Prop Extension Failures

While at OSH I heard of an alarming event. The new, O-360-A2A powered, E-Racer of Jimmie and Ferne Hays had an off field landing due to prop extension failure. The occupants escaped without injury but, as you can see in photo one, the E-Racer was severely damaged.

The photos were provided by Bill Oertel who went on to explain that this was known to be the third prop extension to have failed. He said he didn't know the names of the other pilots but that Bruce Tifft did.

Thanks to Jimmie's skill they both walked away

I contacted Bruce and found there had been three failures, all on O-360 engines. The first two, on Bob Beard's 180 hp O-360-A4K powered Two EZ and Danny Maier's 200 hp Velocity, were purchased from John Queener's Sport Flight after Herb Sanders had sold the company. They were both 8" extensions and were made of 6061, an aluminum alloy weaker than 2024 which is prefered for prop extensions. The 6" prop extension with 7" diameter flange on the Hays 180 hp E-Racer was manufactured by Brock.

Examination of the second photo, at the top portion of the failed area, shows what looks like a peened surface. The lower separated area looks to have been ripped away.

A recent letter from Gary Hertzler indicated he had the company metallurgy department look at the failed Hays prop extension. They could find nothing in the way of defective material or abusive machining to have caused the failure. The part failed in what is known as high cycle fatigue up to a point where a large chunk was torn out. There was not enough left of the radius to determine if it was excessively small, but looking at the other end of the extension, and without being biased by the failure, the radius looks to be normal for the part.

Gary and Nat Puffer both pointed out that crankshaft flange runout could be a contributor to this failure. Lycoming permits a .005" runout on the prop flange. This dimension would be OK if there were no propr extension. With an extension, however, the magnitude of runout will be exagerated depending upon the extension's length. This flange runout will cause additional prop runout which will increase the vibration and will add to the mean stress on the extension. When the cyclic loads are applied over the top of a possibly elevated mean stress, fatigue crack initiation and propagation may occur.

Gary offered two suggestions for improving the design.

1. Increase the fillet radius to be as large as possible without having to back spot face to the drive lug bushings.

2. Continue the bore which excepts the crankshaft prop pilot only as deep as necessary to axially clear, continuing the rest of the way with a smaller diameter bore. This will provide added wall thickness at the high stress points.

If you are using a 6" or longer prop extension, especially on the O-360 engine, please check for cracks in the radius area. Gary Hertzler has suggested that we **all** (regardless of engine size) examine our prop extensions at each oil change. Three failures is enough!

The Hays airplane had 73 hours on it so high time is not necessarily a factor in these failures.

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I talked to Burt Rutan at an OSH bull session. He suggested the failure might be caused by prop vibration in resonant frequency. If a pilot were to operate at the resonate RPM the extension would soon fail.

I asked Burt how we might determine what this frequency was on our airplanes so we don't operate in it. He explained it was **simply** a matter of hooking up an accelerometer and oscilloscope and interpreting the wave form to determine resonant frequency. Until that frequency was determined he felt we should ground our airplanes!

I indicated that wasn't likely to happen and would appreciate RAF developing a portable device that CSA could borrow/purchase and run frequency evaluations at our three fly-in events per year. He indicated he would investigate that idea and see what could be developed.

Mike and RAF are working on the problem, which is not a simple thing to do. The results may not be conclusive as probably every airplane will be different. All testing, so far, has been done on Mike Melvill's Long-

EZ, N26MS after work hours. This aircraft was chosen because it has exactly the same engine and prop extension that Jimmie Hays had. Jimmie had a B&T prop while Mike's prop is a modified Great American with 10 plies of carbon wrapped on each blade.

This morning (8-10-94) I got a call from Mike Melvill with an update on his progress. He had spent an hour talking with Jimmie Hays and found Hays was returning from the Jackpot Race when the failure occured. Jimmie felt a slight vibration at 2,600 RPM cruise and slowed to 2,300. The vibration was still there so he decided to try 2,400 RPM, but at that moment the vibration became extreme, and with a loud bang the prop departed the aircraft.

Jimmie reported slowing down to 90 knots and was on left base leg trying for a dirt road, when a control problem was encountered. Initially full right aileron (all the way to the stop) was sufficient to level the airplane. Then he had to re-enter the bank to get lined up with the road. This maneuver took full opposite aileron and rudder to level the wings. At no time did the bank ever exceed 30-40 degrees nor did the speed fall below 90 knots. This caused an over shoot of the very short road section and touchdown was made on the front slope of a fairly gentle hill covered with reasonably low sage brush. The left main gear failed shortly after touchdown. The right main and nose gear didn't fail until just about the end of the slide. The aircraft was substantially damaged, but no one was hurt.

