



QUALITY MANUALS | FIRST EDITION

Second Life Battery Management

Automotive Quality Manual

STABLE RELEASE

Document No. IAF-MAN-SLB-001 | Revision 01

Retired battery assessment, stationary storage integration,
commissioning, operation and final disposition

International Automotive Federation

English master text | 15 September 2026

iaf.com

Publication identity and use

This manual defines the assessment and integration controls for retired automotive lithium-ion batteries proposed for stationary energy storage. It requires evidence of safety, condition and suitability for the intended duty before a battery enters a new system or installation.

Control	Publication record
Document	IAF-MAN-SLB-001 IAF Second Life Battery Management Manual
Edition and revision	First Edition Revision 01 Stable Release
Text issue	15 September 2026 English master text
Document owner	IAF Quality function and the relevant automotive technical committee
Custodian	IAF Secretariat and Document Controller
Authority	Competent authority under the IAF Constitution and document-control process.
Operational adoption	The accountable operating organisation records its actual scope, approvals and effective date.
Classification	Public core manual. Completed product, personnel and technical records follow their assigned access controls.

Application of requirements

“Shall” identifies a requirement when adopted by an organisation or agreement.
“Should” identifies a recommendation. The responsible organisation shall implement the requirements through competent personnel, validated methods and controlled local specifications. Worked examples use fictional data and establish no universal test setting, tolerance or operating permission.

Publication and operational acceptance

Stable Release identifies the completed publication text. Actual technical validation, permits, product decisions and safe work authorisations shall be recorded by the responsible organisation. Mandatory requirements and current product-specific safety instructions remain controlling for the operation. Using this manual alone does not confer certification, accreditation, Corporate Recognised status or IAF mark rights.

Control of local implementation

Maintain exact legal identifiers, applicable dates, technical limits and operating parameters in controlled local registers. Use the annexes to build case records with actual evidence, names and dates. Apply the IAF Documents and Records Guide to revisions, retention, access and disposal. No approval or historical implementation is implied by a blank form or an illustrative calculation.

Contents

Select an entry to open its section. Page numbering includes the cover.

1 Purpose and second life scope	4
2 Terms and performance quantities	4
3 Governance and system responsibility	5
4 Programme adoption and operating obligations	5
5 Application requirements and duty profile	6
6 Provenance and service history	6
7 Vehicle removal and safe handover	6
8 Transport and intermediate storage	7
9 Receipt and quarantine procedure	7
10 Identity data integrity and battery history record	8
11 Initial condition and exclusion decisions	8
12 Test plan and progression controls	9
13 Instrumentation calibration and uncertainty	9
14 Capacity and usable energy assessment	10
15 Power capability and resistance assessment	10
16 Self discharge and stability observation	11
17 Insulation connections and protective interfaces	11
18 Thermal behaviour and cooling condition	12
19 Battery management system and diagnostic evidence	12
20 Grading and module compatibility	13
21 Pack opening and module separation	13
22 Restoration and replacement boundaries	13
23 Mechanical architecture and enclosure design	14
24 Electrical architecture and protective coordination	14
25 Thermal management and fire safety design	15
26 Energy management software and cybersecurity	15
27 Solar energy storage integration	16
28 Factory backup and load support	16
29 Grid interface and electrical installation	17
30 Factory acceptance and integrated verification	17
31 Delivery installation and site readiness	18
32 Commissioning and operational handover	18
33 Operation monitoring and preventive maintenance	19
34 Alarm handling and incident response	19
35 Ageing review and remaining useful life	20
36 Warranty service and customer information	20
37 End of second life and final disposition	20
38 Environmental economic and performance measures	21
39 Competence audits and practical exercises	21
40 Records interfaces and revision control	22
Annex A Application adoption and system design brief	22
Annex B Battery assessment dossier	23
Annex C Assessment method and acceptance register	24
Annex D Module matching and assembly genealogy	24
Annex E Worked capacity and energy assessment	25
Annex F Factory acceptance and site commissioning record	26
Annex G Service review and retirement decision	26
Annex H Abnormal trend and communication loss exercise	27

1 Purpose and second life scope

1.1 This manual defines the quality controls for assessing retired automotive lithium-ion batteries and integrating suitable units into stationary energy storage. It covers collection, safe handover, history review, testing, grading, system design, commissioning, operation and final disposition. Applications may include solar energy storage, factory demand management and backup power within an explicitly validated operating envelope.

1.2 A measured capacity below 70 percent of a defined original reference may trigger assessment within an adopted programme. It shall not create automatic second-life eligibility, require every vehicle battery to be removed or establish a universal end-of-vehicle-life threshold. Batteries above that value may be unsafe or unsuitable; batteries below it require the same evidence-based safety and application assessment.

1.3 The operating organisation shall approve the battery families, architectures, sites and applications within scope. Approval for intact-pack evaluation shall not authorise module disassembly, cell repair or unrestricted integration into another enclosure. Each activity shall have the necessary competence, equipment, technical information and lawful authority before it is performed.

1.4 The intended output is a traceable stationary system with a declared performance and safety basis. An automotive battery's former vehicle approval or successful capacity test shall not be represented as approval of the new installation. Product and site-specific instructions shall supply actual test settings, protection limits and operating conditions.

2 Terms and performance quantities

2.1 State of charge describes the estimated available charge relative to the applicable usable range. State of health describes condition relative to a specified reference and may concern capacity, energy, power or another characteristic. Reports shall identify the metric rather than use one percentage as a complete description of battery health or safety.

2.2 Capacity shall be reported in ampere-hours and energy in watt-hours or kilowatt-hours, with the measurement boundary and conditions. Power in kilowatts describes a rate of delivery and cannot be inferred from energy alone. A storage system supplies previously stored energy; it is not an independent energy-generating source merely because it supports a factory during an outage.

2.3 A cell is the basic electrochemical unit; a module contains an arranged group of cells; a pack includes additional structures and controls. A battery energy storage system combines battery assemblies with power conversion, protection, control, thermal management and the necessary installation interfaces. Suitability shall be assessed at every relevant level.

2.4 Remaining useful life is an estimate conditional on future duty, environment and the end criterion. It shall include assumptions and uncertainty. A retired pack, an assessed candidate, an accepted module and a commissioned storage system are distinct statuses, each requiring its own decision and retained evidence.

3 Governance and system responsibility

3.1 The accountable director shall appoint a technical owner for battery assessment and a design authority for the stationary system. Quality shall control acceptance evidence and release. Safety, environmental, electrical and fire specialists shall approve controls within their competence. The system integrator shall retain responsibility for interactions that individual component suppliers cannot assess in isolation.

3.2 The role matrix shall cover removal contractors, transporters, assessment laboratories, assembly personnel, commissioning engineers, site operators and end-of-life processors. Each handover shall define the actual condition, restrictions and outstanding actions. A supplier's statement that a pack is disconnected shall not transfer responsibility for verifying the next safe work boundary.

3.3 Release authority shall distinguish candidate acceptance, module grading, design validation, factory acceptance and site energisation. No single commercial approval shall replace these decisions. Independent technical review shall be required for significant safety cases, departures from the validated design and unresolved discrepancies between history and test results.

