Manufacturing a Certified Aircraft Seat Cushion in Saudi Arabia

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This paper presents a practical, regulation-aligned roadmap to design, certify, and produce transport-category aircraft seat cushions in Saudi Arabia under GACAR Parts 21 and 25, harmonized with the technical standards of 14 CFR Part 25. It consolidates design approval paths for cushion changes, distinguishing Supplemental Type Certificates from minor changes, and outlines EASA DOA and FAA §21.93 classification along with preservation of dynamic-seat compliance per §25.562 and AC 20-146A. The production section compares approval options in the Kingdom, acceptance of FAA and EASA articles, release on EASA Form 1 with GACAR §21.263 import conditions, and limited fabrication under §21.15. Flammability compliance is addressed through §25.853, Appendix F methods, the seat-cushion oil-burner test, vertical burn screening, and typical fire-blocking constructions. The organizational and facility framework defines essential team roles and quality controls, equipment and environmental requirements, in-house screening, use of accredited labs, and release documentation under recognized production approvals. A stepwise plan covers design, certification testing, production authorization, small-batch manufacturing with full traceability, airworthiness release, and installation consistent with §121.312. The approach enables low-rate programs to achieve compliance while leveraging external DOA and POA support to reduce overhead.

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I.Required Certifications and Approvals

Commercial aircraft seat cushions manufactured or installed in Saudi Arabia fall under the General Authority of Civil Aviation regulatory framework in GACAR Part 21 for approvals and GACAR Part 25 for airworthiness standards. For transport category airplanes, GACAR Part 25 incorporates the technical requirements of 14 CFR Part 25 by reference, including flammability and dynamic-seat criteria. [1][8]

1) Design approval

Design changes to seats or cushions are approved either as major changes via a Supplemental Type Certificate (STC) or as minor changes when the change has no appreciable effect on weight, balance, structural strength, reliability, operational characteristics, or other airworthiness characteristics. Under EASA, a Design Organisation Approval holder may classify and approve minor changes within its privileges. Under FAA, the major versus minor classification is defined in 14 CFR 21.93. [6][7][10]. Under EASA, a DOA holder may classify and approve minor changes within the privileges of Part 21 point 21.A.263. [6] When following an FAA path, an FAA designee may approve engineering data on Form 8110-3, which is a data-approval instrument and not an installation approval by itself. [11] If the cushion is installed on a seat qualified to the dynamic occupant protection rule, compliance with 14 CFR §25.562 must be preserved and may be shown by analysis or similarity where appropriate as described in FAA AC 20-146A. [9][12]

Note that; Engineering data that substantiates compliance may be approved on FAA Form 8110-3 by an FAA engineer or a DER in accordance with AC 25.853-1. Approval of technical data does not by itself constitute installation approval. Installation approval depends on the selected certification path such as STC, approved minor change by a DOA, or other applicable mechanism. [3][4][5][11]

2) Production approval

To manufacture cushions as approved aviation articles in the Kingdom, the production approval options include Saudi Arabia Parts Manufacturer Approval (SAPMA) under GACAR Part 21 Subpart G or Saudi Arabia Technical Standard Order authorization under Subpart J when manufacturing to a recognized minimum performance standard. GACAR Part 21 also recognizes FAA PMA, FAA TSO, and EASA ETSO as acceptable approval bases for articles, as well as approvals in conjunction with type certification or STC. [1]

Where cushions are produced under an EASA Part 21G Production Organisation Approval, release is made on EASA Form 1. Acceptance in Saudi Arabia requires that import conditions in GACAR §21.263 are met, which include that the exporting authority has an applicable agreement with the United States or the Kingdom and that an export airworthiness approval accompanies the article. The EASA-GACA working arrangement provides the framework for such acceptance. [1][2][15]

For very limited situations, GACAR §21.15 allows fabrication of parts by an appropriately rated certificate holder with a quality system when the part is consumed in a repair or alteration under GACAR Part 43. This is distinct from serial production and does not replace the need for SAPMA, TSO, or an equivalent approval when manufacturing for sale as replacement parts. [1]

II.Teams and Organizational Requirements

Design and Engineering Team

The engineering team defines the cushion geometry for the target seat model and attachment scheme, selects materials including foam, fire-blocking, and dress cover, and prepares the complete technical data set such as drawings, material and process specifications, conformity points, and substantiation reports. [1] Cabin interior materials, including seat cushions, must comply with 14 CFR §25.853 using the test methods in Part 25 Appendix F, which include the oil-burner method for cushions. [3][4] Change classification governs the approval path, with the minor versus major definition in 14 CFR §21.93. [7]

