

**WARBIRD NOTES #1** 21 Mar 93 (33)  
**HYDRAULIC LOCK ON ROUND ENGINES**

I originally wrote this letter to Bill Harrison, President of the E.A.A. Warbirds of America on 21 Mar 93. It has been suggested that I include it as the first of what will probably be a series of notes or

bulletins concerning the operation of warbirds and other large reciprocating engine aircraft. Also, after publishing the original letter I became aware of some important additional information from Dave Clinton, which I'll add to the last page at the end of the original letter. These bulletins are distilled from the experiences of many people with these aircraft over the years. I'll attempt to faithfully record their recollections and experiences.

Dear Bill,

This past weekend at Galveston at the warbird conference left me with a feeling of concern about the confusion that still exists regarding hydraulic lock on round engines. I guess what prompts this letter is the questions people asked me after the meeting, apparently these were what several people were afraid to ask in public in a seminar of over a hundred people. For more years than I care to think about we've talked about this problem all over the country (or world, for that matter) and we are still seeing HIGH dollar damage to the engines of our assorted vintage aerospace vehicles.

Jim Fausz and I discussed this the day preceding the conference and agreed we would re-tackle the subject during the maintenance portion of the first day. When Jim got to this part we were interrupted and never did really get into it as we intended. The next day we did have some discussion of it and that is where I could see evidence of what happens when pilots with flat engine and/or turbine engine backgrounds start operating radials. Unh - - - upon further reflection and consideration of the above statement I believe I'll modify it and say that I've seen mistreatment of these machines by people whose experience goes back (W-A-A-Y back) to WW II. So, what to do? Maybe including what follows in a subsequent issue of Warbirds Magazine would be helpful and prevent some expensive engine damage and possible injury to someone. This is certainly not rocket science. I seem to remember most of it from way back in cadets or instructor or test pilot school. It's probably available in some old musty USAF mechanic training manual some pack rat saved somewhere. It was common knowledge when jets were new and props were conventional. But back then tailwheels were conventional and nosewheels were not, right? Things change, I guess!

What follows represents my experiences along with those of friends and associates over many years. Other's experiences may cause them to have differing perceptions of some points. I hope the reader views this as a form of "hangar flying" and will feel free to share his/her comments or questions. And keep in mind I'm just an instructor pilot trying to communicate the things we've learned the hard way, not a professional writer!

First, we should probably take a look at why this happens, then later discuss how to deal with it. Whenever a radial engine remains shutdown for even a short period of time the possibility exists of oil draining into the lower cylinders. Obviously, the longer the period at rest, the greater the possibility that the amount of oil will exceed the combustion chamber volume available at the limit of the pistons' travel, also referred to as Top Dead Center (TDC). Upon subsequent rotation (in a forward direction) as the piston approaches TDC of the compression stroke both valves will be closed. The aforementioned oil (liquid) is incompressible and will stop the piston motion. If the crank continues to rotate, something's gonna give! In many years of association with Jack Sandberg at his engine shop, we saw two manifestations of this, heads loosened or blown right off the cylinder barrel and, more likely, bent or broken connecting rods (Illustration #1). Before you ever get to the point of flying the thing, a good look at the engine on preflight can tell you all sorts of things if you are unacquainted with the particular aircraft you are about to fly. A very close look at the area of the cylinder hold-down studs may reveal either a broken stud or evidence of oil seepage. The same holds true in looking for evidence of leakage at the cylinder barrel/head interface area. A loosened spark plug insert also is a telltale of damage.

A total lock (one which stops crankshaft rotation) while starting is going to result in serious damage to the engine. Bad as this seems, given my druthers, I'd much prefer this to happen than what I'll describe next. This would be the case of a partial lockup that wasn't detected (or, perish the thought, was disregarded as not particularly important) at the time. The piston meets extreme resistance but isn't completely stopped, the engine jerks and slightly hesitates and then completes the start as the succeeding cylinders fire. That particular connecting rod can have a varying amount of bend which will allow the engine to run. What we have here is the equivalent of a time bomb just waiting to fail, the only question is, when? It would probably take a very mechanically oriented pilot attuned to that particular aircraft to detect the slight difference in sight, sound or feel between a normally operating engine and this one and, even if detected, the problem might be blamed on some other mechanical reason. Howard Pardue and "Doc" Christgau come to mind immediately as examples of the above situation, flying the same aircraft often, but very few of us can say the same. The failure will very likely take place under conditions of high power and stress such as a takeoff or go-around, just when you'd least want to deal with it. So, if you're going to have it happen, hope it bends something enough to make it obvious, then you won't ever get to the second situation. If you do have it happen, **STOP**. Don't fly it and don't let your buddy fly it!

