



QUALITY MANUALS | FIRST EDITION

IAF GIGAFACTORY & ADVANCED ASSEMBLY MANUAL

Battery production and
electric vehicle assembly

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Dry rooms and cell-to-pack control
High-voltage and collaborative automation
Validation, traceability and release

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Publication identity and use

IAF Gigafactory & Advanced Assembly Manual

This manual provides the requirements, operating procedures and evidence framework for its defined automotive manufacturing activities. Apply it through a controlled site implementation plan and equipment-specific work instructions.

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Reading and applying requirements

“Shall” identifies a requirement when adopted by a site, programme or agreement. “Should” identifies a recommendation. An example is illustrative; it is not a machine setting, test acceptance limit or completed operating record. Annex worksheets may be reproduced for controlled internal use.

Controlled implementation

Stable Release identifies the completed publication text. Site approval, process validation, competence authorization and equipment release are recorded when performed. A missing safety limit, test criterion or release authority prevents activation of the affected operation. Mandatory law, product requirements and validated equipment instructions remain applicable.

Relationship to IAF recognition

Use of this manual does not by itself confer membership, Corporate Recognised status, accreditation, certification or a licence to use IAF marks. Those decisions follow the applicable IAF guides, independent evaluation and recorded scope.

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Using the annexes

Enter actual values, evidence references, names and dates in the worksheets. A blank, unsigned or illustrative record is not proof of completion. Retain the record with its governing instruction and revision.

1 Purpose and technology boundaries

1.1 This manual governs battery manufacturing and advanced EV assembly within a declared site scope. It covers controlled environments, cell handling, cell-to-pack assembly, thermal and electrical interfaces, high-voltage work, collaborative automation, test, release and recovery. It applies to pilot and volume operations, including contracted processes.

1.2 A site shall distinguish cell manufacture, module assembly, cell-to-pack (CTP) assembly, cell-to-body or structural-pack integration, and vehicle commissioning. Cell manufacture includes additional chemical and formation hazards. A plant receiving sealed cells does not automatically require the same environmental conditions as an electrolyte filling operation.

1.3 Engineering shall identify chemistry, cell format, energy and voltage range, mechanical architecture, cooling concept, software configuration and intended product use. Controls shall reflect the actual design and process. The labels “400 V” and “800 V” describe nominal architectures and shall not be used as the maximum possible voltage for tools, equipment or protective design.

1.4 This manual establishes control and authorization requirements. Equipment-specific instructions and validated schedules supply numerical process windows, test methods, safe-state verification and emergency arrangements. It does not authorize unqualified work inside energized battery packs or prescribe generic live electrical interventions.

1.5 The site shall apply IAF-MAN-LMS-001 to standard work, traceability and process improvement, and IAF-MAN-OTC-001 to automation and secure software provisioning. Product, workplace, environmental and transport obligations shall be identified separately for the jurisdiction and activity.

2 Terms, states and product identity

2.1 A cell is the basic electrochemical unit. A module groups cells where that design uses modules. A pack integrates cells or modules with mechanical structure, electrical interconnection, protection and thermal management. Cell-to-pack eliminates or reduces intermediate modules; it does not eliminate the need for cell-level genealogy and defect containment.

2.2 A dry room controls moisture to process requirements. A cleanroom controls particulate contamination to defined conditions and methods. These are different attributes. A room can meet a dew-point requirement and fail particulate control, or meet a particle class while remaining too moist for an exposed material.

2.3 State of charge (SOC) is an estimate of remaining charge relative to the defined capacity basis. It is not proof of absence of hazardous voltage or stored energy. An isolated pack can retain energized internal cells and conductors. The safe state shall be defined for the exact work location and task.

2.4 State labels shall distinguish received, accepted, process-ready, electrically connected, test-authorized, released, quarantined, damaged and disposal-controlled items. Labels shall show identity and restrictions without exposing secrets. Moving a pack or removing its external connection does not change its status automatically.

2.5 Thermal runaway is an uncontrolled self-heating failure condition that can propagate and release hazardous gases and material. A collaborative application is the complete robot, tool, workpiece, environment and human task; a robot sold as a cobot is not evidence that every application can operate without safeguarding.

3 Roles, competence and independent gates

3.1 The Site Director owns resources and site adoption. Battery Product Engineering owns the design and permitted product states. Process Engineering owns validated assembly and manufacturing windows. Facilities owns dry-room and utility performance. Quality owns acceptance, genealogy, containment and release evidence.

3.2 The designated electrical safety authority shall define task categories, competence, work permissions and safe-state procedures. Authorization shall identify equipment families, voltage and energy scope, work type, supervision and restrictions. An EV awareness course does not authorize high-voltage isolation, energized diagnosis or internal pack repair.

3.3 The automation integrator shall deliver the application risk assessment, safety function design, configuration, validation and operating information. A competent site representative shall accept the integrated cell. Robot programming competence and functional safety validation competence shall be assessed separately.

3.4 EHS and emergency coordinators shall plan chemical exposure, fire, gas, stored energy, lifting and evacuation controls with relevant specialists and responders. Maintenance shall preserve facility and equipment capability. OT security shall control remote access, recipes, safety-related configuration and software changes.

3.5 Any worker may stop an unsafe or unidentified operation. Production managers coordinate but cannot override a failed electrical, environmental, safety-function or product release gate. Each shift shall have named cover for critical decisions and a defined route when that competence is unavailable.

