CIVIL AVIATION SAFETY AUTHORITY AUSTRALIA

AIRWORTHINESS BULLETIN

Test Club Propellers - Calibration

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1. Applicability

Test Club Propellers (TCPs) used for testing of piston engines used in aircraft.

2. Purpose

This Airworthiness Bulletin (AWB) provides guidance on the calibration of TCPs where calibration information is not available from the manufacturer of the TCP. Instructions from the manufacturer must be followed where available.

3. Background

3.1 Aircraft piston engines require testing after overhaul to ensure that the engines produce the rated power within the parameters and limits set by the manufacturers. There are three basic methods to measure the engine power output, (1) by using a dynamometer which indicates the power absorbed by it, (2) by using a torque measuring system in conjunction with a load dissipating device and (3) by using a calibrated TCP. This AWB relates only to the use of TCPs for engine testing.

3.2 Piston engine testing using TCP, also referred to as the “fan method of testing” consists of running the engine on a test stand with a calibrated TCP and test instrumentation as specified by the manufacturer. Engine power output under this test condition is indicated by the engine Revolutions Per Minute (RPM), corrected for the atmospheric conditions prevailing at the time of test. This method of engine power measurement is critically dependant on the use of a calibrated TCP, test instruments and application of correction factors.

4. Choice of Test Club Propellers

4.1 TCPs recommended by the engine manufacturers must be used. Where the manufacturer has only provided the specifications of acceptable TCPs, an appropriate choice has to be made and substantiated. An alternate TCP can be used per approved data, which takes into consideration the power dispersal characteristics, ability to withstand prolonged operation under test conditions and ability to meet engine-cooling requirements.

4.2 TCPs are available in two types: those that have a single set pitch that cannot be altered and those that have multiple preset pitch positions that can be selected and locked to suit engine type and model. TCPs with single set pitch are usually made with square tipped blades of laminated wood construction. The blades are made wide to provide maximum power absorption and air flow with minimum tip diameter. These TCPs are initially made with larger diameters than required and are “cropped” during initial calibration to meet the power and speed requirements of a specific engine.

4.3 The power absorption characteristics of the multiple pitch setting TCPs are varied during calibration, by resetting the pitch stops incorporated in the hub. These settings must not be altered without further recalibration at the altered settings.

4.4 A flight propeller may be modified for use as a TCP. The design of the modification should include an adjustment procedure for use during calibration and regular maintenance actions to ensure its integrity. Once a flight prop has been used as a TCP it should not be used again for flight purposes, because of higher stresses induced during engine testing.

5. Test Club Propeller Calibration

5.1 The calibration of a TCP is best carried out in the engine test cell using a torque measuring system. However where engines are tested in open air, without the confines of test cell walls, a TCP could be calibrated in a similar facility.

5.2 It is preferable to use a test facility with a torque measuring system to calibrate a TCP because the power developed and RPM can be measured simultaneously during calibration runs. The following procedure is applicable to such a facility, and may be used where manufacturer's instructions for TCP calibration are not available.

5.3 In general TCPs are to be calibrated at corrected take-off power subject to engine manufacturer's instructions. The engine instrumentation, installation details including cooling shrouds and safety precautions are to be per manufacturer's instructions. It is important that data used for TCP calibration are corrected for the atmospheric conditions, because a calibrated TCP that is properly maintained can remain in service for several years, under different atmospheric conditions, without the need for re-calibration. The following correction factors are adapted from UK-CAA Leaflet 7-5, "Piston Engine Overhaul – Correcting Engine Test Results" and should be used when data from engine manufacturers are not available or are inadequate.

5.4 Before the start of a calibration engine run, it is recommended the target Brake Horse Power (BHP_t) and the target speed (RPM_t) are calculated.

5.5 The Target Brake Horse Power (BHP_t) is calculated by the following formula for un-supercharged engines at full throttle:

$$BHP_t = BHP_r \frac{415\left(p_o - \frac{p_o}{R}\right)}{(400+t_o)\left(1013-\frac{1013}{R}\right)}$$

Where

BHP_t = Target BHP to be achieved during test club calibration engine run;
BHP_r = Rated take off BHP of the engine at sea level conditions;
p_o = Atmospheric pressure in hectopascals;
t_o = Air intake temperature, ^{0}C;
R = Engine compression ratio.

See UK-CAA Leaflet 7-5 for supercharged engines

5.6 The Target Speed (RPM_t) is calculated by the following method:
In the Chart 1, draw a vertical line from the observed air temperature on the horizontal scale to the correction curve, and from that point of intersection draw a horizontal line. The intersection of the horizontal line and the vertical scale gives the correction factor (K).

$RPM_t = RPM_r / K$

Where

RPM_t = Target speed to be achieved during test club calibration engine run;
RPM_r = Rated take off engine speed at sea level conditions;
K = Correction factor read from Chart 1.

