Application Note:

DynaVibe Procedure for Aircraft Propellers

RPX-AFA-PR-BAL-00-A

September 2016

This application note is for reference only and does not modify, replace, substitute for, or supersede official regulations or the aircraft manufacturer's instructions. There are risks and hazards associated with modifications to aircraft and these modifications are potentially dangerous and could cause harm. RPX Technologies, Inc. assumes no liability, either express or implied in the use of this procedure.

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Important Notice

Any system that distracts a pilot while operating an aircraft is a safety hazard.

During the balancing procedure please use extreme caution. Be very careful with cables and components, especially on pusher type aircraft. ALWAYS confirm the ignition is off before rotating the propeller.

Areas of this manual will highlight specific safety concerns while operating the dynamic balancing system. Please review these before operating the system.

1.1 Equipment required:

Quantity	RPX Part Number	Description
1	GX2	DynaVibe GX2
	or	*or*
	GX3	DynaVibe GX3
1	A01S30AP	Accelerometer
1	LIGHT-30	Optical tach
1	TAPE	Reflective tape
1	B01	Angle bracket
1	B03	Optical tach bracket

2 Introduction

A rotating mass such as an engine crank, propeller, propeller extension, or starter ring will always have small imbalances and tolerance variations. Mass variations will cause vibration in the engine and airframe.

Vibration can cause damage throughout the aircraft, including: the crank bearings, engine mounts, firewall, instrument panel, exhaust, intake, etc. Vibration causes accelerated wear and fatigue on equipment and passengers. The negative effects of vibration can be reduced by dynamically balancing the aircraft's rotating assembly. This will balance the crank, prop extension, propeller, and spinner as a combined unit.

Dynamic balancing is accomplished by monitoring an accelerometer and an optical tach attached to the unbalanced equipment. By using these sensors to monitor rotational speed and detect movement as the assembly rotates, the dynamic balancer is capable of quantifying the vibration caused by the mass imbalance. Based on this measured vibration magnitude and location, corrections to the assembly increase alignment of the center of mass to the rotational axis and thereby reduce the vibration.

While not all vibration can be eliminated, any reduction in vibration will reduce fatigue and damage. Some vibration from engine combustion, gear reductions, and accessories will not be affected by dynamic balancing.

3 Pre-Balance Inspection

Most dynamic balancing issues can be avoided by performing a thorough pre-balance propeller and engine inspection and rectifying any problems found. Any time saved by skipping the inspection steps could result in much more time spent troubleshooting and could allow unsafe conditions.

3.1 Airworthiness Directives / Service Bulletins

The first step in the pre-balance inspection is to review all available Airworthiness Directives (AD) and service bulletins for the propeller and powerplant. ADs and service bulletins will contain specific information about problems, updates, or issues pertaining to the particular propeller and powerplant.

Example: Certain combinations of engines and propellers may require modified dampers due to increased torque impulses.

3.2 Determine Applicable Procedure

For aircraft or propeller manufacturers that provide procedures for dynamic balancing, propeller balancing is not considered a major airframe alteration. When approved aircraft and propeller manufacturer's procedures are not available, there are other acceptable dynamic balancing procedures. Dynamic balancing of propellers using FAA-approved or FAA-accepted dynamic propeller balancing procedures is not considered a major propeller repair unless the propeller static balance weights are altered. Reference *FAA Advisory Circular 20-37E "Aircraft Propeller Maintenance."*

3.3 Blade Inspection

The propeller blade should be closely inspected for any damage to the propeller and general condition. Any maintenance that needs to be performed should be completed prior to dynamic balancing. Any dent or chip repair, painting, or finish treatments should be completed before proceeding.

Reference *FAA Advisory Circular 20-37E "Aircraft Propeller Maintenance"* and *FAA Advisory Circular 43.13-1B "Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair"* Chapter 8.

3.4 Spinner Installation

Prior to dynamic balancing, the spinner should be removed and inspected. The spinner should be checked for any mass imbalances caused by foreign material, missing screws, or damage. The attachment bulkheads should be inspected for cracks or damage and repaired as required.

NOTE: Mud daubers, wasps, and other insects or small animals may quickly build a nest inside the spinner housing; often in as short as a few days. These must be removed prior to balancing.

There are instances where spinners have been installed in such a manner as to allow the front of the spinner to move relative to the propeller. If the spinner structure has any flexibility, it may move from one side to another at high RPM, causing the out-of-balance location to shift periodically. The spinner should be firmly mounted and should not move when laterally loaded.