4 Product and process validation strategy

4.1 Before equipment procurement or product launch, define requirements for safety, performance, dimensions, lifetime, transport, repair and end-of-life handling. Translate these into process risks, critical characteristics, prevention controls and verification. Review interfaces between cell supplier, pack designer, automation integrator and vehicle manufacturer.

4.2 Validation shall cover representative chemistry, format, material tolerances, environmental conditions, tool wear and production rates. Define trial population, acceptance criteria and required independent review before testing. Destructive trials shall be performed only in facilities designed and authorized for their hazards.

4.3 For CTP and structural designs, assess cell support, insulation, expansion allowance, vent paths, adhesive durability, cooling, crash loads and repair restrictions. A change that appears to improve assembly time can affect serviceability and failure propagation. Obtain design-owner acceptance for changes to structural or protective functions.

4.4 Equipment acceptance shall verify installation, utilities, protective functions, software configuration, calibration, process repeatability and records. Factory acceptance at the supplier does not replace site acceptance after installation. Shipping, integration and local utilities can change the risk and performance conditions.

4.5 Approve a process only for the demonstrated scope. Open validation gaps shall block the affected routine operation or limit a documented controlled trial. Preserve test failures, raw data and assumptions; a summary pass statement without traceable evidence is insufficient.

5 Dry-room and cleanroom requirement schedule

5.1 Facilities and Process Engineering shall jointly specify each controlled zone. The schedule shall identify exposed materials, operation, dew or frost-point convention, temperature, pressure reference, particle requirements, differential pressure, airflow strategy, occupancy and allowable material exposure. Limits shall derive from material and process validation, not from a generic industry number.

5.2 Specify the measurement location and meaning of every value. Supply-air dew point does not necessarily represent the condition at the exposed workpiece. Relative humidity depends on temperature; a percentage reading shall not be treated as interchangeable with dew point. Record units, sensor range and compensation assumptions.

5.3 Cleanliness requirements shall distinguish airborne particles, surface contamination and process-specific conductive or metallic debris. Specify the particle sizes, sampling method, locations and room state used for any cleanliness classification. A filter specification alone does not establish the condition of the occupied process area.

5.4 Define alert and action limits, permitted response time and validated exposure budgets for sensitive materials. An alert prompts investigation; an action limit triggers the defined protective response and product assessment. A sensor fault or missing record shall have its own reaction and shall not be treated as compliant conditions.

5.5 Annex A is the mandatory site parameter register. Critical fields shall be completed, approved and linked to qualification evidence before production. No default dew point, room class, oxygen value or exposure period is adopted by this manual.

6 Room qualification, entry and contamination control

Owners: Facilities for the environment; Process Engineering and Quality for product suitability. Qualification shall address the installed room with representative equipment, occupancy and material movements.

Step / owner	Required action and evidence
1 Qualify the zone	Map environmental conditions at critical locations and credible worst cases. Challenge recovery after access, loading and utility disturbances under an approved protocol. Verify alarms, records and response responsibilities.
2 Authorize entry	Train personnel in garment use, material transfer, door discipline, contamination prevention and emergency exit. Check occupancy restrictions and current room status before allowing process exposure.
3 Transfer materials	Use the approved airlock and packaging removal sequence. Verify material identity, cleanliness, temperature equilibration where required, and the start of any exposure clock.
4 Maintain cleanliness	Use qualified cleaning materials and methods. Control fibres, metallic debris, oils and incompatible chemicals. Separate waste and maintenance tools from clean production supplies.
5 Protect personnel	Evaluate worker comfort, static charge, chemicals and any inert-gas hazards. Dry air is not proof of oxygen deficiency; oxygen monitoring is specified where the actual gas and ventilation risk requires it.
6 Requalify changes	Assess new equipment, airflow changes, increased occupancy and construction work. Restore verified cleanliness and environmental capability before sensitive work resumes.

Door opening, emergency egress and personnel protection shall remain safe. Process environmental controls shall not trap people or obstruct evacuation. Record qualification state and restrictions at the room entry and in the production system.

7 Environmental excursion and material disposition

Trigger: an action-limit breach, sensor failure, loss of environmental records, unqualified maintenance opening or other event that may invalidate exposure control.

Step / owner	Required action and evidence
1 Protect and notify	Stop new exposure and follow the approved safe process response. Inform Facilities, Process Engineering and Quality. Preserve the event time, sensor identity, material status and affected zone.
2 Establish boundaries	Identify exposed lots, start and end times, location, packaging and cumulative exposure. Include material waiting in buffers and partially assembled cells. Do not limit the population to items beside the alarm sensor.
3 Verify the condition	Check sensor health and compare suitable independent evidence. Review room trends, doors, occupancy and utility events. A later normal reading does not erase the earlier excursion.
4 Assess product	Engineering evaluates exposure against validated material limits and failure mechanisms. Quality decides hold, additional evaluation, approved reconditioning or scrap. Drying again is permitted only by a qualified method.
5 Restore the zone	Correct the cause and demonstrate stable conditions at critical locations. Complete any required cleaning and requalification. Record the restart decision and heightened monitoring.
6 Close and learn	Retain affected genealogy, disposition, cause and corrective action. Review alarms, exposure clocks and operator response. Verify that released stock excludes unresolved affected material.

When missing data prevents a justified exposure calculation, the affected material remains held. Production output targets shall not be used as evidence that a moisture or contamination excursion was harmless.

8 Cell manufacture and chemical processes

8.1 This section applies only where cell production is included in the site scope. The process owner shall define raw-material receipt, weighing, mixing, coating, drying, calendaring, slitting, stacking or winding, electrolyte filling, sealing, formation and aging. Each operation needs its own qualified instruction and chemical risk assessment.

