substrate	Agitates more challenging bonded or semi-bonded contamination with minimal risk of damaging the battery web substrate.
Unique, focused air flow design	In addition to the brush and vacuum extraction, positive air is directed onto the substrate surface. This enhances the cleaning performance and helps to remove any latent contamination on the brush fibres.
Brush cleaning cycle setting and cleaning bar insert	Recommended cleaning routine dependent on contamination risk for additional intermittent brush cleaning to avoid any risk of recontamination of battery substrate.
Integrated static control (optional)	Neutralises static charges to optimise cleaning performance and help prevent re-contamination of the substrate.
Unique 'fixed ports' system	The ducting connections to the cleaning head remain stationary, resulting in easier installation and reduced wear and tear.
Air balancing via compatible Meech AHU	Allows complete control of bias between positive and vacuum air flows.
Automatic vacuum pressure control	Automatically monitors and refines vacuum flow to ensure optimum cleaning performance is maintained.
End opening and brush removal mechanism	Easy replacement of brushes.
Optional toxic dust removal AHU upgrade	Range of enhanced AHU features which improve entrapment of toxic and potentially hazardous battery coating dust and prevents recontamination when removing the filter bags.

Engineered Solutions for Battery Manufacture:
Air Handling Units

Product Overview:

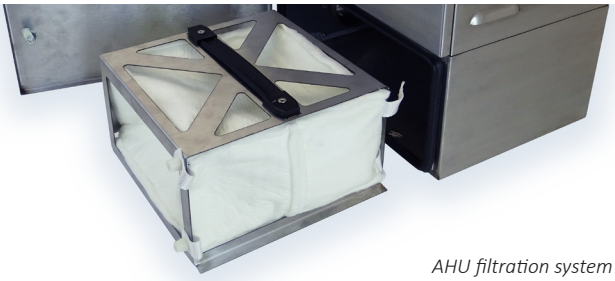
The Meech AHUv3 range is integral to the Cyclean™, Cyclean-R™ and RoClean™ specialised surface cleaners. The AHUv3 provides positive and vacuum pressure airflows and houses the system filters. It is of robust design and requires minimal maintenance.

With several key features, including full touch-screen control and visual display, digital target vacuum adjustment, automatic vacuum pressure control, remote or local interlock functions and password-protected screen lock, the AHUv3 is a leader in its field. These combined features offer the user advanced operational effectiveness, surpassing the competition.

The Meech AHUv3 is offered in a range of specifications, to fully suit your application and system.

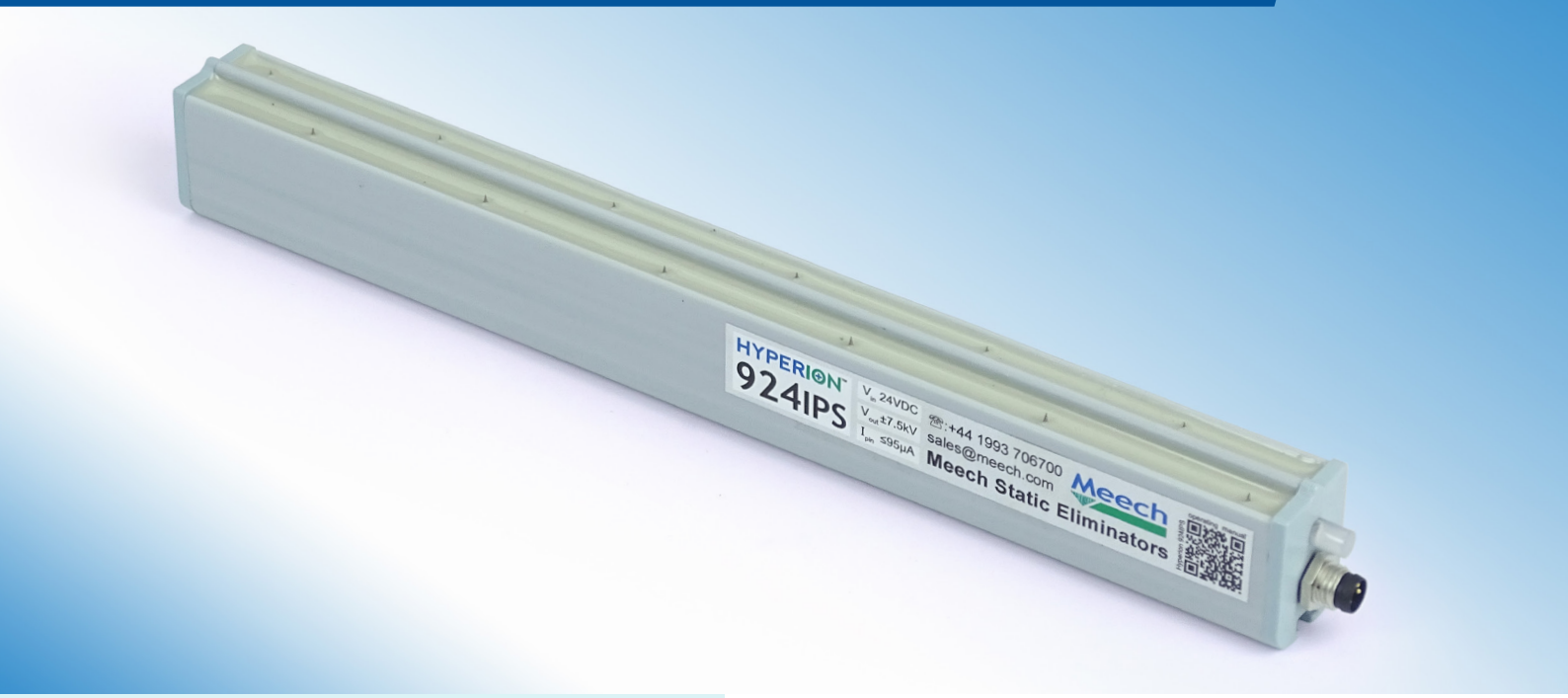
Meech has developed an additional upgrade option to deliver enhanced toxic dust entrapment and safe filter bag removal in order to protect the operator and battery manufacturing cleanroom environment (more information is available upon request).

