Safe Road Transport of LiB - An ADR Compliance Guide for Li-Ion Cells and Batteries

This white paper is a practical guide to ADR regulations for lithium-ion batteries (UN 3480 & UN 3481), covering all transport categories including new, used, defective & damaged and prototype batteries. It also explores emerging chemistries such as NMC, LFP, Solid-State, and Sodium-Ion, alongside the growing EV battery market and evolving ADR frameworks shaping safe road logistics.

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Introduction

Lithium-ion batteries are a cornerstone technology powering electric vehicles, energy storage systems, and a wide range of consumer and industrial applications. With rapidly growing demand, their safe transport has become a priority for regulators and industry stakeholders alike. Lithium-ion cells and batteries are classified as Dangerous Goods (DG) under the UN Recommendations on the Transport of Dangerous Goods, and are regulated under the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR).

This white paper serves as comprehensive guidance for the logistics of Electric Vehicle Batteries (EVB), specifically focusing on Lithium-Ion technology. Supported by a literature review of current safety standards and regulatory frameworks, it provides a clear, step-by-step guide to ADR requirements across all lifecycle stages, including new, used, defective, or damaged units.

The document details correct classification (UN 3480 and UN 3481), capacity thresholds under Special Provisions, and the necessary packaging, marking, and documentation rules.

Tailored to road transport operations, it addresses key industry topics such as the rise of NMC and LFP chemistries and the critical role of EV battery logistics as electrification accelerates. Beyond current practices, it also explores emerging chemistries like Solid-State and Sodium-Ion batteries, outlining future regulatory developments shaping safe transport on European roads.

Li-on Batteries & Cells

Lithium ion batteries & cells

Lithium ion batteries & cells contained in equipment or packed with equipment

Literature Review

ADR’s regulatory evolution and update logic

Functioning as the primary legal instrument for harmonizing the international road transport of dangerous goods, the ADR is positioned by the UNECE (n.d.) not merely as a static treaty which concluded in 1957 and effective since 1968, but as a framework for continuous standardization across contracting parties. Literature typically conceptualizes the ADR as a “living” regulatory organism; its operational vitality resides primarily in Annexes A and B, which undergo periodic revision to accommodate technical advancements while maintaining interoperability with the broader UN-based global transport architecture.

This temporal dynamism is evident in the rigorous cycle of edition changes and transitional measures. By publishing consolidated editions capable of immediate application such as the version applicable as from 1 January 2025, the UNECE operationalizes updates through comprehensive codified volumes rather than fragmented ad hoc adjustments. This method of periodic codification is mirrored in parallel regimes, notably OTIF’s RID text, which similarly enforces consolidated editions "with effect from" specified dates (e.g., 1 January 2025), thereby solidifying a synchronized rhythm of regulatory updates across inland transport modes.

UN Model Regulations as the backbone for lithium battery transport rules

While specific modalities possess distinct operational requirements, the structural coherence of the global dangerous goods regime relies heavily on the UN Recommendations on the Transport of Dangerous Goods (the UN Model Regulations). United Nations (2019) identifies these Model Regulations as the central harmonization anchor, standardizing classification, packaging, and consignment protocols to ensure that national and modal variations remain interoperable. Within this hierarchical architecture, specific UN-numbered entries serve as the universal translation layer for lithium batteries. IATA (2025), for example, explicitly designates UN 3480 (lithium ion batteries) as a Class 9 entry, utilizing it as the foundational node for air-transport classification and packaging decision pathways. This demonstrates how abstract UN entries propagate downward, evolving from high-level recommendations into the concrete operational rules and shipper decision trees used in daily logistics.

Innovation pace vs rule granularity: the prescriptive gap critique

A persistent tension exists between the high velocity of battery innovation characterized by increasing energy densities and novel form factors and the inertia of prescriptive regulatory frameworks. Critiques in both policy and technical spheres suggest that static thresholds often lag behind technological reality. Consequently, the regulatory response is rarely a wholesale system redesign, but rather a series of incremental tightenings involving shipment conditions and segregation logic. PHMSA’s 2019 Interim Final Rule serves as a case study in this incrementalism: by operationalizing passenger-aircraft prohibitions and codifying the 30% SoC condition for specific cargo scenarios, the rule addresses immediate risks through targeted constraints on existing provisions rather than rewriting the fundamental classification structure.

Modal contrasts (ADR vs ICAO/IATA) and redistribution of regulatory control

A sharp divergence in risk tolerance distinguishes air from road transport regulations. The literature attributes aviation's stricter controls to the unique flight environment, characterized by limited fire suppression and catastrophic failure consequences. By 2016, policy discourse pivoted toward restricting lithium-ion cargo on passenger aircraft and introducing state-of-charge (SoC) limits. The Flight Safety Foundation (2016) highlights how safety imperatives ultimately outweighed commercial concerns, favoring rigorous mitigations like the 30% SoC cap.

These debates rapidly crystallized into mandates. AACO (2016) documents the prohibition of lithium-ion cargo on passenger aircraft effective April 2016, while FAA analyses (Webster, 2016) detail how ICAO Technical Instructions operationalized these restrictions into binding rules. Scholars note that this generates a "hydraulic" effect: as air transport becomes prohibitive, volumes shift toward surface modes. This migration amplifies the necessity for rigorous ADR compliance and packaging integrity, placing a premium on safety without requiring fresh accident statistics to justify the heightened scrutiny.

Hazard mechanisms in lithium-ion batteries relevant to transport regulation

Regulatory parameters regarding packaging performance and segregation are not arbitrary; they derive directly from experimental characterizations of thermal runaway, which research identifies as the central failure mode driving transport controls. Finegan et al. (2017) significantly advanced the mechanistic understanding of this phenomenon by inducing internal short circuits under controlled settings, reinforcing the argument that transport regulations must account for "worst-case" initiation scenarios rather than merely gradual thermal events.

Building on this, subsequent research by Finegan et al. (2018) elucidated the physics of rupture during thermal runaway, demonstrating how venting limitations and rapid gas generation precipitate energetic failures, findings that directly validate regulatory obsessions with containment capability and package-level resilience. More recently, the focus has shifted from individual cell failure to system-level escalation; Fransson et al. (2024) quantify how propagation likelihood fluctuates based on cell chemistry and electrical connectivity. This trajectory of research underscores the scientific imperative for regulating not just the inherent hazard of the cell, but the configuration-level risk inherent in dense consignments.

Risk assessment methods and use of incident databases

Contemporary safety scholarship has largely pivoted from anecdotal event reconstruction to structured, data-driven risk assessment. Kwasiborska and Ścigaj (2025) exemplify this methodological shift by constructing an aviation-focused risk assessment model that utilizes FAA-reported occurrence data not as isolated stories, but as empirical inputs for systematic hazard categorization and severity scoring.

Complementing this quantitative approach, PHMSA (2021) utilizes evidence synthesis to bridge the gap between regulatory intent and industry reality. By auditing packaging practices for air transport and identifying specific compliance voids, their work illustrates how regulators and technical bodies essentially use gap analysis to refine compliance expectations and tighten the feedback loop between rule-making and real-world application.

Beyond Europe: convergence and emerging chemistries

The hegemony of the UN model extends well beyond European borders, fostering a "UN-aligned convergence" where national systems adapt global standards to local contexts. Keller and Heckman (2024) note that China's Ministry of Transport explicitly aligned its May 2024 amendments to JT/T 617-2018 with ADR 2023 structures. Similarly, compliance summaries highlight the immediate effectiveness of these updates, reinforcing the observation that major industrial economies are increasingly synchronizing their domestic regulations with the ADR/UN evolutionary track.

In the United States, the governance of hazardous materials falls under Title 49 of the Code of Federal Regulations (49 CFR) administered by PHMSA; while structurally distinct from ADR, it incorporates harmonization provisions (Subpart C) that accept UN-standard packaging and labeling for international commerce.ations.

The landscape in Russia and the Eurasian Economic Union (EAEU) presents a hybrid model: while the Russian Federation is a contracting party to the ADR for international road transport, domestic movements are frequently overlaid with GOST standards and Technical Regulations of the Customs Union (TR CU), necessitating a dual-compliance strategy for cross-border operators.

Finally, the regulatory discourse is expanding beyond traditional lithium-ion frameworks. Recent updates (ADR 2025) now formally recognize alternative chemistries like Sodium-ion and mandate digital transparency through mechanisms like the Battery Passport, topics which will be practically detailed in the subsequent sections of this white paper.

Following sections of whitepaper will include market growth overlook, ADR framework, emerging chemistries and New & Upcoming regulations.

Market Growth Overlook

The global shift toward electrification is transforming energy, mobility, and supply chains at an unprecedented pace. Lithium-ion batteries sit at the heart of this transition, enabling not only electric vehicles but also stationary storage solutions, consumer electronics, and emerging applications such as micro-mobility and grid balancing.

As demand accelerates, lithium-ion battery production is entering a phase of rapid industrialization. Growth is primarily driven by electric vehicle adoption, supported by strong policy incentives, expanding gigafactory capacity, and continuous cost reductions in cell manufacturing. Electric Vehicle Batteries (EVBs) are expected to remain the dominant application, with energy storage systems and consumer electronics following as secondary demand drivers.

For Europe, this surge is reshaping logistics patterns, with Turkey positioned as a key manufacturing and transport hub bridging Asian supply chains and EU markets. This means greater shipment volumes, higher frequency of cross-border road transport, and growing importance of robust ADR compliance to ensure safe and efficient flows.

Expectations for li-on batteries

Global lithium-ion battery demand is projected to grow sixfold by 2030, from ~700 GWh in 2022 to nearly 4,700 GWh, representing a compound annual growth rate of ~27%.

Regional Outlook

China will remain the largest producer and consumer, but Europe and the United States are expected to capture an increasing share as domestic gigafactory capacity scales up.

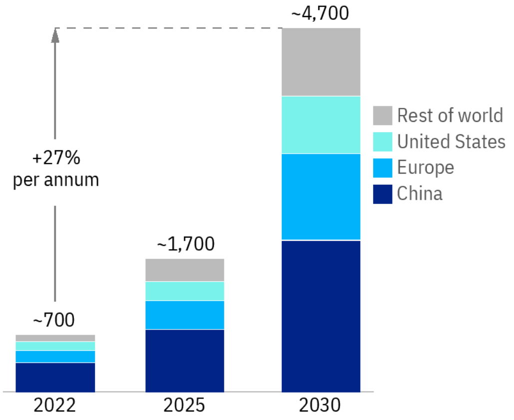
Sector Outlook

Mobility, primarily electric vehicles, will account for the majority of demand growth, while stationary energy storage and consumer electronics represent smaller but steadily rising segments.