8.2 Powders, solvents, binders and electrolytes shall have controlled identity, storage, transfer and exposure arrangements. Evaluate combustible dust, flammable atmosphere, toxic exposure, incompatible materials and reactive waste as relevant to the chemistry. Closed handling, extraction and engineered protective measures shall be specified by the hazard assessment.

8.3 Electrode production shall control material proportions, mixing conditions, coating mass and uniformity, drying outcome, porosity-related process variables, burrs and particulate contamination. Parameters shall be linked to cell performance validation. Visual appearance alone does not demonstrate residual moisture or solvent acceptance.

8.4 Stacking or winding shall preserve polarity, separator integrity, alignment and cleanliness. Filling and sealing shall control environmental exposure, electrolyte quantity, seal integrity and identity. Rejects and samples shall remain traceable to the manufacturing conditions and material lots.

8.5 Chemical additions, cleaning, maintenance and waste removal shall use approved instructions with appropriate competence and safe states. Do not apply generic neutralization, drying or fire-response recipes across chemistries. Record the process-specific hazards and emergency information required by responders.

9 Cell receipt, storage and lot release

Applies to purchased cells and cells transferred from an internal manufacturing area. The receiving gate shall establish identity, condition, specified evidence and safe handling status before assembly.

Step / owner	Required action and evidence
1 Verify delivery	Check supplier, cell type, revision, lot, quantities and packaging. Review required transport and supplier quality documents. Identify any abnormal shock, moisture or temperature indication where monitoring is specified.
2 Inspect safely	Use the approved external inspection method. Look for damage, swelling, leakage, corrosion, contamination or abnormal condition without opening or probing a suspect cell. Escalate evidence of an active hazard.
3 Segregate stock	Separate accepted, pending and damaged items. Protect terminals from short circuit using approved packaging. Follow validated storage conditions, spacing, quantities and monitoring appropriate to the product risk.
4 Verify performance	Apply the approved incoming test plan for relevant electrical and physical characteristics. Test equipment and connection methods shall prevent unintended shorting or excessive stress. Link results to individual cells or defined lots.
5 Release to process	Quality accepts the actual scope supported by evidence. Record approved use, storage life, exposure restrictions and any matching criteria. Unreadable or inconsistent identities remain held.
6 Control aging	Monitor inventory age and specified periodic checks. Reassess material after storage excursions or handling incidents. Expired acceptance or missing history prevents automatic transfer to assembly.

SOC and storage limits are product-specific. A low SOC label does not establish a safe electrical state. Damaged or suspect items follow Section 22 and the site emergency plan, not routine stock rotation.

10 Cell characterization, matching and genealogy

10.1 Engineering shall define which characteristics matter to the pack design, such as capacity, impedance, dimensions, voltage at a specified condition and relevant age or lot restrictions. Matching tolerances and test conditions shall be justified by design validation. Generic grouping by open-circuit voltage is insufficient for all chemistries and conditions.

10.2 The measurement plan shall specify conditioning, stabilization, temperature, test method, uncertainty and the treatment of borderline results. A resistance value without its method and conditions is ambiguous. Test equipment shall be suitable for the cell and protected against incorrect polarity and connection faults.

10.3 The manufacturing system shall link each cell identity or approved traceable population to its final pack position. Where a design permits lot-level rather than individual traceability, the decision shall demonstrate adequate containment capability. CTP construction does not justify losing the relationship between cells and finished vehicles.

10.4 Prevent unauthorized mixing of cell revisions, lots, chemistries or suppliers. A substitution requires design and process review, not only purchasing acceptance. Record removed and replacement cells with their affected test and assembly history.

10.5 Preserve raw results, disposition and the matching algorithm or rule version. A changed grading model shall be validated and its first affected population identified. Quality shall verify that a future suspect cell lot can be mapped to affected packs, vehicles, locations and release status.

11 Cell-to-pack mechanical assembly

Owner: Process Engineering. Prerequisites: released cells and components, validated pack design, controlled environment, capable tooling and trained personnel. This procedure does not authorize energized internal pack work.

Step / owner	Required action and evidence
1 Prepare the structure	Verify tray identity, revision, cleanliness, dimensions, insulation and permitted surface condition. Inspect cooling and vent interfaces before they become inaccessible. Record the product and tooling configuration.
2 Prepare cell placement	Confirm cell type, matching results, orientation and approved placement map. Verify handling tools, protection against terminal contact and foreign-object control. Hold a cell with unknown or suspect status.
3 Dispense interfaces	Apply the approved adhesive or thermal interface material with controlled batch, quantity, pattern and usable life. Record preparation, mix and exposure conditions relevant to bond or thermal performance.
4 Locate and retain	Place cells using validated handling forces and locating features. Avoid uncontrolled compression, impact or contact with terminals. Verify positional and insulation criteria before further integration.
5 Complete structure	Install approved restraints, barriers and structural connections in the specified sequence. Maintain expansion and vent allowances. Capture critical fastening, cure and dimensional evidence.
6 Verify the assembly	Inspect inaccessible features before closure. Reconcile cell genealogy, process results and defects. Release only the defined mechanical state to electrical interconnection or subsequent test.

Structural bonding changes require design-owner approval. Cell removal, adhesive rework and damaged-tray repair need validated methods; forcing a cell out of a bonded structure is not a permitted generic recovery action.

12 Electrical interconnection and insulation

The electrical process owner shall define every transition at which assembled energy or accessible voltage changes. Controls shall follow the actual circuit, including temporary connections and test equipment.