Jimmie's inspection found the left aileron wing root push rod had failed at the threads of the aft rod end, and surmised it may have failed when the prop departed. That event may have caused the continued wing drop that Jim experienced when he re-entered the bank to get lined up with the road.

Just before the flight to Jackpot Jimmie had torqued and tracked his B & T "Monster Prop". He said he had never had a prop that tracked so perfectly and that the engine was running smoothly.

The phone call further revealed that Mike has completed static testing with the accelerometer and oscilloscope on his O-360-A4A powered Long-EZ. He has borrowed a sophisticated large device for determining dymanic vibration in flight and is in the process of installing it now for fight testing. The device "looks at" the teeth on the starter ring gear to check for resonate vibration and records a trace of the vibration on paper. Any resonate vibration will show as a spike on the trace. Mike hopes to have the testing done by 8-14-94. He said he would send me copies of findings.

Mike also sent a drawing of a stiffer 8" prop extension that was desgined by Bob Beard in 1988. Bob, who has since passed away, indicated the new design with a 4.5" diiameter spool would be as stiff as a traditionally designed 4" prop extension and would have resonance occur above 4,000 RPM.

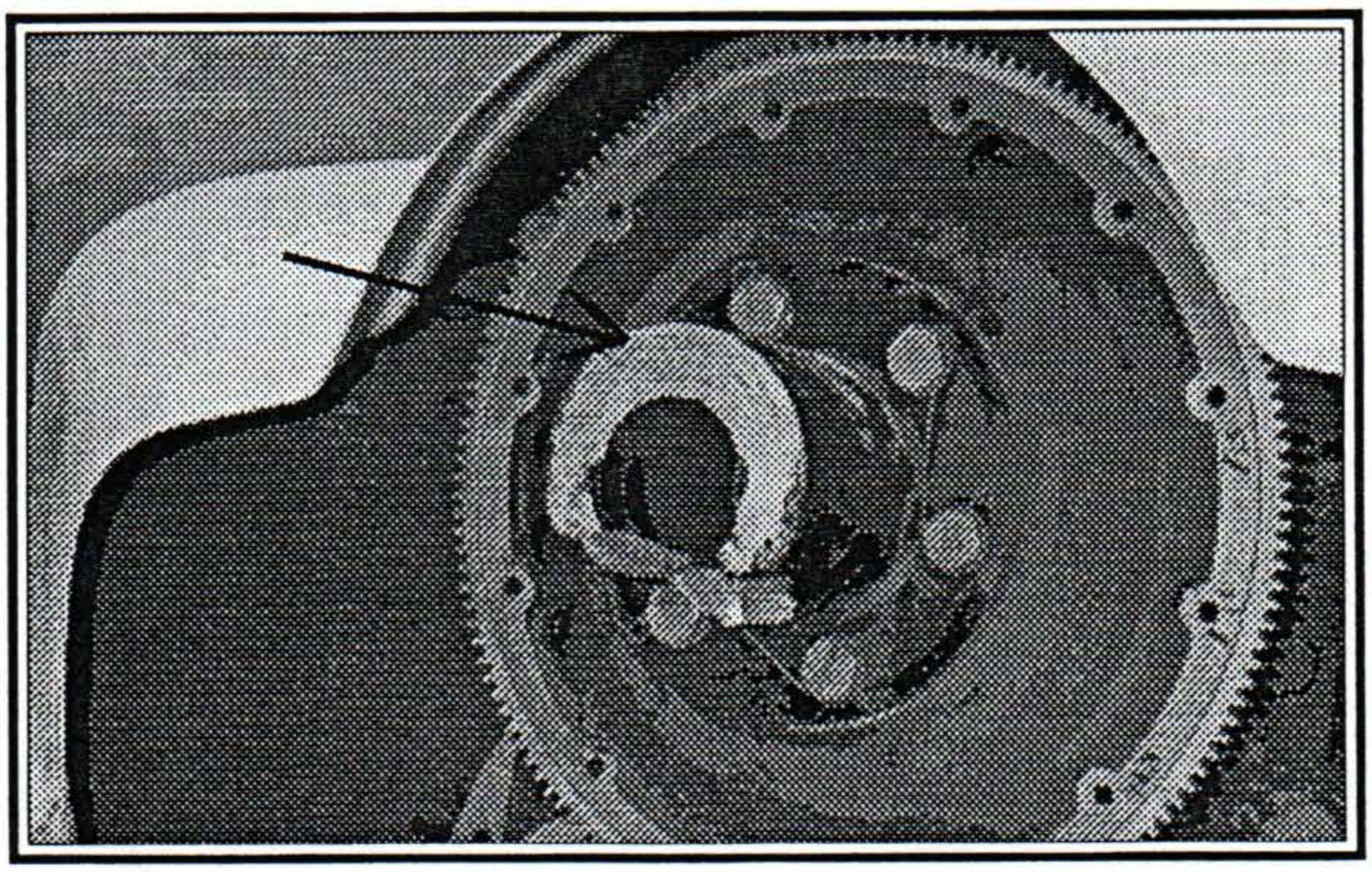
I always get concerned when someone says they had a "slight vibration" before an event occurred. I guess I don't know what a *slight vibration* is. Jimmie Hays recapped the incident in a recent letter.

