European Aviation Safety Agency

Certification Specifications for Propellers

CS-P

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EASA Certification Specifications
for
Propellers

CS-P
Book 1

Airworthiness code

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SUBPART A – GENERAL

CS-P 10 Applicability
(See AMC P 10)

(a) This CS-P contains airworthiness specifications for the issue of type-certificates, and changes to those certificates, for Propellers, in accordance with Part 21.

(b) The applicant is eligible for a Propeller type-certificate when compliance with subparts A, B and C has been demonstrated. If the additional compliance with subpart D has not also been shown, this must be stated in the Propeller type-certificate data sheet.

[Amdt. No.: P/1]

CS-P 15 Terminology

(a) This issue of CS-P must be used with the version of CS- Definitions existing at the date of issue. In addition to the definitions of CS-Definitions, in this CS-P the following terminology is applied. Where used in CS-P, the terms defined in this paragraph and in CS-Definitions are identified by initial capital letters.

(b) General definitions

Adjustable Pitch Propeller	means a Propeller, the Pitch setting of which can be changed in the course of ordinary field maintenance, but which cannot be changed when the Propeller is rotating.
Beta Control	means a system whereby the Propeller blade angles are directly selected by the air crew, or by other means (normally used during ground handling).
Feather	means moving the blade angle to Feathered Pitch.
Feathered Pitch	means the Pitch setting, which in flight corresponds with a windmilling torque of approximately zero and approximately zero rotational speed.
Flight Idle	typically, the lowest power lever and associated minimum blade Pitch position permitted in flight. (In-Flight Low Pitch Position)
In-Flight Low Pitch Position	means the minimum Pitch permitted in flight.
Maximum Propeller Over-torque	means the transient maximum Propeller torque demonstrated in CS-P 410.
Pitch	means the Propeller blade angle, measured in a manner and at a radius declared by the manufacturer and specified in the appropriate Propeller Manual.
Pitch Control System	means the components of the Propeller System that functions to control Pitch position, including but not limited to governors, Pitch change assemblies, Pitch locks, mechanical stops and Feathering system components.
Propeller System	means the Propeller plus all the components necessary for its functioning, but not necessarily included in the Propeller type design.
Reverse Pitch	means the Propeller blade angle used for producing reverse thrust with a Propeller. Typically this is any blade angle below ground idle blade angle.

(c) Terms associated with Propeller Critical Parts

Approved Life	means the mandatory replacement life of a part which is approved by the Agency.
Attributes	means inherent characteristics of a finished part that determine its capability.
Damage Tolerance	means an element of the life management process that recognises the potential existence of component imperfections as the result of inherent material structure, material processing, component design, manufacturing or usage and addresses this situation through the incorporation of fracture resistant design, fracture mechanics, process control, and non-destructive inspection.
Propeller Critical Part	means a part that relies upon meeting the prescribed integrity specifications of CS-P 160 to avoid its Primary Failure which could result in a Hazardous Propeller Effect.
Propeller Flight Cycle	means the flight profile, or combination of profiles, upon which the Approved Life is based.
Engineering Plan	means a compilation of the assumptions, technical data and actions required to establish and to maintain the life capability of a Propeller Critical Part. The Engineering Plan is established and executed as part of the pre- and post-certification activities.
Manufacturing Plan	means a compilation of the part specific manufacturing process constraints, which must be included in the manufacturing definition (drawings, procedures, specifications, etc.) of the Propeller Critical Part to ensure that it meets the design intent as defined by the Engineering Plan.
Primary Failure	means a Failure of a part which is not the result of the prior Failure of another part or system.
Service Management Plan	means a compilation of the processes for in - service maintenance and repair to ensure that a Propeller Critical Part achieves the design intent as defined by the Engineering Plan.

(d) Terms associated with Propeller safety analysis

Dormant Failure	a failure the effect of which is not detected for a given period of time.
Extremely Remote	the probability of occurrence is $1x10^{-7}$ or less per Propeller flight hour.
Failure Condition	a condition with direct, consequential Propeller-level effect, caused or contributed to by one or more failures.
Failure Mode	the mechanism of the failure or the manner in which an item or function can fail.

Hazardous Propeller Effect	means an effect that results in any of the following: (i) The development of excessive drag. (ii) A significant thrust in the opposite direction to that commanded by the pilot. (iii) A release of the Propeller or any major portion of the Propeller. (iv) A failure that results in excessive unbalance.
Major Propeller Effect	means an effect that results in any of the following: (i) An inability to Feather the Propeller (for feathering Propellers). (ii) An inability to change Propeller Pitch when commanded. (iii) An uncommanded change in Pitch. (iv) An uncontrollable torque or speed fluctuation.
Remote	The probability of occurrence is $1x10^{-5}$ or less per Propeller flight hour.

[Amdt. No.: P/1]

CS-P 20 Propeller Configuration and Identification

(a) The list of all the parts and equipment, including references to the relevant drawings and software design data, which defines the proposed type design of the Propeller, must be established.

(b) The Propeller identification must comply with 21A.801(a) and (c), and 21A.805.

CS-P 30 Instructions for Propeller Installation and Operation

(a) Instructions for installing the Propeller, (see AMC P 30(a)), must be established, which must:

(1) Include a description of the operational modes of the Propeller control system and its functional interface with the aircraft and engine systems.

(2) Specify the physical and functional interfaces with the aircraft, aircraft equipment and the engine.

(3) Define the limiting conditions on the interfaces specified in CS-P 30 (a)(2).

(4) List the limitations established under CS-P 50.

(5) Define the hydraulic fluids approved for use with the Propeller, including grade and specification, related operating pressure and filtration levels.

(6) State the assumptions made to comply with the specifications of this CS-P.

(b) Instructions must be established, which must specify the procedures necessary for operating the Propeller within the limitations of the Propeller type design.

[Amdt. No.: P/1]

CS-P 40 Instructions for Continued Airworthiness

(a) In accordance with 21A.61 (a), manual(s) must be established containing instructions for continued airworthiness of the Propeller. They must be up-dated as necessary according to changes to existing instructions or changes in Propeller definition.

(b) The instructions for continued airworthiness must contain a section titled airworthiness limitations that is segregated and clearly distinguishable from the rest of the document(s). This section must set forth each mandatory replacement time, inspection interval and related procedure required for type certification.

(c) The following information must be considered, as appropriate, for inclusion into the manual(s) required by CS-P 40 (a):

(1) A description of the Propeller and its components, systems and installations.

(2) Installation instructions, including proper procedures for uncrating, de-inhibiting, acceptance checking, lifting and attaching accessories, with any necessary checks.

(3) Basic control and operating information describing how the Propeller components, systems and installations operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, locations of lubrication points, lubricants to be used and equipment required for servicing.

(5) Scheduling information for each part of the Propeller that provides the recommended periods at which it should be cleaned, inspected, adjusted, tested and lubricated, and the degree of inspection, the applicable wear tolerances and work recommended at these periods. Necessary cross-references to the airworthiness limitations section must also be included. In addition, if appropriate, an inspection programme must be included that states the frequency of the inspections necessary to provide for the continued airworthiness of the Propeller.

(6) Trouble shooting information describing probable malfunctions, how to recognise those malfunctions and the remedial action for those malfunctions.

(7) Information describing the order and method of removing the Propeller and its parts and replacing parts, the order and method of disassembly and assembly, with any necessary precautions to be taken. Instructions for proper ground handling, crating and shipping must also be included.

(8) Cleaning and inspection instructions that cover the material and apparatus to be used and methods and precautions to be taken. Methods of inspection must also be included.

(9) Details of repair methods for worn or otherwise non-serviceable parts and components along with the information necessary to determine when replacement is necessary. Details of all relevant fits and clearances.

(10) Instructions for testing including test equipment and instrumentation.

(11) Instructions for storage preparation, including any storage limits.

(12) A list of the tools and equipment necessary for maintenance and directions as to their method of use.

CS-P 50 Propeller Ratings and Operating Limitations

(a) Propeller ratings and operating limitations must:

(1) Be established, appropriate to the installation and environmental conditions.

(2) Be included directly or by reference in the Propeller type-certificate data sheet.

(3) Be based on the operating conditions demonstrated during the tests required by this CS-P as well as any other information necessary for the safe operation of the Propeller.

(b) The ratings and operating limitations must be established for the following, as applicable:

(1) Power and rotational speed for:

(i) Take off.

(ii) Maximum continuous.

(iii) If requested by the applicant, other ratings may also be established.

(2) Over-speed and over-torque limits.

CS-P 70 Tests - History

(a) In order to enable compliance with 21A.21 (c)(3), should a failure of a Propeller part occur during the certification tests, its cause must be determined and the effect on the airworthiness of the Propeller must be assessed. Any necessary corrective actions must be determined and substantiated.

(b) The development history of the Propeller or component or equipment of the Propeller must be considered. Any significant event, relevant to airworthiness of the Propeller, occurring during development and not corrected before certification tests, must also be assessed under CS-P 70 (a).

SUBPART B - DESIGN AND CONSTRUCTION

CS-P 150 Propeller Safety Analysis (See AMC P 150)

(a) (1) An analysis of the Propeller must be carried out to assess the likely consequences of each Failure Condition under stated aircraft operating and environmental conditions. This analysis will consider:

(i) The Propeller System in a typical installation. When the analysis depends on representative components, assumed interfaces, or assumed installed conditions, such assumptions will be stated in the analysis.