Step / owner	Required action and evidence
1 Confirm safe task state	Verify authorized personnel, product state and approved instruction. Identify energized internal portions, exposed conductive parts and prohibited access. Apply barriers and tools specified for the task.
2 Verify components	Check busbars, fuses, conductors, connectors, insulators and protective devices against the released bill of materials. Confirm orientation, clearance and surface cleanliness before joining.
3 Make controlled joints	Use the qualified welding or fastening programme. Prevent spatter, burrs, debris and unintended current paths. Record required signatures, joint IDs and tool or programme revision.
4 Inspect inaccessible areas	Verify insulation placement, connector engagement, routing, strain relief and protective separation before closure. Maintain evidence at the resolution needed to reconstruct the assembly.
5 Test defined features	Perform only the approved checks with suitable guarded equipment and test parameters. Confirm that the method is compatible with connected electronics and protection components. A generic dielectric test can damage a product.
6 Reconcile and release	Quality verifies completion, out-of-window events and disposition. Preserve original failures and link approved rework. Update product state and permitted next operations.

An external contactor, service disconnect or pyrotechnic device does not necessarily make all internal pack conductors safe. The electrical architecture and task-specific isolation boundary govern access.

13 Thermal systems, sealing and structural closure

13.1 The process owner shall control cooling plate, pipe, hose, manifold and interface identity, cleanliness and damage. Materials and fluids shall match the design's compatibility requirements. Substitution can affect corrosion, sealing and electrical isolation and requires technical approval.

13.2 Leak testing shall use an approved medium, fixture, pressure profile, stabilization, measurement method and acceptance limit. Consider trapped pressure, fixture failure, test temperature and operator protection. A pressure-decay number shall not be compared with a different test setup without establishing equivalence.

13.3 Thermal interface materials shall be controlled for storage, conditioning, mix, quantity, distribution, thickness-related design requirements and cure. A visually complete bead is not sufficient evidence of the intended thermal contact. Verify the characteristic using the qualified method and sampling plan.

13.4 Before closure, inspect foreign-object removal, insulation, routing, vent paths, seals, fasteners and the absence of trapped tools. Confirm that every concealed critical feature has an accepted record. Closure shall not be used to make an unresolved defect inaccessible.

13.5 After closure, apply the specified sealing and functional checks and assess any re-opened pack through an approved rework route. Preserve the original seal and closure history. Reuse of seals, fasteners or adhesives shall follow their validated reuse rules; default reuse is not authorized.

14 High-voltage architecture and work authorization

14.1 The electrical safety authority shall maintain an equipment and task register covering nominal and maximum voltage, stored energy, available fault conditions, isolation points and residual energized portions. Include chargers, test stands, capacitors, vehicle drives and temporary supplies. A nominal architecture label is insufficient for equipment selection.

14.2 Assess electric shock, arc and thermal effects, inadvertent movement, tool shorting and stored mechanical or chemical energy. Shock approach arrangements and arc-related protection are different controls. Protective equipment, distances and test instruments shall be selected from the applicable assessment and equipment data.

14.3 Define authorization categories for awareness, operation of enclosed guarded tests, de-energized work, isolation and verification, and exceptional energized diagnosis. State who may issue a permit, perform the task, provide supervision and release the work area. Review competence after changes or evidence of inadequate performance.

14.4 De-energized work is the default wherever the task permits it. Any legally permissible energized task shall have a documented necessity, qualified personnel, task-specific risk controls, rescue arrangements and approval before work. Schedule pressure, convenience or a wish to avoid stopping production is not a technical justification.

14.5 Local instructions shall identify compatible voltage-rated instruments, leads, protective equipment and verification methods. Inspect equipment before use and maintain its required checks. This manual intentionally supplies no generic approach distance, glove class, arc rating or waiting time for 400 V or 800 V+ systems.

15 Isolation, verification and return to service

Only authorized electrical personnel may execute the equipment-specific procedure. The sequence below defines required gates and records; it is not a substitute for the manufacturer's detailed isolation instruction.

Step / owner	Required action and evidence
1 Plan and identify	Confirm the exact product, electrical diagram, task boundary, sources, stored energy and required safe state. Prevent unintended movement and remote activation using the approved method.
2 Establish isolation	Operate the specified isolation devices and secure them against re-energization. Address external supplies, charging, auxiliary circuits and other relevant energy paths. Record the isolation boundary and responsible person.
3 Control residual energy	Follow the validated method and timing for the equipment. Treat unisolated internal cells and conductors as energized. Waiting for a nominal discharge period alone does not prove absence of voltage.
4 Verify before access	A qualified person uses the prescribed test method at the defined points with suitable equipment. Verify instrument function before and after testing as required by the procedure. Record the result and the authorized work boundary.
5 Perform bounded work	Maintain barriers and isolation control. Stop if the configuration or task changes. Group work, shift transfer and contractor involvement require a documented transfer of protective responsibilities.
6 Restore under control	Confirm completed work, people and tools clear, protective covers restored and required checks passed. Follow the authorized lock-removal and energization procedure; record the readiness and product-release decisions.

An emergency stop, software inhibit or disconnected low-voltage supply is not automatically a verified high-voltage isolation. Unexpected voltage or an uncertain instrument result requires stopping and specialist assessment.

16 Formation, aging and electrical test facilities

This section applies where formation, cycling, aging or charge/discharge testing is performed. The facility shall be designed for the product energy, chemistry and credible failure conditions.