3.4 IAF adoption supports a common management approach within the agreed scope. It shall not itself grant electrical installation permission, grid access, product certification or IAF mark rights. The responsible legal entities shall record their actual obligations, approvals and competent persons before the battery or system enters the relevant stage of use.

4 Programme adoption and operating obligations

4.1 Before accepting batteries, the organisation shall identify the applicable product, waste, transport, electrical, environmental, planning, privacy and fire-safety obligations. The controlled register shall record exact requirements, versions, dates, responsible interpretations and evidence. A reused battery shall not be assumed to retain the same legal classification throughout removal, transport, processing and resale.

4.2 The adoption record shall define the approved battery families, known chemistries, permissible histories, test capability and intended application classes. It shall identify excluded work, including activities for which technical data or safe facilities are unavailable. Expansion from one pack family to another shall receive a documented assessment of design and hazard differences.

4.3 The readiness review shall confirm suitable premises, quarantine capacity, emergency arrangements, verified equipment, trained personnel, data access and qualified downstream partners. A trial programme shall remain controlled until the assessment route and integration design are supported by evidence. Demonstration equipment shall not be supplied as an unrestricted commercial system.

4.4 The compliance owner shall review changes to markets, installation conditions and operating permissions. Published guidance shall remain separate from the actual local approval record. Where requirements are uncertain, the affected activity shall pause for competent determination while unrelated approved work may continue under clear segregation.

5 Application requirements and duty profile

5.1 The system owner shall define the service before batteries are selected. Requirements shall include usable energy, continuous and transient power, operating duration, charge opportunities, ambient conditions, availability, expected cycling and the consequences of service loss. Solar shifting, peak reduction and emergency backup can impose different duty patterns and shall not share assumptions without assessment.

5.2 The design basis shall identify the electrical boundary at which performance is promised. Battery-terminal energy, inverter output and energy delivered to the supported load are different quantities. Auxiliary consumption, conversion losses, reserve requirements and degradation allowance shall be included when converting a battery assessment into a customer-facing capacity promise.

5.3 Critical loads shall be identified separately from discretionary loads. The owner shall define acceptable transfer interruption, startup demand, load shedding and the role of other power sources. Second-life storage shall not be credited as the sole support for a critical function unless the complete reliability and safety case permits that use.

5.4 The duty profile shall become an input to test selection, grading, thermal design, protection settings and warranty. Changes to the load, solar array, operating schedule or site environment shall trigger review. A system accepted for gentle daily cycling shall not automatically be suitable for repeated high-power industrial starts.

6 Provenance and service history

6.1 Purchasing shall obtain lawful ownership and available evidence of the battery's identity, vehicle application, chemistry, age, service exposure and prior repairs. History shall address collision, flood, overheating, abnormal charging, prolonged storage and relevant recalls or field campaigns. Missing information shall remain visibly unknown rather than be replaced by a standard clean-history declaration.

6.2 Data supplied by the vehicle, battery controller, owner and service network shall be reconciled where access is lawful. Differences in serial numbers, reported capacity or fault history shall be investigated. A controller replacement or reset may limit the reliability of accumulated history and shall be recorded as such.

6.3 The acceptance policy shall define which histories are excluded from ordinary second-life processing and which require specialist evaluation. Capacity testing alone shall not resolve credible evidence of hidden damage. The organisation shall avoid purchasing conditions that financially reward a supplier for withholding adverse history.

6.4 Supplier approval shall consider data quality, safe removal practices, packaging, response to discrepancies and actual rejected-condition trends. Contracts shall preserve the right to inspect and reject. Legal title, commercial valuation and technical suitability shall remain separate decisions so that payment does not become evidence of acceptance.

7 Vehicle removal and safe handover

7.1 Removal shall be performed by authorised personnel using current vehicle-specific information and a task-specific safe work procedure. The work plan shall address

vehicle stability, high-voltage isolation, stored energy, lifting, coolant or other connected services and emergency response. This manual does not provide a generic disconnection sequence suitable for every vehicle architecture.

7.2 Before removal, the responsible technician shall assess damage, unusual temperature, leakage, deformation and other indicators that may require a specialist recovery route. The battery shall not be energised or mechanically disturbed merely to obtain convenient diagnostic data when its condition makes that action unsafe. Uncertainty shall be escalated to the designated technical and safety leads.

7.3 The handover record shall state the battery identity, vehicle identity where lawfully retained, observed condition, completed isolation steps, remaining energy hazards and handling restrictions. A disconnected pack may retain hazardous internal voltage and chemical energy. The recipient shall verify the information needed for its own task rather than presume the assembly is energy-free.

7.4 Removal damage, missing fasteners or disturbed cooling connections shall be documented. Lifting and transport provisions shall protect the pack against structural load paths it was not designed to support. The battery shall enter an identified custody and status record before it leaves the removal location.

8 Transport and intermediate storage

8.1 A competent transport function shall determine classification, packaging, documentation and routing for the actual battery condition. Damaged, defective, recalled or otherwise restricted batteries may require different arrangements from intact used batteries. The shipper shall not use an ordinary used-product description to avoid controls applicable to the consignment.

8.2 Packaging shall prevent movement, short circuit, damage and unintended contact with conductive objects. It shall be compatible with the battery's geometry, mass and condition. Required state-of-charge conditions and transport restrictions shall come from the applicable approved route; no single percentage in this manual applies to every battery and transport mode.

8.3 Intermediate storage shall have a defined responsible custodian, segregation, environmental conditions, inspection and emergency access. The logistics record shall retain departures from planned conditions, impact events, delays and handling damage. An unexplained event shall be assessed before the battery enters routine electrical testing.

8.4 Before shipment, the sender shall obtain receiving-site acceptance and confirm that the intended destination can manage the declared condition. Route changes shall preserve those capabilities. The chain of custody shall continue until receipt is confirmed, including any rejected consignment or transfer to a specialist recovery contractor.

9 Receipt and quarantine procedure

9.1 Receiving personnel shall reconcile the consignment, identifiers, condition statement and transport evidence without opening or energising an uncertain battery. The initial screen shall identify visible damage, leakage, abnormal heat, odour, deformation and missing protection. It shall occur in an area suitable for the site's accepted battery types and response arrangements.

9.2 Every item shall receive an intake identity and a status that prevents routine charging or assembly before assessment. The quarantine record shall state the reason, access restrictions, responsible owner and next review. Batteries with different hazard conditions shall not be grouped indiscriminately merely because all are awaiting inspection.

9.3 Any sign of active deterioration shall trigger the site's emergency procedure and trained response. Personnel shall not move, open, immerse or attempt to cool an unstable pack using an improvised method. Emergency specialists shall determine protective actions for the actual design, condition and location, with life safety taking priority over asset recovery.

9.4 A controlled technical review shall authorise entry into the next assessment stage. Commercial acceptance or a capacity estimate supplied by the seller shall not release the quarantine. Prolonged holds shall be reviewed for changing condition, storage suitability and the need to transfer the item to a qualified specialist.