(ii) Consequential secondary failures and Dormant Failures.

(iii) Multiple failures referred to in CS-P 150 (d) or that result in the Hazardous Propeller Effects.

(2) A summary must be made of those failures, which could result in Major Propeller Effects or Hazardous Propeller Effects, together with an estimate of the probability of occurrence of those effects. Any Propeller Critical Part must be clearly identified in this summary.

(3) It must be shown that Hazardous Propeller Effects will not occur at a rate in excess of that defined as Extremely Remote. The estimated probability for individual failures may be insufficiently precise to enable the total rate for Hazardous Propeller Effects to be assessed. For Propeller certification, it is acceptable to consider that the intent of this paragraph is achieved if the probability of a Hazardous Propeller Effect arising from an individual failure can be predicted to be not greater than $1x10^{-8}$ per Propeller flight hour. It will also be accepted that, in dealing with probabilities of this low order of magnitude, absolute proof is not possible and reliance must be placed on engineering judgement and previous experience combined with sound design and test philosophies.

(4) It must be shown that Major Propeller Effects will not occur at a rate in excess of that defined as Remote.

(b) If significant doubt exists as to the effects of failures or likely combination of failures, any assumption of the effect of the failure may be required to be verified by test.

(c) It is recognised that the probability of Primary Failures of certain single elements (for example, blades) cannot be sensibly estimated in numerical terms. If the failure of such elements could result in Hazardous Propeller Effects, they will be identified as Propeller Critical Parts and reliance must be placed on meeting the prescribed integrity specifications of CS-P 160. These instances must be stated in the safety analysis.

(d) If reliance is placed on a safety system or device, such as beta lockout, reserved feathering oil, instrumentation, early warning devices, maintenance checks, and similar equipment or procedures, to prevent a failure progressing to Hazardous Propeller Effects, the possibility of a safety system failure in combination with a basic Propeller failure must be covered. If items of a safety system are outside the control of the Propeller manufacturer, the assumptions of the safety analysis with respect to the reliability of these parts must be clearly stated in the analysis and identified in the instructions for installation and operation required under CS-P 30.

(e) If the acceptability of the safety analysis is dependent on one or more of the following, it must be identified in the analysis and appropriately substantiated:

(1) Maintenance actions being carried out at stated intervals. This includes the verification of the serviceability of items which could fail in a dormant manner. Maintenance actions to verify the absence of Dormant Failures which could, in combination with another failure, lead to Hazardous Propeller Effects at a rate in excess of Extremely Remote, must be published in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required under CS-P 40. If errors in maintenance of the Propeller could lead to Hazardous Propeller Effects, the appropriate procedures must be included in the relevant Propeller manual(s).

(2) Verification of the satisfactory functioning of safety or other devices at pre-flight or other stated periods. The method of demonstrating satisfactory functioning must be published in the appropriate manual(s).

(3) The provisions of specific instrumentation, not otherwise required. Such instrumentation must be published in the appropriate interface documentation.

(4) A fatigue assessment being made.

(f) The safety analysis must include assessment of indicating equipment, manual and automatic controls, governors and Propeller control systems, synchrophasers and synchronisers, as applicable.

[Amdt. No.: P/1]

CS-P 160 Propeller Critical Parts Integrity
(See AMC P 160)

The integrity of the Propeller Critical Parts identified under CS-P 150 must be established by:

(a) An Engineering Plan, the execution of which establishes and maintains that the combinations of loads, material properties, environmental influences and operating conditions, including the effects of parts influencing these parameters, are sufficiently well known or predictable, by validated analysis, test or service experience, to ensure Propeller Critical Parts have a high level of integrity throughout their service life. Any Approved Life must be published as required in CS-P 40(b).

(b) A Manufacturing Plan which identifies the specific manufacturing constraints necessary to consistently produce Propeller Critical Parts with the Attributes required by the Engineering Plan.

(c) A Service Management Plan which defines in-service processes for maintenance and repair of Propeller Critical Parts which will maintain Attributes consistent with those required by the Engineering Plan. These processes shall become part of the Instructions for Continued Airworthiness as required by CS-P 40.

[Amdt. No.: P/1]

CS-P 170 Materials and Manufacturing Methods
(See AMC P 170)

(a) The suitability and durability of materials used in the Propeller must :

(1) Be established on the basis of experience, tests, or both.

(2) Account for environmental conditions expected in service.

(b) All materials used in the Propeller, together with associated specifications and processes, and all manufacturing methods which will be part of the type design, must be identified.

(c) The design values of properties of materials must be suitably related to the most adverse properties stated in the material specification.

[Amdt. No.: P/1]

CS-P 210 Variable and Reversible Pitch Propellers
(See AMC P 210)

(a) No single failure or malfunction in the Propeller will result in unwanted travel of the Propeller blades to a position below the In-Flight Low-Pitch Position. The extent of any intended travel below the normal In-Flight Low-Pitch Position must be documented in the appropriate manuals. Failure of structural elements need not be considered if the occurrence of such a failure is shown to be Extremely Remote under CS-P 150.

(b) In Propellers incorporating a method to select blade Pitch below the In-Flight Low-Pitch Position, provisions must be made to sense and indicate to the flight crew that the Propeller blades are below that position by an amount defined in the Propeller instructions for installation. The method for sensing and indicating the Propeller blade Pitch position must be such that its failure does not affect the control of the Propeller.

[Amdt. No.: P/1]

CS-P 220 Feathering Propellers
(See AMC P 220)

(a) Feathering Propellers must be designed to Feather from all conditions in flight, while taking into account likely wear and leakage. Feathering and unfeathering limitations must be documented in the appropriate manual(s).

(b) Propeller Pitch Control Systems that use engine oil to Feather must incorporate a method to allow the Propeller to Feather if the engine oil system fails.

(c) Feathering Propellers must be designed to be capable of unfeathering after being feathered for the maximum expected diversion time at the minimum declared steady state outside air temperature.

(d) Where there is a minimum Engine/Propeller rotational speed and/or associated aircraft speed below which Propeller feathering cannot be accomplished, the Propeller type-certificate data sheet must be endorsed accordingly.

[Amdt. No.: P/1]

CS-P 230 Propeller Control System
(See AMC P 230)

The specifications of this paragraph are applicable to any system or component that controls, limits or monitors Propeller functions.

(a) The Propeller control system must be designed, constructed and validated to show that:

 (1) Operation in normal, alternative modes and transition between operating modes performs the intended functions throughout the declared operating conditions and flight envelope.

 (2) Functionality is not adversely affected by the declared environmental conditions, including temperature, electromagnetic interference (EMI), high intensity radiated fields (HIRF) and lightning. The environmental limits to which the system has been satisfactorily validated must be documented in the appropriate Propeller manual(s).

 (3) A method is provided to indicate that an operating mode change has occurred if flight crew action is required. In such an event, operating instructions must be provided in the appropriate Propeller manual(s).

(b) The Propeller control system must be designed and constructed so that, in addition to compliance with CS-P 150:

 (1) No single failure or malfunction of electrical or electronic components in the control system may result in a Hazardous Propeller Effect.

 (2) The effects of failures or malfunctions in a typical installation directly affecting the Propeller control system, such as structural failures of attachments to the control, fire or overheat, must not lead to a Hazardous Propeller Effect due to a control system failure.

 (3) No loss of normal Propeller Pitch control may cause a Hazardous Propeller Effect under the intended operating conditions.

 (4) The failure or corruption of data or signals shared across Propellers must not cause a Propeller effect greater than Major.

(c) Electronic Propeller control system embedded software must be designed and implemented by an approved method, which is consistent with the criticality of the performed functions and minimises the existence of software errors.

(d) The Propeller control system must be designed and constructed so that no failure or corruption of aircraft-supplied data will result in Hazardous Propeller Effects.

(e) The Propeller control system must be designed and constructed so that the loss, interruption or abnormal characteristics of aircraft-supplied electrical power will not result in Hazardous Propeller Effects. The power quality specifications must be described in the appropriate Propeller manual(s).

(f) Propeller control system components which are located in a designated fire zone must be at least Fire Resistant**.**

[Amdt. No.: P/1]

CS-P 240 Strength
(See AMC P 240)

The maximum stresses developed in the Propeller must not exceed acceptable values considering the particular form of construction and the most severe operating conditions. Due consideration must be given to the effects of any residual stresses.

[Amdt. No.: P/1]

SUBPART C - TYPE SUBSTANTIATION

CS-P 330 General (See AMC P 330)

(a) The configuration of the Propeller or components or parts to be tested must be sufficiently representative of the type design for the purpose of the test.

(b) All automatic controls and protection must be in operation unless it is justified that this is not possible or that they are not required because of the nature of the test.

[Amdt. No.: P/1]

CS-P 340 Inspections, Adjustments and Repairs

(a) Before and after conducting the tests prescribed in this subpart, the test article must be subjected to an inspection, and a record must be made of all the relevant parameters, calibrations and settings.

(b) During all tests, only servicing and minor repairs must be permitted except that Major repairs or replacement of parts may be allowed, provided that the parts in question are subjected to an agreed level of additional testing. Any unscheduled repair or action on the test article must be recorded.