Step / owner	Required action and evidence
1 Qualify the facility	Validate channels, connections, monitoring, protective cut-offs, ventilation and emergency response interfaces. Define the maximum approved product population and separation or containment arrangements.
2 Authorize the recipe	Use only approved current, voltage, temperature and time profiles with product compatibility checks. Record recipe revision and approval. Prevent uncontrolled profile changes or cross-use between chemistries.
3 Load and identify	Verify cell or pack condition, polarity, fixture integrity and genealogy. Separate suspect items. Confirm that each physical position is correctly associated with its test channel and data record.
4 Monitor the process	Capture electrical and environmental trends. Monitor defined abnormal indicators and sensor health. Protective responses shall not depend solely on an unvalidated business network or manual observation.
5 Respond to alarms	Follow the validated safe response, including stopping new loading and escalating abnormal heat, gas or electrical behaviour. Do not approach, move or reconnect an actively failing item through a generic operator procedure.
6 Review and release	Quality and Engineering review acceptance, abnormal traces, interrupted cycles and equipment faults. Release only the supported scope. Preserve failed and incomplete test results with the final disposition.

A successful test cycle does not prove all lifetime or abuse-performance requirements. Validation and routine production testing have different purposes and shall remain identifiable in the records.

17 Robot and cobot application risk assessment

17.1 The integrator shall assess the complete application: robot, payload, end effector, cell or pack, fixtures, adjacent equipment, human tasks and foreseeable misuse. Consider loading, teaching, cleaning, jam recovery, maintenance and power restoration, not only the normal automatic path.

17.2 Select the protective concept from the application hazards. Options may include guarded separation, monitored stopping, hand guiding, speed and separation monitoring, or power and force limiting where suitable. A tool that is sharp, hot, electrically hazardous or capable of trapping a person can invalidate an assumed contact-tolerant arrangement.

17.3 Define safeguarded and restricted spaces, approach routes, reach-over or reach-under hazards, crushing points and escape paths. Include payload changes, dropped objects, battery damage and interaction with mobile equipment. Floor tape identifies a boundary but does not implement a safety function.

17.4 For a collaborative mode, determine and validate the actual speed, force, pressure, distance and stopping behaviour required by the assessment. Account for tool and workpiece geometry, contact type, uncertainty and credible approach. No universal “safe cobot speed” is established by this manual.

17.5 The site shall retain the risk assessment, chosen safety functions, configuration, validation evidence and residual-risk instructions. Public robot specifications or a conformity statement for the arm alone do not establish acceptance of the integrated application.

18 Robot cell validation, teaching and recovery

Owners: competent integrator and site automation safety authority. A production programme change can change the safety assumptions even when the robot hardware remains unchanged.

Step / owner	Required action and evidence
1 Verify configuration	Record robot, tool, payload, fixtures, safety controller, firmware and safety settings. Protect configuration access and keep an approved baseline under IAF-MAN-OTC-001.
2 Validate functions	Test the required protective functions, detection coverage, stop behaviour, mode selection and reset arrangements using an approved protocol. Record actual evidence and close failures before production.
3 Authorize teaching	Define who may enter, select teach mode and control movement. Use the manufacturer's approved enabling and reduced-risk arrangements. Coordinate any additional people within the cell.
4 Control operation	Verify correct programme, payload and tool configuration. Monitor protective devices and access points. An unexplained protective stop requires investigation, not repetitive resetting or disabling the function.
5 Recover safely	Use a task-specific jam or part-recovery instruction with the required safe state. Identify trapped or damaged cells. Do not enter or guide an automatic robot by relying on a verbal assurance that it will remain still.
6 Revalidate change	After changes to path, speed, tool, payload, fixture, scanner or safety logic, reassess affected hazards and repeat the relevant validation. Record release and operator training before resuming routine work.

An emergency-stop reset shall not itself initiate hazardous movement. Remote support shall remain bounded by local authorization and verified plant state; network access is not permission to move the robot.

19 Functional safety and production interlocks

19.1 The engineering authority shall identify protective functions for equipment and product handling, including hazardous motion prevention, guarded test access, emergency response and safe recovery. Define each function's trigger, required response, operating modes, performance requirement and validation method.

19.2 Electrical and software architecture shall prevent an ordinary production command from silently overriding a protective function. Safety-related settings and code shall have restricted access, independent review and traceable change control. Where functions share networks or hardware, assess common-cause and communication failures.

19.3 For pack and vehicle systems, test relevant interlock, contactor, precharge, isolation-monitoring and fault-response behaviour under the approved product plan. Use manufacturer-defined methods and safe fixtures. Bridging an interlock or forcing a contactor is not a normal production recovery method.

19.4 Any temporary test arrangement shall be engineered, authorized, physically controlled and limited to its purpose. Record installed links, fixtures and software modes and positively verify their removal or final state before product release. A test exception shall not become an undocumented production configuration.

19.5 Validation shall cover loss of power, communications and sensors, unexpected restart, configuration mismatch and foreseeable abnormal sequences. Record whether the actual safe response was achieved. A passed network test or absence of an alarm does not establish a functional safety result.

20 EV mating, commissioning and end-of-line release

The vehicle manufacturer shall define the exact build configuration and test plan. Battery release, vehicle assembly release and software provisioning evidence shall reconcile to the same vehicle identity.