Certification and Quality Team

Certification specialists coordinate with GACA on the applicable certification basis and amendment level for the change and control the compliance package, including flammability evidence and any dynamic-seat substantiation as required. [1][8] For production authorization in the Kingdom, GACAR Part 21 provides the framework for article approvals and the associated quality system, including organization, supplier control, inspections, and nonconformance management. [1] Where production is conducted under EASA privileges, an EASA Part 21G Production Organisation Approval with release on EASA Form 1 can be used, with acceptance in Saudi Arabia subject to GACAR §21.263 and the working arrangements between EASA and GACA. [15][1][2]

Manufacturing Team

Manufacturing personnel cut and shape foam, integrate fire-blocking layers, and fabricate covers to the approved design using controlled processes with travelers and inspection points to ensure full conformity to the engineering data. [1] The production quality system covers receiving inspection, in-process and final inspection or test, documented control of nonconforming product, and internal audits consistent with GACAR Part 21 article approvals. [1] When production is performed under an EASA POA, parts are released on EASA Form 1 in accordance with the organization’s privileges and procedures. [15]

Testing and Laboratory Support

Flammability compliance for cushions follows §25.853 and the methods in Part 25 Appendix F, including the seat-cushion oil-burner test and any applicable vertical Bunsen burner tests for associated materials. [3][4] If the cushion change could affect the seat’s dynamic performance, substantiation must show continued compliance with §25.562 and may rely on validated analysis or testing as outlined in AC 20-146A. [9][12] Where the seating system has been approved to the C127-series seat TSO or ETSO, the modified configuration must continue to meet the relevant minimum performance standards in addition to the airworthiness rules. [14]

Team Sizing and External Support

A compact team can execute a low-rate cushion program if the roles above are covered by qualified staff, including an engineer or designee authorized to make findings and production personnel trained to aerospace procedures. [1] External resources are commonly used where in-house authority or facilities are not available, for example an EASA DOA to approve a minor change or an EASA POA to produce articles released on Form 1 that GACA can accept under §21.263 and the EASA–GACA working arrangement rather than duplicating approvals. [6][15][1][2]

III.Regulations and Standards to Follow

Design and manufacture of the cushion must comply with the applicable airworthiness regulations and material performance standards to ensure safety and airworthiness. [1][8]

Flammability requirements

Commercial transport-category seat cushions are subject to 14 CFR §25.853, which requires demonstrating compliance using the methods in Part 25 Appendix F. [3][4] The seat-cushion oil-burner test in Appendix F Part II exposes representative bottom and back cushion assemblies to a high-intensity flame for 2 minutes and evaluates burn length and weight loss as the pass–fail metrics. [4] The FAA guidance further clarifies acceptance criteria, including the threshold that burn length must not exceed 17 inches on at least two of the tested sets, with weight loss limits applied to the horizontal cushion. [5] Typical compliant constructions employ an internal fire-blocking layer, for example an aramid wrap, over the foam core to achieve rapid self-extinguishment and limited burn length and weight loss in the oil-burner test. [4][5] Other interior materials used in the cushion system, such as fabrics, foams, hook-and-loop and threads, are additionally evaluated using the vertical Bunsen burner methods in Appendix F Part I, including 12-second and 60-second tests as applicable. [4][5] While §25.853 does not prescribe gaseous toxicity limits for seat cushions, many operators or seat OEMs specify compliance with proprietary smoke and toxicity standards such as Airbus ABD0031; selecting aviation-grade materials with documented low smoke and toxic emissions is common practice to satisfy these specifications. [3][17]

Airworthiness and safety, structural and operational

Any cushion change must not compromise compliance of the approved seat system with the transport-category dynamic-seat rule in 14 CFR §25.562, which governs occupant protection under specified 16 g crash pulses. [9] For many cushion substitutions that retain similar stiffness, thickness and geometry to the original, substantiation may rely on analysis or similarity rather than new dynamic testing, consistent with FAA guidance for dynamic seats. [12] If differences are significant, analysis and, sled testing are used to demonstrate continued compliance with the §25.562 performance measures, such as head-injury criterion and lumbar loads. [9][12] If the cushion is intended to serve as an individual flotation device, it must meet the performance and marking requirements of TSO-C72c; compliance is demonstrated by separate flotation testing to verify buoyancy and related criteria. [13] Replacement interior materials installed in air carrier cabins must also meet the applicable fire-safety standards under the operational rule 14 CFR §121.312. [16]

