



Australian Government
Civil Aviation Safety Authority

DRAFT

ADVISORY CIRCULAR

AC 21-21

Aircraft Production – Flight Test Considerations

Advisory Circulars are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Advisory Circulars should always be read in conjunction with the relevant regulations.

Audience

This Advisory Circular (AC) applies to:

- applicants for Production Certificates
- People responsible for flight testing aircraft certified or manufactured under Part 21
- Production Certificate holders.

Purpose

This AC provides background information and guidance regarding the production flight test requirements of *Civil Aviation Safety Regulations 1998 (CASR)* Subparts 21.F and 21.G.

For further information

For further information on this AC, contact CASA's Airworthiness and Engineering Standards Branch (Telephone: 131 757; Email: airworthiness.standards@casa.gov.au).

Status

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v1.0	March 2015	Initial issue.

Unless specified otherwise, all subregulations, regulations, Divisions, Subparts and Parts referenced in this AC are references to the *Civil Aviation Safety Regulations 1998 (CASR)*.

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1 Reference material

1.1 Acronyms

The acronyms and abbreviations used in this AC are listed in the table below.

Acronym	Description
AC	Advisory Circular
AFM	Aircraft Flight Manual
APIS	Approved Production Inspection System
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations 1998
CG	Centre of Gravity
CoA	Certificate of Airworthiness
FTS	Flight Test Schedule
ISA	International Standard Atmosphere
PC	Production Certificate
PFT	Production Flight Testing
RPM	Revolutions Per Minute
SFP	Special Flight Permit
TC	Type Certificate
TP	Test Pilot

1.2 Definitions

Terms that have specific meaning within this AC are defined in the table below. Additional definitions are available in the CASR Dictionary.

Term	Definition
Certification Flight Testing	means those flight tests conducted for the purpose of demonstrating, or verifying, compliance with the applicable airworthiness standard.
Experimental/Developmental Flight Testing	means those flight tests conducted for the purpose of defining or expanding an aircraft's flight envelope.
Flight Test	means the process of developing and gathering data during operation and flight of an aircraft and then analysing that data to evaluate the flight characteristics of the aircraft (see regulation 21.35). In this AC flight test does not mean a practical test of a person's knowledge and practical flying skill (as per Part 1 of CAR).
Production Flight Testing	means those flight tests conducted for the purpose of ensuring each individual aircraft conforms with its Type Design and is in a condition for safe operation.

1.3 References

Regulations

Regulations are available on the ComLaw website <http://www.comlaw.gov.au/Home>

Document	Title
Part 21 of CASR	Certification and airworthiness requirements for aircraft and parts

CASA advisory material

CASA's ACs are available at <http://www.casa.gov.au/AC>

Document	Title
AC 21-09	Special flight permits
AC 21-14	Production certificates
AC 21-20	Production Under Type Certificate Only
AC 21-47	Flight Test Safety

2 Introduction

2.1 Background

2.1.1 Australian type certificated aircraft manufactured in accordance with Part 21, either Subpart 21.F or Subpart 21.G, must be subject to a post-production flight test process as required by regulation 21.127 and subparagraph 21.143(1A)(c)(v). These regulations call for manufacturers of such aircraft to establish flight test procedures and associated check-off forms for use in ensuring a newly constructed production aircraft is safe to operate and fly in accordance with its type design.

2.1.2 This AC provides background information on the production flight testing requirements and guidance regarding the procedures and flight test techniques that could be included in any quality system manual or equivalent documentation written to satisfy those requirements. While the requirements are applicable to all aircraft, the information provided is focussed toward flight testing of those at the lighter-weight and lower-speed ends of the scale, principally those in the primary, normal, utility or acrobatic categories.