CS-P 350 Centrifugal Load Tests (See AMC P 350)

It must be demonstrated that the Propeller complies with CS-P 350 (a), (b) and (c) without evidence of failure, malfunction, or permanent deformation that would result in a Major or Hazardous Propeller Effect. When the Propeller could be sensitive to environmental degradation this must be taken into account.

(a) The hub, the blade retention system, and the counterweights must be tested for a period of one hour to a load equivalent to twice the maximum centrifugal load to which the Propeller would be subjected at the Maximum Permissible Rotational Speed or Maximum Governed Rotational Speed, as appropriate.

(b) If appropriate, blade features associated with transitions to the retention system must be considered in showing compliance with CS-P 350 (a).

(c) Components used with or attached to the Propeller such as spinners, de-icing equipment, and blade shields, must be capable of withstanding for a period of 30 minutes a load equivalent to 159 percent of the maximum centrifugal load to which the component would be subjected at the Maximum Permissible Rotational Speed or Maximum Governed Rotational Speed, as appropriate. This may be performed by either:

   (1) Testing at the required load for a period of 30 minutes or

   (2) An analysis based on test.

[Amdt. No.: P/1]

CS-P 360 Bird Impact (See AMC P 360)

It must be demonstrated, by tests or analysis based on tests or experience on similar designs, that the Propeller is capable of withstanding the impact of the birds which are specified in the aircraft specifications applicable to the intended installation of the Propeller, except that the mass of the bird must not exceed 1.8 kg, at the most critical location and the flight conditions which will cause the highest blade loads in a typical installation without causing a Major or Hazardous Propeller Effect.

[Amdt. No.: P/1]

CS-P 370 Fatigue Characteristics
(See AMC P 370)

(a) A fatigue evaluation of the Propeller must be conducted by tests, or analysis based either on tests or previous experience, to show that Hazardous Propeller Effects due to fatigue will be avoided throughout the intended operational life of the Propeller on either

(1) The intended aircraft. In such case compliance with CS-P 550 is required, or

(2) A typical aircraft.

(b) (1) When necessary for complying with the safety objective of CS-P 370 (a), fatigue characteristics must be established for:

(i) Hubs,

(ii) Blades,

(iii) Blade retention components and

(iv) Other Propeller components, which are affected by fatigue loads and which are shown under CS-P 150 as having a fatigue Failure Mode leading to Hazardous Propeller Effects.

(2) The fatigue characteristics must take into account

(i) All known and reasonably foreseeable vibration and cyclic load patterns that are expected in service, and

(ii) Expected service deterioration, variations in material properties, material fatigue scatter, manufacturing variations and environmental effects.

[Amdt. No.: P/1]

CS-P 380 Lightning Strike
(See AMC P 380)

It must be demonstrated, by tests or analysis based on tests or experience on similar designs, that the Propeller is capable of withstanding a lightning strike without causing a Major or Hazardous Propeller Effect. The limits to which the Propeller has been qualified must be documented in the appropriate manual(s).

[Amdt. No.: P/1]

CS-P 390 Endurance Test
(See AMC P 390)

Endurance tests on the Propeller System must be made on a representative engine in accordance with CS-P 390 (a) or (b), as applicable, without evidence of failure or malfunction.

(a) Fixed Pitch Propellers and Adjustable Pitch Propellers must be subjected to one of the following tests:

(1) A 50-hour flight-test in level flight or in climb

The Propeller must be operated at take-off power and rotational speed during at least five hours of this flight test, and at not less than 90 percent of the take-off power and rotational speed for the remainder of the 50 hours.

(2) A 50-hour ground test

The Propeller must be operated at take-off power and rotational speed.

(b) Variable Pitch Propellers must be subjected to one of the following tests :

(1) A 110-hour endurance test which must include the following conditions :

(i) 5 hours at take-off power and rotational speed and thirty 10-minute cycles composed of

- Acceleration from idle,
- 5 minutes at take-off power and rotational speed,
- Deceleration, and
- 5 minutes at idle,

(ii) 50 hours at maximum continuous power and rotational speed

(iii) 50 hours, consisting of ten 5-hour cycles composed of

- 5 accelerations and decelerations between idle and take-off power and rotational speed,
- 4.5 hours at approximately even incremental conditions from idle up to, but not including maximum continuous power and rotational speed, and
- 30 minutes at idle.

(2) Operation of the Propeller throughout the engine endurance tests prescribed in CS-E 440 or CS-E 740.

(c) An analysis based on tests of Propellers of similar design may be used in place of the tests of CS-P 390 (a) and (b).

[Amdt. No.: P/1]

CS-P 400 Functional Test
(See AMC P 400)

(a) For a Variable Pitch Propeller, except as provided under CS-P 400 (c), the same Propeller System used for the test of CS-P 390 (b) must complete the functional tests of CS-P 400 (b) without evidence of failure or malfunction.

(b) As applicable, the following functional tests will be performed on a representative engine in a test stand or on an aircraft:

(1) For a manually controllable Propeller, 500 representative cycles must be made across the full range of Pitch and rotational speed.

(2) For a governing Propeller, 1500 complete cycles must be made across the range of Pitch and rotational speed.

(3) For a feathering Propeller, 50 cycles of feathering and unfeathering operation.

(4) For a Reversible Pitch Propeller, 200 cycles must be made from minimum Flight Idle Pitch to maximum Reverse Pitch. For each cycle, while at maximum Reverse Pitch, the Propeller must be run for at least 30 seconds at the maximum power and rotational speed to be approved.

(c) An analysis based on tests of Propellers of similar design may be used in place of the tests of CS-P 400 (b).

[Amdt. No.: P/1]

CS-P 410 Over-speed and Over-torque

(a) When approval of a Maximum Propeller Over-speed is sought, it must be demonstrated, by test, service experience on similar designs, analysis or combination thereof, that the Propeller is capable of performing 20 runs, each of 30 seconds duration, at the Maximum Propeller Over-speed condition without evidence of failure or malfunction.

(b) When approval of a Maximum Propeller Over-torque is sought, it must be demonstrated, by test, service experience, analysis or combination thereof, that the Propeller is capable of performing 20 runs, each of 30 seconds duration, at the Maximum Propeller Over-torque condition, without evidence of failure or malfunction.

CS-P 420 Components of the Propeller Control System (See AMC P 420)

By tests or analysis based on tests or service experience on similar components, it must be demonstrated that each component of the Pitch Control System can withstand cyclic operation that simulates the normal load and pitch change travel to which the component would be subjected during not less than 1000 hours of typical operation in service.

[Amdt. No.: P/1]

CS-P 430 Propeller Hydraulic Components

It shall be established by test, validated analysis or combination thereof that Propeller components which are subject to significant gas or liquid pressure loads can withstand, for a stabilised period of one minute:

(a) A Proof Pressure equal to 1.5 times the maximum operating pressure without permanent deformation or leakage that would prevent performance of the intended function.

(b) A Burst Pressure equal to 2.0 times the maximum operating pressure without failure. Leakage is permitted and seals may be excluded from tests.

CS-P 440 Propeller Systems and Components

For those systems or components which cannot be adequately substantiated by the specifications of this subpart, additional tests or analysis must be made to demonstrate that the systems or components are able to perform their intended functions in all declared environmental and operating conditions.

SUBPART D - PROPELLER VIBRATION, FATIGUE EVALUATION AND FLIGHT FUNCTIONAL TESTS

CS-P 510 Applicability

This subpart prescribes the tests and evaluations to be performed on the Propeller with the engine and airframe combination for which approval is sought.

CS-P 530 Vibration and Aero-elastic Effects (See AMC P 530)

(a) It must be demonstrated by tests, analysis based upon tests or previous experience on similar designs that the Propeller does not experience harmful aero-elastic effects (including flutter) or harmful effects of vibration throughout the operational envelope of the aircraft with suitable stress margins.

(b) When necessary for complying with the safety objective of CS-P 530 (a), the magnitude of the Propeller vibration stresses or loads, including any stress peaks and resonant conditions, must be determined throughout the declared operational envelope of the intended aircraft by either:

(1) Measurement of stresses or loads through direct testing or analysis based on direct testing of the Propeller on the aircraft and engine installation for which approval is sought, or

(2) Comparison of this Propeller to similar Propellers installed on similar aircraft installations for which these measurements have been made.

[Amdt. No.: P/1]

CS-P 550 Fatigue Evaluation (See AMC P 550)

(a) An evaluation of the Propeller must be conducted to show that failure due to fatigue will be avoided throughout the intended operational life of the Propeller, using the fatigue and structural data obtained in compliance with CS-P 370 and vibration data obtained in compliance with CS-P 530. This evaluation must include:

(1) A determination of operating limitations, service life, mandatory replacement times and inspection intervals for the Propeller and its Propeller Critical Parts.

(2) The intended loading spectra, including all reasonably foreseeable vibration and cyclic load patterns, considering identified emergency, over-speed or over-torque conditions.

(3) The effects of temperature, humidity and likely deterioration expected in service.

(b) Each determined mandatory replacement period and inspection interval must be included in the airworthiness limitation section of the instructions for continued airworthiness required by CS-P 40.

(c) Any operating conditions or speed ranges shown by the fatigue evaluation and vibration survey to require limitation must be clearly stated in the Propeller certification documentation.

