

WARBIRD NOTES # 9 27 Feb 95 (21)
HYDRAULIC LOCK – – – REVISITED

In the year and some months since I first wrote about the recurring hydraulic lock problem with our engines I've found out some things I wish I'd known back then.

Other things have been questioned. We should talk about those things and just kind of revisit this subject. It seems to me that enough time has passed to permit anyone that wished to comment on a developing mini-controversy to have sent a letter to the magazine editor. Unfortunately, every answer seems to have engendered two more questions – so – this may become as long as the original.

WARBIRD NOTES # 1 was written as a result of the first National Warbird Operator's Conference (NWOC) at Galveston in 1993. I think these meetings have been even more valuable than Bill Harrison envisioned when he almost single handedly put together that first one. However, we encountered the natural reluctance of some to speak up from the floor, either to ask questions or to tell about some experience that they'd had with this problem. That's too bad since almost all the people who've spent any time in this business or who were interested enough to travel that distance probably had something valid to share that would've added to our collective wisdom. Anyhow, that's how these notes originally started. I mentioned in the original bulletin that I hoped others would share their comments or questions, that's how we all can learn. In trying to chronicle the hard won experiences of those (before they've all gone west) who had to deal with these problems I'd hoped to encourage people to recount some experience or insight that might save us all some aeronautical grief.

One fly in the ointment, however, might be that once we've adopted a preconceived idea it's sometimes very hard to let go of that idea if we think we'll lose face. There must have been a lot of red faces around when Columbus didn't sail off the edge of a flat earth. Another false maxim that comes to mind is "never turn into a dead engine". This is one more old wife's tale I observed still being taught in all seriousness a few years ago at a flight instructor renewal course I attended. Another is "climb it a little above cruise altitude and get this thing on the step", thoroughly discredited years ago but still receiving affirmation today, even among those who should know better. A whole litany of items could be cited here but, suffice it to say, the word "*dogmatism*" is probably apropos here. The danger in all this is in the passing on, through a bombastic "I was there" attitude, of things once accepted as certainties but unable to stand the scrutiny of knowledge acquired later on. To someone just getting started it's very easy to listen to "a voice of experience", because many times they talk the loudest. I can remember years ago when Jack Sandberg and I were visiting a now defunct operation in Chino hearing an "old head" expounding on some problem. I commented that this guy must really be the guru with his thirty years of experience. One of his fellow workers quietly observed that what the guy really had was "one year's experience – repeated thirty times". I don't know anyone of us involved in this business who was born "knowing it all" for all time. Most of this stuff is acquired over the years the hard way by listening and observing and thinking, sometimes with pain and unfortunately sometimes after damage to equipment or worse yet – injury or loss of life. And later research might then cause these perceptions to change. The preceding sentence is the reason for trying to sift through and sort out enough recollections to write this stuff, if something valid is passed on here it sure beats trashing some very expensive machinery!

Now, regarding John Mitchell's letter to Air Classics in which he says they'd still be fighting the Japanese if they hadn't turned hydraulic locked engines backwards all the time on Tinian / Saipan / Guam or wherever to make schedule. Yeah, I know, that went

