APPLICATION NOTE

POWER AND CONTROL SOLUTIONS FOR SEPARATORS

Battery Recycling (UL)

Are you looking for power and control solutions to support continuous operation and safety for your battery recycling equipment?

ABB offers solutions to help improve equipment performance, energy consumption, and design time for separator applications.

What are separators?
Separators are devices used to differentiate shredded battery components based on their physical properties, such as density, size, shape, and magnetic susceptibility. During the lithium-ion battery recycling process, batteries are mechanically broken down into smaller fragments and separated based on the different elements that can be extracted from them. Various types of separators can be utilized to extract these materials. Depending on the properties of the materials and the desired output, this separation can be achieved using magnets, vibration, air, or liquid.

Why is power and control important for separator applications?
Power and control are essential during the separation process to ensure a high-quality output of materials and to help avoid the risk of hazards and fires. Lithium-ion batteries contain flammable components and reactive metals, making precise control over the motor loads and timing important to prevent overheating or mechanical stress that could lead to thermal runaway. Controlled operation also helps maintain consistent separation performance, especially when handling fine powders like black mass, which are sensitive to vibration and airflow. Fault detection through monitoring relays can identify abnormal conditions early, helping prevent equipment damage and ensure safe operation. Additionally, optional remote monitoring via communication can provide visibility into equipment status and performance, supporting proactive maintenance and improved reliability.

Main benefits

Continuous operation
Intelligent protection and control solutions, including circuit breakers, softstarters, and monitoring relays, safeguard equipment and help maintain uptime.

Energy-efficiency
Boost control panel energy efficiency with our AF coil technology, which reduces energy consumption and dissipates less heat, resulting in a lower temperature rise and increased panel density.

Safety & protection
Enhance safety and thermal management, reduce the risk of hazards and fires, and prevent downtime using circuit breakers, surge protective devices, monitoring relays, or safety components.

Compact & easy to install
Compact designs and user-friendly installation features help reduce setup time and save valuable space in control panels.

Battery recycling process

The lithium-ion battery recycling process involves several stages from pretreatment to refining, resulting in the recovery of precious metals.

Processing technologies involve discharging and disassembling the lithium-ion batteries. Disassembly includes shredding, crushing, and granulating technologies, which are used to reduce the batteries to smaller fragments.

Separation technologies are used to isolate the black mass from other structural components such as copper, aluminum, and plastic. Magnetic, flotation, vibration, and air separation are examples of methods used in battery recycling.

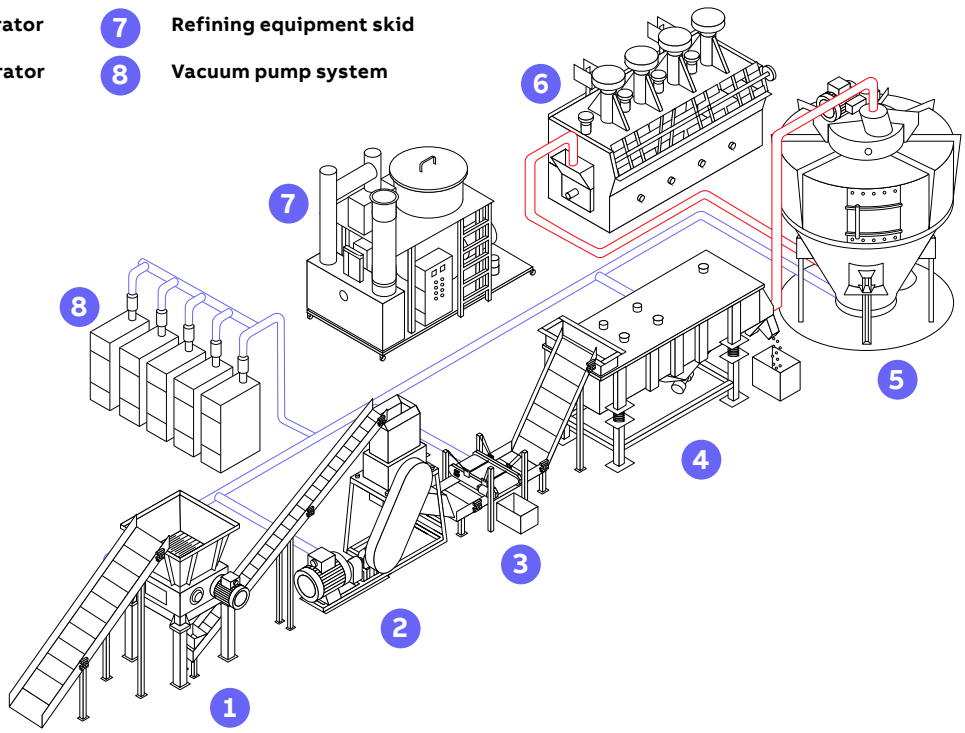
Material recovery technologies or refining encompass hydrometallurgical processes, which extract valuable metals from spent batteries using liquid solutions, and pyrometallurgical processes, which utilize high-temperature furnaces for the same purpose.