3.5 Blade Track and Pitch

It is important to determine that the blade is tracking correctly. If the blade is mounted on an irregular surface, if there is debris under the blade, or if the blade is bent it will be impossible to balance the aircraft because the blade will be aerodynamically out of balance.

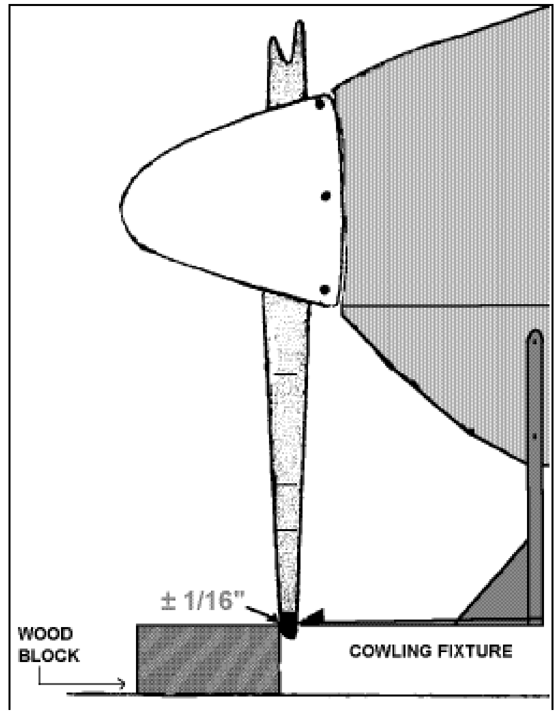
NOTE: If a small metal chip or burr is allowed between the propeller and prop flange, then one blade will have a higher angle-of-attack than another blade, causing a vibration.

CAUTION:

Verify ignition and

fuel are off

prior to moving propeller



Check blade track and pitch AC20-37

The simplest way to check blade track is to position a wood block or other rigid structure next to a blade tip. Then rotate the blade carefully (avoid moving the aircraft) to the next blade and verify that the blade tip is in the same relative position as the previous blade. You may need to remove the spark plugs to allow the engine to rotate freely.

If one blade is positioned differently from another, this indicates that either the blade is bent or the installation is unacceptable. Again, a dynamic balancer will not adequately correct an aerodynamic imbalance. According to *FAA Advisory Circular 43.13-1B*, each blade track should be within 1/16 of an inch.

Any error in track should be investigated thoroughly and eliminated. This may require that the propeller be pulled off the aircraft and sent to a propeller repair station.

3.6 Existing Dynamic Balance Weights

Once the pre-balance inspection is complete, record the position and weight of each dynamic balance correction weight previously mounted. Remove any existing dynamic balancing weights.

3.7 Static balance weights

Weights installed by a propeller repair station, should **not** be removed. Only a propeller repair station may modify static balance weights.

4 NIST Traceability on Certified Ships

Equipment used on certified aircraft must be inspected and calibrated. The DynaVibe is available with National Institute of Standards and Technology (NIST) traceable calibration. Contact RPX for further information.

5 Precautions

Secure All Cabling

Secure all cabling from the accelerometer and the optical tach to the engine and aircraft using tape and zip ties as needed. Route the cabling into the cabin of the aircraft. Cables should not be allowed to hang free as they may become entangled in rotating equipment. For pusher aircraft and rotorcraft, this can be particularly dangerous. The cabling must always be secured and any doors or loose cowlings should be thoroughly secured to prevent damage during engine run-up.

Secure all cabling

Tie-down the Aircraft

Propeller dynamic balance measurements are performed with the aircraft stationary on the ground. Wheel chocks alone will typically be insufficient to counteract the thrust generated during runup. Therefore, the tail of the aircraft should be securely tied down during the entire procedure and brakes should be applied during any runup.

CAUTION:

Verify ignition and fuel are off

CAUTION:

After you add, remove, or otherwise change weight, rotate the propeller slowly to confirm clearance of all components to confirm that you have not introduced any clearance issues.

Confirm that no bolts are protruding into the cowling, starter, alternator, or other components!

6 Installation of Equipment

6.1 Access Sensor Mounting Area

Remove the cowling, if needed, to gain access to the area immediately behind the propeller. For typical powerplant installations, this would require removing the upper cowling of the aircraft, giving access to the top of the engine.