Step / owner	Required action and evidence
1 Confirm mating readiness	Check vehicle and pack identity, revision, acceptance, lifting fixtures, attachment points and line state. Verify compatible hardware and software configurations before mechanical integration.
2 Integrate mechanically	Use approved lifting, alignment, fastening and connector methods. Protect seals, cooling and high-voltage interfaces. Record critical joint results and inspect concealed features before closing access.
3 Complete utilities	Perform approved fluid fill, bleed, leak and interface checks. Use validated parameters and protect personnel against pressure and electrical hazards. Resolve every relevant failure before commissioning.
4 Authorize energization	Confirm required electrical and protective checks, access control and competent personnel. Execute the controlled commissioning instruction. Record actual product state and any restrictions.
5 Provision and test	Use IAF-MAN-OTC-001 for software and credentials. Complete the approved functional and safety tests with the correct vehicle configuration. Preserve failures, retries and recovery actions.
6 Release the vehicle	Reconcile genealogy, hardware, software, test results, open holds and temporary test configurations. Quality authorizes release only after required evidence passes. Shipping status shall remain blocked for incomplete units.

High-voltage insulation or dielectric test settings shall be selected for the actual product and connected electronics. Repeated testing after a failure requires engineering disposition; it shall not be used to obtain a passing result by chance.

21 Handling, internal logistics and shipment

21.1 The logistics plan shall identify approved containers, terminal protection, lifting points, mass, orientation, stack limits, routes and storage conditions. Packaging and fixtures shall protect both the battery and people. A cell or pack that has been dropped, crushed or exposed to an unapproved condition shall be reassessed before use.

21.2 Segregate pedestrian routes from vehicles and mobile robots where the risk assessment requires it. Verify floor loading, aisle clearance, battery handling equipment and parking arrangements. Automated guided vehicles carrying batteries shall have validated interaction and emergency recovery controls.

21.3 For external shipment, the responsible specialist shall determine the applicable dangerous-goods classification, packaging, tests, documentation, marking and carrier restrictions for the item, condition and transport mode. Evidence for a normal product shall not be assumed to cover damaged, defective, prototype or waste batteries.

21.4 Control shipment configuration, SOC where specified, transport mode, destination and required acceptance evidence. The transport requirement register shall identify actual legal and carrier sources and their current editions. This manual does not provide a universal shipping SOC or packaging instruction.

21.5 If an incident occurs in transit, preserve shipment identity and available monitoring information and coordinate with the carrier and trained responders. A returned battery remains in an assessed receiving state; it shall not re-enter normal stock merely because its original manufacturing test passed.

22 Suspect batteries, quarantine and emergency response

22.1 The site shall plan for overheating, venting, smoke, electrolyte release, damaged packaging, internal short indications and abnormal electrical behaviour. Define alarm routes, evacuation, access restriction, responder information and command responsibility. The plan shall reflect chemistry, quantity, location and facility design.

22.2 Personnel shall raise the alarm and follow the trained protective response. Routine operators shall not open, puncture, dismantle, re-energize or move an actively failing battery. Isolation, cooling, firefighting, gas monitoring and post-incident handling require the site's engineered arrangements and trained responders.

22.3 Quarantine is a controlled status and location appropriate to the hazard assessment; it is not simply an empty pallet space. Define acceptance of suspect items, monitoring, segregation, access and the conditions for specialist transfer. Do not seal a venting item in an improvised container.

22.4 After an incident, responders and technical specialists shall determine re-entry, stabilization and handling conditions. A normal surface-temperature reading at one time does not establish that internal hazards have ended. Maintain the specified monitoring and restrictions until competent release.

22.5 Quality shall contain potentially related cells, packs and vehicles using genealogy and failure evidence. Preserve records safely, notify the relevant product owner and authorities where required, and conduct a cause and effectiveness review. Emergency drills shall test decision and communication quality as well as evacuation.

23 Rework, repair, dismantling and circularity

23.1 Rework shall be authorized for the exact product condition and operation. The method shall define electrical state, chemical and mechanical hazards, competence, tools, component replacement rules and required requalification. A standard assembly instruction is not automatically a safe reverse-disassembly instruction.

23.2 Before opening a pack, identify design limitations, residual energized regions, pressure or vent hazards and approved access methods. An isolated external circuit does not make internal cell interconnections de-energized. Work outside the available competence or validated method shall be referred to the authorized specialist.

23.3 Preserve cell, component and software genealogy through repair. Record removed parts, replacement identity, altered joints and repeated tests. Do not erase the original failure or represent repaired output as first-pass production. Changes affecting warranty, conformity or customer requirements need the appropriate authorization.

23.4 For second use, remanufacture or recycling, establish a separate suitability and legal assessment for the intended destination. Remaining capacity alone does not demonstrate safety or fitness. The receiving organization shall have the competence and authorizations required for its actual activity.

23.5 Waste handling shall prevent unintended electrical contact, release and uncontrolled reuse. Control documentation, chain of custody and disposal evidence through the applicable retention rules. Material-recovery objectives shall not override safe handling or truthful product-status declarations.

24 Measurement, data and change control

24.1 The plant shall maintain measurement capability for environmental, electrical, dimensional, leak and joining characteristics. The range, uncertainty, response time and operating conditions shall suit the decision. Calibration intervals and intermediate checks shall reflect risk and equipment behaviour, with stricter legal or method requirements retained.

24.2 Environmental and process records shall use a synchronized and documented time basis. Associate data with room zone, sensor, channel, product, recipe and software revision. Missing or implausible data shall trigger review; interpolation or replacement values shall not be presented as original measurements.