Control and monitoring systems are essential to ensuring operational efficiency. Automating processes and monitoring them enhances efficiency, reduces human error, and improves the quality of the recycled materials. Additionally, tracking material flow and ensuring safety are crucial for managing inventory levels and optimizing recovery operations safely.

The thorough recycling of lithium-ion batteries not only conserves valuable resources but also reduces the environmental risks associated with improper disposal. By integrating advanced processing, separation, and recovery technologies with robust control systems, this approach allows for the efficient retrieval of valuable materials while minimizing environmental impact.

The figure below shows the typical components in a lithium-ion battery recycling system.

1. **Shredder**
2. **Crusher or granulator**
3. **Magnetic separator**
4. **Vibration separator**
5. **Air classifier**
6. **Flotation separator**
7. **Refining equipment skid**
8. **Vacuum pump system**



Pretreatment

Pretreatment
Pretreatment includes both processing and separation technologies. It begins by discharging the batteries before going through their disassembly process to extract the black mass. Size reduction is performed to break down the material, access the internal components, and facilitate successful separation. These technologies are essential for recovering high-purity black mass, which contains lithium, cobalt, nickel, and manganese.

1. **Discharge**
This step is necessary to avoid thermal runaway or fire hazards and is typically accomplished using brine pools and electronic load discharge systems.

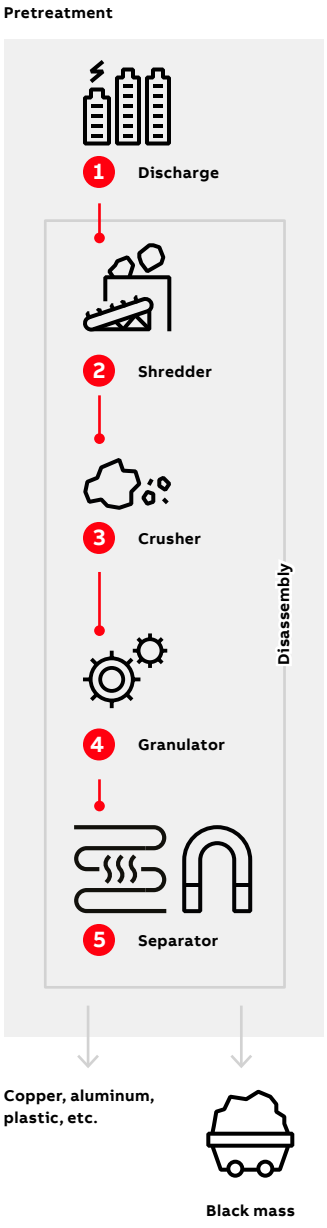
2. **Shredder**
This equipment uses rotating knives to disassemble the battery packs into smaller components, enabling further processing.

3. **Crusher**
This equipment reduces the components to a uniform size using high-strength blades and screens for controlled output size.

4. **Granulator**
This equipment further reduces the size of the crushed material to a finer, more uniform granularity, thereby increasing the efficiency of the separation and purification processes.

5. **Separator**
This equipment isolates recyclable components from non-reusable components using various methods, including magnetic, vibration, air, or flotation.

