Interior Inspection for Equipment and Furnishings System of Civil Aircraft

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Abstract. Equipment and Furnishings System of civil aircraft has many sub-systems, including Pilot Seat, Observer Seat, Cabin Attendant Seat, Galley, Lavatory, Passenger Seat, Overhead Bin, Cockpit Lining, Cabin Lining, Cargo Lining, Emergency Equipment, Passenger Service Unit and Placards/Markings. Inspection (MOC7), as one of means of compliance for certification, is usually used for the certification of the regulations of FAR25.562, 785, 815, etc. The sub-systems in Equipment and Furnishings System are very different at every aspect. They have different functions, working principles and system architectures. These differences make the inspection of Equipment and Furnishings System complicated. A lot of details need attention. This article described the inspection requirement and Pass/Failure criteria for Equipment and Furnishings System.

1. Introduction
There are 10 Means of Compliance (MOC) for certification, as shown in Table 1:

| MOC | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|-----|---|---|---|---|---|---|---|---|---|---|
| Compliance Statement | Design Review | Analysis / Calculation | Safety Assessment | Laboratory Test | Ground Test | Flight Test | Compliance Inspection | Simulation | Equipment Qualification |

MOC7, Compliance Inspection is widely used in the certification for Equipment and Furnishings System of civil aircraft. This article, based on the experience of civil aircraft design and certification and combining the requirement in AC25-17A [1], made a summary of MOC7 work for Equipment and Furnishings System.

2. Regulations
According to TSO-C127b, a passenger seat has to pass Dynamic Test and Static Test [2]. FAR/CS/CCAR 25.561, 562 and 785 have the similar requirement. The difference is that TSO-C127b’s concerning is only the performance of the seat itself, but FAR/CS/CCAR concern the interface strength between the seat and the track as well.

Dynamic Test includes 16g Dynamic test, 14g Dynamic test, Head-path test, Front-row HIC test and Row-to-row HIC test.

Related regulations for Equipment and Furnishings System MOC7 are: FAR25.562, 785, 787, 789, 791, 803, 807, 809, 811, 812, 813, 815, 853 and 1411. They are generally related to Evacuation Exit, Aisle, Passageway, Placards and Emergency Equipment which have influence on aircraft occupants’
emergency evacuation [3]. The execution methods for MOC7 for these regulations usually are Measurement, Visual Inspection and Operation Inspection.

3. Inspection Requirement and Pass/Failure Criteria

3.1. FAR25.562
a) All seats (including flight crew seats, cabin attendant seats and passenger seats) shall have the approval of TSO-C127a or TSO-C127b. If required, the TSO seats need to obtain another kind of approval from the authority, in the form of VDA, LODA, etc.;
   b) TSO tag shall have the proper seat type (e.g., type A) marking, seat cushion part numbers, restraint system part numbers, and forward or aft facing. The part numbers of seat cushion are often to be inspected;
   c) The testing and installation of seats shall consider all limitations, including: the range of occupants, front-row setback and row-to-row pitch. Seat testing shall consider 5th to 95th human body. For the front-row seat, the front-row setback usually is 42 inches (for Economy Class Passenger Seat) or 45 inches (for Business Class Passenger Seat), but it can be adjusted according to the test result of Head Path Dynamic Test [4]. The row-to-row pitch is determined by passenger row-to-row HIC test;
   d) Each occupant in the aircraft shall have a seat place;
   e) Seat tracks part numbers on the airplane shall be as the same as the seat tracks used in the dynamic seat testing. If not, it must be proved that the real track used in the aircraft are not weaker than the track used in dynamic test. Besides, it’s acceptable to do a supplemental test for the real track using the 6 component loads measured in dynamic test [5] to the show the interface strength between seat and track is strong enough. This test is too complicated, so it’s usually suggested to use real track in seat dynamic test;
   f) The permanent deformations of the seats shall not exceed the limits required in AC25.562-1B [4];
   g) Injury criteria shall be met for each seat place, including: HIC, Femur load, Lumbar load and Belt load.