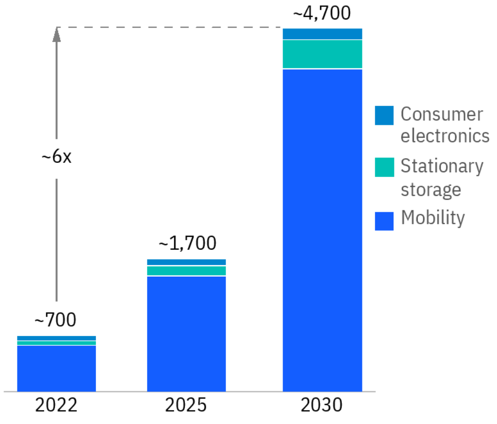
This rapid expansion will dramatically increase the number of shipments on European and cross-border roads, making ADR compliance and safe logistics practices more critical than ever.

Global Li-ion battery cell demand, GWh, Base case

By region

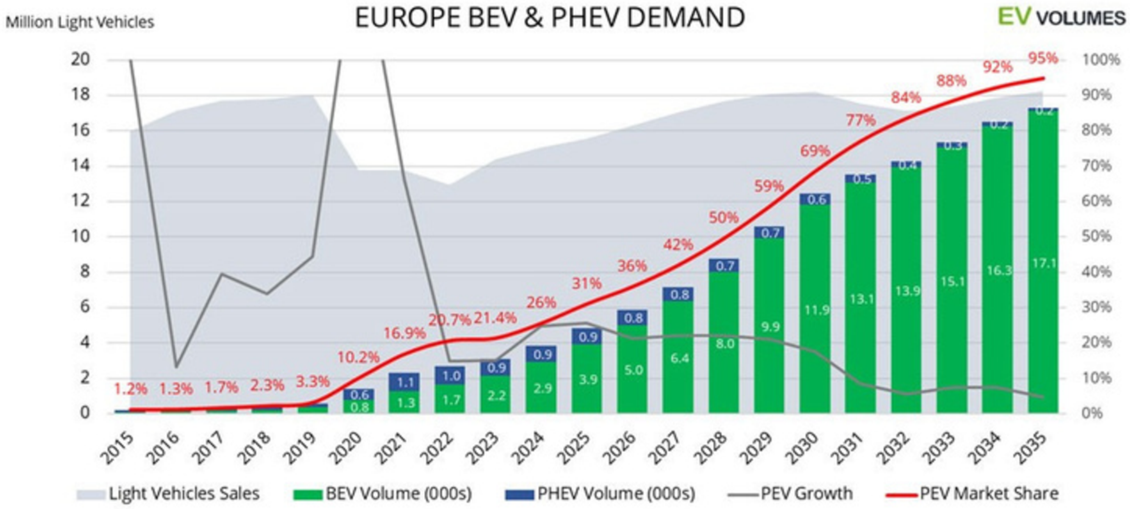


By sector



Including passenger cars, commercial vehicles, two-to-three wheelers, off-highway vehicles and aviation.
Source: McKinsey Battery Insights Demand Model

Europe is entering a decisive decade for vehicle electrification. Battery Electric Vehicle (BEV) demand is projected to surge from under 2 million units in 2022 to over 16 million units by 2035, pushing plug-in vehicle (PEV) market share above 90%. This rapid transition will significantly increase the flow of lithium-ion batteries on European roads, reinforcing the need for harmonized ADR compliance and safe transport practices.



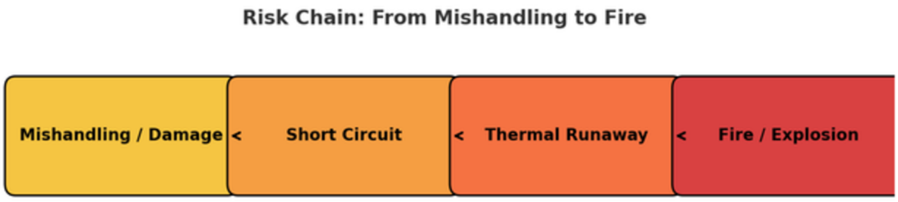
Source: EV Volumes

The chart illustrates how BEVs are set to dominate Europe's electrified mobility landscape. While Plug-in Hybrid Electric Vehicles (PHEVs) initially contributed a meaningful share during the early phase of transition, their growth plateaus beyond 2028 as fully electric BEVs gain momentum. By 2030, BEVs account for roughly 85% of all plug-in vehicle sales, a shift driven by stricter EU emission targets, expanding charging infrastructure, and rapid declines in battery cost per kilowatt-hour.

This acceleration is also fueled by stronger national incentives, rising consumer awareness of sustainability, and major automakers' strategic commitments to phase out internal combustion engines across their fleets.
In contrast, PHEV volumes stabilize around 0.5–0.7 million units per year, reflecting tightening regulations that favor zero-emission vehicles. As shown in the chart, the BEV share of total light vehicle sales climbs from just 1% in 2018 to nearly 95% by 2035, confirming a full market transformation that will multiply the number of lithium-ion battery shipments transported via road across Europe.

Why Regulations Exist?

Lithium-ion batteries are classified as Dangerous Goods (DG) as we mentioned before, under the UN Recommendations on the Transport of Dangerous Goods because of their inherent chemical and electrical hazards. When damaged, improperly packaged, or short-circuited, they can enter thermal runaway a chain reaction in which internal heat generation triggers electrolyte decomposition and venting of flammable gases such as hydrogen, carbon monoxide, and hydrofluoric acid vapors, potentially leading to intense fires or explosions.



Risk Chain: From Mishandling to Fire

Mishandling / Damage < Short Circuit < Thermal Runaway < Fire / Explosion

These risks are not theoretical, real world incidents have led to truck fires, highway closures, and significant supply chain disruptions. The high energy density that makes lithium-ion batteries so valuable also makes them potentially hazardous if mishandled during transport.

Regulations such as ADR exist to:

- Prevent accidents by setting strict requirements for packaging, marking, and short-circuit protection.
- Ensure harmonization across borders so that lithium-ion batteries are transported under consistent safety standards in all participating countries.
- Protect human life and infrastructure by reducing the risk of fire, leakage, and uncontrolled energy release on public roads.

In this context, ADR provides a structured framework that defines classification (UN 3480 and UN 3481), capacity thresholds (e.g., SP 188), and compliance steps, enabling safe and predictable transport of lithium-ion cells and batteries across Europe and beyond.

Real-World Incidents

Fire in truck carrying lithium ion batteries leads to 3-hour evacuation.**Columbus, Ohio(2023)**

A truck carrying hybrid cars ignited on the M5 Highway, closing 11 km of road. Lithium batteries in the vehicles intensified the blaze.
Australia (2025)

A truck carrying lithium batteries caught fire after overturning, burning for hours and highlighting road transport fire risks.
Taiwan (2024)

Under the ADR framework, two main UN entries govern the road transport of lithium-ion batteries and related products:

- UN 3480 – Lithium-Ion Batteries: Applies to batteries and cells shipped independently ("as batteries").
- UN 3481 – Lithium-Ion Batteries Contained in or Packed with Equipment: Applies when batteries are installed inside or transported alongside equipment within the same package.

These UN numbers serve as the primary reference for determining packaging, labeling, and documentation requirements under ADR.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Agreement concerning
the International Carriage
of Dangerous Goods by Road

ADR
2025

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UNITED NATIONS

Battery Types and Regulatory Differentiation

ADR distinguishes between lithium-ion battery shipments based on their condition, purpose, and intended destination since each stage of a battery's lifecycle introduces different transport risks.

Four main categories are defined:

- **New / Functional Batteries:** Fully compliant, tested products ready for use or installation. Often exempt from full ADR obligations under Special Provision 188 when below defined energy thresholds.
- **Used / Second-life Batteries:** Previously operated batteries transported for reuse, repurposing, or recycling. Require careful inspection and controlled packaging to prevent short-circuits or thermal events.
- **Damaged or Defective Batteries:** Batteries showing signs of swelling, leakage, or electrical malfunction. They require reinforced containment, temperature stability, and are handled under the most stringent safety provisions.
- **Prototype or Low-volume Production Batteries:** Early-stage or pilot production batteries that have not yet undergone the UN 38.3 testing process. These shipments are treated with additional caution and specialized packaging standards.

This differentiation enables ADR to align risk level with regulatory intensity, ensuring that packaging, labeling, and documentation requirements scale appropriately from safe, functional units to potentially unstable or untested ones.

ADR Class

As explained earlier in the Why Regulations Exist section, lithium-ion batteries combine electrical, chemical, and thermal hazards that can trigger fires, explosions, or gas venting in cases of short-circuit, overcharging, or mechanical damage.

Because these risks do not fit into any single hazard class, they are grouped under **ADR Class 9 – Miscellaneous Dangerous Goods**, which covers materials posing multiple or unique transport hazards.

This classification requires:

- Robust packaging and containment,
- Short-circuit and thermal protection, and
- Distinct hazard labeling with the Class 9 diamond mark.

By assigning lithium-ion batteries to Class 9, ADR ensures consistency with the UN Model Regulations and promotes a preventive safety approach by managing low probability but high impact events such as thermal runaway and road transport fires.

ADR Special Provisions

ADR defines several Special Provisions (SP) that specify how lithium batteries should be classified, tested, and transported based on their condition and configuration.

Both for UN 3480 and UN3481 , the following SPs apply:

- SP 188 – Defines capacity limits (≤ 20 Wh per cell, ≤ 100 Wh per battery) and conditions for exemption from full ADR.Requires drop test (1.2m) and Lithium Battery Mark. No Transport Category assignment.(for new, functional and used,functional)
- SP 230 – Confirms compliant lithium batteries may be shipped under this entry. (for all types)
- SP 310 – Refers to transport of prototype batteries pending UN 38.3 testing.
- SP 348 – Requires watt-hour marking for lithium-ion batteries manufactured after 2011. (for new)
- SP 376 & SP 377 – Define conditions for transporting damaged or defective batteries, including those for disposal or recycling.
- SP 636 – Specifies packaging and handling for waste lithium batteries.