[Amdt. No.: P/1]

CS-P 560 Flight Functional Tests (See AMC P 560)

A flight test of not less than 50 hours must be conducted on a Propeller, as detailed below, to demonstrate its functional characteristics when installed on the intended engine and aircraft.

(a) The Propeller must be fitted with all parts, such as spinner and de-icing equipment, which are normally used with it, and must be installed on a representative engine and aircraft.

(b) Throughout the Pitch range for which certification is sought Fixed, Adjustable or Variable (non-governing) Pitch Propellers must demonstrate that:

  (1) The declared Maximum Permissible Rotational Speed or maximum torque are not exceeded under all normal and likely emergency operations.

  (2) During ground run-up, take-off and climb at best-rate-of-climb aircraft speed, the Propeller must not cause exceedence of any approved engine limitations.

  (3) During ground run-up and take-off, the Propeller must not limit the engine speed below its approved speeds.

  (4) During a closed-throttle glide at speeds up to the aircraft VNE speed, the Propeller must not cause the engine to exceed its maximum continuous limitations.

(c) Variable Pitch Propellers (governing). As applicable the test must demonstrate that, over the whole range of normal and likely emergency operations of the Propeller and in an environmental envelope appropriate to the intended aircraft:

  (1) No incompatibility with the engine or the aircraft is encountered.

  (2) The Maximum Governed Rotational Speed is not exceeded.

  (3) Governing is stable under all oil temperature conditions.

  (4) The Propeller is appropriately responding to rapid throttle movements.

  (5) Governing and feathering is possible at all aircraft speeds up to VNE.

  (6) Unfeathering is possible, especially after being feathered for the maximum diversion time at the minimum declared steady state outside air temperature.

  (7) Beta Control response and sensitivity is adequate.

  (8) All stops and warning lights adequately function.

(d) Propellers designed for operation in Reverse Pitch. 50 landings must be made using the Reverse Pitch at the maximum Propeller rotational speed allowed for such operation.

[Amdt. No.: P/1]

EASA Certification specifications
for
Propellers

CS-P
Book 2

Acceptable means of compliance

SUBPART A - GENERAL

In addition to the Acceptable Means of Compliance in Book 2 of these Certification Specifications, AMC-20 may also provide acceptable means of compliance to the specifications in Book 1 of this CS-P.

AMC P 10
Applicability

(1) If included as part of the Type Design then the structural integrity and functionality of the Propeller de-icing equipment is approved during Propeller certification to this CS-P.

The Propeller type certification does not approve de-icing equipment ice protection performance. Aircraft icing capability is demonstrated on the aircraft in accordance with applicable aircraft airworthiness requirements.

(2) If approval is granted after compliance has been shown with subparts A, B and C of CS-P, the Propeller Type Certificate Data Sheet will include the following statement:

"This Propeller has been certificated in accordance with CS-P subparts A,B and C. Compliance with the requirements of Subpart D, which is specific to each aircraft installation, has not yet been demonstrated."

[Amdt. No.: P/1]

AMC P 30(a)
Instructions for Propeller Installation and Operation

(1) The installation manual is provided as an interface document between Propeller and Aircraft/Engine TC holders.

(2) The installation manual should include control system characteristics, and define operation in primary and all alternate operational modes. If there is any change in operating characteristics in transition between modes or in backup modes, then these should also be described.

(3) The typical contents of an installation manual for a constant speed, Feathering, and reversing Propeller are listed below. It is provided as a guide to compiling an installation manual, although not all items will be applicable to all types of Propellers.

Drawings - List of top level Propeller drawing titles and numbers

Propeller type data and description

Components and accessories

Propeller System description

Control system description.

Propeller properties and limitations
- Diameter
- Number of blades

- Power and rpm limits
- Torque limits
- Over-speed and over-torque limits
- Propeller shaft loads
- Propeller System mounting instructions and bolt torques
- Propeller balance
- Vibration environment
- Altitude versus ambient temperature limitations
- Ground de-icing limitations

Propeller System component weights
- Moments of inertia
- Centre of gravity
- List weights

Pitch change
- Settings
- Pitch change rate
- Beta sensor position
- Limits on intended movement below the In-Flight Low-Pitch-Position
- Feathering limitations and minimum declared temperature

Recommended operating procedures including:
- Ground operation
  - Starting
  - Propeller brake operating
  - Over-speed governor check
  - Secondary low Pitch stop check
  - Limitations and restrictions
- De-icing operation
- Flight operation
- Emergency operations
- Fault detection, isolation and accommodation
- Time limited dispatch requirements

Ice protection system - System description

Electrical - System description
- Power requirements
- Loss of aircraft electrical power effects
- EMI/Lightning protection
- System description
- Qualification results
- Limitations

Actuation and lubrication system
- Actuating fluids
- Propeller pump fluid requirements
- Fluid filtration
- Lubricating fluid
- Auxiliary motor and pump

Assumptions
- Safety Analysis
- Design
- Operation

[Amdt. No.: P/1]

SUBPART B - DESIGN AND CONSTRUCTION

AMC P 150
Propeller Safety Analysis

(1) Introduction

This AMC describes acceptable means, but not the only means, for demonstrating compliance with the requirements of CS-P 150.

Compliance with CS-P 150 requires a safety analysis, which should be substantiated when necessary, by appropriate testing and/or comparable service experience.

The depth and scope of an acceptable safety analysis depend on the complexity and criticality of the functions performed by the systems, components or assemblies under consideration, the severity of related Failure Conditions, the uniqueness of the design and extent of relevant service experience, the number and complexity of the identified failures, and the detectability of contributing failures.

Examples of methodologies are Fault Tree Analysis (FTA), Failure Mode and Effects Analysis (FMEA) and Markov Analysis.

(2) Objective

The ultimate objective of a safety analysis is to ensure that the risk to the aircraft from all Propeller Failure Conditions is acceptably low. The basis is the concept that an acceptable overall Propeller design risk is achievable by managing the individual major and hazardous Propeller risks to acceptable levels. This concept emphasises reducing the likelihood or probability of an event proportionally with the severity of its effects. The safety analysis should support the Propeller design goals such that there would not be Major or Hazardous Propeller Effects that exceed the required probability of occurrence as a result of Propeller Failure Modes. The analysis should consider the full range of expected operations.

(3) Specific guidance

(a) Classification of effects of Propeller failures

Aircraft-level failure classifications are not directly applicable to the Propeller safety analysis since the aircraft may have features that could reduce or increase the consequences of a Propeller Failure Condition. Additionally, the same type-certificated Propeller may be used in a variety of installations, each with different aircraft-level failure classifications. Accordingly the classification of the consequences of Propeller failures should only be based on assumptions for a typical Propeller/Engine/aircraft combination in the absence of actual safety classifications from the Aircraft and Engine manufacturers.

CS-P 150 defines the Propeller-level Failure Conditions and presumed severity levels.

Since aircraft-level requirements for individual Failure Conditions may be more severe than the Propeller-level requirements, there should be early co-ordination between the Propeller manufacturer, engine manufacturer and the aircraft manufacturer to ensure Propeller, Engine and aircraft compatibility.

(b) Component Level Safety Analysis

In showing compliance with CS-P 150 (a), a component level safety analysis may be an auditable part of the design process or may be conducted specifically for demonstration of compliance with this rule.

The specific requirements of CS-P 230 for the Propeller control system should be integrated into the overall Propeller safety analysis.

(c) Typical installation

The reference to "typical installation" in CS-P 150 (a)(1)(i) does not imply that the aircraft-level effects are known, but that assumptions of typical aircraft devices and procedures, such as governors, annunciation devices, etc., are clearly stated in the analysis.

CS-P 150 (f) requires the applicant to include in the Propeller safety analysis consideration of some aircraft components.

It is recognised that, when showing compliance with CS-P 150 (a)(3) and (4) for some Propeller effects, the applicant may not be in a position to determine the detailed failure sequence, the rate of occurrence or the dormancy period of such failures of the aircraft components.

In such cases, for Propeller certification, the applicant will assume a failure rate for these aircraft components. Compliance with CS-P 150 (d) requires the Propeller manufacturer to provide, in the installation instructions, the list of failures of aircraft components that may result in or contribute to Hazardous or Major Propeller Effects. The mode of propagation to this effect should be described and the assumed failure rates should be stated.

During the aircraft certification, the Propeller effect will be considered in the context of the whole aircraft. Account will be taken of the actual aircraft component failure rate.

Such assumptions should be addressed in compliance with CS-P 30.

(d) Hazardous Propeller Effects

(i) The acceptable occurrence rate of Hazardous Propeller Effects applies to each individual effect. It will be accepted that, in dealing with probabilities of this low order of magnitude, absolute proof is not possible and reliance should be placed on engineering judgement and previous experience combined with sound design and test philosophies.

The probability target of not greater than 10^{-7} per Propeller flight hour for each Hazardous Propeller Effect applies to the summation of the probabilities of this Hazardous Propeller Effect arising from individual Failure Modes or combinations of Failure Modes other than the failure of Critical Parts (for example; hubs, blades). For example, the total rate of occurrence of excessive drag, obtained by adding up the individual Failure Modes and combination of Failure Modes leading to an excessive drag, should not exceed 10^{-7} per Propeller flight hour. The possible dormant period of failures should be included in the calculations of failure rates.