on back then. I also know that the Wright 3350 didn't have a very good reputation. Matter of fact, we'd have to admit it had a terrible reputation. Maybe after all these years John has finally revealed part of the reason. Last summer a former W.W.II B-29 pilot and I were discussing this problem. His comment, cleaned up for publication, was that he'd like to talk to the "#*!+(@%" S.O.B. that had turned the "&)^*>\$" prop backwards on the "%&*+(~*#" aircraft he had to ditch with engine failure right after takeoff. I've spent a lot of time with the guys who flew it on the raids against Japan and books could be filled with what they've told me about those days when the weapon was deployed with the test program uncompleted. Valve problems, cylinder problems, fuel consumption, blister windows, etc. and always – the fires! I am loath to get involved in any dispute between maintenance and flight people. I've done my share of both. Both sides enjoy freely telling their war stories containing, in most cases, a measure of validity. What they disclose mostly, I guess, is a tendency for some folks to feel the other guy's experience (or lack thereof) just doesn't provide enough data base to have a clue. I've been on both ends working, I can really remember using about every word alluded to above about the "dishpan" on # 2 while trying to recowl "FIFI" after a maintenance inspection. I was absolutely convinced – after trying screwdrivers, pry bars, tapered punches and finally a small hydraulic jack – that that particular aluminum assembly had to have started life originally on some other B-29. So I do have experience with removing the spark plugs. Ever since I flew her home from China Lake I've also had the experience (along with countless other volunteers) of trying to sell cockpit tours, a couple of bucks at a time, to generate funds to keep this ancient 400 g.p.h. bird (archaeornis?) funded so the public can see her. Several of us volunteers could testify how it gets real personal, real quick when it's your own VISA or Phillips card involved.

One could make the observation that the Brits knew as early as 1943 not to turn it backwards, their Fortress II manual specifically prohibited it. Most of the other U.S. military manuals also told our guys it was a no-no. However, a while after I wrote the bulletin I did find one USAAC magazine of that era that had mentioned doing it. It'd be hard to sit here and say some old top sergeant line chief didn't come along and tell his people to do it but – that was then, this is now. These round engines are costing anywhere from 20 to 60 thousand bucks a pop to overhaul and, as Mike O'Leary said, "we're not fighting a war anymore". If John really believes turning one backwards won't hurt it, could he send his VISA card number along with the next letter?

Something we really need to mention are the photos of a bent link rod used as a training aid at the 1994 NWOC in Ft. Worth. These pictures of a P&W 1830-94 provide graphic evidence for any doubters of the destructive possibilities after an engine has been turned backwards moving oil from a cylinder into the intake pipe. This was after the lock had been detected during pull through, the spark plug pulled, cylinder drained, engine turned, plug reinstalled, engine rotated six blades with starter - no more lock and then, switch on and a couple of cylinders begin firing – BAM! By the way, the force behind the backwards rotation wasn't human. It was a tornado, days earlier! This nighttime storm struck from the rear with enough force to damage the elevator hinges of the C-47 aircraft. Later detective work disclosed the props had been seen moving backwards.

One thing that I think now may have been partially in error in the original WARBIRD NOTES # 1 was that I said that oil in the intake pipe would be sucked into the cylinder when the engine started. The oil would remain in the intake like a "snake in the grass" defying all efforts to coax it out by subsequently turning the engine in the correct direction, no matter how many blades! It'd just wait until the engine began firing to strike! In a subsequent discussion with Sam Torvik at the 1994 NWOC I suddenly realized that

I had disregarded an important factor while writing the original. Sam had originally discounted to some degree the possibility of damage from the intake pipe theory. However, after looking at the bent rod and reviewing the associated circumstances at the NWOC he changed his mind. Originally we pictured the oil being sucked into the cylinder. I think that equally important weight should be given in explaining the dynamics involved to the plug of oil being shoved out by the force of a ten-to-one impeller coming alive at start-up. I think this is one of the few things I would disagree with in Fred Helmick's letter in which he says oil displaced to the intakes would be returned to the cylinders but would be diluted by the fuel-air mixture. Wish it were so but, unfortunately, there is a high likelihood that glob will be shoved back full strength, incompressible and malevolent. Then, BAM, gotcha! Gasoline is a liquid and just as incompressible as oil. However, the original thought still may not be totally in error since I do know of several cases of hydraulic lock in the smaller Jacobs, Continental and Lycoming engines. Since none of these engines have an impeller, that force is obviously absent as a problem source. In these cases I just don't know whether they were the result of not finding the lock prior to start or from turning backwards when one was found. Now, the question is, did the blown cylinders and bent rods on these smaller (but still expensive, just ask the owners) engines come from failure to pull through prior to start or from the intake pipe problem? Or, could they have come from a backfire (in some cases) through the intake system which shoved the oil into the cylinder. We just don't know and I haven't found anyone who wants to try it on his engine just for the sake of experimenting. At any rate we do know that the end result is disastrous to the checkbook! Bill Jones probably said it best the other day, "who cares whether it sucks or blows out of the intake pipe, the damage is still the same".

