Manual No. 193, Volume 1
61-03-93
Revision 2
April 2023

Information Manual for Experimental Aircraft

Volume 1

Propeller Vibration Compatibility on Reciprocating Engines

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IMPORTANT MESSAGE

People who build, modify, and/or operate experimental aircraft should recognize that various types of risks are involved; and they should take all precautions to minimize them, since they cannot be eliminated entirely. The propeller is a vital component of the aircraft. A mechanical failure of the propeller could cause a forced landing or create vibrations sufficiently severe to damage the aircraft, possibly causing it to become uncontrollable.

Propellers are subject to constant vibration stresses from the engine and airstream, which are added to high bending and centrifugal stresses.

Before a propeller is certified as being safe to operate on an airplane, an adequate margin of safety must be demonstrated. Even though every precaution is taken in the design and manufacture of a propeller, history has revealed rare instances of failures, particularly of the fatigue type.

It is essential that the propeller is properly maintained according to the recommended service procedures and a close watch is exercised to detect impending problems before they become serious. Any grease or oil leakage, loss of air pressure, unusual vibration, or unusual operation should be investigated and repaired, as it could be a warning that something serious is wrong.

For operators of uncertified or experimental aircraft an even greater level of vigilance is required in the maintenance and inspection of the propeller. Experimental installations often use propeller-engine combinations that have not been tested and approved. In these cases, the stress on the propeller and, therefore, its safety margin is unknown. If a failure occurs, it could be as severe as a loss of propeller or propeller blades and cause loss of propeller control and/or loss of aircraft control.

Hartzell Propeller Inc. follows FAA regulations for propeller certification on certificated aircraft. Experimental aircraft may operate with unapproved engines or propellers or engine modifications to increase horsepower/maintain horsepower output with a reduction in fuel flow. These modifications affect the vibration output of the engine and the stress levels on the propeller. Significant propeller life reduction and failure are real possibilities.

Frequent inspections are strongly recommended if operating with a non-certificated installation; however, these inspections may not guarantee propeller reliability, as a failing device may be hidden from the view of the inspector. Propeller overhaul is strongly recommended to accomplish periodic internal inspection.

Inspect the propeller/blades in accordance with the applicable operation/maintenance documents.

RECORD OF REVISIONS

This is a record of all revisions to this manual.

ATTENTION: Always use the current revision of this manual. The current revision is available on the Hartzell website at www.hartzellprop.com.

Revision Number	Issue Date
Original	Sep/22
Rev. 1	Jan/23
Rev. 2	Apr/23

Revision Number	Issue Date

INTRODUCTION - CONTENTS

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1. Introduction and Applicability

   A. Introduction

      Hartzell Manual 193 consists of multiple Volumes that describe the commonly used propeller configurations and options for experimental aircraft including discussions of installation guidelines, engine/propeller compatibility, and considerations for selecting a Hartzell Propeller for an experimental aircraft. These documents provide a summary/overview, and are not intended to be a replacement for guidance from the aircraft, engine, and/or propeller manufacturers about the appropriate propeller selection. When in doubt, please consult Hartzell Propeller Owner's manuals and/or the appropriate aircraft kit manuals. Additionally, you may contact Hartzell and/or the aircraft designer directly for guidance.

   B. Applicability

      Guidance in this manual is intended to enhance the safety and efficiency surrounding the use and integration of propellers on experimental aircraft. Government regulations, specifically 14 CFR Parts 23, 33, and 35, may not have regulatory requirements applicable to the aircraft in question. However, the builder/operator/integrator of an experimental aircraft, regardless of whether it is newly built or a modified version of an existing aircraft, should consider the same governmental regulations, policy, and guidance materials when developing and testing their aircraft. These topics regularly address physical concepts that apply regardless of airworthiness category. The ultimate responsibility for determining the proper integration of the propeller and aircraft lies with the aircraft owner/operator.

2. Propeller/Blade Model Designation

   A. Model Number Designation System

      Hartzell Propeller Inc. uses a model number designation system to identify specific propeller and blade assemblies. The propeller model number and blade model number are separated by a slash (/).
      Example: *propeller model number / blade model number*
      (e.g. HC-C2YR-1BFPX/F7497X)

      Parentheses shown in the propeller/blade model number in this, or any other Hartzell publication, indicate that there are characters (letters or numbers) that, depending on the specific configuration, may or may not be present.

      For additional information about the propeller/blade model designation system, refer to the applicable Hartzell propeller owner's manual and/or the applicable Type Certificate Data Sheet (TCDS).

3. WARNINGS and CAUTIONS

WARNING 1: THIS DOCUMENT, IN CONJUNCTION WITH THE PROPELLER OWNER'S MANUAL, PROVIDES IMPORTANT INFORMATION AND WARNINGS REGARDING THE INSTALLATION, OPERATION, AND PERFORMANCE OF YOUR PROPELLER.