If each individual failure is less than 10^{-8} per Propeller flight hour then summation is not required.

(ii) When considering Primary Failures of certain single elements such as Propeller Critical Parts, the numerical failure rate cannot be sensibly estimated. If the failure of such elements could result in Hazardous Propeller Effects, reliance should be placed on their meeting the prescribed integrity requirements of CS-P 160. These requirements are considered to support a design goal that failure of the component should be Extremely Remote throughout its operational life. There is no requirement to include the estimated Primary Failure rates of such single elements in the summation of failures for each Hazardous Propeller Effect due to the difficulty in producing and substantiating such an estimate.

(e) Major Propeller Effects

Compliance with CS-P 150 (a)(4) can be shown if the individual failures or combinations of failures resulting in Major Propeller Effects have probabilities not greater than 10^{-5} per Propeller flight hour. No summation of probabilities of Failure Modes resulting in the same Major Propeller Effect is required to show compliance with this rule.

Major Propeller Effects are likely to significantly increase crew workload, or reduce the safety margins.

(f) Reserved

(g) Determination of the effect of a failure

Prediction of the likely progression of some Propeller failures may rely extensively upon engineering judgement and may not be proven absolutely. If there is some question over the validity of such engineering judgement, to the extent that the conclusions of the analysis could be invalid, additional substantiation may be required. Additional substantiation may consist of reference to Propeller test, rig test, component test, material test, engineering analysis, previous relevant service experience, or a combination thereof. If significant doubt exists over the validity of the substantiation so provided, additional testing or other validation may be required under CS-P 150 (b).

(h) Reliance on maintenance actions

For compliance with CS-P 150 (e)(1) it is acceptable to have general statements in the analysis summary that refer to regular maintenance in a shop as well as on the line. If specific failure rates rely on special or unique maintenance checks, those should be explicitly stated in the analysis.

In showing compliance with the maintenance error element of CS-P 150 (e)(1), the Propeller maintenance manual, overhaul manual, or other relevant manuals may serve as the appropriate substantiation. A listing of all possible incorrect maintenance actions is not required in showing compliance with CS-P 150 (e)(1).

Maintenance errors have contributed to hazardous or catastrophic effects at the aircraft level. Events may arise due to similar incorrect maintenance actions being performed on multiple Propellers during the same maintenance availability by one maintenance crew, and are thus primarily an aircraft-level concern. Nevertheless, precautions should be taken in the Propeller design to minimise the likelihood of maintenance errors. However, completely eliminating sources of maintenance error during design is not possible; therefore, consideration should also be given to mitigating the effects in the Propeller design.

If appropriate, consideration should be given to communicating strategies against performing concurrent maintenance of Propellers on multi-engine aircraft.

Components undergoing frequent maintenance should be designed to facilitate the maintenance and correct re-assembly.

In showing compliance with CS-P 150 (e)(2), it is expected that, wherever specific failure rates rely on special or unique maintenance checks for protective devices, those should be explicitly stated in the analysis.

(4) Analytical techniques

This paragraph describes various techniques for performing a safety analysis. Other comparable techniques exist and may be used. Variations and/or combinations of these techniques are also acceptable. For derivative Propellers, it is acceptable to limit the scope of the analysis to modified components or operating conditions and their effects on the rest of the Propeller.

Various methods for assessing the causes, severity levels, and likelihood of potential Failure Conditions are available to support experienced engineering judgement. The various types of analyses are based on either inductive or deductive approaches. Brief descriptions of typical methods are provided below.

- Failure Modes and Effects Analysis. This is a structured, inductive, bottom-up analysis which is used to evaluate the effects on the Propeller of each possible element or component failure. When properly formatted, it will aid in identifying latent failures and the possible causes of each Failure Mode.

- Fault tree or Dependence Diagram (Reliability Block Diagram) Analyses. These are structured, deductive, top-down analyses which are used to identify the conditions, failures, and events that would cause each defined Failure Condition. They are graphical methods for identifying the logical relationship between each particular Failure Condition and the primary element or component failures, other events, or their combinations that can cause the Failure Condition. A Fault Tree Analysis is failure oriented, and is conducted from the perspective of which failures should occur to cause a defined Failure Condition. A Dependence Diagram Analysis is success-oriented, and is conducted from the, perspective of which failures should not occur to preclude a defined Failure Condition.

[Amdt. No.: P/1]

AMC P 160
Propeller Critical Parts

(1) Introduction

Because the failure of a Propeller Critical Part could result in a Hazardous Propeller Effect, it is necessary to take precautions to avoid the occurrence of failures of such parts. Under CS-P 150 (c), they are required to meet prescribed integrity requirements.

For that purpose, an Engineering Plan, a Manufacturing Plan and a Service Management Plan are required under CS-P 160. These three plans define a closed-loop system which link the assumptions made in the Engineering Plan to how the part is manufactured and maintained in service; the latter two aspects are controlled by the Manufacturing and Service Management Plans respectively. These plans may generate limitations which are published in the Airworthiness Limitation Section of the Instruction for Continued Airworthiness. This AMC provides guidance for the establishment of such plans.

(2) General

(a) Identification of Propeller Critical Parts

The safety analysis required under CS-P 150 identifies Propeller Critical Parts that are required to comply with CS-P 160. A Propeller Critical Part is a Critical Part, by definition, with regard to compliance with Part-21.

If a part is made of various sub-parts, which are finally integrated in an inseparable manner into a unique part, and any one of the sub-parts is identified as a Propeller Critical Part, the entire part is then treated as a Propeller Critical Part.

(b) Attributes of a part

'Attributes' include, but are not limited to, material mechanical properties, material microstructure, material anomalies, residual stress, surface condition, and geometric tolerances. Processes such as forging, casting, machining, welding, coating, shot peening, finishing, assembly, inspection, storage, repair, maintenance and handling may influence the Attributes of the finished part. Environmental conditions experienced in service may also affect the Attributes.

(c) Content of a Plan

The Engineering Plan, Manufacturing Plan and Service Management Plan should provide clear and unambiguous information for the management of the Propeller Critical Parts.

'Plan', in the context of this rule, does not necessarily mean having all technical information contained in a single document. If the relevant information exists elsewhere, the plan may make reference to drawings, material specifications, process specifications, manuals, etc., as appropriate. It should be noted that these references should be clear enough to uniquely identify the referenced document. The plan should allow the history of the individual part number to be traced.

(3) Guidance for defining an Engineering Plan

(a) Elements of an Engineering Plan

An Engineering Plan should address the following subjects:

- Analytical and empirical engineering processes applied to determine the Approved Life.

- Structured component and Propeller testing conducted to confirm Propeller operating conditions and to enhance confidence in the Approved Life.

- Establishment of the Attributes to be provided and maintained for the manufacture and service management of Propeller Critical Parts.

- Development and certification testing, and service experience required to validate the adequacy of the design and Approved Life. Any in-service inspections identified as critical elements to the overall part integrity, should be incorporated into the Service Management Plan.

(b) Establishment of the Approved Life

The major elements of the analysis are:

(i) Operating conditions

For the purposes of certification, an appropriate flight profile or combination of profiles and the expected range of ambient conditions and operational variations will determine the predicted service environment.

The appropriateness of the Propeller Flight Cycle should be validated and maintained over the lifetime of the design. The extent of the validation is dependant upon the approach taken in the development of the Propeller Flight Cycle.

(ii) Stress analysis

The stress determination is used to identify the limiting locations such as bores, holes, changes in section, welds or attachment slots, and the limiting loading conditions. Analytical and empirical Engineering processes are applied to determine the stress distribution for each part. All methods of stress analysis should be validated by experimental measurements.

(iii) Life analysis

The fatigue life prediction method is based upon test data obtained from cyclic testing of representative laboratory, sub-component, or specific component specimens and should account for the manufacturing processes that affect fatigue capability, including fabrication from production grade material. The fatigue life prediction method should also account for environmental effects, such as vibration and corrosion, and cumulative damage.

When the fatigue life is based on cyclic testing of specific parts, the test results should be corrected for inherent fatigue scatter. The factors used to account for scatter should be justified.

(4) Guidance for Defining a Manufacturing Plan

(a) Introduction

The Manufacturing Plan is a portion of the overall integrity process intended to ensure the life capability of the part. The Engineering Plan includes assumptions about how Propeller Critical Parts are designed, manufactured, operated and maintained: each can have an impact on the part life capability. Therefore, it is essential to ensure that the Attributes required by the Engineering Plan are maintained.

(b) Elements of a Manufacturing Plan

The part specific Manufacturing Plan should consider the Attributes of the part delivered by the manufacturing process from raw material to finished part and should highlight all sensitive parameters identified as being significant with regard to part life which should not be changed without proper verification.

(c) Development and Verification of the Manufacturing Plan

The Manufacturing Plan should be reviewed and verified by the appropriate key Engineering and Manufacturing skills, which may include:

- Engineering
- Material Engineering
- Non-Destructive Inspection
- Quality Assurance
- Manufacturing Engineering

Hence, this same skill mix should evaluate and approve process validation and the procedures for manufacturing change control and non-conformance disposition to ensure that the product of manufacturing is consistent with the design assumptions of the Engineering Plan.