3.2. FAR25.785
a) All seats shall have the approval of TSO-C127a or TSO-C127b;
   b) There shall have no potentially injurious objects within striking radius of the head. The striking radius is a arc scope of 35 inches radius [1], as shown in Figure 1;

![Figure 1. The definition of “35 inches”](image)
c) Armrests when folding up shall not be beyond the seat back;
d) Footrests, legrests, or headrests shall have no potential injurious features;
e) If the footrest or legrest deploy into required crossaisles or passageways, they shall have a mechanical lock-out in the stowed position;
f) If the footrest or legrest is electrically operated, they shall have a manual override to facilitate stowage in the event of loss of electrical power. Otherwise, they may have negative influence on emergency evacuation;
g) Seat belt shall have TSO approval and there’s no tendency for the seat belt shackle to become tangled or hung up on seat structure;
h) Cabin attendant seat shall have shoulder harnesses and lap belts. Usual attendant seat belt is 4-point constraint system and can comply with this requirement;
i) Handholds shall be provided to help occupants to steady themselves. Usually the slot in Overhead Bin is used as the handholds. If no slot in Overhead Bin, the seatback of passenger seat shall comply with following requirement [6]:
   1) Row-to-row pitch shall be no more than 65 inches;
   2) The seatback shall not break over with a 111N load applied on the top of the seatback.
j) All projecting objects, which may be contacted in flight, shall be padded. The door structure needs more attention. Usually, Doors have big hinges projecting into the cabin. It’s hard to make the HIC value not to exceed 1000 as required by FAR25.562 if let the ATD hit the door structure, according to engineering experience. The easiest way is to cancel the seat place or adjust the seat dimension to make the passenger’s headpath keep away from the door structure. At the meantime, sometimes we may have to move the seat track to ensure the seat width.

3.3. FAR25.787
a) Each compartment shall have a weight limit placard or it’s dedicated for emergency equipment only or no stowage;
b) Compartments are completely enclosed;
c) Double latches shall be provided where necessary;
d) There shall have provisions to account for wear and tear in service. To satisfy this requirement, it’s necessary to multiply a factor (1.33 or 1.15) when calculating static load;
e) Means of latching shall be positive with a positive indication when latched or unlatched.

3.4. FAR25.789
a) All objects shall be constrained at each direction. We also need to do static test or analysis to prove that the constraints are solid enough when bearing the emergency landing load and aircraft flight/ground load;
b) For convenience, the aft baggage bar of passenger seat is not necessary.

3.5. FAR25.791
a) A passenger information sign shall be visible from each flight attendant and passenger seat;
b) If there are seats that translate or swivel, a sign shall be visible from each seat position.

3.6. FAR25.803
a) There shall have no tripping hazards present in the aisle, crossaisles or passageways;
b) There shall have no other impediments (projecting objects) to rapid evacuation.

3.7. FAR25.807
a) All clear exit openings shall equal or exceed the minimum required dimensions, including any protrusions from linings, hinges etc.;
b) A flight attendant seat shall be positioned adjacent to each Type A exit.
3.8. FAR25.811
a) All of the required signs (locator, bulkhead, marking) shall be present and visible to persons in the main aisle. And the evaluation shall include consideration of a range of occupants (5th percentile female to 95th percentile male);
   b) The next exit sign shall be visible from each point in the aisle;
   c) All exit signs shall be positioned such that they lead persons to exits and not into galleys or other “dead ends”;
   d) Curtains or other features, e.g. video monitors, shall not interfere with exit sign visibility;
   e) Exit operating instructions shall be clear.

3.9. FAR25.812
The interior modification shall not cause influence on emergency lighting, e.g. creating new shade for emergency lighting or making new shadows.

3.10. FAR25.813
a) All passageways shall be unobstructed from the aisle to the exit opening and have assist space. In aircraft design, it’s common to find Galley and cabin attendant seat intrude passageways, so it’s necessary to consider this problem when making cabin LOPA;
   b) A assist space of 12 inches × 20 inches shall be provided near required exit;
   c) Assist space shall have assist handhold;
   d) there shall be an unobstructed projected opening of overwing exits for the width of a seat, including the seatback in any position. That’s why the seat in front of exit usually is designed to only have a fixed seatback.

3.11. FAR25.815
a) When measuring aisle width, seatback recline, break over and rotation of seat shall be considered, especially at divided zones;
   b) When measuring aisle width, the rubstrips on seat, Galley and so on shall be considered;
   c) Curtain tiebacks shall be readily movable, where they project into the required aisle;
   d) Movable armrests that protrude into the required aisle return to the normal position when released; Are latches discreet (not easily discovered by passenger) when used to control a movable armrest that protrude into the required aisle.

3.12. FAR25.853
a) Waste compartments are completely enclosed;
   a) Lavatory outside shall have ashtrays;
   b) All wiring shall be protected from abrasion and crushing;
   c) Seats are fire-blocked. Cockpit flight crew seats only need to comply with FAR25.853(a), but Cabin seats have to comply with FAR25.853(a) and 853(c). If F/C and B/C passenger seat and E/C passenger use large nonmetal panels, the seats shall comply with FAA25.853(d). SAE ARP6199 provides clear instructions for evaluating if the seats need to do Smoke Density and Heat Release test required by FAA25.853(d).

