

4/25/2003

Multiblade Propeller STC to Piper Pawnee

TEST REPORT: LOW-NOISE MULTIBLADE PROPELLER ON PAWNEE

Tests conducted by: Mile High Gliding, Inc.
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Period: March 18, 2000 – March 31, 2003
Location: Boulder Municipal Airport, CO (K1V5)

These tests were conducted under local FAA Office Field Approval on form 337. This report is submitted in support of an application for a Supplemental Type Certificate on propeller substitution.

BACKGROUND

Modern glider operators now require powerful towplanes to expeditiously accelerate heavy modern gliders and deliver them to altitude. Meanwhile, agricultural operators have turned to large turbine aircraft for spray operations and the early generation of cropdusters is rarely cost-effective for them. Starting in the 1980s, used cropdusters such as the Piper Pawnee PA-25 became available at reasonable prices and they have been widely adapted as glider towplanes, replacing Citabrias and Supercubs.

One drawback of using these former cropdusters is that the standard engine (Lycoming O-540 235HP), propeller (McCauley 1A200/FA8452), and muffler combination generate considerably more noise than earlier 150HP-180HP towplanes. This was noticed immediately in Europe where the population density is high and citizens quick to complain about the noise of over-flying aircraft. In fact, preserving the peace and quiet of the neighbors is a major reason most German glider operations use silent winch-launching and avoid airplane towing altogether.

The Europeans soon determined that the major source of noise was the Original Equipment metal two-blade propeller with its supersonic tip speeds. Switching to a four-blade propeller of lesser diameter preserved the power output and RPM settings while making the aircraft much quieter. The Hoffmann company in Germany developed a series of four-blade propellers made of hardwood to meet that service, including applications to various aircraft (Pawnee, Callair, Supercub...) and engines (180HP, 235HP, 260HP...) and these have long been JAA (Europe) and LBA (Germany) Type Certificated, and FAA (USA) Type Certificated since at least 1996.

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The use of four-blade propellers on glider towplanes for noise reduction has become so standard in Europe that almost no two-blade propeller towplanes operate in Germany. In the United Kingdom, most have the Hoffmann four-blade propeller as well.

EUROPEAN STC PRECEDENTS

We reviewed much information about the European experience supplied to us in English by the UK Hoffmann dealer, Michael Barnett of Skycraft Services Ltd., www.skycraft.co.uk. To summarize, government approvals are in place for these propellers and their application to glider towplanes in at least:

- Germany. LBA.G.0014
- United Kingdom CAA AAN No. 20697, 22953
- Sweden LFV MAS M4A/79
- Europe JAA SA6/00

USA STC PRECEDENTS

Two USA STCs already exist for installing Hoffmann four-blade propellers on Pawnees:

- SP00066BO HO 4/27BHM-190B108 on a PA-25-260 (Normal)
Issued 11-05-96 to Caesar Creek Soaring Club, Wellington, OH.
- SA2515NM HO 4/27BHM-185 120 on a PA-25-260 and -235 (Restricted)
Issued 09-25-84 to Calistoga Soaring Center, Calistoga, CA.

The first is for a propeller only 3% larger in diameter, 5% less in pitch and 10% wider in blade compared to our present test configuration. The second is for a propeller identical to our test configuration except for a 4% greater propeller pitch.

As of May 20, 2003, ownership of the SA2515NM STC has been transferred to us, Mile High Gliding, Inc. This is appropriate as neither Caesar Creek nor Calistoga did many tows with their systems. We are the USA experts in operating 4-blade propellers on towplanes, having done nearly 10,000 trouble-free tows. Furthermore, we operate close to a very noise-sensitive town and have almost no option but to use these low-noise propellers on our high-power towplanes.

USA STC REVISION PETITION

As the owner of STC SA2515NM for the 120 pitch variant of the HO 4/27BHM-185, with our extensive satisfactory experience documented in this report for the 115, and with the knowledge of long-term European success with other pitches, we wish to revise our STC to mention the normal range manufactured by Hoffmann, 110 to 135 cm, in 5 cm steps. For a given aircraft, the adjustable parameter of average pitch can serve to slightly optimize performance for climb vs. cruise, low vs. high power, low vs. high altitude. For example, PA-25 tests by Skycraft would recommend pitch selections of:

	HP:	<u>235</u>	<u>260</u>
Altitude: Sea Level:		110	115
7,000':		115	120

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The choice is a minor adjustment (all within 20%) and all pitch variants perform safely, but we wish to explicitly offer STC permission customers the full range manufactured and proven in Europe. You may note, for instance, that UK Civil Airworthiness Approval Note No. 20697 was issued in reference to the HO 4/27BHM-185 115 and later "addenda" extended to other variants (e.g. 110) as not significantly different.

TEST PROPELLER

We purchased the new manufacture HO 4/27BHM-185 115, built by Hoffmann in Germany and ordered for us by Skycraft Services in England. This is a four-blade fixed-pitch propeller of laminated hardwood construction, with brass mesh leading edge protection layer, aluminum inserts in the tips, light fiberglass outer cover, and lacquer finish. It comes with a small skull-cap spinner and hub spacer and is a simple bolt-on replacement for the OEM propeller, per Hoffmann Propeller Manual E0110.74 (02-92). Per FAA AD 2000-04-10, the mounting bolt torque must be checked every 50 hrs.