10 Identity data integrity and battery history record

10.1 The record system shall link original pack and module identifiers to each new assessment, restoration and system identity. Where assemblies are separated or regrouped, the parent-child relationship shall remain recoverable. A newly assigned serial number shall not erase the retired battery's history or imply that its cells are newly manufactured.

10.2 The data record shall identify the source, time, method and limitations of each history item or measured value. Raw test data and interpreted grades shall be distinguishable. Corrections shall preserve the earlier value and reason. A copied controller display shall not be treated as an independently measured capacity result.

10.3 Access to diagnostic information, firmware and security credentials shall be lawful and limited to authorised roles. Personal data from the former vehicle owner shall be minimised and separated from technical evidence. Data sharing with integrators and operators shall provide the information needed for safe use without exposing unrelated personal or proprietary material.

10.4 The final system record shall permit a search from an affected original battery or component lot to every installed location. The organisation shall periodically demonstrate that this search works. Unlinked modules shall remain on hold until reliable identity is established or a permitted alternative disposition is selected.

11 Initial condition and exclusion decisions

11.1 The technical assessor shall review the history and intake observations before authorising electrical tests. The assessment shall consider structural damage, corrosion, liquid ingress, evidence of thermal events, unusual cell imbalance and missing safety controls. A battery that appears mechanically intact may still have an unresolved history affecting suitability.

11.2 The programme shall define conditions that exclude an item from the routine assessment route. Suspected thermal damage, compromised containment or unresolved internal faults shall require specialist disposition rather than ordinary capacity cycling. Engineering shall document whether additional non-invasive evidence can resolve the concern without increasing risk.

11.3 The assessor shall classify each item as eligible for the next test stage, held for specified investigation or rejected for the proposed second-life application. The decision shall identify the evidence and residual uncertainty. Rejection for one application shall not automatically establish suitability for a supposedly less demanding application.

11.4 Any alternative route shall retain the original concern and receive its own competent approval. Staff shall not reset fault history, replace a label or dilute a suspect population with acceptable modules to obtain a better average grade. Where safe reuse cannot be demonstrated, the item shall enter the authorised material recovery route.

12 Test plan and progression controls

12.1 Engineering shall approve a test plan for each battery family and intended duty class. The plan shall define sequence, fixtures, instrumentation, environmental conditions, permitted operating range, data capture and acceptance criteria. It shall distinguish screening, unit verification, family validation and tests that deliberately stress or damage designated specimens.

12.2 Progression shall depend on accepted evidence from the preceding stage. History and condition review shall precede controlled energisation; relevant safety checks shall precede performance cycling. The exact sequence shall follow the approved design and facility assessment. An operator shall not skip a failed prerequisite because the next test might produce a useful commercial result.

12.3 Each test shall have observable stop conditions and a safe response established before it begins. Abnormal voltage behaviour, temperature, leakage, communication loss or protection malfunction shall trigger the specified hold and investigation. Automated equipment shall not continue charging an uncertain item solely because a data field is missing rather than explicitly failed.

12.4 The plan shall define repeatability checks, retest rules and how missing data affects acceptance. Additional testing shall have a reason and an approved method. Repeated cycling until a favourable result appears shall be prohibited. The final assessment shall report the full relevant history, including failed, interrupted and invalid tests.

13 Instrumentation calibration and uncertainty

13.1 The test laboratory shall maintain a register of current, voltage, temperature, time, insulation and other measurement resources. Each resource shall be suitable for the range and decision being made, with verified configuration and calibration or other appropriate traceability. Fixture losses and sensor placement shall be considered where they materially affect results.

13.2 The operator shall record battery identity, equipment identity, software revision, environmental conditions and the test method before starting. Channels shall be mapped to the correct cells or modules. Time synchronisation shall support interpretation of electrical and thermal events. A plausible graph shall not be accepted when its channel identity is uncertain.

13.3 Engineering shall evaluate repeatability, drift and uncertainty for the relevant result. Acceptance near a limit shall follow a predefined decision rule. Capacity

estimates from a controller, a rapid diagnostic model and a measured cycle shall not be treated as interchangeable without validation of their relationship and limitations.

13.4 Equipment faults shall trigger review of results produced since the last reliable verification. The laboratory shall identify affected batteries and suspend unsupported grades. After repair, reference checks shall demonstrate that the measurement chain works correctly, while a separate product-impact assessment determines whether previous units require retest or containment.

14 Capacity and usable energy assessment

14.1 The capacity method shall specify the battery family, initial conditioning, charge and discharge boundaries, current profile, temperature, rest conditions and data treatment. All operating settings shall remain within the validated safe test envelope. The laboratory shall use appropriate containment, supervision and protective controls for the battery's assessed condition.

14.2 Measured charge shall be calculated from the integrated current over the defined interval, and energy from integrated voltage and current. The report shall retain actual test conditions and the measurement boundary. Energy measured at the battery terminals shall not be reported as energy delivered through an inverter to the final load.

14.3 State-of-health calculations shall use a stated, comparable reference. Changes in temperature, usable window, rate or reference definition can change the percentage and shall be disclosed. A value below 70 percent shall prompt the programme's defined evaluation; it shall not bypass the safety, power and remaining-duty assessment required for second-life acceptance.

14.4 Repeat testing shall follow the approved stability and validity rules. Engineering shall investigate unexpected variation or divergence from history. The final grade shall include uncertainty and any restricted operating conditions. It shall not promise a remaining service duration solely from one measured energy or capacity percentage.

15 Power capability and resistance assessment

15.1 The power assessment shall establish whether the battery can support the intended load within its approved electrical and thermal limits. Engineering shall select a method appropriate to chemistry, architecture, condition and duty. A pack with adequate energy may still be unsuitable for a high-power load because voltage drop, heating or protection limits constrain delivery.

15.2 Where a resistance or pulse method is used, the procedure shall define state of charge, temperature, pulse profile, measurement interval and calculation. The battery shall first satisfy the prerequisites for that method. Operators shall not apply an arbitrary high-current pulse to an uncertain assembly to estimate its condition.

15.3 Results shall be interpreted against a validated reference and the actual application. Contact resistance, fixtures, control behaviour and temperature shall be considered when comparing modules. A single resistance number shall not be treated as a complete safety or ageing diagnosis, and values obtained by different methods shall not be pooled without justification.

15.4 The accepted power envelope shall be recorded alongside energy and capacity. Any derating shall be enforced by the system design and controller configuration, not

only stated in a report. Evidence of abnormal heating, unstable response or unexplained imbalance shall create a hold and specialist review before further cycling or integration.

16 Self discharge and stability observation

16.1 The assessment plan shall define an observation method capable of detecting abnormal loss of charge or developing imbalance. The method shall specify initial conditions, rest period, environmental control, data intervals and the influence of connected electronics. The observation duration shall be justified for the family and risk; this manual sets no universal safe waiting period.