3.13. FAR25.1411
a) It shall be easy to fetch emergency equipment. Usually a 50th participant will be used to fetch emergency equipment to show the compliance;
   b) Emergency equipment stowage locations shall be conspicuously and conveniently marked.
   c) Placards as close to eye level height as practicable,
   d) Additional arrows shall be needed to locate the specific stowage location;
   e) Curtains shall not block access to, or markings of, emergency equipment;
f) Emergency Equipment shall be protected from damage in its stowage location. So belts or brackets are usually used to fix emergency equipment;

g) There shall have sufficient type and quantity of required items;

h) Life vests shall be easily removable by a seated, belted, and untrained person, at all locations;

i) There shall have a placard for all seats, including the forward rows, indicating the location of the vest. For front-row, the related placards are stick to the bulk in front. For other rows, the related placards are printed or stick to the backrest table for forward seats. Some aircraft use flotation cushion to replace life vest. If yes, there shall have a placard of “cushion can be used as flotation”.

3.14. Others

3.14.1. Galley. a) There shall have no compartment doors that could interfere with exit opening. They can be design to be spring loaded closed or they can be easily pushed out of the evacuation path in emergency evacuation;

b) For the folding cart ramps that could be left down for takeoff and landing the they shall not pose a tripping hazard;

c) All waste compartment doors self shall be closing or marked to be closed when not in use. If waste containers are required to meet fire containment requirements, the waste compartment shall be placarded to require the waste container;

d) Fixed items shall be installed for inspection, such as ovens, coffee makers;

e) All wiring shall be protected from abrasion, especially from rotatable items;

f) The “close for taxi, takeoff, and landing” placards shall be conspicuous, even when compartment doors are open;

g) The load limit placards shall be conspicuous when the compartment doors are open.

3.14.2. Lavatory. a) If the lavatory door open into the aisle, it shall have a mechanism to make it back to stowed position. If not, there shall have a placard instructing to close and latch when not in use. To avoid that the lavatory door impacts emergency evacuation, a folding door is the best choice;

b) Oxygen drops shall be compatible with both standing and seated occupants;

c) There shall have no potential stowage areas that could lead to a fire hazard. If yes, they shall have “NO STOWAGE” placards;

d) There shall have an ordinance (i.e., No Smoking, Return To Seat) sign;

e) There shall be a means to unlock the lavatory door from the outside, without the use of tools;

f) Waste compartments shall be designed with wear and tear in mind.

3.14.3. Monitor and Overhead Bin. a) Aisle mounted monitors shall be at least 73-inches off the floor, or retractable and so placarded?

b) All sharp corners shall all been eliminated from the monitor shroud;

c) The monitors shall not obscure any required exit sign;

d) There shall have a manual means to retract monitors that are normally powered;

e) In-arm monitors shall be easily break away if contacted by a passenger during turbulence;

f) Possible head contact surfaces shall be padded;

g) Monitors shall be located under sidewall stowage bins retractable;

h) In-arm monitors in front rows, at cross aisles or at exits shall be stowed, or become unstowed, such that they interfere with exit passageways or other egress routes;

i) In-arm video monitors shall break away easily without breaking off or, if they do break, are there any sharp or hazardous protrusions? Is the monitor capable of being re-stowed for taxi, takeoff and landing;

j) Required placarding for stowage shall be visible to the seated occupant;

k) The in-arm cavity shall be “completely open or completely closed” to address the collection of flammable materials.
4. Conclusion

Based on the experience of civil aircraft design and certification, this article summarized the Compliance Inspection requirement, pass/failure criteria and related design proposals for Equipment and Furnishings System. Some inspections need 5\textsuperscript{th}-95\textsuperscript{th} person to participate, so it’s suggested to find 3 testing personnel: 5\textsuperscript{th}, 50\textsuperscript{th} and 95\textsuperscript{th} for the inspection activity, but it’s only necessary to concern their body heights. Above all, the content of inspection needs to be discussed and confirmed with the authority and described in Certification Plan which is used as the guide for all certification activities.

Reference

[1] AC25-17A Transport Airplane Cabin Interiors Crashworthiness handbook, 05/18/2009.
[2] TSO-C127b Rotorcraft, Transport Airplane, And Small Airplane Seating Systems, 06/06/2014.
[3] 14 CFR Part 25 - AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES (FAR25), 11/18/2003.
[4] AC25,562-1B Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes, 01/20/2006.
[5] SAE AS8049B Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft, 01/2005.
[6] SAE ARP5526C Aircraft Seat Design Guidance and Clarifications, 05/2011.