Effective pretreatment helps ensure safety, enhances material recovery, and supports the sustainability of lithium-ion battery recycling. Innovations in discharge systems, disassembly equipment, and advanced separation technologies are driving improvements in efficiency and environmental performance.

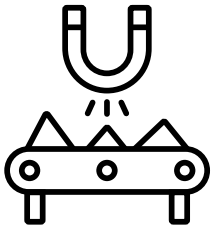


Separator equipment

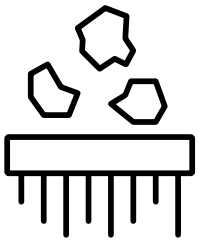
Separators are used to sort and isolate materials after they have passed through shredders, crushers, and granulators. This step is designed to further separate valuable metal and non-metal materials. The equipment is capable of isolating materials such as plastics, metals, and electrolytes, leaving behind the black mass for the refining processes.

Separator equipment works by isolating materials based on physical properties such as size, weight, magnetic susceptibility, or chemistry. Further dividing different materials through this process allows for better gathering and recovery of the specific material being processed. Using multiple types of separators in combination improves the efficiency and purity of recovered materials, making downstream processes more effective.

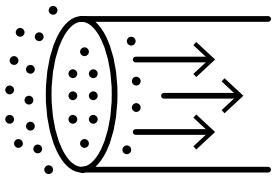
There are several types of separators commonly used in lithium-ion battery recycling including:
- Magnetic (e.g., drum magnetic separator, overhead magnet)
- Vibration (e.g., vibrating screen classifier, shaking table)
- Air classifier (e.g., cyclone separator, jet air classifier)
- Flotation (e.g., froth flotation, column flotation)



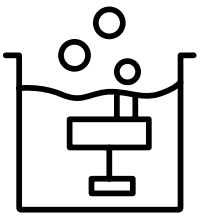
Magnetic



Vibration

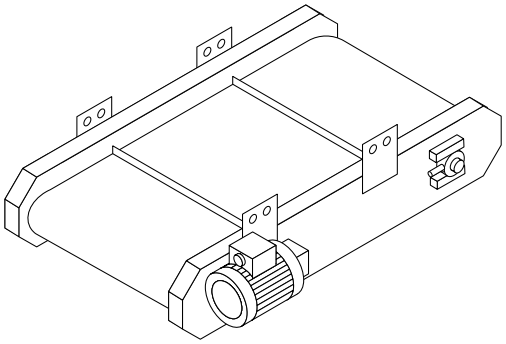


Air classifier



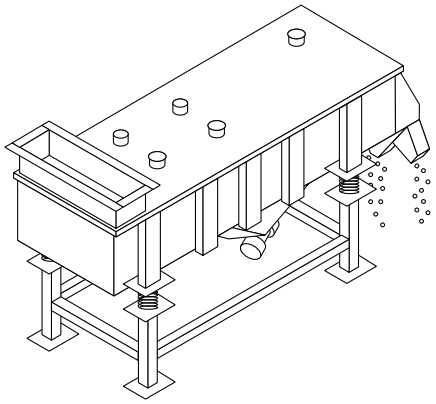
Flotation

Common types of separators



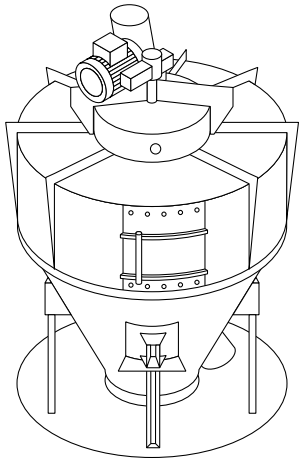
Magnetic

Magnetic separators are used to extract ferromagnetic materials such as steel casings and iron-containing components from non-magnetic materials. They are particularly useful in the early stages of battery recycling to remove structural elements and reduce contamination in the black mass.