24.3 Changes to chemistry, cell format, supplier, adhesive, tray, electrical architecture, environmental limit, robot path or test software require impact assessment. Define affected variants, trials, acceptance, training and the first changed unit. Site approval shall follow evidence, not precede validation as a formality.

24.4 Digital access and backups follow IAF-MAN-OTC-001. Safety configurations, release logic and test limits shall be protected from unauthorized editing. Supplier remote sessions shall be approved and supervised with the appropriate safe plant state.

24.5 Retain validation, genealogy, competence, environmental excursions, electrical work, safety-function tests and release records under IAF-GUI-DOC-001 and the applicable product, customer and legal schedule. An investigation or legal hold suspends relevant disposal. Preserve readability and access to the interpretation context.

25 Audits, metrics and management review

25.1 The quality plan shall audit real production, abnormal recovery and records across the site scope. Include dry-room transfer, cell genealogy, incomplete tests, failed joints, high-voltage work permissions, robot interventions and pack release. Review night and contractor work where the risk justifies it.

25.2 Measures shall include first-pass yield by operation, environmental excursions, unmatched genealogy, rejected cells, joint failures, test-channel faults, protective-device failures, training validity and open critical actions. Report quantity and severity; a low count of severe failures is not an acceptable result by itself.

25.3 Energy and yield improvement shall use validated process windows. Dry-room setpoint changes, formation profile changes and faster robot motions require technical review. A reduction in energy consumption or cycle time shall not be claimed as improvement if it increases latent failure risk or invalidates qualification.

25.4 Management shall review implementation and effectiveness at least annually and after a major incident or technology transition. Review resources, supplier changes, emerging failure modes, emergency readiness, competence, assurance evidence and overdue actions. Record decisions and responsible owners.

25.5 Findings involving unknown battery state, failed protective functions, uncontrolled environmental exposure or unreliable release data require immediate containment. Closure requires evidence that the condition and its cause were addressed. Passing a later audit does not retrospectively validate affected product.

26 Implementation gates and readiness criteria

26.1 Begin with a declared technology and process scope, then perform a gap assessment against this manual. Identify whether the plant manufactures cells, assemblies sealed cells, integrates structural packs or performs energized commissioning. Assign a technical owner to every included activity.

26.2 Complete the parameter register, process risk analyses, electrical authorizations, emergency plan and integrated automation validation before a representative pilot. Verify facilities, test equipment, competent personnel, current instructions and traceability. Missing critical fields prevent activation of the related operation.

26.3 Pilot with identified products, bounded conditions and approved disposition. Exercise abnormal scenarios safely through simulation or controlled tests where practicable: environmental alarm, identifier mismatch, failed test, robot protective stop and interrupted software provisioning. Do not create a hazardous battery failure on an ordinary production line.

26.4 At readiness review, accept full operation, restricted trial or continued hold based on recorded evidence. Record open noncritical actions with owners and dates. A restricted trial shall specify who may operate, which units are included and how shipment is prevented until release.

26.5 After rollout, verify all shifts and representative variants. Revisit assumptions when volume, occupancy, chemistry, equipment or staffing changes. Use Annexes A to G to document the decisions and maintain the actual effective date; the publication date does not certify the factory's readiness.

Annex A Site parameter and limit register

Form reference: GAA-A. Complete one record per zone, process or test. Approved values are mandatory before activation; blank fields are not default acceptance.

Parameter group	Required definition and entry
Identity / scope	Zone / asset: _____ Product / chemistry / state: _____
Environmental moisture	Dew/frost-point basis, units, sensor locations, limits: _____
Temperature / pressure	Process temperature, pressure basis and differential limits: _____
Particles / contamination	Sizes, class if adopted, sampling method, room state: _____
Exposure budget	Material, permitted duration, cumulative clock and packaging: _____
Assembly process	Joining, dispensing, cure, force and dimensional schedule: _____
Electrical envelope	Maximum voltage / energy scope and test compatibility: _____
Test parameters	Method, limits, uncertainty and product configuration: _____
Robot application	Approved mode, limits, stopping validation and configuration: _____
Reaction	Alert / action / sensor-fault response, hold and restart: _____
Evidence / approval	Validation reference, owner, approvers, revision and date: _____

Changes require an impact review and updated validation where needed. Keep setpoint, permissible process window and protective trip setting distinct. A trip threshold shall not be silently widened to accommodate poor process capability.

Annex B Environment and excursion record

Form reference: GAA-B. Zone: _____ Date / shift: _____ Event: _____

Record item	Entry / evidence
Current configuration	Room qualification / recipe / occupancy: _____
Sensor status	IDs, calibration, time synchronization and health: _____
Observed condition	Value / units / location / start and end time: _____
Limit and basis	Approved alert or action requirement / revision: _____
Material population	Lots, quantities, positions and exposure-start records: _____
Protective response	Stopped exposure / packaging / notification: _____
Technical evaluation	Cumulative exposure, evidence and validated disposition: _____
Restoration	Cause corrected, stability evidence and requalification: _____
Release	Material disposition / room restart / approvers and date: _____
Follow-up	Corrective action, owner, deadline and effectiveness: _____

Review prompts

Were supply-air and product-area readings distinguished? Were door events, buffers, open containers and missing data considered? Can all affected material be traced? Was any reconditioning method validated for the exact material? Did the restart verify conditions at the relevant locations?

Attachments and open restrictions: _____

Annex C HV task authorization and permit

Form reference: GAA-C. Administrative authorization record only. Attach the approved equipment-specific work instruction and risk assessment; this form is not an electrical work method.