Compliance with GACA and international standards

For Saudi-registered transport aircraft, GACA adopts the technical standards of 14 CFR Part 25 by reference in GACAR Part 25; meeting FAA Part 25 or EASA CS-25 requirements therefore aligns with GACA's technical expectations for interiors and seats. [8] GACAR Part 21 provides acceptance and import-acceptance mechanisms for articles and design approvals from recognized foreign authorities, which can include FAA or EASA approvals when applicable agreement conditions are met. [1][2] Applicants generally target the most demanding applicable requirement among FAA, EASA and GACA, and incorporate any airline-specific requirements into the compliance plan and matrix reviewed during approval. [1][2][8]

IV.Facility Requirements for Production

Setting up a facility to manufacture aircraft seat cushions even in small batches requires capabilities and controls that ensure conformity to approved design data under the production approval framework. [1]

Manufacturing space and equipment

The facility should include dedicated areas for foam cutting/shaping and upholstery, with suitable tools such as band saws or CNC foam cutters for precise foam geometry and industrial sewing machines capable of handling fire-blocking fabrics and dress covers. [1] Jigs/fixtures, cutting tables, patterns, and calibrated measuring devices are required to maintain repeatable conformity of seam positions, attachment features (e.g., hook-and-loop tapes), and overall dimensions to the approved drawings. [1] Where production is conducted under EASA privileges, the organization manufactures in conformity with approved design data within a Part 21G Production Organisation Approval (POA) scope. [15]

Environmental controls and safety

Clean, organized assembly areas reduce contamination risk to foams and textiles and support consistent assembly quality under the required production quality system. [1] Where adhesives or coatings are used, appropriate ventilation/fume extraction and climate control (temperature/humidity) help ensure process consistency and worker safety as described in the organization's approved procedures. [1] Controlled storage preserves material properties (e.g., avoiding moisture pickup in fire-blocking fabrics and foams), and a quarantine area is needed for nonconforming product pending disposition under the quality system. [1]

Testing capabilities

For conformity and lot-acceptance screening, many facilities maintain a small vertical-burn test cabinet to perform Appendix F Part I checks on incoming or lot-change materials in alignment with the compliance plan. [4] The full seat-cushion oil-burner test defined in Appendix F Part II typically is performed at specialized laboratories due to the calibrated burner, rig, and instrumentation requirements; organizations often pre-screen in-house and then use accredited external labs for certification testing. [4][5][18] Measuring devices used for burn-test criteria (e.g., scales for weight loss and rulers for burn length) should be maintained and calibrated per the production approval's quality-system procedures. [1] If the cushion is intended to serve as an individual flotation device, a water-tank setup may be used for pre-verification, with formal compliance shown against TSO-C72c at a qualified facility. [13]

Quality management system and release documentation

The production approval (e.g., SAPMA/SATSO under GACAR Part 21 or an EASA POA) requires a documented quality system covering configuration control, document control, supplier control, receiving inspection, in-process and final inspection, nonconformance/escape management, and internal audits. [1][15] Each article must be produced in conformity with approved design data and released with the appropriate authorized release documentation—such as EASA Form 1 for POA holders or FAA Form 8130-3 for FAA-approved articles—when applicable to the export/import pathway accepted by GACA under §21.263. [15][19][1][2] Facilities should expect initial and periodic surveillance by the competent authority or its designees to verify continued compliance with Part 21 requirements. [1]

V.Production Plan (Design through Installation)

1) Design & engineering phase

Define the target aircraft and seat models to drive size, shape, attachment method, and special features, and capture those constraints in controlled requirements and drawings. [1] Reverse-engineer the incumbent cushion or seat pan as needed to confirm geometry and attachment details for conformity with the approved design data path selected. [1] Select materials and construction to meet the transport-category flammability rule in 14 CFR §25.853 using the test methods in Part 25 Appendix F (vertical Bunsen burner for materials and the oil-burner method for cushions). [3][4] The oil-burner test is a severe 2-minute flame exposure on representative bottom and back cushion assemblies with pass/fail criteria based on burn length and weight loss. [4][5] In practice, compliant cushions typically employ an internal fire-blocking layer (e.g., aramid wrap) around the foam to limit burn length and weight loss in the oil-burner test. [5] Where operators or OEMs impose smoke/toxicity specifications (e.g., ABD0031), material selection should address those requirements in addition to §25.853. [17][3] Design changes are classified as minor or major under 14 CFR §21.93; this classification governs whether approval proceeds via a minor-change route or requires an STC. [7] Under EASA, a DOA holder may classify and approve minor changes within 21.A.263 privileges. [6] If the cushion is part of a 16 g dynamically qualified seat system, the design must preserve compliance with §25.562; this may be shown by validated analysis or similarity per AC 20-146A when the change is benign (e.g., similar thickness/stiffness). [9][12] If the cushion is intended to function as an individual flotation device, the design must meet TSO-C72c performance and marking requirements, demonstrated by separate flotation testing. [13]