Only for UN 3481 following provison apply:

- SP 360 – Specific to batteries installed in or packed with equipment, clarifying packaging and protective measures during transport. (for all types in equipment)

ADR Packaging Requirements

ADR specifies a series of standardized packaging instructions to ensure the safe containment and transport of lithium-ion cells and batteries across all conditions.

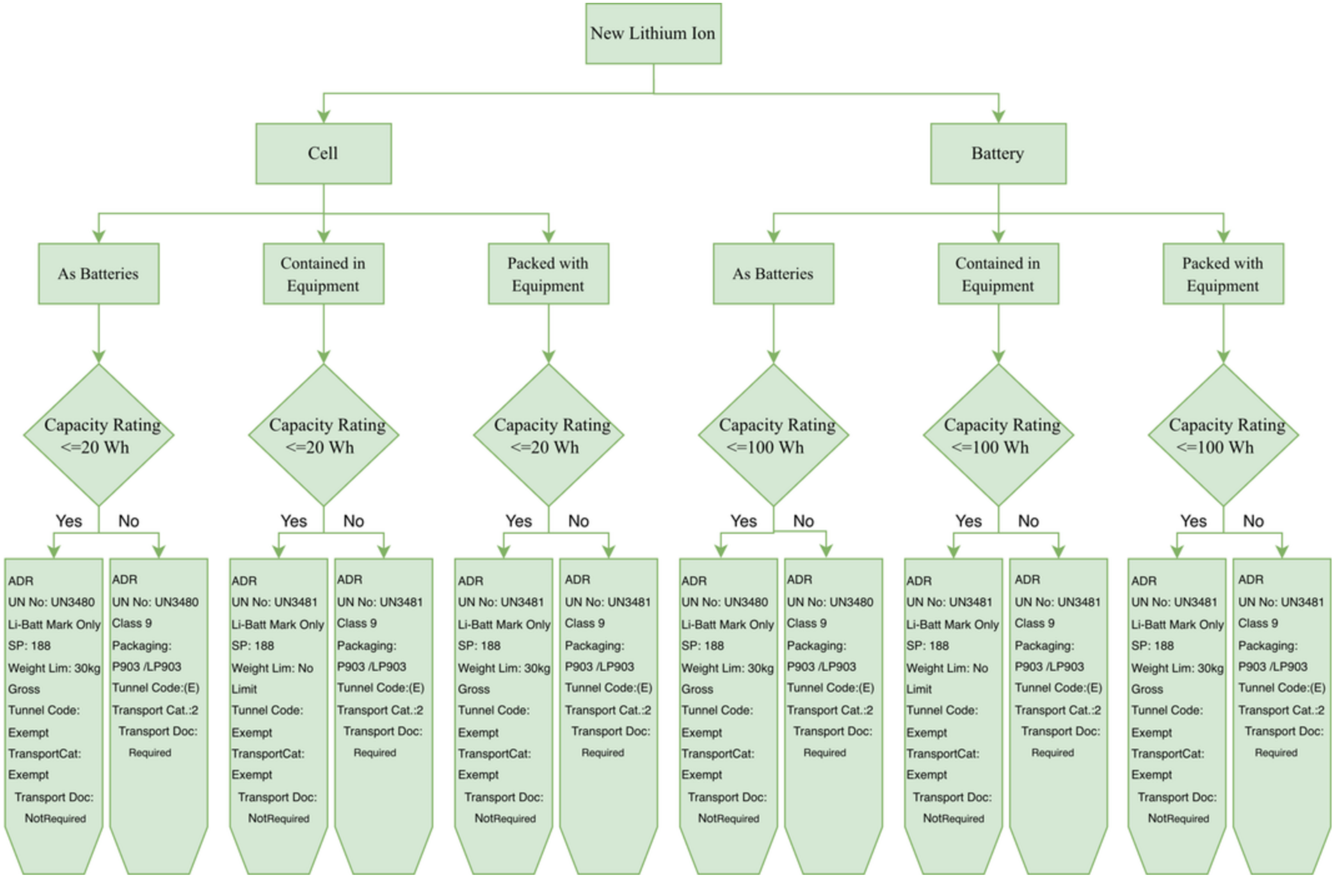
Both UN 3480 and 3481 reference the following:

- P903 / LP903 – Standard packaging for compliant, tested batteries.
- P908 / P909 / P910 / P911/ LP904 / LP906 – Used for damaged, defective, waste, or prototype batteries depending on their condition.

Proper selection and application of these instructions are essential to prevent short circuits, leakage, and mechanical damage during road transport.

Regulations for New,Functional Li-on Cells and Batteries

This checklist summarizes the ADR requirements for transporting **new and functional** lithium-ion cells and batteries in **7 steps** with a flow.



New Lithium Ion
- Cell
  - As Batteries
    - Capacity Rating <=20 Wh
      - Yes: ADR UN No: UN3480 Li-Batt Mark Only SP: 188 Weight Lim: 30kg Gross Tunnel Code: Exempt TransportCat: Exempt Transport Doc: NotRequired
      - No: ADR UN No: UN3480 Class 9 Packaging: P903 /LP903 Tunnel Code:(E) Transport Cat.:2 Transport Doc: Required
  - Contained in Equipment
    - Capacity Rating <=20 Wh
      - Yes: ADR UN No: UN3481 Li-Batt Mark Only SP: 188 Weight Lim: No Limit Tunnel Code: Exempt TransportCat: Exempt Transport Doc: NotRequired
      - No: ADR UN No: UN3481 Class 9 Packaging: P903 /LP903 Tunnel Code:(E) Transport Cat.:2 Transport Doc: Required
  - Packed with Equipment
    - Capacity Rating <=20 Wh
      - Yes: ADR UN No: UN3481 Li-Batt Mark Only SP: 188 Weight Lim: 30kg Gross Tunnel Code: Exempt TransportCat: Exempt Transport Doc: NotRequired
      - No: ADR UN No: UN3481 Class 9 Packaging: P903 /LP903 Tunnel Code:(E) Transport Cat.:2 Transport Doc: Required
- Battery
  - As Batteries
    - Capacity Rating <=100 Wh
      - Yes: ADR UN No: UN3480 Li-Batt Mark Only SP: 188 Weight Lim: 30kg Gross Tunnel Code: Exempt TransportCat: Exempt Transport Doc: NotRequired
      - No: ADR UN No: UN3480 Class 9 Packaging: P903 /LP903 Tunnel Code:(E) Transport Cat.:2 Transport Doc: Required
  - Contained in Equipment
    - Capacity Rating <=100 Wh
      - Yes: ADR UN No: UN3481 Li-Batt Mark Only SP: 188 Weight Lim: No Limit Tunnel Code: Exempt TransportCat: Exempt Transport Doc: NotRequired
      - No: ADR UN No: UN3481 Class 9 Packaging: P903 /LP903 Tunnel Code:(E) Transport Cat.:2 Transport Doc: Required
  - Packed with Equipment
    - Capacity Rating <=100 Wh
      - Yes: ADR UN No: UN3481 Li-Batt Mark Only SP: 188 Weight Lim: 30kg Gross Tunnel Code: Exempt TransportCat: Exempt Transport Doc: NotRequired
      - No: ADR UN No: UN3481 Class 9 Packaging: P903 /LP903 Tunnel Code:(E) Transport Cat.:2 Transport Doc: Required

Step 1 – Identify the Battery Type

Determine if it’s a cell or a battery, and whether it is:

- As Batteries
- Contained in Equipment
- Packed with Equipment

Step 2 – Check Capacity Rating (SP188)

- Cells: ≤ 20 Wh
- Batteries: ≤ 100 Wh

YES: Falls under SP188 → simplified ADR (no transport document)
NO: Full ADR compliance required

Step 3 – Assign UN Number & Classification

- UN 3480: Batteries shipped alone
- UN 3481: Contained in/with equipment.
- No SP 188: ADR Class: 9 Tunnel Code: (E)

Step 4 – Apply Packaging Instructions

Use P903 / LP903, ensuring:

- Short-circuit protection
- Strong outer packaging
- Max 30 kg (unless in equipment)

Step 5 – Verify Special Provisions

- SP188: Capacity limits
- SP230: Authorization
- SP348: Watt-hour marking (>2011)

Step 6 – Prepare Documentation (if required)

If SP188 doesn’t apply → include transport document with:
UN number, shipping name, Class 9, and P903/LP903 reference.
For SP 188: No official ADR Transport Document is required.