WARNING 2: DETERMINING THE PROPER INTEGRATION OF THE PROPELLER AND AIRCRAFT IS THE RESPONSIBILITY OF THE AIRCRAFT INTEGRATOR. HARTZELL PROPELLER INC. SUPPLIES A PROPELLER BASED ON INFORMATION PROVIDED BY THE AIRCRAFT INTEGRATOR THAT HARTZELL CANNOT AND MAY NOT BE ABLE TO VERIFY. NEW PROPELLER APPLICATIONS REQUIRE CAREFUL TESTING AND EVALUATION. TESTING OR OPERATION OF THE PROPELLER, THEREFORE, CARRIES WITH IT A RISK OF SERIOUS INJURY, DEATH, AND/OR SIGNIFICANT PROPERTY DAMAGE.

WARNING 3: THERE IS A RISK OF SERIOUS INJURY, DEATH, AND/OR SIGNIFICANT PROPERTY DAMAGE IF THE PROPELLER HAS NOT BEEN TESTED AND SHOWN TO BE COMPATIBLE WITH THE ENGINE AND AIRCRAFT INSTALLATION, OR IF IT IS OPERATED IN A MANNER THAT EXCEEDS THE ESTABLISHED LIMITS FOR THE PROPELLER. IN THESE INSTANCES, VIBRATION LOADS CAN EXCEED THE DESIGN LIMITATIONS AND CAN RESULT IN PROPELLER OR BLADE SEPARATION FROM THE AIRCRAFT.

WARNING 4: STABILIZED OPERATION WITHIN THE PROPELLER RESTRICTED RPM RANGE CAN GENERATE HIGH PROPELLER STRESSES AND RESULT IN FATIGUE DAMAGE TO THE PROPELLER. THIS DAMAGE CAN LEAD TO A REDUCED PROPELLER FATIGUE LIFE, PROPELLER FAILURE, AND LOSS OF CONTROL OF THE AIRCRAFT.

4. Trademarks and Disclaimers

A. Designers/Kit Manfacturers

This manual mentions various suppliers of aircraft kits, designs, engines, and aftermarket products. The information contained herein is not endorsed, or approved by, any of these entities.

PROPELLER/ENGINE VIBRATION COMPATIBILITY - CONTENTS

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1. Statement of Purpose

   This document is intended as a reference document to inform prospective propeller buyers and current propeller owners/operators about the vibration compatibility of propeller/engine combinations for use on experimental aircraft.

   Some of these propeller/engine combinations are applicable to engines that are offered as experimental versions of certified aircraft engines, while others are purely experimental engines based upon certified aircraft engine design architecture.

   Only combinations which are known to be satisfactory from the standpoint of propeller vibration are included. In general, if the propeller/engine combination is not listed in this document, Note 9 of the propeller Type Certificate Data Sheet, or is not used on an FAA Part 23 certified aircraft, it is not known to be a compatible combination. If there is any uncertainty about the compatibility of a propeller/engine combination, please contact Hartzell Propeller Inc. for more information.

2. Propeller Vibration Definitions

   Hartzell often receives comments about “propeller vibration”, which is generally discussed in the context of propeller imbalance. The topics discussed in this document are unrelated to imbalance or dynamic balancing, which is the process for removing the imbalance of the propeller when installed and operated on the engine.

   In this document, the terms “propeller vibration”, or just “vibration”, refer to the loads and dynamic response of the propeller structure as a result of vibration coming from the engine.

   “Operating restrictions” or “placards” are limitations developed to prohibit the pilot from operating the propeller in conditions that produce unsafe propeller loads. Certified aircraft are required to include propeller operating limitations in the Limitations section of the aircraft flight manual and include placards in the aircraft and markings on instruments (e.g. tachometer) as appropriate; experimental aircraft should follow these practices as well.

   The term "stabilized operation" indicates that operation of the propeller in the specified regimes is to be limited to passage through that range only. This term is typically used as part of an RPM range restriction. Therefore, the propeller rotational speed must be transitioned through the specified range without the RPM settling to a consistent speed.

3. Determination of Vibration Compatibility

Propellers and engines work intimately together as the powerplant system for the airframe. They are bolted directly to each other and changes to one can directly affect the other. Propellers are highly stressed components and careful consideration must be taken when determining the compatibility of a propeller/engine combination, including any engine modifications or enhancements.

Hartzell Propeller Inc. uses FAA certification standards to determine propeller/engine compatibility. Successful use of a particular propeller/engine combination on a similar Experimental-Amateur Built installation does not meet these standards. Further, it cannot guarantee that similar installations will experience acceptable service life.

Hartzell conducts in-depth testing to understand the structural capability and operational loading of the propellers we produce and sell. These tests include thorough fatigue testing and in-flight propeller vibration surveys using specially instrumented propellers. These tests are completed to identify operational conditions which produce harmful loads in the propeller. With this information, Hartzell can provide guidance on the safe operation of the propeller.

Before Hartzell advertises compatibility of a specified propeller/engine combination, the combination receives the same level of scrutiny that an FAA certified aircraft would. We hope this gives you, the builder, maintainer, and pilot of the aircraft, confidence in the reliability of our products when operated in accordance with our recommendations.