3 Production Flight Test Objectives

3.1.1 The holder of an Australian Type Certificate (TC) can manufacture the associated aircraft under that TC in accordance with Subpart 21.F or, when the requirements of Subpart 21.G have been satisfied, under a Production Certificate (PC). The Production Flight Testing (PFT) requirements are effectively the same in either case. PFT is conducted to ensure that each production aircraft conforms to the approved type data set, and that all its systems are functioning correctly. PFT is essentially the final stage in the production process; its satisfactory completion is a prerequisite to each aircraft being issued with a Certificate of Airworthiness (CoA) and being released to the customer.

3.1.2 Ensuring each aircraft conforms to the Type Design and is in a condition for safe operation does not necessarily demand that the full suite of flight tests associated with the type certification process be repeated. Notwithstanding, regulation 21.127 requires that, as a minimum, each production flight test program include the following:

- a. an operational check of the trim, controllability, or other flight characteristics to establish that the production aircraft has the same range and degree of control as the prototype aircraft
- b. an operational check of each part or system operated by the crew while in flight to establish that, during flight, instrument readings are within their normal range
- c. a determination that all instruments are properly marked, and that all placards and required flight manuals are installed after flight test
- d. a check of the operational characteristics of the aircraft on the ground
- e. a check of any other items peculiar to the aircraft being tested that can best be done during the ground or flight operation of the aircraft.

4 Production Flight Test Preparation and Procedures

4.1.1 PFT is the final phase of the manufacturing and inspection process and should therefore be included in the manufacturer's Approved Production Inspection System (APIS), referred to in AC 21-20 for production under type certificate only, or the quality system required to be established under regulation 21.139 and explained in AC 21-14.

4.2 Procedures Manual

4.2.1 PFT procedures and specifications belong in the quality manual required under regulation 21.143. The PFT sections are probably best located as part of any 'Production Procedures Manual' volume in the quality manual set and should contain details of how PFT is approved and controlled, who is authorised to conduct PFT operations, the tests required, acceptable tolerances, reporting requirements and documentation. To this end the PFT sections in most Production Procedures Manuals have three distinct divisions:

- a. authorisation
- b. a schedule of tests (the production flight test procedures requirement of regulations 21.127 and 21.143)
- c. a reporting format (the flight test Check-Off List requirement of regulations 21.127 and 21.143).

4.2.2 Subregulation 21.143(1) states that the PC quality manual is to be submitted to CASA for approval. When considering the PFT sections for such approval CASA flight test personnel will check that the proposed flight test schedule (FTS) and Check-Off List will adequately validate the flight characteristics and systems operability aspects of the aircraft's approved type data and that the personnel nominated to carry out the PFT hold appropriate qualifications and experience (see subsection 4.3.3).

4.2.3 The FTS should detail those tests of the handling, performance and systems functionality considered essential to proving the airworthiness and safe operation of the each aircraft after it has been rolled out of the factory. It is limited to testing those parts of the aircraft and its equipment that cannot be checked for proper operation on the ground following production or maintenance activity. The FTS should incorporate and detail the procedures and flight test techniques to be used during production flight testing (see section 4.5).

4.2.4 The flight test Check-Off List(s) are used by the flight test crew during the actual flight test sequences and form the basis for recording the results of each individual test program. The master Check-Off List is a supplementary document of the FTS (see section 4.6).

4.2.5 When published, the FTS and associated Check-Off Lists are to be maintained throughout the life of the type and model of aircraft or equipment to which it refers. They should be subject to an annual review of their content. The FTS should also be amended each time the aircraft equipment is upgraded, or major modifications or configuration changes affecting aircraft performance or other aircraft characteristics tested during the PFT are implemented.

4.3 Flight Test Organisation and Personnel

4.3.1 Production flight test personnel are normally resident in a sub-section of the overall company production organisation. Considerations are as follows:

4.3.2 Management Responsibilities:

4.3.2.1 Management and functional responsibilities should be detailed in the Production Procedures Manual. A description of the chain of authority and its application to production flight test operations should be included. Management also holds direct responsibility for flight safety aspects (see AC 21-47).