Required field	Entry
Task and equipment	Work order: _____ Product / asset / diagram revision: _____
Task category	Enclosed operation / isolation / de-energized work / energized diagnosis: ____
Electrical scope	Nominal and maximum voltage; energy sources; residual live areas: ____
Necessity and boundary	Task justification, work limits and prohibited areas: _____
Authorized people	Performer / competence scope / supervisor / permit issuer: _____
Protective arrangements	Safe-state method, equipment, barriers and rescue reference: _____
Verification evidence	Isolation and test record, instrument identity and checks: _____
Validity	Start: _____ Expiry / shift transfer condition: _____
Stop conditions	Unexpected voltage, changed scope, equipment fault or loss of control: ____
Return to service	Work completed, protective restoration and approval record: _____

Permit issuer / date: _____ Performer acceptance: _____

Completion / handback authority: _____

A permit cannot make an unsafe or unlawful task acceptable. Energized diagnosis requires separate evidence of necessity, competence and task-specific precautions under the applicable site rules.

Annex D Robot application acceptance record

Form reference: GAA-D. Application: _____ Integrator: _____ Site owner: _____
 Product / task: _____

Acceptance item	Evidence / result / verifier
Configuration	Robot, tool, payload, fixture, firmware and safety baseline: _____
Risk coverage	Operation, teaching, recovery, maintenance and misuse: _____
Protective concept	Guarding / monitored stop / guiding / separation / limiting: _____
Human interaction	Approach routes, trapping, sharp tools, battery hazards: _____
Safety functions	Required functions, performance basis and test records: _____
Collaborative limits	Validated limits, method, conditions and uncertainty: _____
Stop and reset	Measured stopping behaviour, access and restart prevention: _____
Instructions	Authorized modes, competent people and abnormal recovery: _____
Change protection	Access, backup, revision and revalidation triggers: _____
Decision	Accepted scope / restrictions / open actions / approver: _____

Acceptance date: _____ First operational configuration: _____

A robot-arm declaration or marketing designation cannot replace this application record. Record “not applicable” only with a technical reason. Any unresolved protective-function failure prevents the affected mode from being released.

Annex E Pack genealogy and release traveller

Form reference: GAA-E. Pack ID: _____ Vehicle ID where assigned: _____ Design / build revision: _____ Production order: _____

Gate	Record reference / status
Inputs	Cells, tray, busbars, barriers, adhesives, cooling components: _____
Cell map	Cell identities / approved lot mapping and positions: _____
Environment	Exposure and zone records / excursions / disposition: _____
Mechanical assembly	Placement, bonding, structure and critical fastenings: _____
Electrical joining	Programme, signatures, inspection and rework: _____
Cooling and closure	Leak, cleanliness, insulation, seals and concealed checks: _____
Electrical tests	Method, equipment, limits, raw results and failures: _____
Software	Authorized software manifest and provisioning receipt: _____
Holds / repairs	Original failure, disposition, retests and unresolved items: _____
Final release	Configuration reconciliation, releaser, date and scope: _____

Disposition: released / restricted / held / rejected. Destination: _____

Store references to secure provisioning evidence without private keys, passwords or reusable diagnostic secrets. A later repair record shall link to this traveller and preserve the original manufacturing history.

Annex F Emergency and readiness exercise

Form reference: GAA-F. Exercise scope: _____ Coordinator: _____ Date: _____
Scenario is simulated unless an approved specialist test protocol states otherwise.

Scenario	Expected demonstration
Environmental alarm	Stop new exposure; identify lots; preserve readings; obtain technical disposition and qualified restart.
Damaged cell at receipt	Protect people; segregate through the approved route; identify the shipment and assess related stock.
HV safe state uncertain	Stop the task; prevent unauthorized access; obtain the electrical safety authority's assessment.
Robot protective stop	Avoid repeated reset; establish safe recovery; verify configuration and revalidate if changed.
Test-channel anomaly	Contain connected products; review channel and recipe; retain failed results and define retest authorization.
Thermal / venting alarm	Raise alarm, evacuate as planned, restrict entry and give responders accurate product and location information.

Observed response / timing / communication gaps: _____

Corrective actions / owners / dates: _____

Effectiveness review and exercise closure: _____

Do not generate thermal runaway, expose live conductors or disable safeguards on a normal production line to make an exercise realistic. Use simulation or specialist facilities appropriate to the hazard.

Annex G System interfaces and retention

Reference / owner	Required interface
IAF-QM-001 / Quality	Process accountability, risk, competence, audit, corrective action and management review.
IAF-GUI-DOC-001 / Controller	Approved master text, station instructions, revision notices, record retention, archive and disposal.
IAF-MAN-LMS-001 / Production	Standard work, material flow, first-off checks, maintenance, downtime and restart.
IAF-MAN-OTC-001 / OT security	Access, automation changes, recipe protection, secure flash, incident response and recovery.
IAF membership / recognition guides	Independent admission, status and scope decisions; no automatic recognition from using this manual.
IAF privacy / reporting / conflicts policies	Protected personal information, good-faith reporting and independent technical judgment.

Minimum retained evidence

Retain design and process validation, parameter schedules, room qualification, environmental records, chemical and material identity, cell-to-pack genealogy, joining and test data, electrical authorizations, robot validation, release and incident records. Each record class shall identify owner, access, retention trigger and approved disposal authority.

Set retention from the applicable product lifetime, safety obligations, legal requirements and customer commitments. No single retention period is suitable for every record. Preserve evidence under investigation or legal hold; ensure long-term files remain readable with software and method context.

Operational commencement reference and date: _____