Now, what have we learned over the years about how to prevent the situation? In the fifties we had about 160 B-25s at Lubbock. In the sixties we operated about 35 DC-3s (Wrights) and about the same number of Convairs on the airline. Everyone was aware of the possibility and the simple procedure of always rotating six blades with the starter on these engines prior to prime and ignition sufficed. As an aside, on the Boeing C-97 Startocruiser we always counted 20 blades first but this was touted as also being for lubrication of the R-4360. At any rate we were taught from the earliest T-6 days and in turn taught our students what we were looking for while starting. Practices vary somewhat among different pilots. Probably it's been fairly commonly accepted that if an engine has been shutdown for 30 minutes or so to check for lock. However, during the process of writing this I talked to two pilots who experienced it after only 10 minutes. A word to the wise!

Pulling the blades through by hand is one way of detecting hydraulicizing. What we are looking for here is a feel of sharp or sudden resistance (unlike the buildup of normal compression) to continued forward rotation of the prop. Right here we should mention a very common problem of untrained help from the crowd whose assistance (they only want to help) can cost you, the owner, big bucks! You need to know what hydraulicizing feels like and make sure only you or someone who also knows is involved in pulling the prop through. Don't make a gorilla race out of the process - the best description I can think of is just leisurely walk it through while looking (feeling is actually a better word) for a problem. We need to talk also about the number of people. I've always taught one person on a R-670 through 1340. Two people on an 1820 through 2800. Three people on a 3350 or corncob. If you think more, just get a calculator and figure out the foot pounds transmitted to the connecting rod by that many guys really laying into a 13 foot or so propeller (lever). Jack Sandberg could quote you the figure off the top of his head (along with about anything else). I can't, but do know that he didn't want any engines he built and guaranteed to be pulled through by hand. He figured he'd rather rely on the starter clutch than untrained help in preventing damage. I've done and do it both ways, both have pros and cons. While on the subject, I just remembered something else. On a four engine aircraft, don't let people pull through #1 and 2 or #3 and 4 simultaneously. One engine's blades will be descending as the other one's are being pushed by guys with their heads down. This got us a pretty severe scalp gash on the B-29 a few years back. (Yes Virginia, there are more blood vessels in the scalp than anywhere else on the body's surface!)

If you're going to do it with the starter I think it should be done one blade at a time. This never lets enough momentum build up so as to have to rely on the starter clutch. First, mesh the starter and then intermittently energize the starter, "bumping" it through blade by blade while being alert for any blade to jerk to a stop or stall.

You can figure out for yourself the number of blades using either man power or by the starter. For instance, a 16:9 reduction on a B-25 says just over 3 blades will rotate the power section through a complete power cycle. I'm probably conservative - on a 3 blade like the Hellcat I usually "bump" an

engine through about 6 blades and then go to continuous starter RPM for another 6 or so. On a four blade like the P-47 I use 8 instead of 6. My thought on this is that if any oil is residing in the intake pipe I might (see discussion later) suck it into the cylinder at that point while still relying on the starter clutch to prevent damage. During all the aforementioned I've been acting as a mechanic. After this process I stop everything, put on my helmet, harness and whatever, then function as a pilot and start the engine.