4. Operation of Propeller/Engine Combinations Without Known Compatibility

Hartzell Propeller Inc. endorses and supports the freedom to experiment. However, we also believe that experimentation should be conducted in a safe manner, with full understanding of the potential risks of conducting the experiment. If the owner and/or operator of an experimental aircraft chooses to operate a propeller in a propeller/engine combination that Hartzell has not determined to be compatible, they are conducting an experiment.

When operating a propeller/engine configuration that has not been confirmed to be compatible, the pilot may operate the propeller in a way that causes damaging stresses on the propeller. Often, there is no indication to the pilot that they are operating in a harmful condition. Due to the untested nature, operation could lead to a propeller failure. Failure could be as severe as loss of propeller or propeller blades, causing loss of propeller control and/or loss of aircraft control.

Experimental aircraft may operate with untested propellers/engine combinations, meaning that the compatibility and the margin of safety of the combination is unknown. These combinations may contain engine modifications including, but not limited to, the addition of a turbocharger or turbonormalizer, increased boost pressure, increased RPM, altered ignition timing, full authority digital engine controls (FADEC), changes to the mass or stiffness of the crankshaft assembly, the use of untested crankshaft damper configurations, high compression pistons, or the inclusion of electronic ignition systems. These engine configuration options, and others, can affect the vibration output of the engine and the stress levels on the propeller. Significant propeller life reduction and failure are possibilities when operating a propeller on engine configurations that have not been verified to be compatible.

The owner and/or operator must accept these risks if they choose to operate a propeller/engine combination with unknown compatibility and unknown margin of safety.

Frequent inspections are strongly recommended when operating a propeller/engine combination with unconfirmed compatibility. However, these inspections may not guarantee propeller reliability, as a failing device may be hidden from the view of the inspector. Propeller overhaul is strongly recommended to accomplish periodic internal inspection.

5. Other Sources for Compatible Propeller/Engine Combinations

This guide is not a complete source for all compatible propeller/engine combinations for propellers that Hartzell Propeller Inc. produces and sells.

Type Certificate Data Sheets (TCDS) are an additional source of information for compatible propeller/engine combinations. Note 9 on the propeller TCDS lists acceptable propeller/ engine combinations when used with unmodified engine configurations.

Other sources of compatible propeller/engine combinations are the TCDS for FAA Part 23 certified aircraft. All FAA Part 23 certified aircraft must use approved propeller/engine combinations, therefore these data sources implicitly provide compatible propeller/engine combinations.

6. Common Propeller Configuration Considerations

A. Raptor Propellers

Raptor-series propellers, ( )C1-(L,R)( )A1( )X models, can be configured with aluminum shank blades or stainless steel shank blades. Aluminum shanks allow for weight savings, but do not have the same fatigue resilience as stainless steel shanks. Aluminum shank blades are designated with "C" in the model number (e.g. "76C03"). Stainless steel shank blades are designated with "CS" in the model number (e.g. "76CS03").

Some listed propellers may optionally use aluminum shank "C" blades or stainless steel shank "CS" blades. This option is available when the propeller blade is denoted as "C(S)", e.g. 76C(S)03.

Aluminum shank blades are only compatible on the exact engine configurations listed. If the operator chooses to operate a Raptor-series propeller on a propeller engine combination that has not been determined to be compatible, it is strongly recommended that stainless steel shanks be used. This adds an additional level of fatigue resilience, but does not guarantee a margin of safety when operating on engines that have not been determined to be compatible.

7. Common Considerations for Vibration Compatibility

A. Introduction

The following considerations must be taken into account for all propellers listed in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual. These considerations have been shown to have significant impacts on the vibration characteristics and loads experienced by the propeller. They therefore play a critical role in the compatibility of the propeller for a given installation.

B. Aircraft Configuration Compatibility

The combinations listed in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual are considered compatible only on single-engine aircraft, with tractor type engine configuration. Propeller vibration characteristics and loads on pusher type configurations are influenced by the aircraft aerodynamic effects upsetting the air entering the propeller disk. Therefore, analysis of the compatibility of a propeller on pusher configuration aircraft must be handled on a case-by-case basis.

C. Magneto Ignition Compatibility

The combinations listed in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual are considered acceptable only when the magnetos have been set up per the representative engine TCDS timing setting. **Use of engines with unverified magneto timing setup is done at your own risk.**

D. Electronic Ignition Compatibility

The combinations listed in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual are considered acceptable only with the ignition systems noted. Hartzell is actively testing to investigate the effect that electronic ignition systems have on propeller vibration. Preliminary data has shown that electronic ignition systems can produce increased vibrational loads for the propeller. The specific effects of adding electronic ignition can vary depending on the exact propeller/engine/ignition system combination.

Electronic ignition systems operating at fixed timing also have the capability to increase propeller stresses. Vibration testing has shown that changing from magneto ignition with standard timing setting to fixed timing electronic ignition at the same timing setting can make a significant impact on propeller loads.