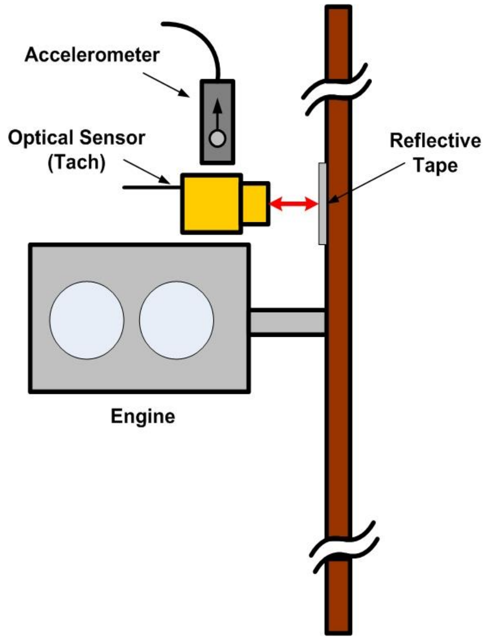
While you have the cowling off, check all the accessories for secure mounting. Check the cowling and baffling for damage that may indicate inadequate clearances. Check for any loose components such as an alternator, starter, etc.

6.2 Mount the Accelerometer and Optical Tach

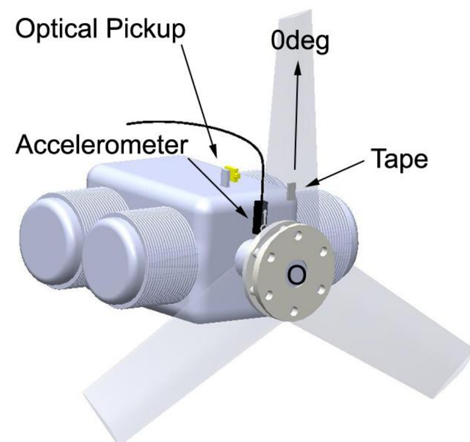
The accelerometer and optical tach are typically mounted on the top of the engine. The optical tach should be mounted approximately six inches behind the back of the propeller. The accelerometer should be mounted as far forward as is safely possible. This will provide maximum sensitivity.

A common mounting technique is to attach an adapter to one of the case bolts along the top of the engine. Mount an accelerometer mounting bracket to the bolt adapter and mount the accelerometer to the bracket. The optical tach bracket can be installed under the bolt or at a different location. Position the optical tach such that the beam projects onto the back of the blade or spinner backplate.

The following Figure shows the relationship between the optical tach, accelerometer, and the propeller. The optical tach is pointing to the back of the propeller onto the reflective tape (to be put on in the next step). The accelerometer is mounted vertically, perpendicular to piston travel.



Relationship between the optical tach's optical pickup, accelerometer, and propeller.



A typical installation for a Lycoming engine.

The optical tach's optical pickup should be at least six inches from the reflective tape, but not so far that the optical tach cannot obtain a reading from the tape.

6.3 Mount Reflective Tape on One of the Propeller Blades

By placing the small piece of reflective tape (provided in the kit), on only one propeller blade, that blade can now be considered the "Master" blade. Cut off approximately 2 inches of tape from the provided roll. Position the tape on a flat, non-rounded surface such that the light emitted from the front of the optical tach strikes the reflective tape and is reflected back to the optical tach's optical pickup.

The optical tach has a red indicator LED on the rear to both indicate alignment with the reflective tape and to indicate signal strength. When the optical tach is correctly illuminating the reflective tape, the back of the optical tach should have a pulsing red LED. The faster the pulse rate, the better the returned signal.

If the LED is illuminated when the reflective tape is not in the optical tach field of view, then there is probably a highly reflective surface opposite the optical tach. It will be best to move the tape to a location with greater contrast.

A simple way to verify that the system is working is to position the “Master” blade so that the light on the back of the optical tach is illuminated. Pass your finger between the beam to cause the light to turn on and off rapidly.

It is also beneficial to move your finger from top to bottom of the tape to verify that the optical tach is reading the center of the tape radially. If the optical tach is reading from the top or bottom edge of the tape, it is best to readjust the optical tach to measure in the center of the tape.

NOTICE: Some chromed spinner backplates may overwhelm the optical tach with strong reflections. Relocate the tape to the starter ring, propeller, or paint the back of the spinner backplate black.

Experimental installation, showing reflective tape on spinner backing plate.