16.2 The laboratory shall distinguish expected relaxation and measurement variation from persistent or unusual loss. Pack-level voltage alone may conceal individual module behaviour, depending on architecture. Where the method cannot observe relevant internal variation, Engineering shall identify an additional evidence route or a limitation on acceptance.

16.3 The record shall preserve beginning and ending conditions, intermediate trends and any interruption. Unexpected change shall be investigated before the item is charged again. A later normal reading shall not erase an earlier unexplained instability, particularly where the history or condition review already indicates possible internal damage.

16.4 Accepted results shall be considered with capacity, resistance, insulation and history. A battery shall not be declared safe solely because it held charge during one observation period. Storage and service monitoring shall continue to track changes after grading, with a defined route for withdrawing a previously accepted item if new evidence appears.

17 Insulation connections and protective interfaces

17.1 The electrical integrity plan shall address insulation, protective bonding where applicable, connectors, contactors, fuses, interlocks and the relevant sensing paths. The test method shall be compatible with the battery and its electronics. Unauthorised high-voltage testing can damage connected controls and shall not be used as a generic screening shortcut.

17.2 Qualified personnel shall establish the safe test boundary and verify the required condition before connecting equipment. The procedure shall identify points that may retain hazardous energy and the protective arrangements for the task. A displayed open-contactor state shall not by itself prove that every accessible point is safe to touch.

17.3 Inspection shall assess corrosion, overheating, damaged seals, loose connections and evidence of incorrect previous work. Functional checks shall verify that required protective signals and switching actions are correctly interpreted. The record shall distinguish a commanded state from an independently verified physical or electrical result where that distinction affects safety.

17.4 Defects shall enter a controlled repair or rejection process. A repair shall be permitted only within the approved scope and shall receive verification of all affected characteristics. Bypassing an interlock, increasing a fuse rating or disabling a diagnostic function shall not be accepted as restoration of conformity.

18 Thermal behaviour and cooling condition

18.1 Engineering shall define thermal assessment relevant to the intended duty and the battery's condition. The plan shall consider temperature distribution, sensor coverage, cooling performance, environmental extremes and abnormal behaviour. A lower average load in stationary service shall not be assumed to eliminate local heating or propagation risk.

18.2 Controlled performance tests shall monitor the specified temperatures and operating variables. Sensor placement and response shall be appropriate to the feature being assessed. Unexplained local heating, rapid change or disagreement between sensors shall trigger the approved stop and investigation process rather than continuation to complete a data curve.

18.3 Cooling circuits, interfaces, seals and heat-transfer materials shall be assessed for leakage, contamination, damage and compatibility. Changes to the original thermal arrangement shall receive design validation. The integrator shall not remove cooling components solely because a brief low-power test showed an acceptable average temperature.

18.4 Tests intended to investigate abuse, fire or propagation shall be performed only by specialist facilities under a dedicated approved test programme using designated specimens. Such tests shall not be improvised on routine production stock. Their results shall be interpreted within the tested configuration and shall not automatically establish the safety of another enclosure or installation.

19 Battery management system and diagnostic evidence

19.1 The assessor shall identify the battery management system, firmware, configuration, sensor arrangement and available history. The assessment shall check whether reported values are plausible and consistent with independent measurements. A healthy-status message shall be treated as one input, not a complete demonstration of battery condition.

19.2 The verification plan shall cover relevant sensing, communication, balancing, contactor control and protective responses. Fault simulation shall use approved safe methods and shall not expose routine units to uncontrolled hazards. The plan shall distinguish faults detected by the original automotive controller from hazards introduced by the stationary integration.

19.3 Controller replacement, reset or software changes shall preserve the actual history and be recorded. The organisation shall not falsify state-of-health values, suppress relevant fault codes or represent a cleared log as proof of recovery. Any recalibration shall have a validated technical basis and a clear relationship to independent test results.

19.4 The final assessment shall state whether the existing controller can remain in use, requires an approved interface or must be replaced within a validated redesign. The integrator shall verify compatibility of protective functions and communication-loss behaviour. No control function shall be assumed to exist merely because it was present in the former vehicle.

20 Grading and module compatibility

20.1 The grading model shall combine provenance, safety-related condition, measured capacity or energy, power capability, stability and relevant remaining-duty evidence. It shall define the application classes each grade permits and the conditions that exclude an item. A commercial grade such as premium shall not replace a technical specification.

20.2 Modules selected for a common assembly shall meet the validated compatibility rules for chemistry, architecture, capacity, resistance, condition and control behaviour. The design shall address the weakest relevant element and the consequences of imbalance. An acceptable average value shall not compensate for a module outside an individual required limit.

20.3 The matching record shall link every selected module to its assessment and assembly position. Differences between new and used components, different histories or different firmware shall be assessed explicitly. Mixing shall be allowed only within a validated design and shall not be used to conceal poor data or an inadequate supply of compatible units.

20.4 Quality shall approve the grade and permitted destination before integration. Rejected or restricted modules shall remain segregated. Regrading after storage, repair or new evidence shall preserve the previous result and reason for change, with review of any assemblies already built from the affected population.

21 Pack opening and module separation

21.1 Pack opening and module separation shall occur only within an expressly authorised scope. The task shall use current design information, a specific safe work instruction, suitable tools and a prepared work area. A general vehicle service qualification shall not establish competence to open every retired battery architecture.

21.2 The responsible technician shall assess the condition and establish the work boundary before opening. Internal voltage, stored energy, sharp conductors, cooling fluids and mechanical restraints shall be addressed. Damaged or unstable packs shall be referred to the specialist route; ordinary dismantling shall not be used to explore an unresolved hazard.

21.3 The separation process shall preserve identity and prevent damage to retained modules, sensors and protective structures. Each removed item shall receive a status and a record of any handling incident. Components whose condition or identity becomes uncertain shall be held rather than returned to an accepted pool.

21.4 Completion shall include reconciliation of modules, associated controls and residual materials. The technician shall record remaining hazards for each output and the receiving person's permitted task. A separated module shall not be labelled safe solely because it has been removed from the original pack or because its open-circuit voltage appears lower.

22 Restoration and replacement boundaries

22.1 Engineering shall define which enclosure, cooling, connection or control repairs are allowed within the programme. Each repair shall have a qualified method, replacement specification and verification plan. The scope shall distinguish replacing an

approved service component from altering cell construction or repairing an internally damaged electrochemical unit.

22.2 Opening, modifying or attempting to restore damaged individual cells shall remain outside the ordinary second-life route unless a separately engineered and authorised specialist process exists. The programme shall not promote improvised recovery of swollen, leaking, thermally damaged or unstable cells. Such items shall enter the appropriate controlled disposition.

22.3 Replacement components shall be traceable and compatible with the design's electrical, thermal, mechanical and ageing requirements. Substitution of seals, connectors, insulation or protective devices shall receive the relevant assessment. A similar shape or nominal rating shall not establish equivalence under the installation's actual conditions.

22.4 After repair, all affected characteristics shall be reverified and the assessment grade reconsidered. The record shall identify the defect, method, parts, personnel and results. Repair cost or customer demand shall not influence the technical decision about whether the restored item is suitable for the intended system.