4.3.3 Production Flight Test Crew:

4.3.3.1 Persons authorised to conduct PFT should be listed by name in the Production Procedures Manual. Production Test Pilots (TPs) should be nominated by the production organisation and listed in the production manual that is approved by CASA. The processes involved in the selection, appointment and training of production TPs should also appear in the manual.

4.3.3.2 The legal minimum TP qualification is a Private Pilot Licence (PPL) with endorsements as appropriate to type. Minimum experience levels are not stipulated, however prospective production TPs would normally be reasonably knowledgeable, skilful and practiced. In the production case the advisability of the TP having experimental test flying qualifications is not as strong as it would be when considering the developmental or certification test flying cases, although it could still be appropriate. Either way, the best production TP is going to be someone with a solid background in operating the general type of aircraft being produced and preferably strong experience on the actual type - i.e. someone who knows the aircraft well and who can easily detect any anomalies with its performance, handling or systems that would constitute non-compliances with the production FTS.

4.3.4 Qualifications, Training and Currency:

4.3.4.1 The minimum company requirements relating to the qualification and training of production flight test crews should be detailed in the Production Procedures Manual. Records of the currency of licenses, medical certificates and any regular training events should be kept.

4.3.5 Support Functions:

4.3.5.1 Advice regarding operational flight test support functions and facilities is provided in AC 21-47.

4.4 Special Flight Permit

4.4.1 Production flight testing of individual aircraft is conducted under a Special Flight Permit (SFP) for the purposes of paragraph 21.197(1)(c). SFP issue procedures and requirements are detailed in AC 21-09.

4.5 Procedures and Flight Test Techniques

Note The following assumes all other production procedures have been completed, that the aircraft presented to the production TP has been rigged and tuned ready for flight, and that procedures are in place for the rectification of defects found during flight testing. It also assumes matters such as the SFP and other preparatory approvals have been addressed.

4.5.1 The schedule of tests should contain sufficient guidance to allow the production TP to determine exactly what is required, how the particular test is to be performed, and what are the acceptable tolerances. It is not always necessary for the schedule to detail techniques for all test items, unless a particular technique is applicable to the type. Nevertheless, reference to the general test techniques or guidance material to be used, or links to where such information can be obtained, should appear.

4.5.2 Specification of acceptable tolerances for each of the test conditions and results are particularly important. Tolerances should be defined for weight and CG condition, airspeeds, performance criteria, and all engine temperatures, pressures and RPMs. In some cases reference to Aircraft Flight Manual (AFM) data is acceptable, but under most tests the aircraft should perform to finer tolerances than the AFM limits; e.g. engine temperatures in climb. The specification of tolerances should include a justification of, or a reference to, their derivation.

4.5.3 General conformity checks should be conducted prior to each production test flight. Particular attention should be paid to ensuring accurate knowledge of the following parameters:

- a. flight control rigging (as detailed in the Type Certificate Data Sheet) and general flight control characteristics (e.g. control friction, free-play)
- b. weight and CG.

4.5.4 Production flight testing is typically done in two phases:

- a. Phase One: initial rigging and engine condition checks
- b. Phase Two: flights to gather specific information to determine compliance with type specifications.

4.5.5 Some manufacturers may choose to include engine ground run checks and adjustments in the FTS. This is generally because the same people responsible for engine set up are also involved with performance of the PFT.

4.5.6 Phase One tests are typically conducted at a light weight and mid CG condition, and the schedule should specify these parameters. The main aims of Phase One are to determine that control rigging is correct, the engine is functioning acceptably and the aircraft is generally safe to fly.

4.5.7 For the engine tests, the purpose is to confirm the required power is available, and there are no obvious problems with engine functioning. In more complicated aircraft tests of powered systems (e.g. undercarriage retraction and extension, pressurisation) might be included in the Phase One tests.