"The onset of the vibration was sudden and had a fairly high frequency, almost a buzz. The amplitude left no question that we had some sort of real problem. The reduction in power didn't seem to make any noticeable change. Altogether, I don't think there was more than 5 to 10 seconds of this vibration before a hard sharp jolt was felt, after which, the engine wound up to just over 4000 rpm. I immediately backed off the throttle to the idle position and the tach went to 0 rpm. Both my passenger and I recognized immediately that the prop had gone it's own way.

Had the gear not been down there is no doubt in my mind that my passenger and I would have had at least significant injury or WORSE!! There would have been significantly more aircraft damage as well, in my opinion. Having the nose gear extended in a previous off field landing in a Long-EZ was also instrumental in getting by with NO DAMAGE or INJURY."

Nat Puffer called (9-13-94) and told how he and Mike Melvill had independently reached the same conclusion on the Hayes prop extension failure. The Brock 6" extension, when mounted on an O-360, has a resonant frequency of 2750 RPM. Apparently Jimmie ran in the resonant range of the Brock extension possibly causing the extension failure.

Remains of the failed extension shows a peened surface



Mike is presently reported to be testing a Woofter/Saber prop extension to determine resonant frequency. It is believed to be much higher because of a stiffer design. **No Woofter extension failure** is known and many are running on the O-360 which has severe power impulses.

The most recent contact with RAF, 10-4-94, found no final answer to the O-360 vibration problem. **The O-235 with 6" extension and the O-320 with 6" extension have no vibration problem.** Presently, it may not be true of the O-360. A finite element analysis is planned but the facts are not presently known. If you are intending to purchase an O-360 for your pusher RAF will recommend you buy one with a 5th order damped crank. Counter weighted crankshafts have their own problems too, so be sure to check all the AD notes before flying over shark infested waters.

More on this discussion will be found in the Cozy Newsletter and the Canard Pusher as it all develops. The O-360 is recommended for the Cozy Mark IV and the Defiant so both these publications will have something to say, I'm sure.

The latest Cozy Newsletter (10-4-94) indicates you should do all things possible to not over speed your engine and possibly get into the resonant RPM range: Check prop flange run-out. Keep it under .002". Check and balance the prop. Check the prop to see if the blade profile is symetrical from blade to blade. I have seen prop airfoil sections that varied considerably from one blade to the other. That causes uneven thrust from blade to blade and hence creates vibration. Mike Melvill limits his cruise RPM to 2600, well under the resonant frequency

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Oil Cooler Outlet Location

Bill Freeman (KS) - Builders looking for an oil cooler air outlet will find the top of the cowl outlet to be more efficient than the bottom exit.

Nylaflow Brake Line Upgrade

Bill Freeman (KS) - It is good to replace old Nylaflow lines that may be getting brittle from age and heat. Replace them with 1/8" OD X .028" wall 3003-O aluminum tube. The neat thing about that size is it slides up inside the old Nylaflow that you glued to the aft edge of the strut. No cutting and repainting of the strut is needed.