At this time, Hartzell can only endorse use with the exact ignition systems listed, in conjunction with the exact propeller/engine combination listed. Electronic ignition systems in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual have been verified to be compatible when tested using the manufacturer's instructions, setup procedures, and preset timing profiles. Changing the timing profile from the manufacturer's settings or other modifications to the setup can change the propeller vibratory loads and is therefore not covered by the compatibility finding.

Use of engines with unverified electronic ignition systems is done at your own risk.

E. Compression Ratio Compatibility

The compression ratios listed are the highest compression ratios that have been tested and verified to be acceptable. Increasing compression ratio beyond what is listed in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual creates increased propeller vibrational loads and may have significant impact on propeller fatigue life and flight safety. **Use of engines with higher compression ratios than listed may cause premature propeller failure. Failure could be as severe as separation of propeller or propeller blades and cause loss of propeller control and/or loss of aircraft control.**

F. Crankshaft Counterweight Compatibility

Certain engine models are equipped with crankshaft counterweights, sometimes referred to as dampers. Counterweights are dynamic engine parts which are attached to the engine crankshaft. Their purpose is to smooth out the vibration imparted into the crankshaft by the piston cycles of the engine. This helps to reduce the stresses in the engine and propeller. Counterweights are only capable of absorbing vibrations at certain frequencies, therefore they are tuned to help absorb the worst vibratory frequencies produced by the engine rotating system. Counterweights are typically described in terms of their quantity and “order” (e.g. 1x 5th order). The term “order” refers to the number of vibration beats per crankshaft revolution that the counterweight absorbs. In addition to the frequency of the counterweight being tuned, the mass of the counterweight can be adjusted to change how much of the vibration is absorbed.

The crankshaft counterweight configurations listed are critical to propeller/engine compatibility. Engines with different crankshaft counterweight configurations, but which are otherwise identical, produce entirely different vibrational characteristics and loads. For example, a common parallel valve Lycoming 360, rated at 180 HP at 2700 RPM, may be configured with and without crankshaft counterweights. The vibratory characteristics and loads experienced by the same propeller design on an engine equipped with crankshaft counterweights will be very different than those on the engine without crankshaft counterweights equipped.

Use of engines with different crankshaft counterweight configurations than listed is not recommended and done at your own risk.

G. Propeller Extension Compatibility

The stiffness of the propeller/crankshaft connection can have significant impact on the vibratory loads and characteristics the propeller experiences.

Therefore, the information in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual is applicable only when the propeller is bolted directly to the engine. Hartzell does not endorse or support the use of propeller extensions which have not been tested for vibration compatibility.

If propeller to cowl clearance dictates a propeller extension, Hartzell can supply a range of integral propeller extensions as a solution to fitment issues.

H. Forced Induction Compatibility

The addition of turbo/super-charging systems increase the power capability of the engine, particularly at high altitude. The impact of this is dependent on the exact specifications of the turbo/super-charging systems. Factors such as, critical altitude, maximum manifold pressure, turbo/super-charger sizing, and intercooling details can have significant impact on power output and also the loads experienced by the propeller. Therefore, propeller compatibility with turbo/super-charging systems must be handled on a case by case basis for the design.

The increased power capability developed by using a turbo/super-charging system has the ability to significantly impact the propeller vibrational loads. Additionally, a turbo-charging system can increase the exhaust back pressure experienced on the pistons during the exhaust stroke. This can also significantly impact the propeller/engine vibrational characteristics.

Due to these factors, the data listed in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual is only applicable for naturally aspirated engines. For details on turbo/super-charged installations, please contact Hartzell.

I. Aerobatic Flight Compatibility

The combinations listed may or may not have been tested with aerobatic maneuvers. Hartzell’s position is that occasional “light” aerobatics (loops, rolls, lazy-eights, wingovers) do not significantly impact propeller compatibility. Installations where frequent "light" or “heavy” aerobatics (snap-rolls, spins, lomcevaks, etc.) are intended need to be evaluated on a case-by-case basis for vibrational compatibility.

J. Propeller Indexing

Propeller indexing, sometimes referred to as “clocking”, can significantly change the loads experienced in the propeller. This effect is mostly due to the relative angular position of the blades to the piston power pulses and to the resonant dynamics present in the engine crankshaft.

Care must be taken to ensure the correct indexing for the engine. See the section on engine specifics for more information about the appropriate indexing for propellers with optional indexing configurations.

8. Information for Specific Engine Series

NOTE: There are many possible engine modifications and configurations available to aircraft owners. Hartzell Propeller Inc. cannot verify the effect of all possible modifications. The following data represents our knowledge of common engine configuration options that have the ability to effect propeller loads. The owner/operator is responsible for determining their engine configuration and using the following information to determine the compatibility of the propeller/engine combination they intend to use. If there is any uncertainty about the compatibility of a propeller/engine combination, please contact Hartzell for more information.

A. 320 Series: Lycoming, Continental (Titan), Superior Air Parts

The (I)O-320 series of engines is typically rated at either 150 HP or 160 HP at 2700 RPM. The change in power output is controlled almost exclusively through the change in compression ratio, 7.0:1 for 150 HP and 8.5:1 for 160 HP. Engines equipped for constant speed propeller operation are otherwise vibrationally similar.