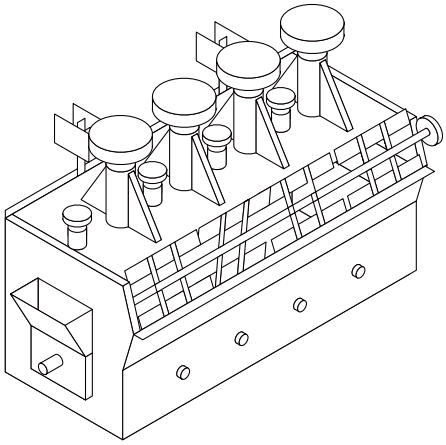
Vibration

Vibratory separators use oscillating screens or tables to sort particles based on size and density. This method is commonly used after crushing or grinding to classify materials into coarse and fine pieces. They help isolate current collector foils (such as Al and Cu) from finer black mass particles, thereby improving downstream separation efficiency.



Air classifier

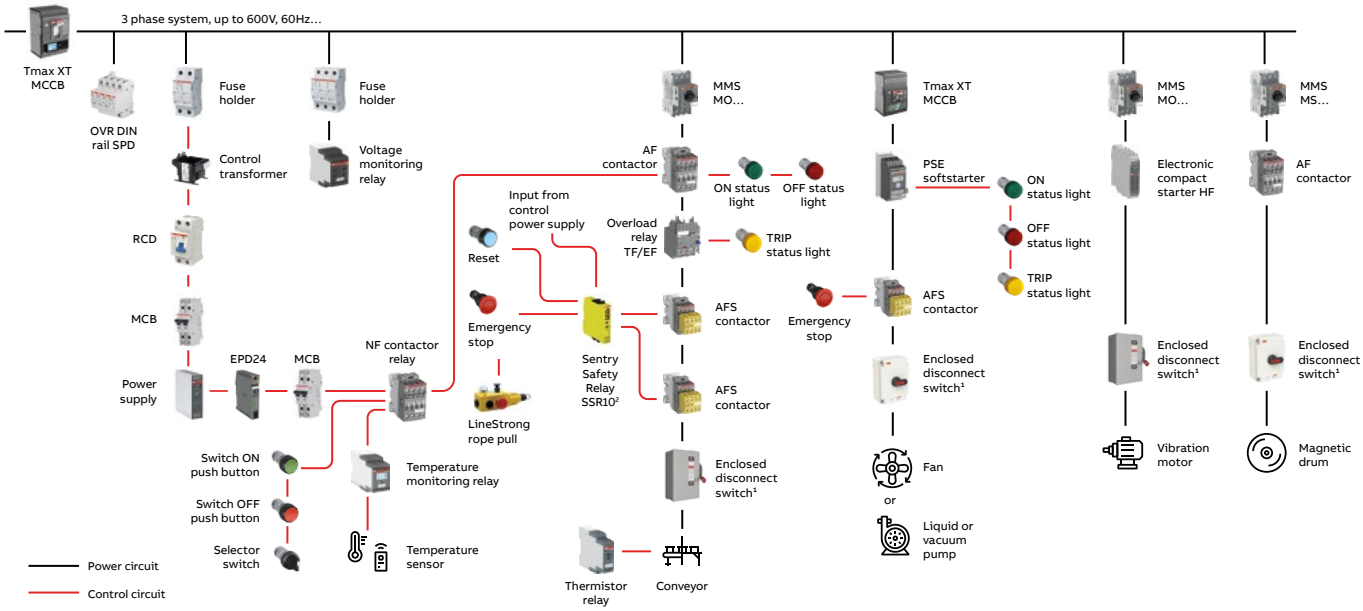
Air classifiers use controlled airflow to separate particles by weight and aerodynamic properties. Lighter particles, such as plastics and carbon black, are carried upward, while heavier metal particles fall due to gravity. This technique is ideal for separating fine powders and is often used to refine black mass before metallurgical processing.



Flotation

Flotation separates materials based on how they interact with liquids. In battery recycling, it's often used to separate graphite from other components like metal oxides. In battery recycling, graphite tends to float while heavier metal particles sink, making it easier to collect and process each type. A common method is froth flotation, where air bubbles help lift the graphite to the surface for easy collection.