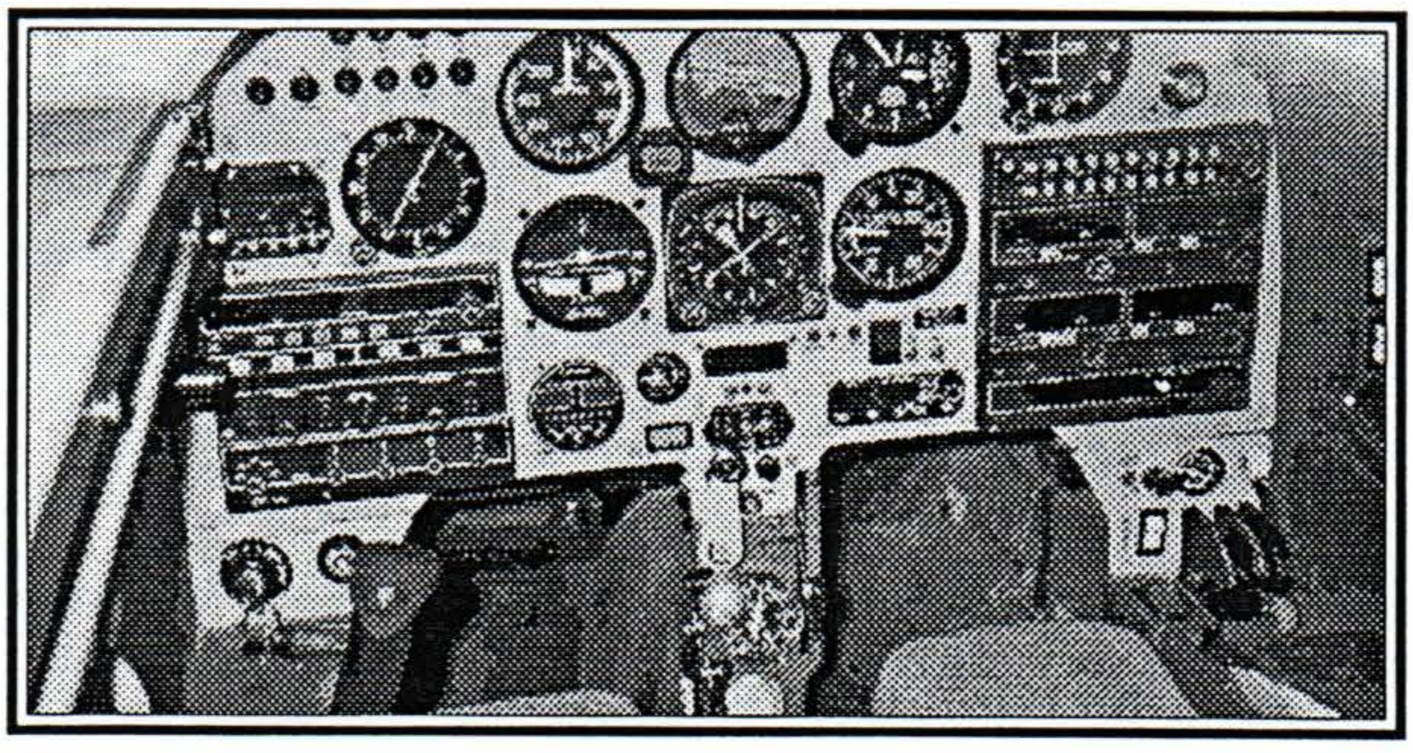
You should leave about a foot or so of Nylaflow outside the strut at the top (in the "hell hole" under the passenger seat) to protect the tube and keep it from kinking or chafing. You will need a piece of flexible hose (I am using Nylaflow, since it is away from heat and UV) to accommodate the large movement of the front mounted master cylinders. I have a parking brake valve mounted to a plywood hard point on each side of the fuselage about 6" ahead of the panel and 6" above the floor. The aluminum tube goes into the valve and the Nylaflow comes out.

You may have a little trouble flaring 1/8", but with a little practice on scrap tube it is not too bad. You will need a pair each of AN822-2D flared tube elbows, AN819-2D coupling sleeves and AN818-2D coupling nuts for the caliper end and probably a pair of AN816-2D flared tube nipples with sleeves and nuts for the other end. I have used mine for 5 years and 500+ hours without a problem.

I always wondered why everyone complained about standard brakes on the Long-EZ, since mine were fine. Terry Yake recently replaced his Nylaflow with the aluminum and reports much firmer and better brake action after about 7 years of Nylaflow. Apparently the Nylaflow was ballooning and using up much of the pedal stroke, decreasing the brake efficiency quite a bit.

I see no need for a flex line at the caliper end since my two Cessna 150's have no flex line or strain relief loop in their aluminum brake lines. They are much larger 1/4" OD and, therefore, much stiffer. Some flex is required to let the caliper float on the caliper pins, however. Tuck the line away from the disc and protect it from direct heat with Fiberfrax and aluminum tape to ensure the fluid doesn't boil. I use DOT 5 spec (very high temp rating) which is compatible with all types of rubber and does not break down with age as does normal automotive brake fluid.

This is your last issue.
It's time to renew.



Check out the extra wide instrument panel on
Sam Kriedel's O-360 powered "Limo-EZ".
This outstanding airplane will be featured in the January issue