Outputs: controlled drawings and models, materials/process specifications, and a compliance plan mapping each requirement to evidence. [1]

2) Certification & testing phase

Build prototype cushions and test specimens to the same construction as the production design for certification. [4] Prepare and test materials (foams, dress covers, fire-blocking) using Appendix F Part I vertical Bunsen burner methods as applicable. [4] Conduct the seat-cushion oil-burner test per Appendix F Part II; acceptance is based on burn-length and weight-loss limits defined by the regulation and FAA test guidance. [4][5] FAA fire-test handbook criteria include burn length not exceeding 17 inches (geometry-based limit) and average percentage weight loss not exceeding 10%, with at least two-thirds of specimen sets also not exceeding 10% weight loss. [18] If testing indicates noncompliance, iterate materials or construction and re-test until compliant. [4][5] For dynamic-seat considerations, substantiate continued compliance with §25.562 by analysis/similarity or sled testing consistent with AC 20-146A depending on the change magnitude. [9][12] For flotation variants, perform buoyancy and related tests to the TSO-C72c standard. [13] Compile the compliance package and obtain the appropriate approval: FAA designees may approve engineering data on Form 8110-3 (data approval, not installation approval), or an EASA DOA may approve a minor change within its privileges; GACA may accept or validate FAA/EASA approvals under the applicable acceptance/working-arrangement provisions. [11][6][1][2]

Outputs: approved design data set (e.g., DER-approved data or EASA minor-change approval) and complete test reports traceable to the design baseline. [1][6][11]

3) Production setup and authorization
Before airworthy manufacture, implement the production approval path (e.g., SAPMA/SATSO under GACAR Part 21 or EASA POA for foreign manufacture) with the required organization, procedures, and quality system. [1][15] Acceptance of imported articles into KSA depends on GACAR §21.263 and any applicable EASA–GACA working arrangement, including proper markings and export airworthiness approval. [1][2] Procure exact, approved materials as tested; substitutions require engineering evaluation and, where necessary, re-test per the compliance plan. [1][4] Train production personnel to the approved manufacturing instructions, emphasizing critical characteristics such as full fire-block encapsulation, seam locations, attachment features, and dimensional tolerances. [1][18]
Outputs: production organization approval, controlled travelers/work instructions, trained personnel, qualified suppliers, and calibrated equipment lists. [1][15]

4) Manufacturing process (small batch)
Fabricate cushions to the approved drawings using controlled processes, jigs/fixtures, and in-process inspections to ensure conformity. [1] Perform receiving, in-process, and final inspections (dimensions, seam patterns, attachment features, workmanship, and weight within allowed tolerance) under the production quality system. [1] For lot changes in key materials, conduct Appendix F Part I screening or other agreed verification and document results to prevent quality drift. [4] Maintain complete traceability from each cushion to material lots, process steps, and inspectors per the approved quality manual. [1]
Outputs: conforming cushions with full traceability records and inspection results. [1]

5) Certification and release of product
Release articles using the appropriate authorized release documentation for the chosen production path—EASA Form 1 for POA holders or FAA Form 8130-3 for FAA-approved articles—so they can be accepted under GACA import provisions. [15][19][1][2] Archive manufacturing, inspection, and test records in accordance with production-approval retention requirements and the receiving operator's contractual needs. [1]
Outputs: properly tagged/released cushions and complete, retained quality records. [15][19][1]

6) Installation on aircraft
Installation is performed by the operator or an appropriately approved maintenance organization in accordance with the approved installation data (e.g., STC or minor-change instructions) and recorded in the aircraft maintenance records. [1][6] For air carrier operations, replacement interior materials must meet 14 CFR §121.312, which references §25.853 compliance for cabin interiors. [16] Post-installation checks confirm fit and function (e.g., compatibility with belts/armrests/tray tables) and document configuration control of seat and cushion part numbers. [1]
Outputs: aircraft records updated with the approval reference, configuration controlled, and the aircraft returned to service under the operator's procedures. [1][16]

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