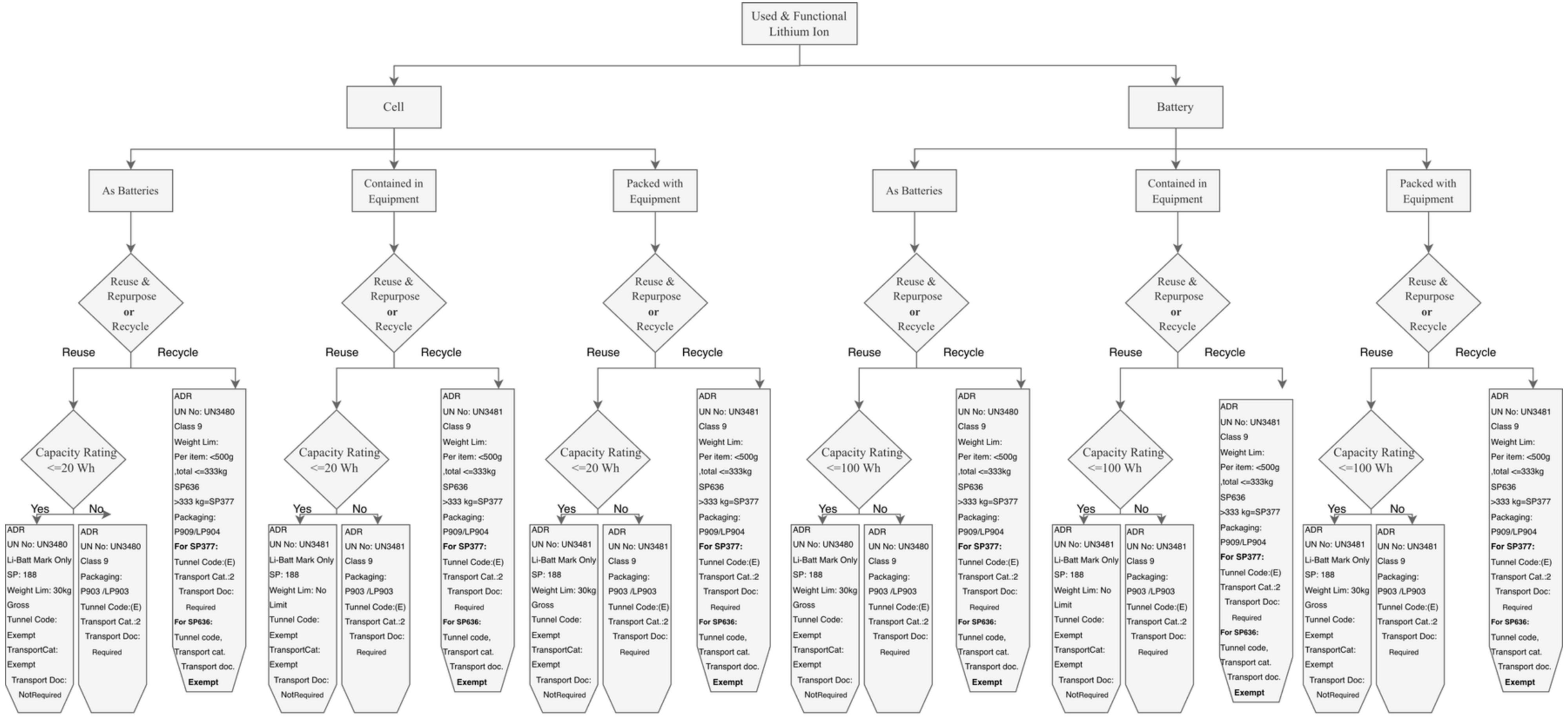
Step 7 – Final Compliance Check

Proper labels and markings
Packaging integrity
Route avoids tunnels under code (E),(Only for fully regulated shipments > 333 kg or non-SP 188).
SP 188 shipments are permitted in tunnels.
Ensure manufacturer or consignor identification and emergency contact details are clearly visible

ADR Compliance Framework

Regulations for Used, Functional Li-on Cells and Batteries

This checklist summarizes the ADR requirements for transporting used and functional lithium-ion cells and batteries in **7 steps** with a flow.



Used & Functional Lithium Ion

- Cell
  - As Batteries
    - Reuse & Repurpose or Recycle
      - Reuse: Capacity Rating <=20 Wh
        - Yes: ADR / UN No: UN3480 / Li-Batt Mark Only / SP: 188 / Weight Lim: 30kg Gross / Tunnel Code: Exempt / TransportCat: Exempt / Transport Doc: NotRequired
        - No: ADR / UN No: UN3480 / Class 9 / Packaging: P903 /LP903 / Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required
      - Recycle: ADR / UN No: UN3480 / Class 9 / Weight Lim: Per item: <500g ,total <=333kg SP636 / >333 kg=SP377 / Packaging: P909/LP904 / **For SP377:** Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required / **For SP636:** Tunnel code, Transport cat. Transport doc. **Exempt**
  - Contained in Equipment
    - Reuse & Repurpose or Recycle
      - Reuse: Capacity Rating <=20 Wh
        - Yes: ADR / UN No: UN3481 / Li-Batt Mark Only / SP: 188 / Weight Lim: No Limit / Tunnel Code: Exempt / TransportCat: Exempt / Transport Doc: NotRequired
        - No: ADR / UN No: UN3481 / Class 9 / Packaging: P903 /LP903 / Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required
      - Recycle: ADR / UN No: UN3481 / Class 9 / Weight Lim: Per item: <500g ,total <=333kg SP636 / >333 kg=SP377 / Packaging: P909/LP904 / **For SP377:** Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required / **For SP636:** Tunnel code, Transport cat. Transport doc. **Exempt**
  - Packed with Equipment
    - Reuse & Repurpose or Recycle
      - Reuse: Capacity Rating <=20 Wh
        - Yes: ADR / UN No: UN3481 / Li-Batt Mark Only / SP: 188 / Weight Lim: 30kg Gross / Tunnel Code: Exempt / TransportCat: Exempt / Transport Doc: NotRequired
        - No: ADR / UN No: UN3481 / Class 9 / Packaging: P903 /LP903 / Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required
      - Recycle: ADR / UN No: UN3481 / Class 9 / Weight Lim: Per item: <500g ,total <=333kg SP636 / >333 kg=SP377 / Packaging: P909/LP904 / **For SP377:** Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required / **For SP636:** Tunnel code, Transport cat. Transport doc. **Exempt**
- Battery
  - As Batteries
    - Reuse & Repurpose or Recycle
      - Reuse: Capacity Rating <=100 Wh
        - Yes: ADR / UN No: UN3480 / Li-Batt Mark Only / SP: 188 / Weight Lim: 30kg Gross / Tunnel Code: Exempt / TransportCat: Exempt / Transport Doc: NotRequired
        - No: ADR / UN No: UN3480 / Class 9 / Packaging: P903 /LP903 / Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required
      - Recycle: ADR / UN No: UN3480 / Class 9 / Weight Lim: Per item: <500g ,total <=333kg SP636 / >333 kg=SP377 / Packaging: P909/LP904 / **For SP377:** Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required / **For SP636:** Tunnel code, Transport cat. Transport doc. **Exempt**
  - Contained in Equipment
    - Reuse & Repurpose or Recycle
      - Reuse: Capacity Rating <=100 Wh
        - Yes: ADR / UN No: UN3481 / Li-Batt Mark Only / SP: 188 / Weight Lim: No Limit / Tunnel Code: Exempt / TransportCat: Exempt / Transport Doc: NotRequired
        - No: ADR / UN No: UN3481 / Class 9 / Packaging: P903 /LP903 / Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required
      - Recycle: ADR / UN No: UN3481 / Class 9 / Weight Lim: Per item: <500g ,total <=333kg SP636 / >333 kg=SP377 / Packaging: P909/LP904 / **For SP377:** Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required / **For SP636:** Tunnel code, Transport cat. Transport doc. **Exempt**
  - Packed with Equipment
    - Reuse & Repurpose or Recycle
      - Reuse: Capacity Rating <=100 Wh
        - Yes: ADR / UN No: UN3481 / Li-Batt Mark Only / SP: 188 / Weight Lim: 30kg Gross / Tunnel Code: Exempt / TransportCat: Exempt / Transport Doc: NotRequired
        - No: ADR / UN No: UN3481 / Class 9 / Packaging: P903 /LP903 / Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required
      - Recycle: ADR / UN No: UN3481 / Class 9 / Weight Lim: Per item: <500g ,total <=333kg SP636 / >333 kg=SP377 / Packaging: P909/LP904 / **For SP377:** Tunnel Code:(E) / Transport Cat.:2 / Transport Doc: Required / **For SP636:** Tunnel code, Transport cat. Transport doc. **Exempt**

Step 1- Confirm scope

Identify item type (Cell or Battery) and configuration (As Batteries / In Equipment / Packed with Equipment). Ensure batteries are used but intact (functional).
Determine purpose: Reuse/Repurpose (Product) or Recycling (Waste).

Step 2- Identify configuration and assign UN

- Based on configuration: As Batteries: UN 3480 Contained in / Packed with Equipment: UN 3481

Step 3- Apply ADR Classification

Reuse: If Cell ≤ 20 Wh or Battery ≤ 100 Wh → SP 188 (Exempt). If higher → Class 9, Tunnel Code (E).
Recycle: If per item **<500 g** and total **<= 333 kg** apply **SP636**, which **exempts** from Tunnel Code, Transport Cat. and documentation. If not, apply **SP377** and include Cat. 2, Code E and full documentation.

Step 4- Select Packaging

Use P903 or LP903. Strong outer packaging preventing short circuits. Reuse (SP 188): Strong outer packaging. Recycle: Use P909 or LP904. Provide short-circuit protection and immobilize contents.

Step 5- Marking and labelling

Class 9 (9A) label and UN number. Reuse (SP 188): Lithium Battery Mark only.
Recycle: Class 9 (9A) label and UN number.
Add wording: “LITHIUM BATTERIES FOR DISPOSAL” or “... FOR RECYCLING.”

Step 6 – Documentation

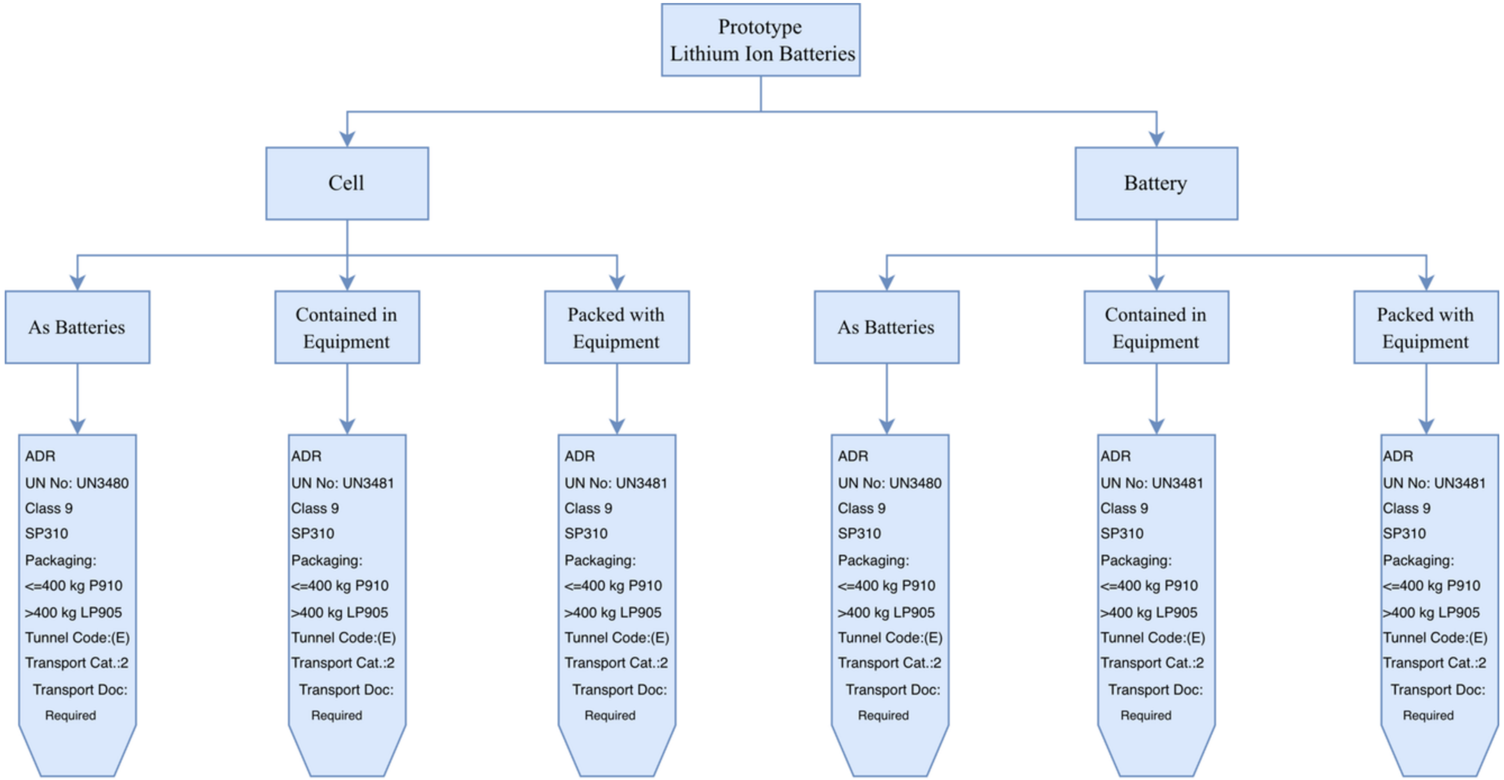
Reuse (SP 188): No transport document required.
Recycle: Transport document must include reference to Special Provision 377 and packing instruction "P909" (or LP904). For SP 636 shipments only: Reference "Special Provision 636.