As the manual explains, 4/27B refers to the number of blades and the hub connection code, HM to the construction materials, 185 to the diameter in cm, and 115 to the pitch in cm (the no-slip advance distance in one revolution at 75% blade radius).

The Propeller itself, along with a whole series of Hoffmann HO 4/27 models, is FAA approved under FAR Part 23, with Type Certificate Data Sheet number P6NE.

TEST AIRCRAFT

We used two similar Pawnees, each with its own HO 4/27BHM-185 115. N8718L, 1970 PA-25-235, S/N 5173, C model (fuel tank in fuselage), with 260HP STC. N9791P, 1975 PA-25-235, S/N 6104, D model (fuel tanks in wings), with 260HP STC. Both of these aircraft were registered to Mile High Gliding, Inc., and previously operated satisfactorily as towplanes (except for the noise) with their OEM two-bade propellers.

TEST SUMMARY

N8718L went into service with its new four-blade propeller on March 18, 2000. As of March 31, 2003 it has done 5,300 glider tows in that configuration. N9791P started flying with the four-blade propeller on June 23, 2000 and did an additional 3,100 tows before March 31, 2003. The majority of our tows are to 8,300' MSL (3,000' AGL) at 65 mph, with about a quarter to "Mile high" altitude, 10,600' MSL. We tow gliders ranging from the single-seat Grob G102 (gross weight 750 lb) to the three-seat Schweizer 2-32 (gross weight 1,430 lb). 30 different towpilots have flown one or both aircraft with no training difficulties and nothing but praise for handling, comfort, and quiet.

NOISE

The noise reduction has been spectacular, which is the whole point of going to this style of propeller. Here is a table of average measurements we took with a hand-held decibel meter at the MHG office at 5,300' pressure altitude and typically 8,000' density altitude.

<u>Configuration</u>	<u>2-blade McCauley, dB(A)</u>	<u>4-blade Hoffmann, dB(A)</u>
Ground run-up at 100' distance	112	90
Full power take-off at 100' distance	118	98
Overhead fly-by at 1,000'	85	68

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Furthermore, the higher frequency components of the sound are largely removed, making the sound a lower pitch more pleasant to observers. Pilots report hearing exhaust and engine noise they never did before, masked as it was by propeller noise.

VIBRATION

The Hoffmann four-blade propeller is lower mass than the OEM metal propeller, with a smoother distribution. Vibration is lower with the Hoffmann. Engine starts are easier.

SLIPSTREAM

At low speeds, below 60 mph, a slight pulsing of the airflow over the rudder and fin can be felt through the rudder pedals, due to the doubled frequency of blade passage compared to the OEM propeller. However, this is a speed range below the best climb rate of the Pawnee and not used for normal towing. We tow SGS 2-33s at 65 mph, and most fiberglass gliders at 70 mph.

THRUST

Without having measured static thrust, all towpilot observations are that the acceleration of the Pawnee from start is as with the OEM propeller. Thrust seems identical.

POWER SETTINGS

We have observed at best a 50 rpm difference up or down in tachometer readings at full power and level cruise, within the margin of error of the instrument.

COOLING

With twice as many blades and a higher pitch close in to the hub compared to the OEM propeller, cooling is improved. We typically observe a 5° F lower EGT reading.

FLIGHT SPEEDS

No change in operating speeds. Both propellers are rated to the same limits.

CLIMB RATES

There is no significant change in rate of climb, which can be masked by density altitude or engine tuning. At density altitudes of around 10,000', we average 400 fpm.

DESCENT RATES

With more blades, there is greater drag at similar low rpm settings. We average 200 fpm greater rate of descent for the same rpm and speeds, allowing a faster return for the next tow without shock-cooling the engine, an advantage to a glider tow operator.

WEIGHT AND BALANCE

The Hoffmann is 15 lb. lighter than the OEM propeller, and this needs to be noted in recalculating the W&B statement. Less weight way in front can be an advantage.

DURABILITY

The smaller diameter puts the blade tips further from the ground, gravel, and dirt, leading to less erosion exposure. However, the lacquer, brass, and wood construction of the Hoffmann is more susceptible to chip damage. On the other hand, the process of filling and painting authorized by the Manual is easier than for a metal propeller.

OTHER

There are more subtle advantages to the Hoffmann. With its low moment of inertia, there are low gyroscopic effects accompanying sudden pitch or yaw movements. We expect less wear and tear on starter systems due to the ease of spinning up. We have even had the misfortune of a propeller ground strike and can report that while the damage to the propeller can be catastrophic, it does not hurt the crankshaft or the remainder of the engine in the slightest.

CONCLUSION

In almost every respect, the Hoffmann four-blade propeller is superior to the OEM McCauley metal propeller, especially for a glider tow operation. Much less noise, equal climb, faster descent, better ground and hangar door clearance. The Hoffmann can be supplied new with a one month order lead time. All glider operators should have them.

QUIET YOUR PAWNEE!



FIT A *HOFFMANN* HO-4/27BHM-185 PROP

The "quiet towplane prop". Proven 20 years in Europe, 20,000 tows by us.

Compared to an OEM 2-blade metal propeller...

- 12 dB(A) less over-flight noise, at lower audio tone.
- Virtually equal thrust, acceleration, climb-rate.
- Improved descent-rate, cooling, vibration, clearance.

- Available pitched for 235HP or 260HP, high or low altitude.
- For Lycoming O-540 PA-25 towplane (B,C,D, Normal/Restricted).
- A&P field installation in 1 hour under FAA STC SA2515NM.