The level of detail in the Plan may vary depending on the specific process step being considered, the sensitivity of the particular process step, and the level of control required to achieve the required life capability.

(5) Guidance for defining a Service Management Plan

(a) Introduction

The Service Management Plan forms part of the overall process intended to maintain the integrity of Propeller Critical Parts throughout their service life. The Engineering Plan includes assumptions about the way in which the Propeller Critical Parts are manufactured, operated and maintained: each can have an impact on the life capability of the part. Therefore, it is essential to ensure that these assumptions remain valid. The Service Management Plan conveys the processes for in-service repair and maintenance to remain consistent with the assumptions made in the Engineering Plan.

(b) Determining the acceptability of repair and maintenance processes

Repair and maintenance processes should be reviewed by the appropriate key Engineering and Product Support skills, which may include:

- Engineering
- Material Engineering
- Non-Destructive Inspection
- Quality Assurance
- Product Support Engineering
- Repair Development Engineering

The role of this cross-functional review is consistent with that laid out for the Manufacturing Plan.

(6) Airworthiness Limitations Section

To ensure a closed-loop between the in-service parts and the Engineering Plan, the importance of the limits to the repair and maintenance of Propeller Critical Parts should be highlighted in the Propeller manuals required by CS-P 40. Further, since inappropriate repair or maintenance could impact the integrity of the part in a hazardous manner, visibility should be provided through the Airworthiness Limitations Section (ALS) of Instructions for Continued Airworthiness. Wording as, or similar to, that shown below should be placed in the appropriate section of the ALS.

"The following airworthiness limitations have been substantiated based on Engineering analysis that assumes this product will be operated and maintained using the procedures and inspections provided in the Instructions for Continued Airworthiness supplied with this product by the Type Certificate holder, or its licensees. For Propeller Critical Parts and parts that influence Propeller Critical Parts, any repair, modification or maintenance procedures not approved by the Type Certificate holder, or its licensees, or any substitution of such parts not supplied by the Type Certificate holder, or its licensees, may materially affect these limits."

[Amdt. No.: P/1]

AMC P 170
Materials and Manufacturing Methods

(1) Metallic Materials and Processes for Propellers

The metallic materials used in Propeller production and the fabrication processes employed should be established on the basis of experience and/or tests. Related procedures should adhere to the following guidelines.

(a) Material selection

Selected materials should be suitable for their intended mechanical and/or physical function and be resistant to degradation by corrosion and by the environment to be encountered in the specific application. When the use of inherently resistant materials is not practical, the use of adequate coating systems should be considered. Alloy-temper combinations that are susceptible to stress corrosion cracking (SCC) should be avoided. Coatings may delay, but not prevent, the onset of SCC. Designs that involve active galvanic coupling of dissimilar metals/alloys should be avoided as much as possible. When such coupling becomes the logical design choice, the use of coatings, films or sealants should be considered.

(b) Specifications

Materials should be procured to adequately detailed specifications. Such specifications should be acceptable to the Agency, either specifically, or by having been prepared by an organisation which the Agency accepts as having the necessary credentials to do so. The detail of the specification should be related to the criticality of the application.

(c) Design values

The assumed design values of properties of materials should be suitably related to the most adverse properties stated in the material specification.

(d) Process Specifications

Manufacturing processes should be performed according to detailed process specifications. Such specifications should be acceptable to the Agency.

(e) Special Manufacturing Methods

Casting, forging, welding and brazing require additional precautions not ordinarily applicable to manufacture from mill products (bar, sheet, plate and the like). The following should be observed:

(i) Classification

Materials requiring special manufacturing methods should be classified according to their functional criticality. This classification becomes the basis for establishing the non-destructive inspection and testing requirements to be listed on the drawing.

(ii) Testing

Materials requiring special manufacturing methods should have provisions for testing the material. A reasonable plan for testing should be developed for these materials. The purpose of the test material would be to verify mechanical properties, microstructure and the like.

(iii) Inspection

Materials requiring special manufacturing methods should be subjected to a suitable non-destructive and destructive inspection process at an appropriate stage and with an appropriate sampling rate.

(2) Castings

(a) The means of maintaining the required quality of all castings should be established by such methods as analysis for correct chemical composition, tests of mechanical properties, microscopic examination, break-up examination, strength tests, radiographic examination, etc. While other forms of examination may be adequate for most parts of castings, radiographic examination, where practicable, should be carried out on the more highly stressed portions in order to establish that the foundry technique is satisfactory.

(b) When radiographic examination is called for, this should be continued until a satisfactory standard of quality has been established.

(c) All castings should be subjected to a suitable flaw-detection process. Such processes should be completed subsequent to any heat treatment.

(d) The drawings of each casting should contain information sufficient to identify the relevant means of manufacture and quality control, either by detailing the necessary information, or quoting the relevant documents. Where necessary, areas of high stress should be identified, but this may be done by a separate drawing.

(3) Forgings

(a) Forgings should be classified as Class 1, Class 2 or Class 3 parts in accordance with the following:
Class 1. Those parts, the failure of which could cause a Hazardous Propeller Effect;
Class 2. Stressed parts not covered by the terms of Class 1; or
Class 3. Unstressed or only lightly stressed parts, not covered by the terms of Class 1.

(b) The means of maintaining the required quality of all forgings should be established by such methods as analysis for correct chemical composition, tests of mechanical properties, microscopic examination, fracture examination, strength tests, radiographic examination, etc.

(c) On the drawings of Class 1 parts, the direction of grain required should be indicated clearly in a manner which will ensure that it is brought to the notice of the person responsible for deciding the forging technique to be adopted. The agreed material properties required should also be identified.

(d) All forgings should be subjected to a suitable crack-detection process at an appropriate stage. Additional crack-detection tests should be made after any subsequent heat treatment has been completed. Where the level and location of residual stresses in forged Critical Parts could be significant in relation to the intended loads, and cannot be assessed by experience on similar designs using similar materials and forging methods, sufficient physical tests should be carried out to give adequate assurance of the level of residual stress likely to be present and of freedom from unacceptable variability.

(e) When radiographic or ultrasonic examination is called for, this should be continued until a satisfactory standard of quality has been established.

(f) The drawings of each forging should contain information sufficient to identify the relevant means of manufacture (e.g. the optimum fabrication method and sequence to obtain the desired level of residual stress and the correct grain flow in the finished forgings) and quality control either by detailing the necessary information or quoting the relevant process control documents.

(g) The strength of forgings classified as Class 1 or Class 2 parts should be proved to be satisfactory by calculation, by test, or comparison with a forging of similar design already proved to be satisfactory.

(h) Tests
Each Class 1 and Class 2 forging should normally incorporate one or more projections which, after heat treatment of the forging, can be used as test piece(s) to establish that the material qualities of the forging are satisfactory.

The location(s) and dimensions of the test piece(s) should be decided in consultation with the forging manufacturer.
In cases where the incorporation of test pieces is impractical, or would adversely affect the design, the drawing should indicate that such test pieces are not required. In such cases a suitable technique of sample testing should be agreed.

(4) Welded Structures and Welded Components

(a) Fusion and resistance welds should be classified in accordance with the following:
Group 1. Those welds the failure or leakage of which could cause a Hazardous Propeller Effect;
Group 2. Highly stressed welds, the failure or leakage of which would not cause a Hazardous Propeller Effect; or
Group 3. All other welds.

(b) The necessary means of maintaining the required quality of all welded structures and components should be established. This may involve the verification of correct application of the approved preparatory and welding techniques, by destructive and non-destructive inspection of representative test specimens, at prescribed intervals during weld production, visual inspection of each weld produced, and pressure testing of welds, where applicable, etc..

(c) All welds should be subjected to a suitable crack-detection process at an appropriate stage. Additional crack-detection tests should be made after any subsequent heat treatment has been completed.

(d) When radiographic examination is called for this should be continued until a satisfactory standard of quality has been established.

(e) The drawings of each welded structure or component should contain information sufficient to identify the relevant means of welding to be used and the quality control method either by detailing the necessary information or quoting the relevant documents.

[Amdt. No.: P/1]

AMC P 210
Variable and Reversible Pitch Propellers

The extent of any intended travel should account for backlash, tolerances, secondary stops, etc.. For example, a hydraulic failure of a dual acting Propeller System with Pitch lock operating at the In-Flight Low-Pitch Positions could permit a small decrease in blade angle due to system backlash. The Pitch lock may require a small blade angle change before it engages. This value is documented in the Instructions for Propeller Installation and Operation.

[Amdt. No.: P/1]

AMC P 220
Feathering Propellers

(1) Emergency conditions in flight are those flight conditions outside of normal operation but not beyond the operational envelope of the aeroplane. Flights speeds above Vne and below the stall warning speed are outside of the range of emergency conditions.

(2) The Feathering and unfeathering characteristics and limitations may include parameters such as the Feather angle, rate of Pitch change, and airspeed limits above which the Propeller may not Feather completely or Feather at a slower rate. Such data should be made available to airframe TC holders, as necessary.

(3) Evaluation at the minimum declared outside temperature may be verified in a cold chamber or by flight test. If a maximum diversion time has been established for the aeroplane installation this would be appropriate to use as the time for stabilisation to a steady state temperature.

