

Designing for Circularity:

How fastening choices can support
assembly, service, and material recovery.



Introduction

As circularity becomes a greater focus in automotive development, engineers must consider how design decisions support dismantling, material recovery, and lifecycle goals. Fastening strategies play a key role, making it essential to define the intended recovery pathway early and validate performance throughout the product lifecycle.

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A vehicle connection is usually judged at two points: installation and use. Circular design adds a third: release. Years after assembly, a clip, bolt, insert or bonded joint may determine whether a component can be serviced, removed intact or separated into a usable material stream.

The practical gap is visible in automotive plastics. European Commission research found that only 19 percent of plastic waste from end-of-life vehicles is sent for recycling. Mixed materials, contamination, limited sorting capability and weak recovery economics all contribute to that result.¹

Design choices cannot solve every downstream constraint, but they establish the conditions that dismantlers and recyclers will encounter. Material selection, component access and joining methods can make recovery simpler or add time, damage and contamination to the process.

Circularity is becoming a vehicle-design requirement

Circularity can follow several paths. Repair keeps the vehicle or component in service. Reuse preserves the component with limited rework. Remanufacturing restores it to a defined condition. Material recycling recovers polymers, metals or other feedstock for another production cycle.

Each path creates a different requirement for the attachment. A serviceable fastener may need to accommodate repeated removal and reinstallation. A component harvested for reuse may only need to be removed once, but the component and its mounting surface must remain undamaged. A fastener that stays with a polymer component may need material compatibility for recycling rather than reusability.

One direction, different regional routes

Most automotive markets are trying to recover more material value and improve access to priority components. They are using different policy tools to get there. Europe ties requirements to the approval of new vehicle types. China focuses heavily on battery identification and safe dismantling. Japan uses its established recycling system to recover more material before shredding. Korea addresses recyclable product design and recycling information. Current federal work in the United States is concentrated on batteries and critical materials.

The European Union provides the clearest timetable. Regulation (EU) 2026/1738 applies starting in September 2028. For applicable new vehicle types, it requires 15 percent post-consumer recycled plastic from September 2032 and 25 percent from September 2036. From September 2032, specified parts must be designed so their removal is unhindered, and electric-vehicle batteries, battery packs and e-drive motors must be readily and non-destructively removable and replaceable. Manufacturer circularity strategies and standardized removal information begin in 2029, followed by the Digital Circularity Vehicle Passport in 2032.²

Region	Primary Direction Relevant to Design and Fastening
Europe	Recycled-content targets, removal requirements, circularity strategies and digital lifecycle information.
China	Digital battery identities and battery connections designed for maintenance and safe dismantling.
Japan	Economic incentives for removing resin and glass before shredding to support higher-value recovery.
Korea	Recyclability through material selection, easier separation and dismantling, plus recycling information.
United States	A developing battery producer-responsibility framework that includes product design and design for recycling.

The regional summary above draws on public government sources for China, Japan, Korea and the United States. (3)

Selected EU ELV regulation milestones

The EU regulation phases in its requirements over several years. The timeline below applies only to the European Union; other markets follow separate regulations and implementation schedules.

2028	2029	2032	2036
Most provisions begin to apply	Manufacturer circularity strategies and standardized removal information	15% post-consumer recycled plastic; specified removal provisions; Digital Circularity Vehicle Passport	25% post-consumer recycled plastic



OEMs are bringing recovery knowledge into development

Published OEM strategies and programs point to three common responses: make priority components more practical to remove, create demand for circular materials, and preserve component value through repair, reuse or remanufacturing. OEMs are not operating to one common technical standard, but they are moving end-of-life knowledge into vehicle architecture, material specifications and supplier development.

These initiatives place new demands on component architecture, material documentation and the joining methods that determine whether priority parts can be accessed and separated.