Now - the important part. Let's say you detect a lock. **Pull a spark plug and drain it!** Just hope and pray no one found it ahead of you and, out of your sight and knowledge, turned the prop backwards! This is the equivalent of inserting a time bomb in your engine. As Jim Fausz said, "Where DO it GO?" The answer is, the piston pushes it into the intake pipe where it waits like a "snake in the grass" to be sucked out as the engine starts (Illustration #2). Then we're right back to the "somethings gotta give" situation. Once someone rotates it backward I don't know of any way to get it out of the intake pipe except to suck it out. An engine shop foreman with years of experience put it in these words: **"DON'T ROTATE IT BACKWARDS OR LET ANYONE ELSE DO SO."** Some feel that a taildragger probably accentuates this problem due to the angle of the intake pipe. If I knew it had been done, I'd pull a spark plug out of all the lower cylinders, disconnect the other plugs on those cylinders, turn it through with the starter several turns, then start the engine and clean up the mess afterwards. It'll blap and snort while blowing oil all over everything but - that's the object, isn't it? I've only been around once while this was done, you don't need to run it more than several seconds to clear it. Too much trouble, you say? Well, O.K., it's your engine and you can easily calculate the cost of pulling the cowling and plugs vs. the cost of an overhaul, you might even get lucky. John Lane at Airpower Unlimited (208-324-3650) can tell you of some failures he's seen and repaired. For those who really want to deal with the above problem professionally he is developing an improved "blowout" plug (rather than the country boy approach we used) to deal with the above problem. The original (but now hard to obtain) version of this plug dates back many years. It temporarily replaces one spark plug with a check valve which allows the cylinder to create suction on the intake but lets the oil blow out on compression. Honest disagreement exists over the need to start the engine. Some people feel that just rotating it through with one plug out at cranking speed will do the trick and they could be right. However, I really question if enough suction is going to be created at cranking speed since viscosity of the oil also enters into this whole equation. On the B-29 a Tech Order requires heating the intake pipes when dealing with this exact problem so we know it is (or was) a matter of concern.

Earlier, I mentioned that abuse occurs even by people whose experience goes back to WW II. Several years ago I remember trying to get to the bottom (pardon the pun) of a R-1820 failure. We, on the investigative board of this particular museum, had heard several people testify that the engine just self-destructed for no apparent reason, yet the teardown revealed a preexisting bent rod. You can imagine our astonishment when a respected mechanic with long time experience on round engines at a major military base said "Well, it couldn't have been hydraulic lock, I helped pull it **backwards** after it stopped on pull through!" (By the way, you're absolutely right, Commander "X" or Colonel "Y", I didn't mention whether he/she was Navy or Air Force - let alone Marine, now am I a model of political correctness/interservice rivalry avoidance or what?)

Jim Fausz mentioned two other items that apply. The first is obvious, make sure the ignition is OFF before pulling the prop through. Anyone who's seen a crop duster/ag pilot/aerial applicator (same guy - just different decades) start a 985 or 1340 on a Stearman with a half hearted leisurely tug on one blade while walking past the nose would understand. The other is that many of these problems might be avoided by using the recommended procedure in your aircraft's manual regarding scavenging the engine crankcase at a certain RPM immediately before shutdown. This made me think of a caveat in closing, after start and/or before shutdown you should ALWAYS do a mag grounding check at idle just to make sure the ignition switch is really functioning O.K.

This has gotten much longer than I ever intended when I started. I've talked with a lot of people while trying to write this. It seems that every time I dredged up something from my memory data bank someone else said "Yeah, and while you're on the subject shouldn't you also mention XXX?" I guess what has happened is that we've skipped a generation in passing on what was common knowledge at

one time. I hope you can find some place or forum to use it where it might prevent damage or injury and we can "Keep em Flying". I'll just assume you can sort out the tongue in cheek from the serious.

Best - Randy  
EAA #2054, WB #71

(15 Dec 93) After writing this Dave Clinton contacted me with some additional thoughts that I wish I could have included in the original letter. He reiterates that the recommended scavenging upon shutdown is, at best, not very efficient. Typically 2 1/2 to 3 gallons of oil remains in the front sump and lower cylinders/rocker covers. An additional problem he cites is the "bleed holes" drilled in the oil ring lands of some pistons which will add to this problem. He mentions that most late Wright manuals he has read prohibit moving the prop by hand in either direction. Instead of relying on possibly untrained help they depend on the starter clutch which is typically set at 500-800 pounds of torque. Now, the most important part of his letter! The installation of the Darton Int'l. "Clean Kit" (619-434-0701) would eliminate the lock problem on these engines. This kit has been widely installed in the T-28 fleet over the past few years.