Power and control solutions for various separator types



Note: This configuration is for a generic system and is not representative of all existing manufacturers.
¹ The type of enclosed disconnect switch used depends on the application and environment.
² The safety circuit can be used to stop multiple motors in a machine. For advanced safety protection, a Pluto PLC can be used instead of the Sentry Safety Relays.

The table below provides an overview of the options for product combinations offered for separator equipment.

Product combination	Key differentiator
MMS + AF contactor + TF/EF overload relay	For standard offerings
MCCB + PSE softstarter	For smooth start and stop
MMS + electronic compact starter	For additional motor control functionality, efficiency, and space savings
MMS + AF contactor	For efficiency and space savings

Main components and functions

Primary Functional Requirements

- Circuit breakers, surge protective devices, residual current devices, and fuses to prevent equipment damage or fires
- Machine safety, including safety relays, emergency stops, signaling devices, and door sensors for users and service personnel

Secondary Optional Requirements

- Measuring and monitoring relays to detect fluctuations that could lead to equipment damage or impact performance (e.g. voltage, current, or temperature monitoring)
- Electronic protection device for overload protection
- Digital capabilities can be added to offer remote and condition monitoring and allow for troubleshooting and maintenance
- Communication can be used with our circuit breakers, softstarters, and smart temperature monitoring relay
- Bus bar systems can be used for quick installation and component replacement using SMISSLINE TP

Power and control components and functionalities

Application	electrical components	functional description
Power circuit	Main circuit breaker	Overload and short circuit protection
Power circuit	Surge protective device	Prevent damage from an electrical surge
Power circuit	Fuse holder	Short circuit protection
Motor load	Manual motor starter (MMS) Magnetic only (MO)	Isolation and short circuit protection
Motor load	AF contactor	Remote isolation and control
Motor load	TF/EF overload relay	Thermal or electronic overload protection
Motor load	Circuit breaker	Overload and short circuit protection
Motor load	Softstarter	Ramp up speed to control startup torque
Motor load	Electronic compact starter	Hybrid starter with direct-on-line and reverse starting
Motor load	Manual motor starter (MMS)	Isolation, overload, and short circuit protection
Motor load	Enclosed disconnect switch	Equipment isolation
Control circuit	Temperature monitoring relay	Monitor the temperature of the motors
Control circuit	Voltage monitoring relay	Monitor for over/under voltage
Control circuit	Thermistor relay	Monitor motor temperature
Control circuit	Residual current device	Ground fault equipment protection
Control circuit	Miniature circuit breaker	Overload and short circuit protection
Control circuit	Control transformer	Reduces voltages from higher to lower
Control circuit	Power supply	Converts an electric input to a different current and voltage output
Control circuit	Electronic protection device (EPD)	Protects and monitors 24 V DC circuits against overloads
Control circuit	Interface relay/NF contactor relay	Isolates, connects, and ensures compatibility between components
Control circuit	Pilot devices	Provide visual status and machine control
Safety circuit	Safety contactor	Redundant contactor stops dangerous machine function
Safety circuit	Safety products	Prevents people from machine hazards (i.e., machine status, emergency stop)

Product offering

Tmax XT MCCBs

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AF contactors

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Manual motor starters

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Overload relays

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Softstarters

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Electronic compact starters

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Miniature circuit breakers

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Surge protective devices

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Residual current devices

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Electronic protection devices

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Control transformers

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Fuse holders

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Measuring and monitoring relays

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Power supplies

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Interface relays and optocouplers

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Assorted pilot devices

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Safety switches

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Enclosed rotary switches

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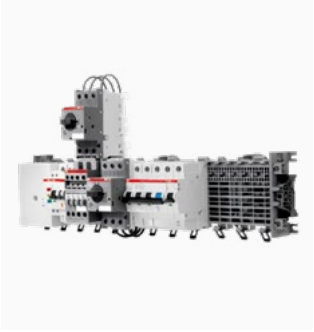
SMISSLINE TP power bar systems



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Jokab Safety Products

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U.S HQ Office:
ABB
305 Gregson Drive
Cary, NC 27511
United States
Phone: (800) 435-7365

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