OEM Response	Changes in Development	Representative Published Examples
Design for dismantling	Access, release method, material selection and removal sequence.	Toyota publishes easier-to-dismantle design practices, including pull-tab ground terminals and harness-routing measures. BMW describes detachable connections and feedback from dismantling operations.
Create demand for circular materials	Material specifications, sourcing, validation and recovered-feedstock quality.	Hyundai reports a Car-to-Car material project. Volkswagen has set a 2040 circular-material target for specified future vehicle projects. Chery describes dismantling, sorting and reuse activity in its published ESG program. BYD publishes battery-recycling information and operates collection points within China.
Preserve component value	Service, remanufacturing, second-life use and component condition after removal.	Stellantis operates a Circular Economy Hub focused on repair, reuse, remanufacture and recycling. GM reports battery refurbishment, reuse and recycling programs.

The representative OEM examples are drawn from published Toyota, Hyundai, BMW, Volkswagen, Chery, Stellantis, and GM sources. (4)

Circularity creates new assembly and component trade-offs

A fastener designed to support circularity must still install reliably and retain the attached component through its required life. It may need to tolerate vibration, impact, moisture, chemicals, temperature cycling and sustained loads. Recovery adds another set of conditions to the engineering decision.

Circularity adds a design condition. It does not relax the requirements for attachment strength, sealing, durability, quality or assembly repeatability.

Engineering Tension	What Engineers Must Resolve
Lifetime retention versus intentional removal	Provide a controlled release method without reducing in-use retention or introducing accidental release.
Assembly speed versus dismantling effort	Balance fast installation with access, identification, tool requirements and removal time after years of service.
Functional complexity versus material purity	Determine whether inserts, seals, adhesives or mixed polymers add enough functional value to justify the separation they require.
Recycled content versus predictable performance	Coordinate material sourcing, formulation, geometry, molding and validation to maintain insertion, retention, creep, impact and durability performance.

Research on automotive plastics and recycled polypropylene supports the material and validation considerations summarized above. (5)

Fastening choices influence what can be recovered

At an attachment point, the fastener helps determine whether a part remains accessible, whether removal damages the adjoining component or mounting surface, how many operations and tools dismantling requires, and whether dissimilar materials can be separated before shredding.

The value of a release feature depends on the recovery pathway. A reusable service connection can preserve a high-value component. A one-time release may allow a battery, motor, electronic module, bumper or harness to be removed before material processing. In other applications, keeping the fastener with a compatible material may be more efficient than separating it.

The design task starts with a specific outcome: preserve the component, recover a material, gain access to another system or simplify the remaining material stream. That outcome determines the release method, access, tools, allowable damage and validation plan.

Considerations for Circular Design



What must remain intact?



What must separate?



Who performs the removal?

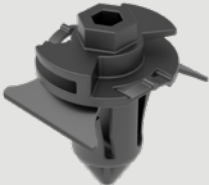
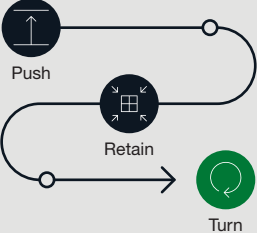
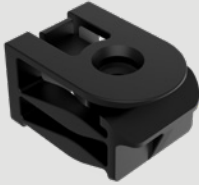
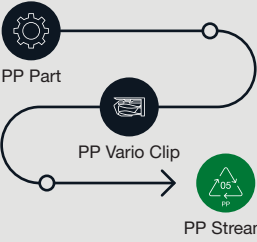
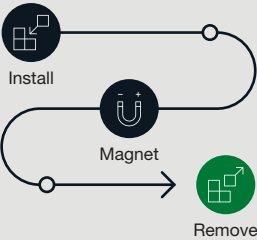
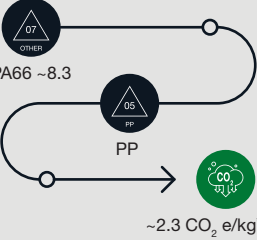


Which tools and access are available?