Step 7- Final Compliance Check

Visual inspection confirms no swelling, leakage, or damage
Terminals insulated; load secured; packaging intact
Route avoids tunnels under code (E) (If no SP188)
Ensure manufacturer or consignor identification and emergency contact details are clearly visible

Regulations for Prototype Li-on Cells and Batteries

This checklist summarizes the ADR requirements for transporting **prototype lithium-ion** cells and batteries in **7 steps** with a flow.



Step 1 – Confirm Scope

Not more than 100 cells or batteries that have not yet passed UN 38.3 testing.
Shipped for testing under SP 310. The transport document must include "Carriage in accordance with special provision 310."

Step 2 –Identify Configuration & Assign UN

- UN 3480: Cells/Batteries shipped alone
- UN 3481: Contained in or packed with equipment
- ADR Class 9 | Tunnel Code (E) | Transport Category 2

Step 3 – Ensure Pre-Packing Safety

Switch equipment off, prevent activation, insulate terminals, and immobilize contents to withstand shock and vibration.

Step 4 – Select Packaging (P910 / LP905)

<= 400 kg (P910): Use UN-tested packaging meeting PG II standards. Must include non-combustible, non-conductive thermal insulation.
> 400 kg (LP905): Use authorized Large Packaging (LP) tested for the specific mass and configuration.

Step 5 – Apply Quantity Rules

- For P910: If a single cell or battery weighs more than 30 kg, it must be packed individually (limit of one per outer packaging).
- For LP905: Batteries exceeding 400 kg must be packed individually in large packaging.

Step 6 – Marking & Documentation

Attach Class 9 (9A) label and UN number. Include SP 310 statement and reference to P910 or LP905 in the transport document.

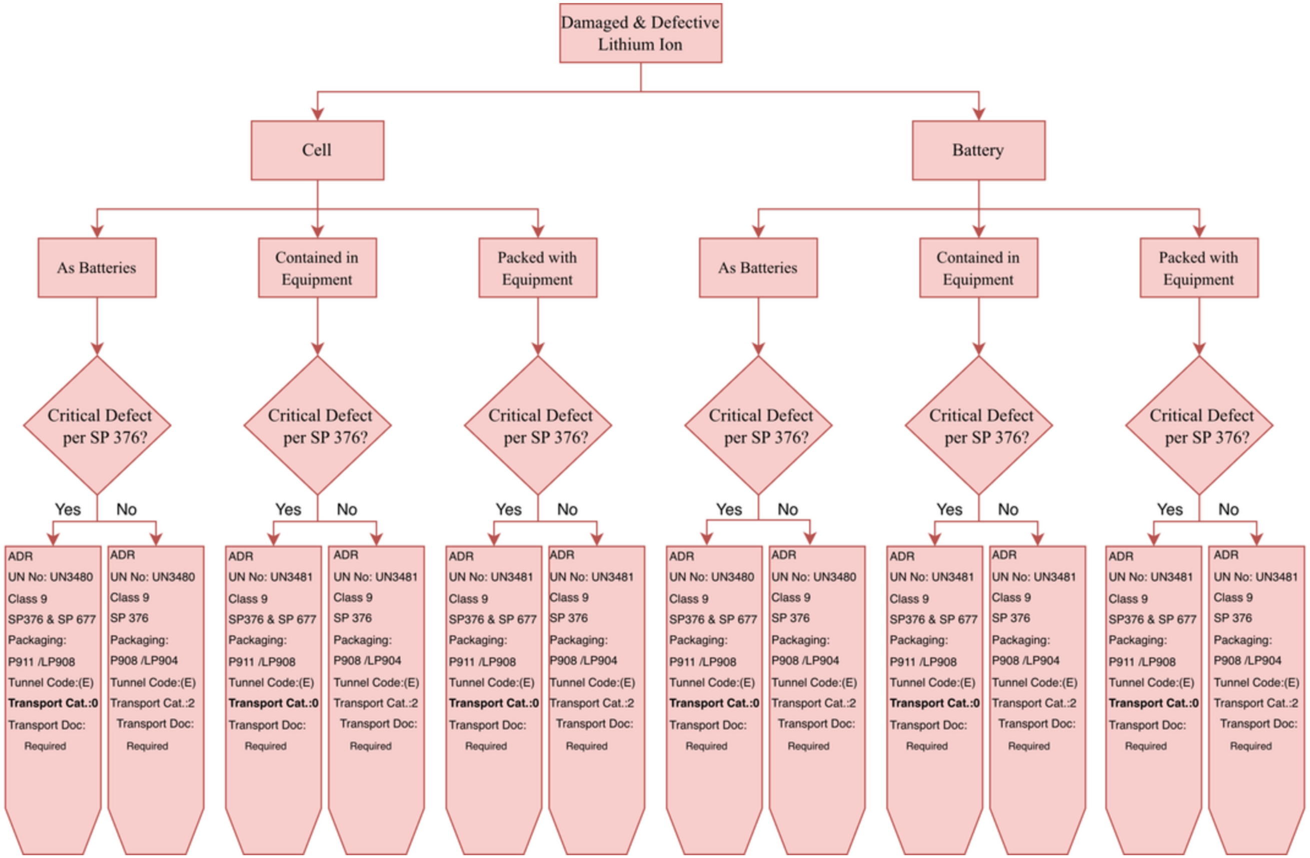
Step 7 – Final Compliance Check

Verify packaging integrity, terminal insulation, and load securement
Route avoids tunnels under code (E)
Ensure manufacturer or consignor identification and emergency contact details are clearly visible

ADR Compliance Framework

Regulations for Damaged & Defective Li-on Cells and Batteries

This checklist summarizes the ADR requirements for transporting **damaged & defective lithium-ion** cells and batteries in **7 steps** with a flow.



Damaged & Defective Lithium Ion

Cell

Battery

As Batteries

Contained in Equipment

Packed with Equipment

Critical Defect per SP 376?

Yes

No

ADR
UN No: UN3480
Class 9
SP376 & SP 677
Packaging:
P911 /LP908
Tunnel Code:(E)
Transport Cat.:0
Transport Doc:
Required

ADR
UN No: UN3480
Class 9
SP 376
Packaging:
P908 /LP904
Tunnel Code:(E)
Transport Cat.:2
Transport Doc:
Required

ADR
UN No: UN3481
Class 9
SP376 & SP 677
Packaging:
P911 /LP908
Tunnel Code:(E)
Transport Cat.:0
Transport Doc:
Required

ADR
UN No: UN3481
Class 9
SP 376
Packaging:
P908 /LP904
Tunnel Code:(E)
Transport Cat.:2
Transport Doc:
Required

Step 1- Confirm scope

Battery/cell shows damage, defect, leakage, swelling, overheating history, or safety recall → SP 376 applies. If not, use the "Used (Functional)" flow.

Step 2 – Identify configuration & assign UN

- As batteries/cells: UN 3480
- Contained in / packed with equipment: UN 3481
- Apply Class 9, Tunnel Code (E), Transport Category 2.

Step 3 – Assess condition per SP 376 (critical defect decision)

Inspect for leakage, deformation, swelling.
If a unit is liable to rapidly disassemble, produce flame, or emit dangerous heat/gases, classify as **critically defective. Apply SP 677.**
→ Critical → P911 / LP906 Non-critical → P908 / LP904

Step 4 – Make safe before packing

Power equipment OFF and prevent activation; insulate terminals, isolate modules, use non-conductive cushioning, and segregate from conductive materials or incompatible goods.

Step 5 – Apply the correct packing instruction

- Non-Critical: Use P908 or LP904. Ensure leak-proof inner containment and short-circuit protection.
- Critical: Use P911 or LP906.

WARNING: These packagings must be verified to contain a thermal runaway event. Usage strictly requires a valid test report and, in many cases, Competent Authority Approval before transport.

Step 6 – Marking, Labelling & Documentation

- Affix Class 9 (9A) label and the correct UN 3480 / 3481.
- Transport document must include SP 376 and the applied P-instruction; add Tunnel Code (E) and Transport Category 2. **If there is a critical defect, apply Transport Category 0.**

Step 7 – Final Compliance Check

Verify packaging integrity, insulation, and load securement; ensure no short-circuit risk and route complies with (E) restrictions.Ensure manufacturer or consignor identification and emergency contact details are clearly visible

New Li-on ADR Regulations Example

To clarify the regulatory requirements, a complete example is provided below.
In this case, we will be transporting a PHEV-C battery pack to illustrate the full ADR compliance process.

Before determining the correct ADR transport classification, it is necessary to review the key technical specifications of the tested battery system.
Listing parameters directly influence whether simplified or full ADR compliance applies.