[Amdt. No.: P/1]

AMC P 230
Propeller Control System

(1) Applicability

CS-P 230 is applicable to all types of Propeller control systems. For instance, these might be hydro-mechanical or hydro-mechanical with a limited authority electronic supervisor or single channel full authority Propeller control with hydro-mechanical back-up or dual channel full authority electronic Propeller control system with no back-up or any other combination. The electronic technology may be analogue or digital.

The Propeller control system includes any system or device that controls, limits or monitors Propeller operation and is necessary for continued airworthiness of the Propeller. This includes all equipment that is necessary for controlling the Propeller and ensuring safe operation of the Propeller within its limits as specified in CS-P 50. This implies consideration of all Propeller control system components including the electronic control unit(s), pitch control unit(s), overspeed governor(s), Feather pump, cables, wires, sensors, etc..

These requirements cover the main Propeller control system as well as protection systems against, for example, over-speed or over-torque.

Propeller monitoring systems are covered by this requirement when they are physically or functionally integrated with the Propeller control system or they perform functions that affect Propeller safety or are used to effect continued-operation or return-to-service decisions.

(2) Objective

The purpose of CS-P 230 is to set objectives for the general design and functioning of the Propeller control system and these requirements are not intended to replace or supersede other requirements.

For electronic Propeller control systems, AMC 20-1 provides additional and detailed interpretation of CS-P 230 with special consideration to interfaces with the aircraft, and the Engine when applicable.

(3) Integrity

The intent of CS-P 230 (c) is to establish Propeller control system integrity requirements consistent with operational requirements of the various applications. In particular, the introduction of electronic Propeller control systems should provide at least an equivalent level of safety and reliability for the Propeller as achieved by Propellers equipped with hydro-mechanical control and protection systems.

(4) Aircraft Supplied Power

Propeller control systems implemented in hydro-mechanical technology or technology other than electrical and electronic technology should inherently be compliant with CS-P 230 (e). However, if the system has functions implemented electrically or electronically that depend on aircraft-supplied electrical power, the system should be evaluated for compliance with this rule (see paragraph 13 of AMC 20-1 for relevant interpretation).

[Amdt. No.: P/1]

AMC P 240
Strength

Steady Loads – Acceptable Levels

(1) The acceptable levels for steady loads are expressed in terms of minimum factors for the resultant stresses when related to the proof stress of the material. Proof stress is based on 0.2% yield stress definition for metal components.

(2) The following factors apply to metal components:

(a) The hubs of Propellers with detachable blades should have proof factors of not less than 2.0 for tension and compression and an ultimate factor of not less than 3.0 in shear.

(b) Detachable Propeller blades should have a proof factor in tension and compression of not less than 2.0 for the root of the blade and of not less than 1.75 for the remainder of the blade. The shear stress ultimate factor should not be less than 3.0.

(c) Fixed Pitch Propellers should have a proof factor in tension and compression of not less than 2.0 except that the blade outboard of the innermost aerofoil section should have a factor of not less than 1.75. The shear stress ultimate factor should not be less than 3.0.

[Amdt. No.: P/1]

SUBPART C - TYPE SUBSTANTIATION

AMC P 330
General

Some tests may be run without automatic controls or safety systems. For example, a primary system may have to be disabled to test a backup system or a governing function may need to be disabled to test an overspeed condition.

[Amdt. No.: P/1]

AMC P 350
Centrifugal Load Tests

(1) The pass/fail criteria for these tests is that the Propeller completes the tests without evidence of:

(a) Failure

A failure would consist of the release of any component or debris. The fracture of a component without release would be a failure. Specifically, the separation of a composite blade bonded to a metallic retention would be a failure, even when the design has a backup system to prevent release of the blade.

(b) Malfunction

Elastic deformation of a hub that would prevent the blades from changing Pitch would be a malfunction.

(c) Permanent deformation is not acceptable.

(2) Hub, retention system and counter weight (Guidance for CS-P 350(a))

(a) The maximum centrifugal load is based on the Maximum Permissible Rotational Speed or Maximum Governed Rotational Speed, as appropriate, declared in the Type Certificate Data Sheet (TCDS). Transient overspeed events are not considered normal and do not constitute the maximum rpm to be used for establishing test conditions.

(b) The test may be conducted on an assembly, either by whirl testing or static testing, by applying the load to the assembled components to simulate the centrifugal load, as appropriate.

(c) This test does not have to include the complete blade. Stub blades, with weights to establish the correct centrifugal load during whirl tests, can be used. The stub blades should have the same blade retention as the full blade, to maintain similarity to the full blade retention.

(3) Blade Features (Guidance for CS-P 350(b))

Blade features such as those associated with transitions from composite blade to the metallic retention can be tested during the hub and retention system test required by CS-P 350(a) or with a separate component test. There may be other applicable configurations, such as the transition associated with a configuration in which the blade of any material construction is bonded or otherwise attached to the portion of the blade that is retained in the hub.

(4) Propeller Components

Propeller components not requiring twice centrifugal load tests should be subjected to test or analysis equivalent to the centrifugal load resulting from 126% rotational speed (equivalent to 159% load at 100% speed) for a period of 30 minutes. These components may also be shown to be acceptable by similarity to existing components with applicable service history. Testing can involve whirl testing, static testing with the assembly or on a component or sub-component level. Analysis methods used to demonstrate compliance for these components should be accepted by the Agency.

[Amdt. No.: P/1]

AMC P 360
Bird Impact

Compliance may be based on similarity and service history to existing Propeller installations, bird impact testing, or analysis combined with similarity and testing. Both static and rotating tests are acceptable. Both natural and artificial birds are acceptable for use in testing.

(1) Selection of critical operating conditions

The selection of critical operating conditions is based on an evaluation of the intended use of the Propeller, the operating conditions when the Propeller will most likely encounter bird populations, and the impact geometry of the Propeller. Typically, this condition occurs at takeoff and landing.

(2) Selection of impact site

(a) Blade. The impact site should be chosen to produce maximum blade loads.

(b) Spinner. An impact site should be chosen that produces maximum loads. The site selected should show that the entire spinner would not separate.

(3) Selection of the bird

Natural birds or artificial birds may be used for testing. Artificial birds may be used if they conform to an international standard or are acceptable to the Agency.

(4) Static or rotating testing

Either static or rotating testing is acceptable. The objective is to simulate a bird strike in controlled manner to assess the resulting blade response and damage. When appropriate, blade hub, retention, and Pitch change hardware should be included as part of the static test set up for assessment of the effect of bird strike on these components.

(5) Damage evaluation

The evaluation for blades, including composite blades, typically includes a combination of:

- Visual examination
- Frequency response tests
- Blade tap tests for delamination evaluation of composite components
- Ultrasonic inspection for delamination and internal damage of composite components
- X-ray inspection for internal damage
- Fluorescent penetrant inspection or magnetic particle inspection of metallic components

[Amdt. No.: P/1]

AMC P 370
Fatigue Characteristics

(1) Vibratory Loads – Acceptable Levels

The acceptable levels for vibratory loads are expressed in terms of minimum factors for the resultant vibratory stress levels when related to the working fatigue limit for the component.

(a) The mean fatigue limit should be established from an S/N Curve constructed from representative tests and other data on the material concerned. Normally a fatigue limit established at 10^8 cycles would be acceptable.

(b) The working fatigue limit should be derived from the mean fatigue limit suitably factored to ensure, with a high degree of confidence, that all components produced to the same drawings and specifications as those tested to produce the S/N Curve of (a) will sustain no unacceptable fatigue damage.

(c) The factor on vibratory stress (including concentration effects) should be not less than 1.5 except for the blades outboard of the root where it should be not less than 1.8.

(2) Combined steady and vibratory loads – Acceptable Levels

The relationship of the acceptable levels of steady and vibratory loads of paragraphs (1)(a) and (1)(b) is illustrated in figure 1 for conventional Propellers with solid aluminium alloy blades. For other materials, such as composites, this relationship may vary.