23 Mechanical architecture and enclosure design

23.1 The design authority shall specify the arrangement, support, restraint and service access for the selected batteries. The enclosure shall be assessed for normal operation, transport, maintenance and credible fault conditions. Reusing a vehicle pack enclosure may preserve useful features but shall not automatically establish suitability for a stationary location.

23.2 Design reviews shall address load paths, corrosion, environmental exposure, accidental contact, ingress and the effect of maintenance access. Battery restraints shall not impose damaging loads on cells or modules. Replacement panels and access points shall preserve the required protection and shall allow inspection without unnecessary exposure to hazardous parts.

23.3 The layout shall support the validated thermal and electrical design, including clear separation of incompatible services and defined cable or pipe routing. Expansion provisions shall remain within the assessed configuration. Empty space in an enclosure shall not constitute approval to add more modules later.

23.4 The configuration record shall identify drawings, component positions, materials, assembly methods and inspection criteria. Changes to enclosure size, module orientation or structural support shall trigger an assessment of their effect on protection, thermal behaviour and fault consequences before production or installation continues.

24 Electrical architecture and protective coordination

24.1 The electrical design shall define operating voltages, current paths, isolation, protective bonding where applicable and coordination of switching and protective devices. Ratings shall consider normal duty and credible faults. The design authority shall assess interactions between batteries, converters, auxiliary supplies and external sources rather than review each item in isolation.

24.2 Protection shall address the hazards identified in the system assessment, including overcurrent, unsuitable voltage, temperature excursions, loss of communication and failures of required sensing. The intended response shall be specified for each condition. A software command shall not be credited as a complete protective measure without evidence that the relevant path operates as designed.

24.3 The design shall prevent unintended energisation and define safe maintenance boundaries. Isolation points, stored-energy hazards and verification requirements shall be visible in technical information and labelling. The system shall not depend on undocumented knowledge held only by the original integrator.

24.4 Engineering shall verify protective coordination through analysis and appropriate controlled testing. Settings shall be version controlled and protected from unauthorised change. Any temporary commissioning override shall have a defined owner and expiry, and its removal shall be verified before operational handover.

25 Thermal management and fire safety design

25.1 The system assessment shall consider heat generation, cooling loss, gas release, thermal propagation and the consequences of an event in the actual installation. Separation, ventilation, detection and response arrangements shall be engineered for the configuration and site. This manual establishes no universal distance, fire rating or extinguishing method for every second-life system.

25.2 Thermal management shall maintain the validated operating envelope across the expected duty and environment. Failure of pumps, fans, sensors or power supplies shall have a defined response. The design shall consider local hotspots and uneven ageing rather than rely solely on an average enclosure temperature.

25.3 The fire-safety strategy shall involve competent specialists and the responsible site and emergency functions. It shall address access, evacuation, detection, shutdown interfaces, exposure to gases and management of contaminated runoff where relevant. An isolated electrical connection shall not be presented as removal of stored chemical energy.

25.4 Evidence from specialist testing shall be linked to the tested battery condition and system configuration. Changes that affect event consequences shall trigger review. Operational staff shall receive clear response instructions that identify when to withdraw and call specialist responders, without requiring them to improvise intervention on an unstable battery.

26 Energy management software and cybersecurity

26.1 The control architecture shall distinguish battery protection, power conversion and higher-level energy scheduling. The design shall identify which functions must continue during network or cloud loss and which services may safely stop. Remote optimisation shall remain within local protective limits and shall not override them to meet a commercial dispatch target.

26.2 Software releases shall have controlled requirements, version identity, verification and recovery arrangements. Configuration changes shall be authorised and recorded. The integrator shall verify that a restored backup reproduces the approved settings and that an update cannot silently expand the battery's operating envelope beyond its accepted grade.

26.3 Access shall use individual identities, least necessary permissions and protected remote-support routes. Security logs shall support investigation while respecting privacy and operational constraints. Shared default credentials and unrestricted supplier access shall be removed before handover. The system shall preserve required protective behaviour when a remote service is unavailable or compromised.

26.4 The acceptance programme shall test relevant communication faults, invalid commands and recovery using safe methods. Cybersecurity findings shall be assessed for their effect on physical operation. The IAF digital integrity and connected-factory controls shall govern detailed security practice, with the system design authority retaining responsibility for battery and installation consequences.

27 Solar energy storage integration

27.1 The application design shall establish the solar generation profile, charging limits, inverter topology and the intended export or self-consumption strategy. The battery shall be selected for the expected energy throughput and environmental conditions. Annual energy production alone shall not describe the daily or seasonal stress imposed on the storage system.

27.2 The control plan shall prevent charging or discharging outside the validated battery envelope during rapid changes in sunlight, grid conditions or load. Curtailment and reserve policies shall be explicit. The system shall not assume that solar output will always be available to restore a required backup reserve before the next outage.

27.3 Performance assessment shall identify the metering boundary and distinguish solar energy generated, energy stored, conversion losses and energy delivered. Claims about renewable supply shall account for any grid charging and the chosen accounting method. A battery installed beside solar panels shall not automatically make all discharged energy renewable.

27.4 Commissioning shall verify the relevant operating modes and failure responses under controlled conditions. Seasonal review shall compare actual duty with the design assumptions. Changes to the solar array, export settings or charging schedule shall trigger an assessment of battery ageing, protection and contractual performance before implementation.

28 Factory backup and load support

28.1 The factory owner shall identify essential loads, allowable interruption, startup requirements and the duration of support required. The design shall distinguish emergency safety functions, production continuity and convenience loads. A second-life storage system shall not be assumed suitable for a life-safety function merely because it can power ordinary factory equipment.

28.2 The capacity calculation shall include usable battery energy, conversion efficiency, auxiliary loads, reserve and ageing allowance. Power capability shall be checked separately for continuous and transient demands. The system shall have a defined load-shedding strategy when available energy or power becomes insufficient for the entire connected load.

28.3 Integration with a generator, utility supply or other source shall have engineered transfer, interlocking and protection. Battery storage is an energy source only to the extent of its stored charge; it does not replenish itself during an outage. Black-start or

island operation shall be claimed only where the complete design supports and verifies that mode.

28.4 Exercises shall use approved conditions that do not endanger personnel or uncontrolled production. The owner shall review actual outage performance, recharge time and reserve availability. Changes in factory loads shall be communicated to the design authority before the backup promise is extended to additional equipment.

29 Grid interface and electrical installation

29.1 The project shall identify the responsible electrical designer, installer, owner and any required network approvals. The interface design shall address the site's connection conditions, protection, power quality, earthing arrangement and permitted operating modes. Approval of the battery modules shall not establish permission to energise the grid-connected installation.

29.2 Installation instructions shall define cable, protection, enclosure and environmental requirements using the approved design. Competent personnel shall verify that the actual site matches the design basis. Unrecorded changes to cable routes, protective devices or auxiliary supplies shall be assessed before energisation.

29.3 Required disconnection and reconnection behaviour shall be verified through the applicable commissioning plan. Tests shall be coordinated with the site and network operator where necessary. The project shall not simulate hazardous grid conditions through improvised switching or defeat protective controls to complete a demonstration.