Also, in retrospect, I may have tried to oversimplify something. The illustration showing a piston forcing the oil into the intake would be the next in a backwards cycle from a lock but would only force that oil in excess of the combustion chamber volume at TDC into the intake pipe, the chamber will still be totally full at TDC until an exhaust valve opens. Then, to be really technical, you'd have to consider whether intake and exhaust valve locations are on the top or bottom of the cylinder on opposite sides of the engine. And you'd have to consider the placement and design of the pipe's curves. And is it installed on a taildragger? So not every cylinder may be a candidate. Clear as mud? Yeah, me too! This is the area where I question Marty Hall's analysis of where the oil goes. Lock can only occur on the compression stroke and the first valve to open when you start moving the prop backwards from that stroke is the intake. Once you put it in the intake pipe its all luck from then on. I know that people have gotten by with it for years - but it just looks like a poor bet to me. I just have to agree (since we're not at war) with Marty's final comment, just – pull – the – plugs! And I fully appreciate the magnitude of what he's saying, thinking of a Fairbanks, Anchorage or Shemya tarmac! Fred and Marty obviously are both highly experienced and make several valid points between them. It would have been easier to follow their discussions if they had read the original letter along with Mitchell's. Anyway, the bottom line and what's really important - judging from the pictures and descriptions of damage sent to me since the article - the possibility/probability of backwards rotation damage is only too real.

Not too long after the bulletin was published Doug Rozendaal sent me his computations of the resultant mechanical forces imposed against a lock. It was based on the piston's position in the cylinder and it really impressed me. Doug takes pains to emphasize that the figures aren't accurate to several decimal points but they are certainly adequate for our purposes. He used a P&W 1340 so as to eliminate gearing complications. Computing the volume of the combustion chamber at top dead center (TDC),

calculations show that just over 3/4 pint of oil would cause a hydraulic lock. Applying 50 pounds of hand force at the prop tip would result in a 900 pound force being generated in the cylinder at 90° before top dead center (BTDC). This would increase to about 11,000 pounds force at 10° BTDC. As the piston approaches TDC the force generated approaches infinity. This last sentence is the killer! If the quantity of oil in the cylinder is only slightly more than the above amount you can see that the force generated by someone (read: unknowledgeable help) really laying into the prop is almost unbelievable.

I've gotten many copies of procedures used by various organizations and museums since the original bulletin was published. Probably one half advocate or specify a pull through by hand and the other half advocate or specify use of the starter. The latter camp is then further about equally divided, half "bumping" it through and half turning it continuously. I'm acquainted with one grizzled old maintenance chief (of long and unquestionable experience) who reminds me of the salty Joe Patroni in the movie "Airport" in vehemently insisting that all engines must be pulled through by hand. After several years of this "shtick" may the Lord forgive me for imploring Him to please let me show up on the tarmac with a Catalina. (Maybe all rules have exceptions, hmmm?)