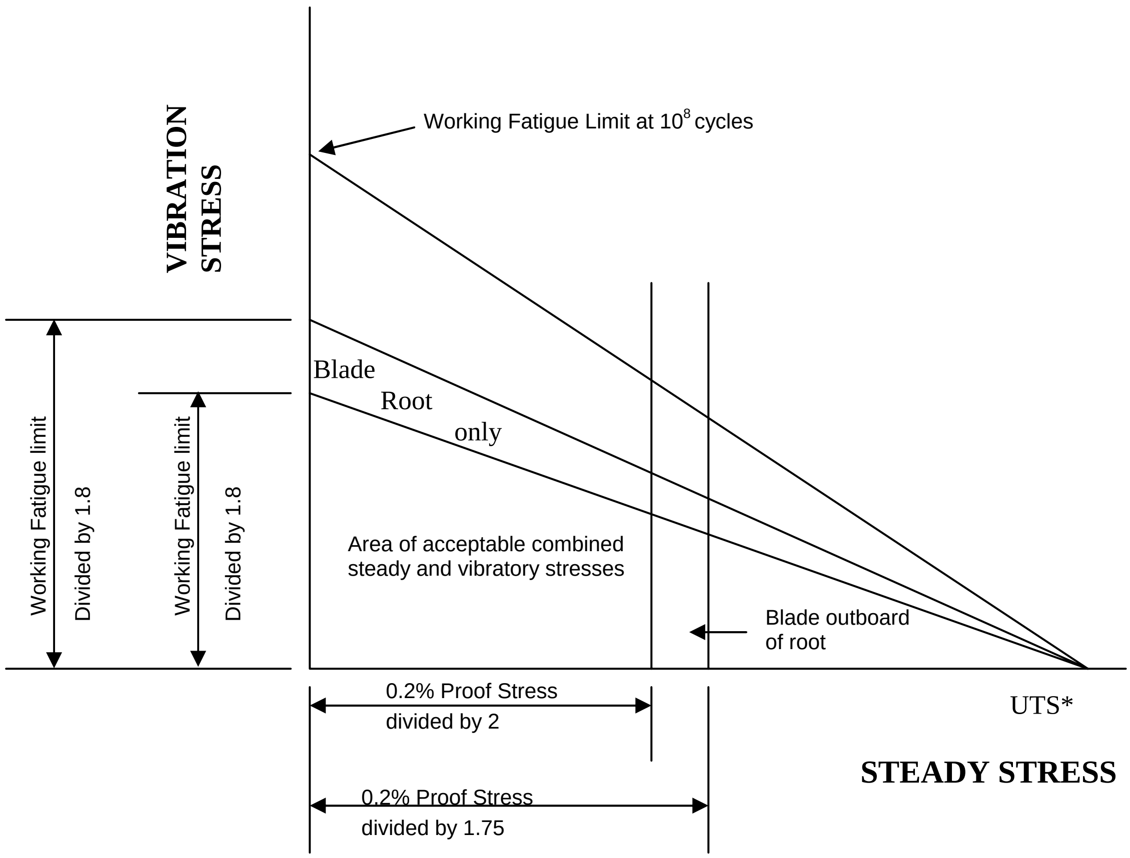

FIGURE 1 ACCEPTABLE STRESS LEVELS FOR CONVENTIONAL PROPELLERS WITH SOLID ALUMINIUM ALLOY BLADES

(3) Verification of Fatigue Limits

The procedures and factors presented by this AMC are intended to produce components with unlimited fatigue lives but the variables introduced by operation of the Propeller may require special procedures to ensure that the fatigue properties of the components are adequately maintained throughout the life of the Propeller. It will therefore be necessary to declare and institute methods to achieve this purpose. Such methods will usually take the form of:

(a) Adequate maintenance procedures (inspections, surface refurbishment, overhaul, etc); and

(b) Specimen fatigue testing of components withdrawn from service at periodic intervals.

(4) Damage Tolerance methodology can be used as an alternative to the establishment of an Approved Life, if agreed by the Agency.

(5) Previous experience will normally be accepted as a demonstration of compliance for wooden Fixed Pitch Propellers of conventional design.

[Amdt. No.: P/1]

AMC P 380
Lightning Strike

This guidance provides a description of test methodology used to determine the effect of a lightning strike on a Propeller. Detailed methods, test set-up information on voltage waveforms, current waveforms, or data collection are provided in the reference documents.

(1) Consideration should be given to all components of the Propeller assembly that could be in the lightning path these include but are not limited to the spinner, blade, hub, blade bearings, and possibly the Pitch change mechanism. Additional consideration should be given to electrical/electronic components that could be influenced by the indirect effects, these include Propeller blade and spinner de-icing system components as well as any other Propeller mounted electrical or electronic components.

(2) The damage caused by lightning is characterised into two categories, direct and indirect. The direct effects associated with lightning depend on the structural component involved, the attachment point and current path through the structure. The indirect effects are classified as damage to electrical equipment by the current or voltages either by the associated electromagnetic field, surges, or by current directly injected into the electrical wires. Indirect effects testing determines the conducted currents, surge voltages, and induced voltages entering the aircraft electrical system through systems such as the Propeller deicing system. Testing involves measurement of voltages at the terminals of the de-icing system or other electrical/electronic systems where they connect to the aircraft electrical system.

(3) The references below provide information regarding test set-up, simulated lightning wave forms, other general procedures to conduct a lightning strike test.

(a) EUROCAE ED-81, “Protection of Aircraft Electrical and Electronic Systems Against the Indirect Effects of Lightning”

(b) EUROCAE ED-14D, “Environmental Conditions and Test Procedures for Airborne Equipment”

(c) EUROCAE ED-91, “Aircraft Lightning Zoning Standard”

(d) EUROCAE ED-84, “Aircraft Lightning Environment and Related Test Waveforms Standard”

[Amdt. No.: P/1]

AMC P 390
Endurance Tests

(1) Test Configuration

Testing should be conducted with the Propeller and all other components required to operate the Propeller on an aircraft. Some components may not be included in the Propeller type design. The Propeller power output should be at least equal to the Propeller take-off and maximum continuous power ratings. Spinner and de-ice components should be installed during the endurance test. Controls should be operated in accordance with the applicant’s instructions. The applicant’s instructions should be those which are proposed to be incorporated in the Propeller manuals.

(2) Propeller diameter

When the Propeller being certified includes more than one acceptable blade design, the Propeller tested need not include the blades that give maximum Propeller diameter. It should be shown that the blades tested will represent all other similar blades to be included in the type design. Testing with blades of different construction than blades for which certification is sought may not be acceptable. For example if both composite and aluminium blade options are to be included in the type design both the composite and aluminium blades should be tested.

(3) Representative engine

The engine used to drive the Propeller during the test should be capable of developing the power and speed for which certification of the Propeller is sought. The engine vibration should be similar to the intended application for the Propeller. For example testing conducted on a turbine engine may not be applicable to show that the Propeller is acceptable on a piston engine.

(4) Continuity of test

The endurance test may be continuous or in increments agreed upon by the Agency.

(5) Stops

Each period should be run non-stop. In the event of a stop occurring during any period, the period should be repeated unless the Agency considers this to be unnecessary. The Agency reserves the right to require the complete test to be repeated if an excessive number of stops occurs.

[Amdt. No.: P/1]

AMC P 400
Functional Test

The functional tests are intended to substantiate the control function in the Propeller System. This test may be performed in conjunction with the CS-P 390, Endurance test.

[Amdt. No.: P/1]

AMC P 420
Components of the Propeller Control System

This requirement is intended to identify functionality and wear of the Propeller Pitch Control System's components for the purpose of establishing appropriate instructions for continued airworthiness. This may be performed in conjunction with the CS-P 400, Functional Test.

[Amdt. No.: P/1]

SUBPART D - PROPELLER VIBRATION, FATIGUE EVALUATION AND FLIGHT FUNCTIONAL TESTS

AMC P 530
Vibration and Aeroelastic Effects

If a test is to be conducted for compliance with CS-P 530, then:

(a) The disposition and number of measuring points should be such as to give adequate indication of vibratory stresses in all significant flapping, edgewise and torsional modes of the blade.

(b) The survey should provide for at least the following:

(i) Ground Engine/Propeller tests using the Engine for which approval is sought, or one sufficiently representative to be an acceptable alternative. The survey should cover all the operating combinations of speed and torque from Ground Idle to Maximum Governed Rotational Speed.

(ii) Aircraft/Engine/Propeller ground and flight tests in the combination for which approval is sought (or one sufficiently representative as to be an acceptable alternative).

The results of (b)(i) should show that the stresses likely to be present in conducting the flight tests of (b)(ii) are not excessive.

The results of (b)(ii) should be used in conjunction with the fatigue data generated in CS–P 370 to carry out the Fatigue Evaluation of CS-P 550.

(iii) In conducting the tests of (b)(ii) the complete range of aircraft and operating conditions should be covered over the range of aircraft weights. The testing should also cover all ground operations, including Reverse Pitch if applicable, over the range of wind speed and directions for which approval is sought.

[Amdt. No.: P/1]

AMC P 550
Fatigue Evaluation

(1) From the fatigue data generated in CS-P 370 (S/N curve) a mean line is established together with a low probability of failure line. The low probability of failure line should take account of statistical variation due to scatter of results and due to the number of test specimens.

(2) The fatigue evaluation on the Propeller, using data generated to show compliance with CS-P 370 and CS-P 530, should use suitable factors to allow for manufacturing and material variations, deterioration during service and the permitted range of aircraft loading. In the absence of any other data the combined effect of these factors should be taken as 1.5. The low probability of failure line should be reduced by this combined factor to produce a working line to be used in the fatigue evaluation.

(3) If the fatigue data on full size components is for full reversal tests with no steady load then the effect of the steady loads should be taken into account in the evaluation. Coupon tests maybe used to establish the effect of steady loads.

(4) The fatigue evaluation can be carried out using safe life methods where the damage sustained during each vibratory cycle in the Propeller's life can be summed using methods such as Miner's rule using a working line on the S/N curve as established in (1) above.

(5) Damage Tolerance methodology can be used as an alternative to the establishment of an Approved Life, if agreed by the Agency.

(6) It is recognized that operation of the Propeller may result in changes to the fatigue properties of the Propeller. Therefore, in addition to adequate maintenance procedures (inspections, surface refurbishment,

overhaul, etc), specimen fatigue testing of components withdrawn from service at periodic intervals may be required.

[Amdt. No.: P/1]

AMC P 560
Flight Functional Tests

Compliance with CS-P 560 may be shown by flight testing or service history such as documented approval for use on an aeroplane Type Certificate Data Sheet.

[Amdt. No.: P/1]