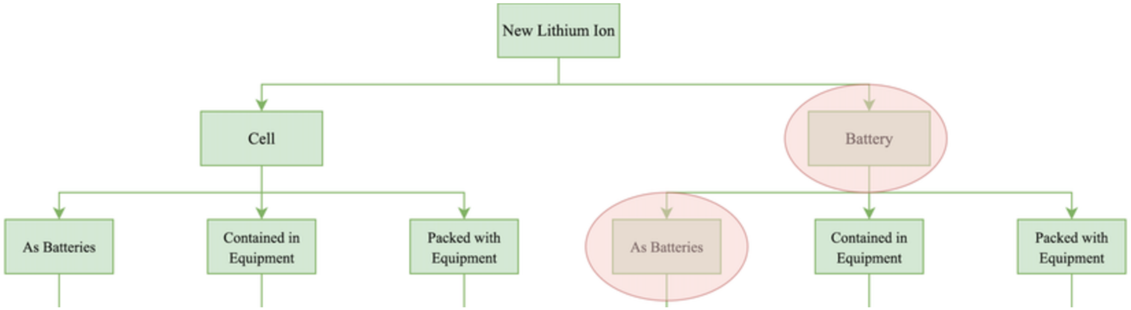
PHEV-C Lithium-Ion Battery Pack Overview

Battery Identification: PHEV-C High-Voltage Lithium-Ion Battery Pack
Configuration: Multi-cell module, nominal voltage ≈ 99 V
Samples Tested: PV1-19 – PV1-22 (4 identical modules tested per UN 38.3)
Nominal Energy: 6.2 kWh per module
Nominal Mass: 32 kg per module
Voltage Range: 98–100 V (stable before and after test)
Measured Losses: 0.00 % in both mass and voltage
UN 38.3 Status: Successfully passed all test sequences (T1–T8)
Condition: New / functional / non-defective.
These data confirm that the PHEV-C module represents a fully compliant lithium-ion traction battery designed for plug-in hybrid electric vehicles (PHEV).

Steps

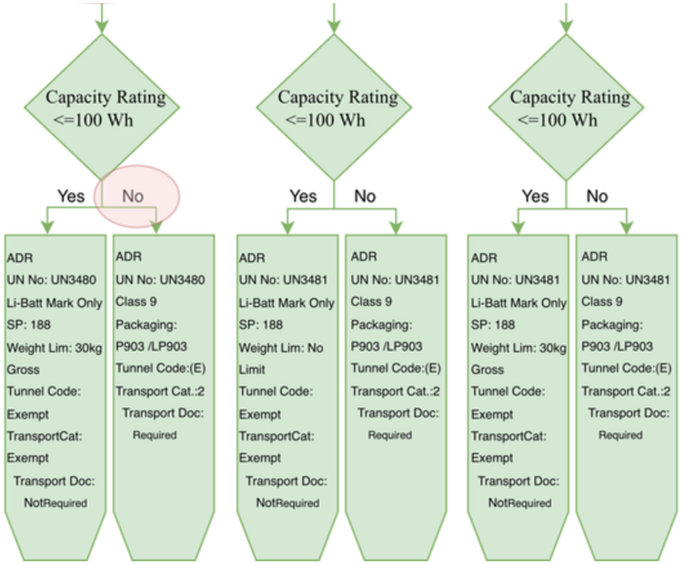
Step 1 – Identify the Battery Type

The item is a battery pack, not a single cell. It is shipped alone (not installed in equipment).
→ Classification Path: Lithium Ion Batteries



Step 2 – Check Capacity (SP 188 Criteria)

Each module ≈ 6.2 kWh and > 12 kg mass (> 100 Wh limit).
Does not qualify for SP 188 exemption. Full ADR compliance required.



ADR Compliance Framework

Step 3 – UN Number & Classification

UN Number: UN 3480

ADR Class: 9 – Miscellaneous Dangerous Goods

Tunnel Restriction Code: (E)

Transport Category: 2

Step 4 – Packaging Instruction

Apply P903 / LP903 requirements for tested batteries:

- Short-circuit protection
- Rigid outer packaging meeting PG II standard
- Secure restraint against movement and shock

Step 5 – Special Provisions to Verify

- SP 188 (checked → not applicable)
- SP 230 (authorization for compliant tested batteries)
- SP 348 (Watt-hour marking required)

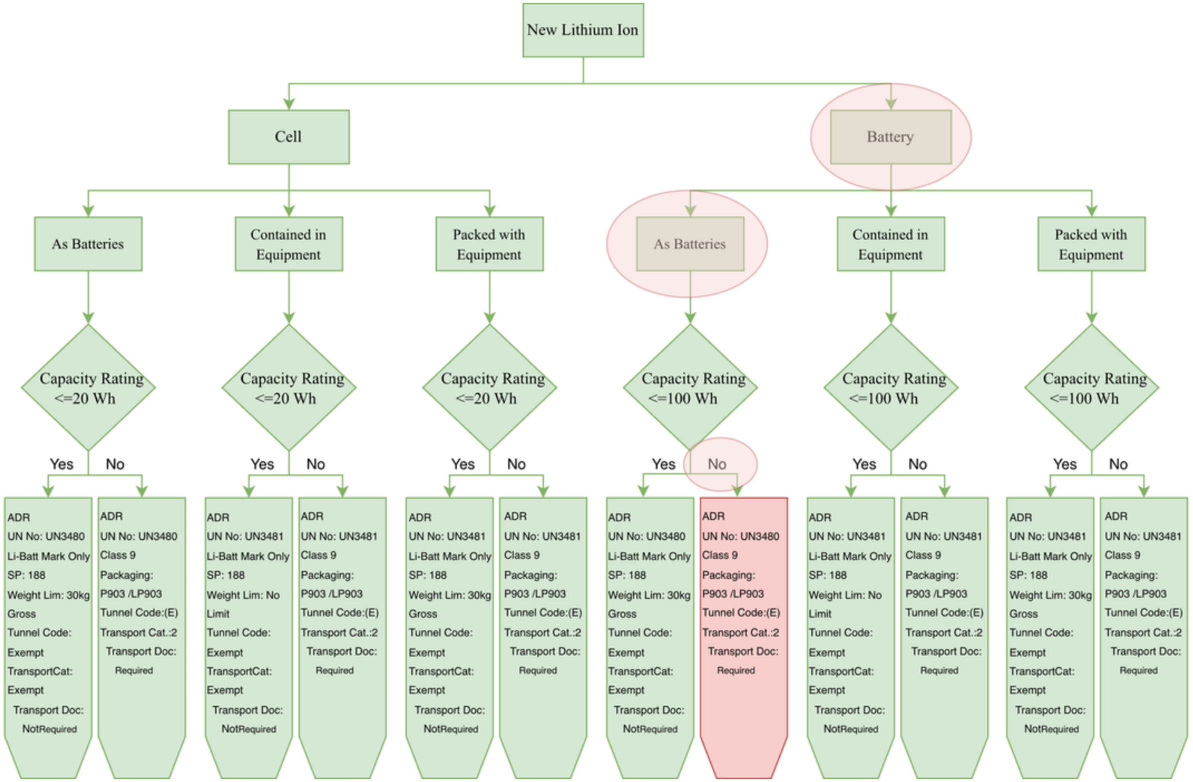
Step 6 – Documentation

Transport document must include: UN 3480, Proper Shipping Name “LITHIUM-ION BATTERIES”, Class 9, Packing Instruction P903 / LP903, net quantity per package, and shipper’s declaration.

Step 7 – Final Compliance Check

- Apply Class 9 label and Lithium Battery mark.
- Verify pack integrity and no mechanical damage.
- Ensure route avoids tunnels restricted under code (E).

Result: You can also see the hard packaging. The PHEV-C Battery Pack (PV1-19 → PV1-22) is shipped as **new lithium-ion battery** under UN 3480, Class 9, P903, with full ADR documentation and marking requirements applied.



Hard Packaging Must Include UN 3480 label, ADR Class 9 label , Manufacturer / Consignor Identification and the proper shipping name text:

“UN 3480 – Lithium-ion batteries.”

UN 3480 – LITHIUM-ION BATTERIES

Emerging Topics & Chemistry Differentiation

The family of lithium-ion batteries encompasses a variety of chemistries, each optimized for specific performance and safety needs. The six major types **NMC** (Nickel Manganese Cobalt), **LFP** (Lithium Iron Phosphate), **LTO** (Lithium Titanate), **NCA** (Nickel Cobalt Aluminum), **LCO** (Lithium Cobalt Oxide), **LMO** (Lithium Manganese Oxide), these chemistries differ in terms of energy density, stability, cost, and thermal behavior. Among these, **NMC and LFP** have emerged as the dominant chemistries in both electric vehicle and stationary energy storage applications. As innovation accelerates, these variations highlight the growing need for adaptable safety frameworks and evolving transport practices aligned with next-generation battery technologies.

NMC(Nickel Manganese Cobalt) Batteries

Nickel Manganese Cobalt (NMC) batteries represent one of the most widely used lithium-ion chemistries, offering a balanced combination of high energy density, power output, and cycle life. The cathode material typically consists of a layered oxide structure with varying ratios of nickel, manganese, and cobalt, commonly expressed as NMC111, NMC532, or NMC811, depending on the composition.

- Nickel increases energy density,
- Manganese enhances thermal stability, and
- Cobalt improves structural integrity and charge transfer.

NMC batteries are predominantly used in electric vehicles (EVs), hybrid vehicles, and portable electronics, where both high performance and compactness are essential. Their operating mechanism is based on the intercalation and deintercalation of lithium ions between the graphite anode and the layered NMC cathode during charge and discharge cycles. Despite their efficiency, NMC cells are sensitive to overcharging and mechanical abuse, requiring robust battery management systems (BMS) and protective transport conditions to prevent thermal runaway.

LFP (Lithium Iron Phosphate) Batteries

Lithium Iron Phosphate (LFP) batteries are characterized by their exceptional thermal stability, long cycle life, and enhanced safety performance. The cathode is composed of olivine-structured $LiFePO_4$, which offers strong P–O bonds that make oxygen release ,and thus combustion risk, significantly lower than in layered oxides like NMC.

LFP cells operate at a slightly lower nominal voltage (around 3.2 V) compared to NMC (typically 3.6–3.7 V), resulting in lower energy density but far greater chemical and thermal robustness.
These properties make LFP chemistry a preferred choice for commercial vehicles, energy storage systems (ESS), and low- to medium-range EVs, where safety, cost efficiency, and durability outweigh compactness.