Propellers approved on engines rated at 160 HP at 2700 RPM, 8.5:1 compression ratio engines, may also be used on engines rated at 150 HP at 2700 RPM, with 7.0:1 compression ratio.

B. 4-Cylinder 360 Series: Lycoming, Continental (Titan), ECI, Superior Air Parts

The 4-cylinder 360 series has three basic crankshaft configurations; “Thick Wall”, “Thin Wall”, and Counterweighted. The “Thick Wall” crankshaft is typically used on “Angle Valve” certified engines with 8.7:1 compression ratio producing 200 HP at 2700 RPM. The “Thin Wall” crankshaft is typically used on “Parallel Valve” certified engines with 8.5:1 compression ratio producing 180 HP at 2700 RPM.

For Lycoming 360 series engines, the fourth digit of the engine suffix provides information about the crankshaft counterweight configuration. Engines featuring a “6” in the fourth digit (e.g. IO-360-B1G6) feature 1x 6.3 and 1x 8th order crankshaft counterweights. Engines not featuring a fourth digit (e.g. O-360-A1C) do not have crankshaft counterweights.

Superior Air Parts 360 series engines are all parallel valve engines. These engines are offered with 2 types of constant speed crankshafts, “Thin-Wall” and “Heavy-Wall”. For Superior engines with "Heavy-Wall" crankshafts, use propellers in the table for Angle Valve Engines. For Superior engines with "Thin-Wall" crankshafts, use propellers in the table for Parallel Valve Engines

C. 370 Series: Continental (Titan) and 375 Series: Aerosport Power

The 370 series and 375 series engines use the same components for the engine rotating system, which is critical for propeller vibratory characteristics.

These engines are offered with or without crankshaft counterweights. For propeller compatibility, Hartzell recommends using the version with crankshaft counterweights.

The engines are offered with two compression ratio options, 8.1:1 and 9.6:1. The 9.6:1 pistons should only be used on engines featuring crankshaft counterweights. Use of compression ratios higher than 8.5:1 in 370/375 series engines without crankshaft counterweights can produce hazardous propeller loads.

D. 390 Series: Lycoming

For Lycoming 390 series engines the second digit in the engine suffix determines the propeller flange indexing. Engines featuring a “1” in the second digit (e.g. IO-390-A1A6) get BHC- hubs. Engines featuring a “3” in the second digit (e.g. IO-390-C3B6) get HC- hubs.

For Lycoming 390 series engines, the fourth digit of the engine suffix provides information about the crankshaft counterweight configuration. Engines featuring a “6” in the fourth digit (e.g. IO-390-A1A6) feature 1x 6.3 and 1x 8th order crankshaft counterweights. Hartzell has only determined compatibility for our propellers on 390 series engines with crankshaft counterweights

E. 540 Series: Lycoming

Lycoming 540 series engines have several counterweight order configurations. Hartzell propellers are only compatible with engines that feature 1x 5th and 1x 6th order crankshaft counterweights of specific mass configurations. These engines are denoted with a “5” in the 4th digit of the engine suffix (e.g. O-540-E4A5).

Lycoming 540 series engines with 1x 5th and 1x 6th order crankshaft counterweights come in several mass configurations. Groups referenced in Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual are defined in Lycoming Service Instruction 1012 which has a comprehensive list of crankshaft counterweight configurations cross-referenced with engine model numbers.

F. 520/550 Series: Continental (Titan)

Continental 520 and 550 series engines are equipped with the same number of counterweights, which are tuned to the same order. Additionally, they feature similar crankshaft assemblies and identical stock compression ratios. Therefore, the two engine series have nearly identical vibratory characteristics.

This results in many favorable combinations and a more flexible vibration environment. Any propeller that has been tested on an IO-550 or IO-520 is acceptable on the other, provided the rated power is similar or lower and the rated RPM is similar or lower.

Tables 1 and 2 in the Vibration Compatibility Tables chapter of this manual list the propeller/engine combinations which are compatible with 520/550 series engines, along with their maximum acceptable rated power and RPM. 520/550 engine models featuring lower power and RPM ratings are also compatible with the listed propellers.

VIBRATION COMPATIBILITY TABLES - CONTENTS

Propeller/Engine Compatibility:

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Number of Blades	Propeller Model	Engine Series	Compatible Diameter(s)	Maximum Allowable Compression Ratio (Maximum Engine Rating)	Compatible Ignition Systems	Operating Restrictions
2	HC-( )2YR-1BF( )X/F7068-2( )X	320 Series, All manufacturers listed	68 to 66 inches	8.5:1 or less (160 HP at 2700 RPM)	Dual Magneto only	None
		Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	68 to 67 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	Stabilized operation is prohibited above 25 inches manifold pressure between 2300 and 2500 RPM, and below 15 inches manifold pressure above 2600 RPM
		Angle Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	68 to 66 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	68 to 66 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
		Continental/Titan 370 Series Crankshaft Counterweights: YES	68 to 66 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Aerosport Power 375 Series Crankshaft Counterweights: YES	68 to 66 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
2	HC-( )2YL-1BF( )X/F7663-4( )X	320 Series, All manufacturers listed	72 to 70 inches	8.5:1 or less (160 HP at 2700 RPM)	Dual Magneto only	None
3	(P)HC-( )3YF-1( )X/F7391(D)( )X	520/550 Series Continental	75 to 73 inches	8.5:1 or less (310 HP at 2700 RPM)	Dual Magneto, Aerosance FADEC	None
2	( )HC-( )2YR-1BFP( )X/F7497( )X	Continental/Titan 340 Series	74 to 72 inches	8.0:1 or less (174 HP at 2700 RPM)	Dual Magneto only	Do not operate above 24 inches manifold pressure below 2500 RPM.
		Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	74 to 72 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto, One Lightspeed Plasma II/One Magneto	None
		Angle Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	74 to 72 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Continuous operation is prohibited above 24 inches manifold pressure between 2350 and 2550 RPM
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	74 to 72 inches	9.0:1 or less	Dual Magneto only	None
		Continental/Titan 370 Series Crankshaft Counterweights: YES	74 to 72 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Aerosport Power 375 Series Crankshaft Counterweights: YES	74 to 72 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 390 Series	74 to 72 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	None
2	( )HC-( )2YR-1BFP( )X/F7499( )X	Continental/Titan 370 Series Crankshaft Counterweights: NO	74 to 72 inches	8.5:1 or less	Dual Magneto only	Do not operate above 24 inches manifold pressure below 2450 RPM. The propeller blades are life limited to 10,000 hours. Blades must be retired after 10,000 hours of operation
		Aerosport Power 375 Series Crankshaft Counterweights: NO	74 to 72 inches	8.5:1 or less	Dual Magneto only	Do not operate above 24 inches manifold pressure below 2450 RPM. The propeller blades are life limited to 10,000 hours. Blades must be retired after 10,000 hours of operation
3	( )HC-( )3YR-1RFX/F7392( )X	Lycoming/Superior 360 Series Crankshaft Counterweights: YES	75 to 73 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation below 15 inches manifold pressure between 2050 and 2450 RPM
		Lycoming 390 Series	75 to 73 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation below 15 inches manifold pressure between 2050 and 2450 RPM

NOTE: Reference the “Propeller/Engine Vibration Compatibility” chapter in this manual for more information about the limitations placed on the vibration compatibility of the propeller/engine combinations listed in this table.

Propeller/Engine Vibration Compatibility: Hartzell Propeller Models with Aluminum Blades
Table 1, page 1 of 3

Number of Blades	Propeller Model	Engine Series	Compatible Diameter(s)	Maximum Allowable Compression Ratio (Maximum Engine Rating)	Compatible Ignition Systems	Operating Restrictions
3	( )HC-( )3YR-1RFX/F7282( )X	Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	74 to 73 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation below 15 inches manifold pressure between 1950 and 2350 RPM
		Angle Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	74 to 73 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation below 15 inches manifold pressure between 1950 and 2350 RPM
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	74 to 72 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation below 15 inches manifold pressure between 1950 and 2350 RPM
		Lycoming 390 Series	74 to 72 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation below 15 inches manifold pressure between 1950 and 2350 RPM
3	(P)HC-( )3YF-1( )X/F7663(D)( )RX	520/550 Series Continental	76 to74 inches	8.5:1 or less (310 HP at 2700 RPM)	Dual Magneto, Aerosance FADEC	None
3	PHC-( )3YF-1( )X/F7691( )X	520/550 Series Continental	78 to 77 inches	8.5:1 or less (310 HP at 2700 RPM)	Dual Magneto only	Do not exceed 20 inches of manifold pressure below 220 RPM.
3	HC-( )3YR-1( )X/F7693( )X	Lycoming 540 Series, Counterweight Group 5	78 to 76 inches	8.7:1 or less (300 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 6	80 to 76 inches	8.5:1 or less (235 HP at 2400 RPM)	Dual Magneto only	None
3	(P)HC-( )3YF-1RF( )X/F7693(D)( )X	520/550 Series Continental	80 to 75 inches	8.5:1 or less (310 HP at 2700 RPM)	Dual Magneto only	None
2	BHC-( )2YF-1BF( )X/F7694( )(T)X	520/550 Series Continental	72 to 70 inches	8.5:1 or less (310 HP at 2700 RPM)	Dual Magneto only	Do not exceed 20 inches of manifold pressure below 2200 RPM.
3	PHC-( )3YF-1( )X/F7694( )X	520/550 Series Continental	78 to 76 inches	8.5:1 or less (310 HP at 2700 RPM)	Dual Magneto only	None
2	( )HC-( )2YR-1BF( )X/F7894( )X	Lycoming/Superior 360 Series Crankshaft Counterweights: YES	78 to 75.5 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Continuous operation is prohibited between 2100 and 2350 RPM with less than 8 inches of manifold pressure.
		Lycoming 390 Series	78 to 75.5 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	Continuous operation is prohibited between 2100 and 2350 RPM with less than 8 inches of manifold pressure.
2	( )HC-( )2YR-1BF( )X/F8477( )X	Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	80 to 78 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	Propeller must be equipped with Hartzell C-1576 Damper Assembly. No operating restrictions.
		Angle Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	80 to 78 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	Propeller must be equipped with Hartzell C-1576 Damper Assembly. No operating restrictions.
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	80 to 78 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Continuous operation is prohibited above 24 inches manifold pressure below 2250 RPM, and below 8 inches manifold pressure between 1950 and 2300 RPM.
		Lycoming 390 Series	80 to 78 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	Continuous operation is prohibited above 24 inches manifold pressure below 2250 RPM, and below 8 inches manifold pressure between 1950 and 2300 RPM.
3	HC-( )3YR-1( )X/F8468( )X	Lycoming 540 Series, Counterweight Group 4	84 to 76 inches	8.5:1 or less (260 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 5	84 to 76 inches	8.7:1 or less (300 HP at 2700 RPM)	Dual Magneto only	None
2	HC-( )2YR-1( )X/F8468( )X	Lycoming 540 Series, Counterweight Group 4	80 to 78 inches	8.5:1 or less (250 HP at 2575 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 6	80 to 78 inches	8.5:1 or less (235 HP at 2575 RPM)	Dual Magneto only	None
2	HC-( )2YR-1BFP( )X/F8068( )X	Lycoming 540 Series, Counterweight Group 4	80 to 78 inches	8.5:1 or less (260 HP at 2700 RPM)	Dual Magneto only	None