29.4 The as-built record shall include approved settings, inspection results, permits, connection decisions and unresolved restrictions. The handover shall identify who may change the interface configuration. Any later expansion or relocation shall receive a fresh assessment of both battery capability and the new installation conditions.

30 Factory acceptance and integrated verification

30.1 Factory acceptance shall evaluate the assembled system against its approved configuration and requirements matrix. The plan shall cover identity, mechanical assembly, electrical integrity, sensing, protective functions, software, communications and relevant performance. Component test reports shall be included but shall not replace verification of their interaction in the completed system.

30.2 The test team shall confirm prerequisites, equipment status, safe test conditions and approved acceptance criteria before energisation. Actual values and observed responses shall be retained. Where a function cannot be fully exercised in the factory, the limitation and required site test shall be explicitly transferred to the commissioning plan.

30.3 Failed tests shall create a nonconformity with population and design impact assessment. Adjustments shall be recorded and followed by the necessary regression checks. A final successful run shall not erase earlier faults or establish that all affected functions were reverified after the change.

30.4 Quality and the design authority shall review the complete evidence before shipment. The release shall identify the exact hardware, software and permitted

operating envelope. Open site-dependent actions shall be listed with owners and shall prevent unrestricted operation until their required acceptance is documented.

31 Delivery installation and site readiness

31.1 Before delivery, the project manager shall confirm site readiness, access, lifting arrangements, environmental protection and the ability to manage an unexpected battery condition. Transport and storage restrictions shall follow the actual system configuration and condition. The installer shall receive the release record and outstanding commissioning actions before accepting the equipment.

31.2 Receipt inspection shall check identity, packaging, impact indicators where used, visible condition and evidence of water or mechanical damage. A transport incident shall trigger assessment before energisation. The system shall not inherit its factory acceptance status unchanged when the journey or storage conditions may have affected integrity.

31.3 Installation shall follow the approved drawings and instructions, with controlled deviations. Required spacing, supports, services, signage and emergency access shall be verified against the site-specific design. The project shall record as-built differences and obtain competent acceptance before they become concealed by completed works.

31.4 The readiness review shall confirm personnel, emergency coordination, permits, communications and safe test boundaries. Missing prerequisites shall hold energisation. Construction completion, payment milestones and customer presence shall not substitute for the technical release required to begin site testing.

32 Commissioning and operational handover

32.1 The commissioning plan shall connect factory evidence with site-specific verification. It shall identify the tests, responsible persons, safe conditions, acceptance criteria and the sequence in which the system may be energised and loaded. Any commissioning override shall be documented and controlled for the shortest necessary period.

32.2 Tests shall verify the relevant operating modes, metering, alarms, protection interfaces, remote commands and response to loss of required services. Simulations shall use safe, approved methods. Results shall distinguish observed behaviour from functions accepted through analysis or factory evidence, with each unresolved item given a clear disposition.

32.3 Before handover, the team shall remove temporary equipment and overrides, confirm final settings and reconcile the as-built configuration. The owner shall receive operating limits, emergency instructions, maintenance requirements, training records and the complete acceptance dossier. Access credentials shall be transferred through controlled processes rather than shared informally.

32.4 Operational release shall identify the approved duty, usable performance boundary and any restrictions. The owner shall accept responsibility for monitoring and maintenance. A signed commercial delivery note shall not be presented as proof that all site tests, statutory permissions or safety actions are complete.

33 Operation monitoring and preventive maintenance

33.1 The operating plan shall define normal duties, permitted commands, monitoring frequency and responsible personnel. Monitoring shall cover relevant temperatures, electrical behaviour, imbalance, alarms, energy throughput and availability. Data quality shall be checked so that a missing sensor or stale value cannot be mistaken for a healthy operating condition.

33.2 Maintenance shall follow the validated design and actual service experience. Tasks may include inspection of enclosures, connections, cooling, filters, sensors and protective functions within the authorised scope. The procedure shall define safe isolation and return-to-service checks. Operators shall not open high-voltage assemblies or alter protective settings beyond their competence.

33.3 Trend review shall compare actual duty and degradation with the accepted assumptions. Repeated alarms, changing resistance, abnormal self-discharge or rising thermal variation shall trigger technical assessment. Resetting a recurring alarm shall not count as corrective action. The system shall be restricted or taken out of service when required evidence of safe operation is lost.

33.4 Maintenance records shall link actions, parts, software and results to the system identity. The owner shall keep emergency contacts and access information current. Remote service providers shall have defined response obligations and controlled permissions, while local personnel retain a workable response when external connectivity is unavailable.

34 Alarm handling and incident response

34.1 The site shall define alarm priorities according to the required protective action and the consequences of delay. Instructions shall identify who may assess, isolate, stop operation, evacuate or contact emergency responders. A display acknowledgement shall not be confused with resolution of the underlying condition.

34.2 For credible signs of thermal deterioration, gas release or other immediate danger, personnel shall follow the approved emergency plan and withdraw where required. They shall not open the enclosure, move an unstable assembly or attempt improvised immersion or suppression. Trained responders shall determine intervention according to the actual battery and site conditions.

34.3 The response shall preserve life safety, access control and necessary information about the system's remaining energy and hazards. Electrical isolation may reduce some risks while chemical energy remains. Re-entry, movement and return to service shall require competent assessment and a recorded decision, not merely the disappearance of visible smoke or an alarm.

34.4 After the event, the organisation shall preserve relevant data and assess affected modules, connected equipment and similar installations. Required notifications and customer actions shall follow the applicable process. Restoration shall include cause assessment, verification of protective functions and approval of any changed operating limits before service resumes.

35 Ageing review and remaining useful life

35.1 The life-management plan shall define the end criteria for the actual application, including capacity, power, stability, safety-related condition and economic or operational limits. It shall use measured trends and service exposure. Calendar age or one state-of-health value shall not independently establish the remaining useful life of every battery.

35.2 Models used to estimate degradation shall be validated for the battery family, history and duty range. The record shall state inputs, uncertainty and conditions outside the model's evidence. Predictions shall be updated when actual behaviour diverges from assumptions. A model output shall not override an observed safety concern.

35.3 Engineering shall define when to derate, regroup, replace or retire a unit. Derating shall be technically justified and enforced in the control system, with relevant performance commitments revised. Replacing the weakest module shall require reassessment of compatibility and the effect on the whole assembly, rather than a simple restoration of the former label.

35.4 The operator shall review the plan after unusual events, prolonged inactivity and changes to duty or environment. Remaining-life claims supplied to customers shall include their conditions and shall not be presented as guaranteed years unless the contract and supporting evidence justify that promise.

36 Warranty service and customer information

36.1 The supply agreement shall identify the system configuration, second-life content, measured performance, accepted duty and warranty. Energy, power, availability and degradation commitments shall have defined boundaries and measurement methods. A percentage derived from battery-terminal testing shall not silently become a guarantee at the customer's load connection.