Like NMC, LFP batteries operate via reversible lithium-ion movement between a graphite anode and the phosphate-based cathode, but their flat discharge profile and resistance to degradation under high temperature offer logistical advantages during storage and transport.

NMC & LFP Comparison

Nickel Manganese Cobalt (NMC) and Lithium Iron Phosphate (LFP) are two leading lithium-ion battery chemistries, each optimized for different performance needs.
LFP batteries offer high safety, thermal stability, long cycle life, and lower production cost due to abundant materials like iron and phosphate, making them ideal for storage systems, buses, and entry-level EVs.
NMC batteries provide higher energy and power density, preferred for high-performance EVs and portable electronics, though their nickel and cobalt content raises cost and sustainability concerns.
See the comparison table below for key technical distinctions.

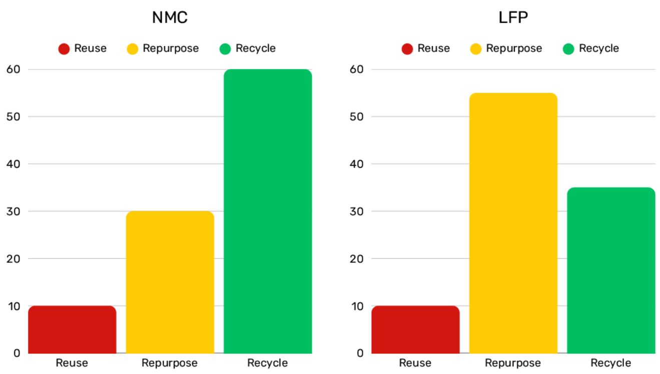
Parameter	LFP (Lithium Iron Phosphate)	NMC (Nickel Manganese Cobalt)
Energy Density	90–160 Wh/kg	150–260 Wh/kg
Cycle Life	> 2,000 cycles (longer lifespan)	1,000–2,000 cycles
Thermal Stability	Very high – stable up to 270 °C	Moderate – risk of thermal runaway above 180 °C
Safety	Excellent; low fire/explosion risk	Moderate; requires advanced cooling and BMS
Cost	Lower due to cheap raw materials (Fe, P)	Higher due to Ni, Co
Raw Material Availability	Abundant and low environmental risk	Scarce; cobalt/nickel raise sustainability issues
Nominal Voltage	3.2–3.3 V	3.6–3.7 V
Power Output	Moderate	High (better for fast acceleration)
Operating Temperature Range	–20 °C to 60 °C	–20 °C to 55 °C
Recyclability	Easier and less costly	More complex and expensive
Environmental Impact	Lower – non-toxic materials	Higher – heavy metals used
Typical Applications	Stationary storage, buses, low cost EVs	High performance EVs, consumer electronics

Regulation & End-of-Life Differences

While **ADR applies the same classification** and packaging rules for both chemistries, their end-of-life paths differ significantly.

As shown in the graph, NMC batteries contain valuable metals like **nickel, cobalt, and manganese**, making them more favorable for recycling through hydro- or pyrometallurgical recovery. These metals retain market value and support closed-loop production.

Battery end-of-life Potential



LFP batteries, on the other hand, use **iron and phosphate** with lower economic value, so they are more often repurposed for stationary storage instead of recycled.
Recycling plants typically separate NMC and LFP waste streams to improve efficiency and meet **EU Battery Regulation (2023/1542)** recovery goals.

Emerging Alternatives to Lithium-Ion Batteries

The rapid evolution of energy storage technologies has led to the emergence of promising alternatives to conventional lithium-ion systems. In this section, we focus on two of the most discussed next-generation chemistries : **Solid-State Batteries** and **Sodium-Ion Batteries**.

Both aim to address key limitations of current lithium-ion technology, such as safety risks, supply chain dependency, and material scarcity, while maintaining efficient electrochemical performance.

Here, we are going to introduce their operating principles, technical characteristics and potential impact on future transport and storage systems.

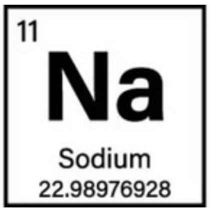
Sodium-Ion Batteries

Sodium-ion batteries (Na-ion) are an emerging alternative energy storage technology designed to complement and, in some applications, replace conventional lithium-ion systems. While the fundamental electrochemical principle is similar—reversible ion transfer between anode and cathode during charge and discharge—the key distinction lies in the use of sodium (Na^+) instead of lithium (Li^+) as the charge carrier.

From a market perspective, sodium-ion technology is currently in the **early commercialization phase**, with several manufacturers in China, Europe, and India scaling pilot production. Major developments have been driven by some companies , focusing on cost-sensitive and resource-stable alternatives to lithium.

In practical applications, sodium-ion batteries are increasingly used in:

- **Stationary energy storage systems** (ESS) for grid balancing and renewable integration, where energy density is less critical but cost and safety are primary drivers.
- **Two- and three-wheeler electric vehicles**, **low-range passenger EVs**, and **industrial mobility equipment**, offering resilience under low temperatures and faster charging capabilities.
- **Backup power**, **telecommunication infrastructure**, and **off-grid systems**, benefiting from long cycle life and robust safety characteristics.

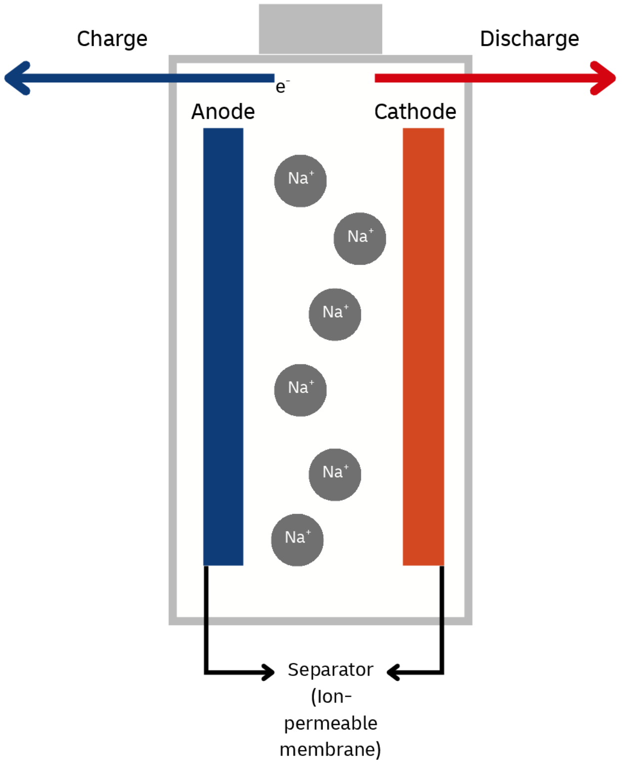


Continuing on this topic, this section further explains the **working principle** of **sodium-ion batteries**.

These batteries operate through the reversible movement of sodium ions (Na^+) between the cathode and anode during charge and discharge cycles, similar in structure to lithium-ion systems.

During charging, sodium ions migrate from the cathode to the anode through an ion-permeable separator, while electrons flow through the external circuit to balance charge transfer. In the discharge phase, the process reverses Na^+ ions return to the cathode and electrons flow back through the circuit, generating electrical current for use.

This electrochemical mechanism is supported by a robust cell architecture optimized for larger sodium ions, prioritizing safety, structural integrity, and low-cost material selection.



The **separator** plays a critical role by allowing ionic conductivity while preventing physical contact between electrodes, ensuring both safety and electrochemical stability.

Typical anode materials include **hard carbon** or **titanium-based compounds**, while cathodes often consist of **layered oxides** (e.g., Na_xMO_2) or **Prussian white analogues**, both capable of storing and releasing sodium ions efficiently.

Because sodium ions are **larger and heavier** than lithium ions, they impose more mechanical stress on the electrode structure, slightly reducing energy density (typically around 100–160 Wh/kg) but offering improved thermal stability, safety, and cost-effectiveness.

The ability to operate reliably under wide temperature conditions and to be safely transported at zero state of charge reinforces sodium-ion's logistical advantages. However, operators must note that while 0V transport eliminates electrical short-circuit risks, these batteries remain regulated under ADR 2025 as Dangerous Goods (UN 3551 or UN 3552) due to the chemical hazard of their flammable organic electrolytes.

As of 2025, sodium-ion batteries are recognized not as replacements but as complementary solutions within the global electrification ecosystem, particularly suited for applications prioritizing cost-efficiency, sustainability, and operational safety over maximum range or compactness.

Solid State Batteries

Solid-state batteries (SSBs) represent the next generation of electrochemical energy storage technologies, designed to address the intrinsic safety and performance limitations of conventional lithium-ion systems.

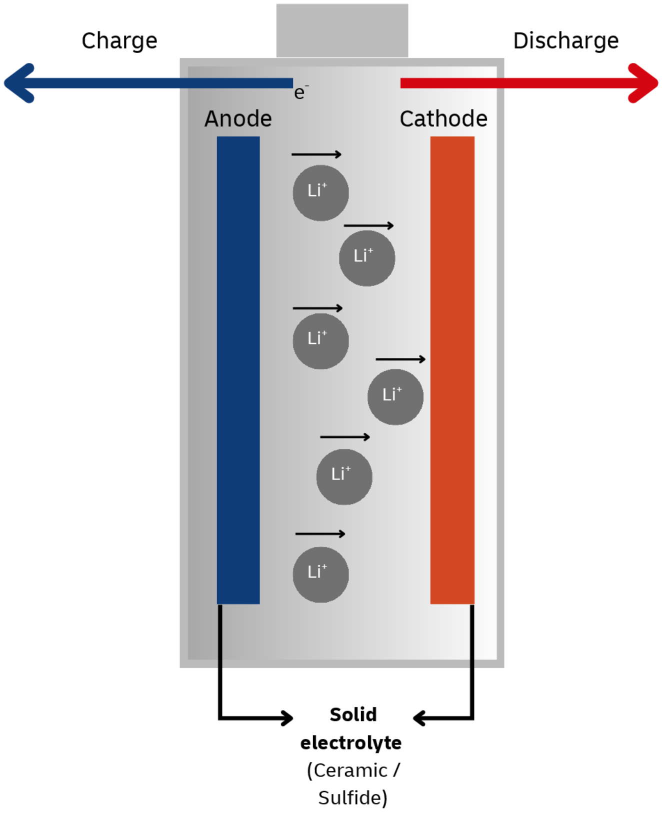
Unlike traditional cells that rely on liquid electrolytes, solid-state designs use **solid ionic conductors** such as ceramic, glass, or sulfide-based materials to enable lithium-ion transport between the anode and cathode.