4.5.8 A typical schedule of Phase One tests for a piston engine aircraft would involve:

- a. engine start and run up in accordance with AFM procedures
- b. confirmation of engine run and set up with respect to idle RPM, maximum static RPM, magneto function and performance, carburettor heat function, and engine temperatures and pressures at the different power settings
- c. control during taxiing – function of brakes and nose/tail wheel steering

- d. nose/tail wheel lift off speed
- e. control rigging and engine performance and condition in climb
- f. control rigging in cruise
- g. control rigging and engine functioning during descent and landing.

4.5.9 In some circumstances, more than one flight will be needed before the Phase One tests are completed to an acceptable standard. When this is achieved the production TP should make a certification that the aircraft has satisfactorily completed the schedule, and may proceed with Phase Two tests.

4.5.10 The objectives of the Phase Two tests are to fine tune the control systems and determine compliance with flight handling, performance, and system specifications. These flights are typically done at the extreme CG conditions and maximum weight. This allows tests of trim systems, flight handling and performance at conditions where there is established certification data upon which to base acceptability criteria. In most aircraft it will be necessary to conduct flights at both ends of the CG envelope to cater for specific performance and handling criteria. Cases where this may not be required would be limited to aircraft in which the allowable CG range is particularly narrow; for example, single place aeroplanes, or those of very light weight with a two-place, side by side seating configuration.

4.5.11 The typical Phase Two schedule should require tests to determine:

- a. engine performance and functioning
- b. longitudinal control system rigging with respect to trim speed ranges, stalling speeds, and control force gradients
- c. precise stall speed definition
- d. take-off, climb, level flight and landing performance
- e. stall handling
- f. for acrobatic category aircraft – spinning and handling characteristics during aerobatic manoeuvres
- g. high speed flight
- h. systems, instrumentation and avionics performance.

4.5.12 Post flight it will be necessary for data gathered during climb performance tests to be reduced. This may be by reduction to ISA sea level conditions for comparison with certification data, but most manufacturers choose to make a comparison with AFM predictions, as the acceptability criteria.

4.5.13 Avionics tests are normally a simple functional test of transmission and/or reception against local ground stations. Other systems are usually not subject to specific tests, but to an observation that the system functions correctly.

4.5.14 The process is complete when the production TP makes certification that all items in the schedule have been tested and found compliant with specifications.

4.6 Production Flight Test Check-Off List

4.6.1 The reporting format, the Check-Off List, should contain space for entering all data, noting satisfactory compliance with each requirement, and for the production TP's certifications. The layout of the Check-Off List is for the manufacturer to determine, but should follow the sequence of tests called up in the FTS.

4.6.2 Manufacturers may choose to have the acceptability tolerances in the Check-Off List rather than in the schedule. This is generally preferable, as it provides an indication to the testing pilot as to whether a particular item is acceptable, without reference to the schedule. In this case the schedule should state that acceptability criteria are contained in the reporting format.

4.6.3 The Check-Off List may be used to record raw data in flight. If there is a deficiency, rectification is required and the item has to be reassessed. Rather than use multiple forms, or overwrite repeat test results, production test pilots may use their own test cards, and only enter complying data on the format. The finalised Check-Off List should indicate that all items in the schedule have been completed, the results are acceptable, and the aircraft is ready for delivery to the customer.

4.6.4 The completed Check-Off List(s) form part of the production data package, and should be stored as such. Manufacturers may choose to provide a copy to customers.

4.7 CASA Approvals

4.7.1 The quality of the applicant's documentation and the competence of the nominated flight test staff will influence CASA approvals. CASA may provide guidance to new PC applicants through help in developing production flight test procedures and documentation. Refinement of procedures and tolerances is a dynamic process, and the FTS and Check-Off Lists will undergo several revisions before being considered mature. This should be achievable by the time about 10 aircraft have been produced.

4.7.2 In the early stages of production CASA may conduct frequent surveillance to ensure satisfactory procedures and mature schedules are established. Subsequent surveillance is to ensure standards are maintained.

5 Flight Test Safety

5.1.1 PFT is a routine procedure almost akin to normal aircraft operation. Nevertheless there are some elements where elevated risk levels are involved. The information provided in AC 21-47, is applicable.

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