For an expected RPM and tape distance from the hub / rotation center, there is a minimum tape width required indicated in the table below. First, find the smallest RPM entry in the table that is at least as large as the cruise RPM of the engine. For instance, if the cruise RPM is 2400, then use 2500 RPM. The tape length is then determined by the distance the tape will be mounted at radially from the center of the hub. For an example, assume 6 inches. At the intersection of the “6 inches from hub center” column and the 2500 RPM row is 1 inch. Therefore, when placed six inches from the center of the hub, the minimum tape length is one (1.0) inch. If the tape is eight inches from the center of the hub with 2400 RPM, using the next step up (12 inches and 2500 RPM), the minimum tape width required would be 1.9 inches.

	Tape Length Required by RPM and Tape Distance from Hub Center		
RPM	Tape up to 6" from hub center	Tape up to 12" from hub center	Tape up to 24" from hub center
500	0.2"	0.4"	0.8"
1000	0.4"	0.8"	1.6"
1500	0.6"	1.2"	2.3"
2000	0.8"	1.6"	3.1"
2500	1.0"	1.9"	3.8"
3000	1.2"	2.3"	4.6"
3500	1.4"	2.7"	5.3"
4000	1.6"	3.1"	6.1"
4500	1.7"	3.4"	6.8"
5000	1.9"	3.8"	7.6"

Insufficient tape width will cause displayed engine RPM to fluctuate and provide erratic readings.

6.4 Setup the GX for AutoBalance

Turn on the GX system and refer to the DynaVibe GX user manual for the proper use of the AutoBalance mode. The initial run will typically be done without any dynamic balance weights installed (static balance weights should not be altered).

CAUTION:

Verify that the area around the propeller is clear of obstructions.

Verify that all cabling is secure.

Start Engine

CAUTION:

Improper ground running can cause significant damage to the engine.

Check with your engine manufacturer for specific information about ground running aircraft engines.

Example: Lycoming recommends that the engine be warmed up at 1000 RPM until oil temperatures have stabilized or reach 140° F. Full-static RPM should be maintained for not more than 10 seconds. After operating at full power, allow the engine to cool down moderately.

Start the engine normally, watching for any shifting of cabling or equipment. Let the engine warm up to reduce wear during the high RPM data collection. Slowly increase the RPM of the engine until it has reached the desired RPM.

6.5 Collect Run Data

Follow the DynaVibe user manual to collect data for a run then follow the aircraft manufacturer's cool down and shut down procedures. Multiple runs will be needed to complete the AutoBalance process. Care must be taken to follow the engine manufacturer's procedures and to do no damage to the engine.

6.6 Mount Trial Balance Weights

Automated Solutions (DynaVibe GX2/GX3)

After the first run, select "Adjust" and the DynaVibe will calculate a trial dynamic balance weight solution. Weigh, then safely and securely mount your trial weights. Enter the actually installed trial balance weight parameters into "Addition 1" and "Addition 2".

Manual Solutions (DynaVibe Classic)

Determine the mass to be added. On the first run, a trial weight is needed to determine the mass/IPS sensitivity of the assembly. Consider using 50 g/IPS as a trial weight on most GA aircraft.

Note: Dynamic balance weights should always be aircraft-grade hardware (such as AN970 or AN960 washers).

6.7 Collect Run Data with Trial Weights

Repeat the “Collect Run Data” process using the installed trial weights. This is typically run 2.

6.8 Mount Adjusted Balance Weights and Test with Additional Runs

Subsequent runs will calculate dynamic balance weight solutions based on the weight sensitivity calculated during the previous run. Continue to follow all safety and manufacturer’s procedures and repeat the process until the vibration magnitude is at or below your target vibration magnitude.

6.9 Move Final Weights to Permanent Mount

FAA or manufacturer procedures may require dynamic balance weights to be mounted in specific locations (generally not on external spinner bolts). If the permanent mounts differ in distance from the hub center compared to the mounting locations used during the dynamic balance process, then a simple calculation to determine the adjusted mass of the dynamic balance weights may be necessary.

6.10 Verify Balance

If the balance weights were moved to a new mounting location, initiate a new run to verify the magnitude is within acceptable limits. If the magnitude changes significantly, verify the mount locations from hub center have not changed. If the distance from hub center changed, verified that the new weight calculations are correct.

6.11 Save Report

Once the vibration magnitude is at or below your target vibration magnitude, select “Finished” and then “Report” to generate an HTML report for the balance. The report may be opened in a browser and printed.

6.12 Update Log and Placard Aircraft

For certified aircraft, requirements include the A&P logging the dynamic balance process and final dynamic balance weights and placarding the aircraft. It is recommended that the dynamic balance also be entered in the log book for experimental aircraft.

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