Seriously, my core belief remains that the people responsible are more than welcome to their strong feelings about how they want the prop pulled through, just so long as the bottom line is – knowledgeable people! If you let volunteers from the crowd "help", the chances are that they won't know a hydraulic lock from a hay bale. Almost invariably they'll gang up on the prop with as many people as can get hold of the prop blade while seeking to amaze you with how fast they can run it through. We already know the results of that number of people's unbridled enthusiasm from reading Doug Rozendaal's calculations. It scares me half to death. Now then, doing it with the starter presents a completely different set of potential problems. Is it an inertia or a direct drive? If you can't "bump" it through while diligently watching for a stalled blade and, instead, have to use full starter speed then you're relying on a starter clutch that you hope is set to a low enough torque value to protect your life and investment. Also, I always look at the inertia of that big prop and it also scares me. As for me and mine, I have to admit I still do it both ways depending on the aircraft and situation. If I'm going to do it by hand I want to do it alone or with the absolute minimum of help and slowly walked through. If with a starter, then bump – bump – bump, a blade at a time. Note to me – What about inertia starters?

I've heard people remark that they've never encountered a hydraulic lock in order for them to know what it would feel like. Well, (risking being shot for blasphemy) you could induce one for training under strict control some time when the people who need the training are all around. You could pull a plug, put your thumb over the hole and bring it up to near TDC on the compression stroke. Then squirt it full of oil and put the plug back in. Then let everybody turn the prop and let them feel the resistance. There isn't any question in anyone's mind after they feel it that they then realize how sudden and sharp the lock feels compared to normal compression. Then, remove the plug and drain the jug! I'd also leave the plug out and start it to guarantee it was cleared out. And stand way back! After the first bulletin we found a lock on an A-26. When they decided to pull the plugs and run it as described I managed to get oil on me even while standing a good 25-30 feet away.

To illustrate the futility of pulling it through blade after blade consider this scenario. A BT-13 sits in a hanger all winter. Pulled through regularly, a drip bucket hangs under the stacks. Springtime comes and oil is very low in tank, oil added to bring level up.

Everybody around the hangar sort of contributes to pulling it through – and through – and through by hand. Many blades later, it has to be clear since no hydraulic lock occurs, right? The battery is known to be low so someone says "You'd better turn the mag switch on first so it'll fire on the first couple of cylinders, else we'll have to hunt around for a power cart". Inertia starter winds up, prop turns and fires, BAM! \$16,000 later, his sad comment, "I wish you'd written WARBLD NOTES # 1 a couple of months earlier so we'd of pulled the lower plugs and ran it".

Are we learning anything here? Well, I'll guarantee you the Soviets have. The M-14 engine on the YAK has removable plugs installed in the lower intake pipes. If you get a lock on one of these, DO pull it backwards and force the oil into the intake. Then unscrew the drain plugs, drain, reinstall and go fly! Of course, if you don't know about these plugs and turn it backwards – – Oh well, new engines for these are fairly cheap and you could sell the cores (two that I'm aware of, one in Tennessee and one in Texas) for boat anchors!

Recently I received a totally unsolicited comment from "Boxcar Willie", a name many of you country music fans will immediately recognize. What follows is probably going to surprise most of his fans. While reminiscing with him in his tour bus before he went on stage I asked him if he'd ever experienced a hydraulic lock on a 3350 or 4360. He said sure and then surprised me with this follow-up – "and I'll guarantee you that anyone who wants to get rid of it by turning it backwards is going to end up with a bent rod". Now I must confess that, no matter how much I admire his ability to finger the hard (for me) "G" chord and sing train songs that make me cry, what has my utmost respect is his real life experience and ability as a B-29/C-97 flight engineer. As Paul Harvey says, "now you know the rest of the story". The guys I flew with in the Air Guard who were running the panel of a C-97 were professionals who had, beyond any doubt, reached the top rung of their ladder. The "Stratocruiser" and the "Connie" represented the pinnacle with spark advance, water injection (ADI), turbo-superchargers or PRTs, ignition analyzer and a host of other complicated devices never to be equaled again. It represented art as much as it did science. After he made this observation I told him about the letter to the editor of Air Classics stating "it (hydraulic lock) wasn't a concern", therefore it was interesting to hear someone else's unsolicited opinion. "Willie" then added a last succinct comment – "friend, if you don't want to bust something when you get a lock, just get out your wrenches and start pulling some spark plugs!"

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