This transition to a solid electrolyte significantly enhances energy density, thermal stability, and operational safety, while virtually eliminating risks associated with leakage or thermal runaway.

As a result, solid-state batteries are viewed as a key enabler for future electric mobility, aerospace systems, and high-performance stationary storage, where both safety and energy efficiency are critical.

Although large scale commercialization remains in development, ongoing research focuses on solving challenges such as interface resistance, manufacturing scalability, and cost efficiency. Once these barriers are overcome, solid-state batteries are expected to redefine the energy-to-safety ratio, setting a new benchmark for advanced battery logistics and next-generation energy transport systems.

Solid-state batteries operate on the same electrochemical principles as conventional lithium-ion cells but replace the liquid electrolyte with a solid ionic conductor, such as a **ceramic** or **sulfide-based material**. During discharge, lithium ions (Li^+) migrate from the anode to the cathode through the solid electrolyte, while electrons (e^-) flow through the external circuit, delivering electrical energy to the connected load. During charging, this process is reversed, driving Li^+ ions back to the anode where they are re-deposited as metallic lithium.



The solid electrolyte acts as both an ionic conductor and a physical separator, preventing direct contact between electrodes and thereby eliminating the risk of electrolyte leakage or dendritic short circuits. This structure enhances safety, thermal stability, and energy density while reducing the likelihood of thermal runaway. Solid-state batteries are viewed as a next generation solution for electric mobility and stationary energy storage, combining the high performance of lithium-based systems with improved operational safety and longevity.

Battery Types Comparison

In the evolving field of energy storage, lithium-ion, sodium-ion, and solid-state batteries represent three of the most significant technological directions shaping the future of electric mobility and renewable energy integration. Each chemistry brings distinct advantages in terms of performance, safety, and cost, addressing different industrial and operational priorities.

Lithium-ion batteries remain the global standard for electric vehicles and portable electronics due to their high energy density and mature supply chain. Sodium-ion batteries, leveraging abundant and low-cost raw materials, are gaining traction for stationary energy storage and short-range electric mobility, where affordability and sustainability take precedence over maximum range. Solid-state batteries, meanwhile, mark the next frontier in electrochemical innovation, offering higher energy density and enhanced safety through the use of non-flammable solid electrolytes making it ideal for high performance EVs and aerospace applications.

These three technologies together form a diversified energy ecosystem, where each contributes to balancing efficiency, sustainability, and safety across the supply chain and transport sectors.
Table below compares Li-ion, Sodium-ion, and Solid-State batteries across core technical and commercial parameters.

Parameter	Li-ion	Sodium-ion	Solid-State
Energy Density	160–250 Wh/kg (up to 300 Wh/kg in top NMC)	100–160 Wh/kg; next-gen 180–200 Wh/kg	250–500 Wh/kg; lab cells up to 800 Wh/kg
Cycle Life	1,000–5,000+ (LFP higher)	2,000–3,000; improving to ~5,000	5,000–10,000+ (potential); lab-only today
Thermal Stability	Sensitive above 130–150 °C	Stable across wide temp; low fire risk	Very high; non-flammable solid electrolytes
Safety	Fire risk if damaged; strict transport rules	Safer chemistry; minimal fire risk	Excellent safety; reduced short-circuit, no venting
Cost	$70–150/kWh; LFP very cheap	$70–100/kWh; lower long term	High (pre-commercial); cost drop expected post-2027
Applications	EVs, electronics, grid, tools, e-bikes	Grid, 2W/3W EVs, cold climates	Future EVs, aerospace, drones, premium devices
Maturity	Fully mature; global scale	Early stage; growing quickly	In R&D; limited pilots, EV use expected after 2027

Li-ion dominates today due to high energy density, established supply chains, and versatility, though it requires robust safety measures. **Sodium-ion** is emerging as a low-cost, safer alternative with moderate performance, ideal for stationary storage and budget mobility. **Solid-state batteries** promise breakthroughs in energy and safety but remain pre-commercial; mass EV deployment is expected post-2027.

New & Upcoming ADR Regulations

The 2025 edition of ADR entered into force on 1 January 2025. The transition period ended on 30 June 2025. As of 1 July 2025, the new provisions are fully mandatory for road transport of battery-powered articles and battery consignments in Europe.

What changed for batteries ?

ADR 2025 adds dedicated entries for sodium-ion systems and clarifies battery-powered vehicle entries:

UN 3551: Sodium-ion batteries
UN 3552: Sodium-ion batteries contained in equipment / packed with equipment
UN 3556: Vehicle, lithium-ion battery powered
UN 3557: Vehicle, lithium metal battery powered
UN 3558: Vehicle, sodium-ion battery powered
Lithium-ion batteries remain under UN 3480 (as batteries) and UN 3481 (in/with equipment).

Packaging and special provisions:

Core instructions continue to apply: **P903/LP903** (new, compliant batteries),**P908/LP904** (damaged/defective-non critical),**P911/LP906** (critically defective) **P909/LP904** (used for reuse/recycling), **P910** (prototype/low-volume). Editorial updates align these with the new sodium-ion entries. Small-battery relief analogous to **SP188** now exists for sodium-ion; **SP360/376/377** remain the key cross-cutting provisions for equipment, damaged/defective, and waste/recycling scenarios.

What Operators Should Do Now

- Classification and UN selection updated to include **UN 3551/3552** for **sodium-ion**; continued use of **UN 3480/3481** for **lithium-ion**.

- Documentation revised to cite the correct UN entry, proper shipping name, hazard class, and **P903/P908/P909/P910** references as applicable.

- Outer-package **marks and labels refreshed** to the correct chemistry/entry; lithium battery mark used where required. Manufacturer or consignor identification and an emergency contact made clearly visible.

- **SOPs and training** amended for the use of BEV/H_2 tractor units under ADR, including parking, isolation, and incident procedures.

- **Data and traceability** processes aligned so battery chemistry, configuration, test status (UN 38.3), and condition are captured at booking and travel with the shipment, this sets up seamless integration with digital provenance tools in the next section.

ADR 2027 Battery-Relevant Items to Monitor

With **ADR revisions expected by 2027**, the following section summarizes the main battery specific changes anticipated under the upcoming framework:

2025→2027

New Special Provision 680 (linked to P911 / LP906)
Draft text introduces SP 680 for consignments using P911 or LP906 to move damaged or defective lithium batteries/cells. Where packaging performance depends on specified environmental/operational conditions, the consignor must describe those conditions and attach them to the transport document, making them available to loaders and carriers. This tightens documentation discipline around P911/LP906 moves.

Disposal/Recycling flows additional packaging option (Li-ion & Na-ion)
The Joint Meeting has advanced an additional packaging option for the carriage of lithium and sodium-ion batteries to disposal/recycling, which is slated for the 2027 text. Track the final wording and cross-references to packaging instructions at adoption.

Harmonization clarifications
Expect alignment edits that: Reflect UN Model Regulations Rev. 24 updates on hybrid batteries containing both Li-ion and Na-ion cells, and clarify assignment of equipment powered by Li-ion or Na-ion to the correct UN 3091 (lithium) or UN 3552 (sodium-ion) entries.
These are classification/wording clarifications rather than new obligations. Other major changes anticipated for ADR-2027 are not battery related.

Beyond ADR: The Digital Battery Passport

While ADR governs physical transport safety, the European Union is now introducing a digital traceability layer that complements, rather than replaces, these road-safety rules the **Digital Battery Passport** (DBP).

From 18 February 2027, under Regulation (EU) 2023/1542, all electric vehicle (EV), light means of transport (LMT), and industrial batteries above 2 kWh must carry a QR-code–linked passport providing standardized lifecycle data.

This initiative adds transparency to the entire value chain from production and shipment to repair, second life, and recycling and will reshape how logistics operators verify and handle batteries.

Did You Know? – The Future of Battery Traceability

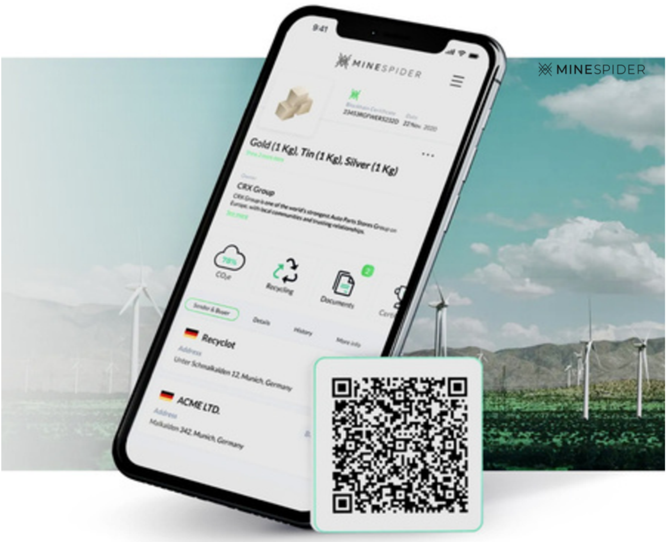
Blockchain-Enabled Battery Compliance: The Minespider Approach

As lithium-ion battery transport evolves under stricter ADR and EU regulatory frameworks, transparency and data traceability are becoming just as vital as physical safety.

Specifically, **ADR 5.4.1** mandates that the transport document must declare the battery's chemical nature and condition. The **Digital Battery Passport** (DBP) serves as the verified "single source of truth" for this critical data. Minespider's blockchain-based platform bridges the gap by allowing logistics operators and roadside inspectors to instantly verify mandatory **UN 38.3** test summaries via a simple QR scan. This digital verification transforms complex customs and safety checks into a seamless process, reducing delays while ensuring full regulatory adherence.

Through collaboration with **Minespider**, DHL advances toward a future where safe transport and digital traceability work hand in hand building trust, improving compliance, and supporting a circular battery economy.

Minespider's Digital Battery Passport helps you map supply chains, collect supplier data, and meet due diligence requirements long before the 2027 deadline. Get started today and future-proof your compliance.



Acknowledgement

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