36.2 The customer shall receive clear maintenance, operating and reporting obligations. Exclusions shall be lawful and proportionate to the conditions that affect performance. The agreement shall identify responsibility for software updates, remote access, site changes, emergency coordination and the final treatment of retired batteries.

36.3 Service intake shall capture the system identity, symptoms, alarms, operating history and recent changes. The investigator shall distinguish battery degradation, integration faults, site conditions and data problems using evidence. Remote diagnostics shall not authorise unsafe field work or unsupported reassurance about an uncertain battery condition.

36.4 Warranty trends shall feed back into grading, design and operating limits. The organisation shall assess whether a discovered defect affects other systems built from the same family or component lot. Customer communication and any restriction, repair or recall shall proceed through the appropriate IAF and market processes.

37 End of second life and final disposition

37.1 Retirement shall occur when the unit no longer meets its approved safety or application requirements, or when continued operation lacks a defensible evidence basis. The decision shall identify the reason, current condition and permitted handling

route. Economic pressure to avoid disposal shall not justify continued use outside the accepted envelope.

37.2 Decommissioning shall be planned by competent personnel using the system-specific procedure. The plan shall address electrical isolation, stored energy, lifting, data retention, hazardous condition assessment and transport. Removal from service shall not be represented as complete discharge or elimination of internal hazards.

37.3 The organisation shall select a qualified receiving processor and verify its capability for the actual chemistry and condition. Classification, packaging and documentation shall follow the approved route. The handover shall retain identity, quantity, condition and confirmation of receipt, including the treatment destination where required.

37.4 The final record shall reconcile components reused under a separately approved route, materials sent for recovery and residual disposal. Claims shall be based on confirmed outcomes rather than shipment alone. Personal and confidential information shall be managed without deleting technical evidence needed for safety, traceability or legal retention.

38 Environmental economic and performance measures

38.1 The programme shall measure accepted yield, rejected-condition categories, energy delivered, efficiency, availability, degradation and final treatment outcomes with clear definitions. Battery-terminal and system-level metrics shall remain separate. Availability shall specify whether scheduled maintenance, external outages and restricted operation are included in the denominator.

38.2 Environmental comparisons shall use a stated functional service and account for relevant collection, testing, replacement, integration, operating losses and final treatment. A second-life route is not automatically environmentally preferable in every duty or location. Conclusions shall reflect actual data, assumptions and the alternative being compared.

38.3 Economic evaluation shall include acquisition, assessment yield, integration, safety systems, maintenance, insurance where relevant and final disposition. Nominal battery capacity alone shall not determine value. The analysis shall consider uncertainty in usable energy, power, remaining duty and downtime without hiding rejected batteries outside the programme cost.

38.4 Management shall review trends and assign actions for deteriorating safety indicators, poor data and repeated service failures. Targets shall not reward suppression of alarms, optimistic grading or delayed retirement. Worked calculations in the annexes are fictional illustrations and do not establish universal performance thresholds or financial returns.

39 Competence audits and practical exercises

39.1 The competence matrix shall distinguish vehicle removal, logistics, intake, electrical testing, high-voltage work, system design, commissioning and operation. Authorisations shall match the task and battery family. Practical assessment shall demonstrate correct response to abnormal conditions, not only familiarity with routine controls.

39.2 The audit programme shall trace installed systems back to original battery histories and assessment results. Auditors shall compare actual settings with the approved envelope and verify that software changes, module replacements and maintenance remained controlled. Missing genealogy or an unexplained acceptance exception shall receive a product-impact assessment.

39.3 Exercises shall include transport damage, uncertain history, communication loss, abnormal temperature and unavailable specialist support using safe simulations. Participants shall demonstrate escalation, record retrieval, isolation authority and customer communication. Live hazardous events shall not be created simply to make an exercise realistic.

39.4 Findings shall produce corrective actions with owners and effectiveness checks. The programme shall review recurring issues for design, workload, data and supplier causes. Staff shall have protected reporting routes under the relevant IAF policies, and commercial pressure shall not override an authorised safety or quality hold.

40 Records interfaces and revision control

40.1 The controlled record set shall include provenance, removal and transport handovers, condition assessment, raw test data, grades, integration design, validation, commissioning, operation and final disposition. Retention shall follow the IAF Documents and Records Guide and applicable obligations. Access controls shall preserve both technical traceability and legitimate privacy.

40.2 This manual operates with the IAF Quality Manual, authorised service, high-voltage safety, incident response, digital integrity and warranty and recall documents. Remanufacturing of non-battery components follows IAF-MAN-RMC-001. Vehicle depollution and final material processing connect to IAF-MAN-ELV-001. Each handover shall identify the next responsible entity and the condition actually transferred.

40.3 Revisions shall follow the competent IAF authority and document-control process. The change notice shall identify affected requirements, reasons and transition arrangements. Operating organisations shall assess effects on existing systems and record their actual adoption, training and configuration changes rather than assume publication updates equipment automatically.

40.4 Technical limits and site-specific procedures shall remain in controlled supplements approved by the responsible specialists. New chemistry, architecture or application shall trigger review of scope and validation. Historical revisions shall remain available for the systems accepted under them, while obsolete operational instructions are removed from active use.

Annex A Application adoption and system design brief

Complete before selecting retired batteries. The brief shall describe the actual service and the organisation responsible for the integrated system.

Record field	Required entry and decision
Project identity	Enter legal entity, site, owner, integrator, manual revision and actual approval date.

Record field	Required entry and decision
Service definition	Specify solar shifting, demand support or backup; identify critical loads, permitted interruption and required operating modes.
Performance boundary	State required energy and power at the agreed electrical boundary, duty profile, ambient range and reserve assumptions.
Battery scope	Identify approved chemistry, pack families, permitted histories, excluded conditions and assessment capability.
Design responsibility	Name the battery assessment owner, system design authority, electrical and fire specialists and quality release authority.
Operating obligations	Link product, waste, transport, installation, network and site requirements with actual decisions and applicability dates.
Readiness	Confirm facilities, quarantine, test equipment, competence, emergency arrangements and downstream partners.
Adoption decision	Record accepted scope, restrictions, unresolved prerequisites and the evidence required before energisation or commercial use.

A published manual and a signed purchase order are not substitutes for an accepted system design and site release.

Annex B Battery assessment dossier

Use one dossier per pack or traceable module. Maintain links to the original history even after a new system serial is assigned.

Record field	Required entry and decision
Provenance	Record original identity, source, ownership, chemistry, architecture, age and the reliability of available history.
Adverse history	Declare collision, flood, thermal events, recalls, controller resets and unknown periods. Identify excluded or specialist-review conditions.
Safe handover	Link removal, transport, observed condition, remaining hazards and the next authorised work boundary.
Test authorisation	Identify the approved plan, prerequisites, equipment, conditions, stop criteria and competent operator.
Measured evidence	Link raw capacity or energy, power, stability, insulation, thermal and control-system results as required by the plan.
Uncertainty	State reference definitions, measurement uncertainty, missing channels, model limits and invalid or repeated tests.
Grade and destination	Record accepted application class, restrictions, matching rules or rejection for the proposed use.
Review	Record technical reviewer, quality decision, date and triggers for reassessment after storage or new evidence.