Feature	Benefit
Fully touch screen controlled	Allows a clear graphical display of the system settings and status whilst also making initial setup very fast.
Interlocks and signals	An interlock for remote start/stop of the AHUv3 ensures the system is always running during production. Signals for filter condition and to show the system is running are also provided.
Automatic vacuum pressure control	Removes the requirement of ongoing operator adjustment. A consistent level of cleaning is achieved for the full life of the filter, resulting in a consistent end product.
Optional toxic dust removal AHU upgrade	Range of enhanced AHU features which improve entrapment of toxic and potentially hazardous battery coating dust and prevents recontamination when removing the filter bags.



AHU filtration system

Engineered Solutions for Battery Manufacture:
Hyperion™ 924IPSv2 Short Range Ionising bar



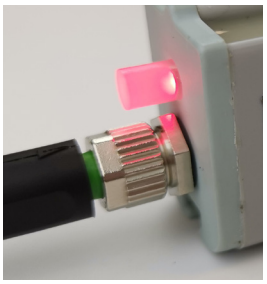
Product Overview:

Unlike simple AC technology, the Hyperion pulsed DC technology of the 924IPSv2 ionising bar allows the ionisation to be optimised to suit the separator film material and application environment.

This is achieved by adjusting the frequency, polarity balance and voltage to deliver rapid decay times and very low residual voltages on the separator film. It is also self-monitoring, with local LED indicator shows the operational status of the bar, which indicates when the bar requires cleaning. The inbuilt 7.5kV pulsed DC power supply allows for easy installation on separator converting and winding machines without the need for routing high voltage cables.

The 924IPSv2 model is compatible with Meech SmartControl™. This offers advanced static control programming, performance monitoring and data logging for a more complete management of your static control systems on the separator film.

Feature	Benefit
Pulsed DC ionising bar	Adjustable frequency, polarity balance and voltage delivers rapid decay times and very low residual voltages on the separator film.
Short-range operating distance (20-200mm)	Designed for compact mounting on the machine, close to the separator film for rapid decay times.
Sealed IP66 Construction	Protected from dust ingress for long life operation.
Clean Pin Alert	LED is constant green when the bar is operational and flashes red when the bar needs cleaning. Solid red illumination indicates a fault with high voltage output.
Output Signal	An output signal can be integrated within OEM HMI for instant awareness.
Compatible with Meech SmartControl™ Remote Control and Monitoring device	Provides advanced monitoring and data logging capability for maximum protection against static charge risks on the separator film.



LED indicators alert operators to the performance/ cleaning needs of the ionising bar.

Engineered Solutions for Battery Manufacture:
SmartControl™ Remote Monitoring & Control

Product Overview:

SmartControl Touch harnesses the power of Industry 4.0 within scaled up battery manufacturing applications by connecting multiple ionisation bars and sensors for advanced monitoring and control.

This system offers our customers improved productivity, quality and safety assurance:

- High speed production can be maintained thanks to remote settings control and closed loop feedback.
- Product rejects and corrective action costs are reduced by more careful static control.
- Real time monitoring, alarms and closed-loop feedback control greatly reduces the risk of static related spark discharges which can damage the separator film and lead to soft shortages.

Feature	Benefit
Central monitoring and control system	Connects multiple Meech Hyperion bars, distance sensors and residual charge sensors to a central control interface. Delivers advanced control on separator converting/winding line.
Enables rapid adjustments from one touch screen interface of all connected devices	Saves time and complexity. Devices can be adjusted and controlled from a central location for a full view of the line operation.
Early warning or critical state alarms if any bar performance or sensor reading falls outside of the set parameter	Prevents loss of production or quality with no reliance on the operator to check the LED status on each bar, or use additional meters to verify the system performance.
SmartControl settings can be accessed and adjusted via remote devices (PC, WiFi Tablet, WiFi phone) with password clearance.	Authorised management and operators can tailor and adapt settings in an instant for optimum performance of the line.
PLC industrial network integration ‘option’	Alarm outputs and information can be interfaced with the exisiting PLC.

Working With You

We Want to Work with You

At Meech, we value your project and want to help you achieve better efficiency and improved quality output. If you are designing a pilot or scaled up battery production line, or have existing contamination or static charge related challenges, please get in touch with one of our industry experts.

Global Presence

With offices covering 3 continents and a network of approved distributors across the world, we are well placed to provide exceptional local support. Our Meech EV battery manufacturing support team are available to meet you and discuss your application either face-to-face or via remote video-call.

Get in Contact

If you have a battery manufacturing project you would like to discuss with our team of EV industry experts, then please get in touch.

We look forward to working together to make your goals a reality.

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