Four fastening strategies for different circularity paths

There is no single fastening strategy for circularity. The right approach depends on what needs to happen later in the component life. Some applications need a defined release method. Others benefit from keeping compatible materials together, preserving a component through repeated service, or changing the fastener material itself.

The four approaches below translate those different requirements into connection design. Each must still satisfy the attachment, assembly and vehicle-life requirements of the application.

Circularity Requirement	ITW Example	Mechanism / Material Story	Proof Points
Controlled Release  Secure in use. Predictable release.	Aero Cover Fixation 	 Push Retain Turn	Insertion: < 50 N Retention: Up to 1,500 N Removal: Non-destructive
Material Compatible  Can fastener and component share a recovery stream?	Vario Clip (PP) 	 PP Part PP Vario Clip PP Stream	Configuration: PP Material Family: Same PP Performance: Validate
Serviceable / Reusable  Remove without damaging the interface.	HideLock 	 Install Magnet Remove	Retention: 330–500 N Service Cycles: 100+ Removal: Damage-free
Lower-Impact Materials  Change material and preserve required function.	Low PCF Cable Strap 	 PA66 ~8.3 PP ~2.3 CO ₂ e/kg*	Material PCF: ~73% Lower* Loop Tensile: 200 N Pull-out: 100 N

Approaches Can Overlap

Start with the intended outcome: what stays intact, what separates, and what must the connection maintain until then?

ITW's approach to designing for circularity

ITW recommends starting with the intended recovery outcome, then working backward to define what must remain intact, which materials must separate, how the connection will be accessed and released, and what performance must be validated.

1. **Define the lifecycle outcome** – Service, repair, reuse, remanufacture or material recovery.
2. **Identify what must be preserved or separated** – Define the component, interface and material streams that matter.
3. **Specify access, tools and removal conditions** – Identify who removes the component, how it is reached and what damage is acceptable.
4. **Select and validate the connection** – Balance assembly, retention, vehicle-life and release requirements.
5. **Document materials and removal information** – Capture the material composition and removal method needed later in the lifecycle.

Define recovery requirements before the architecture is fixed

The fastener must perform during assembly and throughout the vehicle life. Where component or material recovery is intended, it must also enable the final operation that releases the part or separates its materials. Defining that operation early gives engineering teams more options to balance access, attachment performance, material compatibility and removal.

ITW Automotive can work with vehicle and component teams to define the recovery pathway, assess the application and evaluate connection concepts against assembly, vehicle-life and removal requirements.

Ready to take the next step?

ITW Automotive can work with your engineering team to evaluate attachment concepts against assembly, vehicle-life, service, dismantling, and material-recovery requirements.



Scan the QR code to discuss your application with an ITW Automotive engineer.

Endnotes:

1. European Commission, Directorate-General for Environment, “How can the car industry increase plastic recycling? A new supply chain analysis offers EU policy options,” November 6, 2025. Reports that about 19% of automotive plastic waste is sent for recycling and summarizes technical, economic and infrastructure barriers.
2. Regulation (EU) 2026/1738 of the European Parliament and of the Council of July 8, 2026, including Articles 6, 7, 9, 11, 13 and 59. EUR-Lex
3. Regional sources for China, Japan, Korea and the United States. China MIIT | Japan METI | Korea law | U.S. EPA
4. Representative OEM sources used for the response patterns summarized in the article. Toyota | Hyundai | BYD | BMW | Volkswagen | Chery | Stellantis | GM
5. Material and validation context: European Commission automotive-plastics analysis plus peer-reviewed studies of recycled polypropylene for automotive applications. European Commission | Processes study | Materials study
6. ITW Automotive product sources: Aero Cover Fixation value sheet (2024); Vario Clip New Generation value sheet (2024) plus ITW team-provided PP trial context; HideLock one-pager (2025); Airbag Clip one-pager (2026); Low PCF Cable Straps value sheet (2026). Product and performance values are application- or configuration-specific and should receive final engineering/product-management approval before publication.



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