A value below or above 70 percent shall not decide the dossier alone. The complete safety and application evidence controls the disposition.

Annex C Assessment method and acceptance register

Engineering shall populate actual values and method revisions in the local controlled register. No numerical limit is implied by an empty field or by a result from another battery family.

Characteristic	Method conditions to define	Decision evidence
Capacity and energy	Reference basis, temperature, rate, usable range, conditioning, integration and metering boundary.	Actual result, uncertainty, comparable reference and approved application requirement.
Power or resistance	State of charge, temperature, pulse or load profile, fixture effects and calculation interval.	Validated power envelope and response to abnormal drop or heating.
Stability	Initial condition, observation duration, connected-electronics consumption and measurement intervals.	Trend interpretation and disposition of unexplained loss or imbalance.
Electrical integrity	Compatible test method, safe boundary, insulation and protective interface coverage.	Accepted results and evidence that repairs did not bypass protection.
Thermal behaviour	Duty, environment, sensor placement, cooling configuration and approved stop conditions.	Temperature distribution and evidence within the validated design boundary.
Controller functions	Hardware and firmware, sensing, communications, safe fault simulation and protective response.	Observed response, independent checks where required and final configuration.
Final grade	Combined history, safety evidence, energy, power, stability and application constraints.	Authorised decision with explicit permitted duty and rejection conditions.

Confirm prerequisites before each test. Deliberate abuse or propagation testing belongs to a separately approved specialist programme using designated specimens.

Annex D Module matching and assembly genealogy

Complete before modules enter a common assembly. Selection shall follow a validated compatibility envelope rather than a favourable average.

Record field	Required entry and decision
Assembly identity	Enter new system or pack serial, drawing revision and approved application.
Module list	Record each original module identity, source pack and assessment dossier.
Compatibility	Confirm chemistry, architecture, capacity or energy class, power behaviour, history and controller compatibility.
Individual limits	Verify every module meets its required criteria. Record actual values and any permitted matching variation.
Position map	Link each module to its physical and electrical position and sensor channels.

Record field	Required entry and decision
Restoration history	Identify replaced interfaces, cooling components, control devices and associated verification.
Integrated verification	Link assembly inspections, protective-function tests, software configuration and accepted results.
Release and changes	Record reviewer, date and subsequent replacements or regrading while preserving earlier identities.

Do not mix chemistries or incompatible units outside an expressly validated design. Unidentified modules remain on hold.

Annex E Worked capacity and energy assessment

Fictional design exercise. The percentages and efficiencies below are assumptions for the calculation, not operating settings or acceptance limits for real batteries.

Item	Calculation	Decision meaning
Capacity retention	Measured 68 Ah / comparable original reference 100 Ah $\times 100 = 68$ percent.	This triggers the example programme assessment; it does not prove suitability or safety.
Measured energy	A separate controlled test measures 24.0 kWh over its stated reference interval.	Do not derive energy merely by multiplying the capacity percentage by an unrelated nameplate value.
Application window	For this example only, a validated application uses 80 percent of that measured energy: $24.0 \times 0.80 = 19.2$ kWh DC.	Do not apply this factor again if the test result already represents the same restricted window.
Conversion	Assume 95 percent conversion over the defined mission: $19.2 \times 0.95 = 18.24$ kWh AC.	Use a justified system model or measurement for a real project.
Auxiliary demand	Assume 0.40 kWh auxiliary consumption during that mission: $18.24 - 0.40 = 17.84$ kWh to the supported load.	The auxiliary assumption must match the mission duration and boundary.
Mission A	A 16.0 kWh load requirement leaves 1.84 kWh calculated margin.	Energy sufficiency remains conditional on power, safety, reserve and degradation requirements.
Mission B	A 20.0 kWh load requirement exceeds calculated delivery by 2.16 kWh.	The energy requirement is not met; a marketing capacity label cannot remove the shortfall.
Power check	Assess continuous and transient kW separately using the approved envelope.	No power acceptance or remaining-life guarantee follows from the energy calculation.

Retain unrounded calculations and test conditions. Engineering shall approve all real project assumptions before a performance commitment is made.

Annex F Factory acceptance and site commissioning record

Keep factory and site decisions distinct while linking their evidence in one system dossier.

Record field	Required entry and decision
Configuration	Record system identity, battery genealogy, drawings, firmware, settings and approved operating envelope.
Factory prerequisites	Verify assembly completion, equipment status, safe test plan and competent personnel.
Factory results	Link mechanical, electrical, control, protective and performance evidence; preserve failed and repeated tests.
Delivery condition	Record shipment, receipt inspection, incidents and any resulting reassessment.
Site prerequisites	Verify actual installation, permissions, emergency access, utilities and as-built conformity.
Site results	Record required operating modes, interfaces, alarms, metering and outstanding site-dependent functions.
Final state	Confirm overrides removed, final settings verified, credentials controlled and unresolved items closed or expressly restricted.
Handover	Record technical and owner acceptance, training, operating instructions, maintenance and actual release date.

A delivery receipt is not an energisation approval. Do not start unrestricted operation while a required commissioning or safety item remains unresolved.

Annex G Service review and retirement decision

Use at the defined review interval and after abnormal events or material changes in duty.

Record field	Required entry and decision
Service exposure	Record energy throughput, cycle or calendar history, environment and changes from the accepted duty.
Performance trend	Compare usable energy, power, efficiency and availability at consistent boundaries.
Condition trend	Review temperature variation, imbalance, self-discharge, protective events and data reliability.
Technical decision	Choose continued use, justified derating, approved repair, replacement or retirement with supporting evidence.
Configuration action	Record actual setting or hardware changes and the required verification.
Customer effect	Update performance commitments, restrictions and service instructions where the decision affects the supplied service.

Record field	Required entry and decision
End route	For retired units, identify safe decommissioning, transport, qualified receiver and confirmed custody.
Closure	Reconcile genealogy, retained evidence, final treatment records and any required notifications.

A predicted remaining life shall not override an observed safety concern. Reuse in another application requires a new suitability decision.

Annex H Abnormal trend and communication loss exercise

Use fictional data and approved simulation. The exercise shall not heat, damage or disable protection on a live battery.

Record field	Required entry and decision
Initial scenario	A commissioned solar-storage system shows a rising temperature difference in one module group after a software update.
First information	Remote dashboards intermittently lose data; the local controller records repeated protective events.
Decision task	Determine whether the operating evidence remains reliable and apply the approved restriction and escalation process.
Technical task	Retrieve battery history, module map, firmware change, raw data and the actual local protective state.
Site task	Demonstrate who controls access, emergency communication and any authorised isolation without relying on cloud availability.
Population task	Identify other systems sharing the module source, software version or changed configuration.
Recovery task	Define the evidence required for safe return to service and verify removal of temporary changes.
Review	Record gaps, owners and effectiveness checks for procedures, design, data and training.

Success requires a defensible protective decision and reliable evidence, not the fastest possible return to operation.