5.7 A calibrated engine is a new or newly overhauled and tested engine that meets all of the manufacturer's performance data. A calibrated engine may be used for TCP calibration. Calibrated instruments must be used along with cooling shrouds as specified by the manufacturer. The engine run procedures, performance limitations and safety precautions specified by the manufacturer must be followed at all times. Run the engine to the target speed (RPM_t) calculated per paragraph 5.6 and at this speed the power developed as measured by the torque measuring system should indicate the target power (BHP_t) calculated per paragraph 5.5. A tolerance of $\pm$ 20 RPM can be applied for speed and –2% for BHP during the calibration run. Wooden TCPs can be 'cropped' per manufacturers' instructions to achieve the calibration requirements whereas for the adjustable pitch propellers the pitch stops can be adjusted to meet the requirements. When a flight propeller is used as a TCP, the adjustment procedure must be in accord with the document which approves its use as a TCP. The calibration run should be repeated at least three times to ensure consistent results, with each run meeting the calibration requirements.

6. Calibration Records

The following data should be recorded for the TCP after it has met the calibration requirements per paragraph 5.7.

6.1 For the fixed pitch wooden TCP:

- Record the date of calibration, tip diameter, the rated power and speed for which it is calibrated. It is recommended to mark this data on the TCP,
- Record the facility and torque measuring system or engine serial number used for calibration,
- Record the chord and pitch angle of each blade at approximately 6 inch (150 mm) intervals,
- Record the physical condition of the prop, nicks, dents, erosion and other damage using diagrams where appropriate,
- Carry out static balance.

6.2 For the adjustable pitch metal TCP:

- Record the date of calibration, the power and speed for which it is calibrated. It is recommended to mark this data on the TCP,
- Mark the pitch stop settings so that any changes can be easily detected,
- Record the facility and torque measuring system or engine serial number used for calibration,
- Record the physical condition of the prop, nicks, dents, erosion and other damage using diagrams where appropriate,
- Carry out static balance and crack check using Fluorescent Penetrant Inspection (FPI).

6.3 For flight propellers used as TCPs:

- Carry out tasks per paragraph 6.1, or 6.2 for adjustable pitch propellers,
- Carry out crack check per the approving document.

6.4 A record of the engines tested should be maintained for each TCP.

7. Calibration Interval

7.1 For TCPs for which data per paragraph 6 are available regular inspection is adequate to ensure that the TCP remains within calibration limits. The TCP should be inspected to ensure conformance to data per paragraph 6 at intervals consistent with its usage and operating conditions. The calibration system and documentation should have regard to CASA Civil Aviation Advisory Publication (CAAP) 30-2(0).

7.2 A TCP will require re-calibration in the event of any of the following;

- The test facility and or environment where it is used has been changed, modified or altered,
- The TCP has suffered distortion and/or damage as indicated by inspection per paragraph 7.1. Acceptable deviations, and permissible tolerances are difficult to specify for the wide range of TCPs in use. In general, damage towards the TCP tip will have a significant effect compared to that near the hub, and will need to be assessed by competent person/s on a case by case basis. Re-calibration is recommended when the assessment methods are not robust.
- The pitch settings have been altered for adjustable pitch TCP,
- For any reason that the validity of calibration is suspected.

7.3 For TCPs where calibration records per paragraph 6 are not available, the industry practice of re-calibration at 10-year intervals for fixed pitch propellers is recommended.

8. Testing of Engines Using Test Club Propellers

8.1 The general condition of the TCP must be determined before using it for engine testing, especially for evidence of alterations to pitch settings of an adjustable pitch TCP . Calibrated instruments and cooling shrouds per manufacturer's instructions must be used.

8.2 It is recommended that target engine speed per paragraph 5.6 is calculated in preparation for the test and attained within -1% of RPM_t .

9. Summary

9.1 When used for engine testing, only approved TCPs are to be used.

9.2 TCPs must be initially calibrated and must be within their re-calibration interval when used for engine testing.

9.3 Inspection at regular intervals or prior to every use is adequate to extend the re-calibration interval. The inspection should ensure that the physical condition of the TCP has not altered compared to that at the time of initial calibration.

9.4 A TCP should be re-calibrated when the inspection reveals deterioration or when the validity of calibration is suspected.

10. Bibliography

- UK-CAA Leaflet 7-3, "Piston Engine Overhaul – Fan Testing of Overhauled Engines".
- UK-CAA Leaflet 7-5, "Piston Engine Overhaul – Correcting Engine Test Results".
- CASA CAAP 30-2(0), "Calibration of Test Equipment for Maintenance Purposes".

11. Enquiries

Enquiries with regard to the content of Airworthiness Bulletins should be made via the direct link e-mail address included on the Airworthiness Bulletin web site, AirworthinessBulletin@casa.gov.au

Or in writing to: Airworthiness Standards Branch
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Chart 1.
Correction of Observed Engine RPM with Propeller Test Fans.