NOTE: Reference the "Propeller/Engine Vibration Compatibility" chapter in this manual for more information about the limitations placed on the vibration compatibility of the propeller/engine combinations listed in this table.

Propeller/Engine Vibration Compatibility: Hartzell Propeller Models with Aluminum Blades
Table 1, page 2 of 3

Number of Blades	Propeller Model	Engine Series	Compatible Diameter(s)	Maximum Allowable Compression Ratio (Maximum Engine Rating)	Compatible Ignition Systems	Operating Restrictions
3	HC-( )3YR-1( )X/F8068( )X	Lycoming 540 Series, Counterweight Group 4	84 to 78 inches	8.5:1 or less (260 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 5	84 to 78 inches	8.7:1 or less (300 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 6	84 to 78 inches	8.5:1 or less (235 HP at 2400 RPM)	Dual Magneto only	None
3	PHC-( )3YF-1RF( )X/F8068( )X	520/550 Series Continental	82 to 78 inches	8.5:1 or less (300 HP at 2700 RPM)	Dual Magneto only	None
3	HC-( )3YF-1RF( )X/F8429( )X	520/550 Series Continental	80 to 76 inches	8.5:1 or less (300 HP at 2850 RPM)	Dual Magneto only	None
2	( )HC-( )2YR-1BFP( )X/F7666(-2)X	Parallel Valve Lycoming 360 Series Crankshaft Counterweights: NO	76 to 72 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation between 2000 and 2250 RPM
		Parallel Valve Lycoming 360 Series Crankshaft Counterweights: NO	74 to 72 inches	8.5:1 or less (180 HP at 2700 RPM)	One Lightspeed Plasma II /One Magneto	Avoid continuous operation between 2000 and 2250 RPM. Operations above 2600 RPM are limited to takeoff only. Propeller blades are life-limited and must be retired after 8700 hours of operation
		Parallel Valve Superior 360 Series Crankshaft Counterweights: NO	74 to 73 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	Continuous operation is prohibited above 20 inches manifold pressure between 1950 and 2300 RPM. Operations above 2600 RPM are limited to takeoff only
		Angle Valve Lycoming 360 Series Crankshaft Counterweights: NO	74 to 72 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	Avoid continuous operation between 2000 and 2250 RPM.
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	74 to 72 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
2	( )HC-( )2YR-1BFP( )X/F7496( )X	Parallel Valve Lycoming 360 Series Crankshaft Counterweights: NO	74 to 72 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto, One Lightspeed Plasma II/One Magneto, Aerosance FADEC	Do not operate above 22 inches manifold pressure below 2350 RPM. Operation above 2600 RPM limited to takeoff only.
		Parallel Valve Superior 360 Series Crankshaft Counterweights: NO	74 to 72 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	None

NOTE: Reference the "Propeller/Engine Vibration Compatibility" chapter in this manual for more information about the limitations placed on the vibration compatibility of the propeller/engine combinations listed in this table.

Propeller/Engine Vibration Compatibility: Hartzell Propeller Models with Aluminum Blades
Table 1, page 3 of 3

Number of Blades	Propeller Model	Engine Series	Compatible Diameter(s)	Maximum Allowable Compression Ratio (Maximum Engine Rating)	Compatible Ignition Systems	Operating Restrictions
3	3C1-L( )A1( )X/76C(S)03( )X	320 Series, All manufacturers listed	69 inches	8.5:1 or less (160 HP at 2700 RPM)	Dual Magneto only	None
2	( )HC-( )2YR-1N( )X/N7605( )X	Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	76 and 74 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	None
2	( )HC-( )2YR-1N( )X/N7605(C)X	Lycoming/Superior 360 Series Crankshaft Counterweights: YES	76 and 74 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
		Continental/Titan 370 Series Crankshaft Counterweights: YES	76 and 74 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Aerosport Power 375 Series Crankshaft Counterweights: YES	76 and 74 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 390 Series	76 and 74 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	None
2	HC-( )2YR-1N( )X/NG8302( )X	Continental/Titan 340 Series	80 inches	9.0:1 or less (180 HP at 2700 RPM)	Dual Magneto, Dual Lightspeed Plasma III	None
2	( )HC-( )2YR-1N( )X/NG8301( )X	Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	83, 80, 78, and 76 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	83, 80, 78, and 76 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
		Continental/Titan 370 Series Crankshaft Counterweights: YES	83, 80, and 76 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Aerosport Power 375 Series Crankshaft Counterweights YES	83, 80, and 76 inches	9.6:1 or less (195 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 390 Series	83, 80, 78, and 76 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto, Dual Lycoming Certified Electronic Ignition	None
2	HC-( )2YR-1N( )X/NG8301( )X	Lycoming 540 Series, Counterweight Group 4	80 inches	9.1:1 or lower (270 HP at 2700 RPM)	Dual Magneto, Dual Lightspeed Plasma III	None
		Lycoming 540 Series, Counterweight Group 6	80 inches	8.5:1 or less (235 HP at 2400 RPM)	Dual Magneto only	None
3	( )HC-( )3Y1R-1N( )X/NG8301( )X	Lycoming 540 Series, Counterweight Group 4	80 inches	8.5:1 or less (235 HP at 2400 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 6	80 inches	8.5:1 or less (235 HP at 2400 RPM)	Dual Magneto only	None
3	HC-( )3YR-1ANX/NG8301( )X	Lycoming 540 Series, Counterweight Group 5	85, 82, and 80 inches	8.7:1 or less (300 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 580 Series	85, 82, and 80 inches	8.9:1 or less (315 HP at 2700 RPM)	Dual Magneto only	None
3	HC-( )3YF-1N( )X/NG8304( )X	520/550 Series Continental	85 inches	8.5:1 or less (300 HP at 2850 RPM)	Dual Magneto only	None
3	HC-( )3YR-1N( )X/N7605( )X	Lycoming 540 Series, Counterweight Group 4	78 inches	8.5:1 or less (260 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 540 Series, Counterweight Group 6	78 inches	8.5:1 or less (235 HP at 2400 RPM)	Dual Magneto only	None

NOTE: Reference the "Propeller/Engine Vibration Compatibility" chapter in this manual for more information about the limitations placed on the vibration compatibility of the propeller/engine combinations listed in this table.

Propeller/Engine Vibration Compatibility: Hartzell Propeller Models with Composite Blades
Table 2, page 1 of 2

Number of Blades	Propeller Model	Engine Series	Compatible Diameter(s)	Maximum Allowable Compression Ratio (Maximum Engine Rating)	Compatible Ignition Systems	Operating Restrictions
3	3C1-R( )A1( )X/80C(S)01( )X	Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: NO	80, 78, 76, 74, and 72 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	None. Only Compatible with engines featuring a “1” as the second digit of the engine suffix
		Parallel Valve Lycoming/Superior 360 Series Crankshaft Counterweights: YES	80 inches	9.0:1 or less	Dual Magneto, Dual Lightspeed Plasma III	None. Only Compatible with engines featuring a “1” as the second digit of the engine suffix
		Lycoming/Superior 360 Series Crankshaft Counterweights: YES	80, 78, 76, and 74 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 390 Series	80, 78, 76, and 74 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	None. Only Compatible with engines featuring a “3” as the second digit of the engine suffix
3	3C1-R( )A1( )X/76CS03-(2,4)( )X	Parallel Valve Lycoming/Superior 360 Series	74 and 72 inches	8.5:1 or less (180 HP at 2700 RPM)	Dual Magneto only	None
3	3C1-R( )A1( )X/76C(S)03-(2,4)( )X	Lycoming/Superior 360 Series Crankshaft Counterweights: YES	74 and 72 inches	8.7:1 or less (200 HP at 2700 RPM)	Dual Magneto only	None
		Lycoming 390 Series	74 and 72 inches	8.9:1 or less (215 HP at 2700 RPM)	Dual Magneto only	None. Only Compatible with engines featuring a “3” as the second digit of the engine suffix.
3	3C1-R( )A1( )X/76C(S)04-(2,4)( )X	Lycoming 540 Series, Counterweight Group 4	76, 74, and 72 inches	8.5:1 or less (260 HP at 2700 RPM)	Dual Magneto only	None

NOTE: Reference the “Propeller/Engine Vibration Compatibility” chapter in this manual for more information about the limitations placed on the vibration compatibility of the propeller/engine combinations listed in this table.

Propeller/Engine Vibration Compatibility: Hartzell Propeller Models with Composite Blades
Table 2, page 2 of 2