POWERPLANT 113: "ENGINE FAILURE FOR UNKNOWN REASONS"

That's what TCM's analytical report said about the catastrophic engine failure suffered last year by ABS member Lowell Powers. Let's see if we can figure out why his engine came apart.

On November 7, 2007, Rhode Island-based ABS member and 4,000-hour instrument pilot Lowell Powers Jr. climbed into his 2002 B36TC (N428LP) and took off from Mountain Air Airport (2NC0) in mountainous western North Carolina, headed for FlightSafety International for refresher training in emergency procedures. He didn't make it.

Almost immediately after liftoff, Lowell's TSIO-520-UB engine started to lose power. Mountain Air is an extremely challenging airport, with a 2,900' runway carved out of the side of a mountain at a field elevation of 4,432'surrounded by high terrain. (Fig 1.)

Fig1: Mountain Air (2NC0) is a very challenging airport surrounded by high terrain.

An immediate left turn is required after takeoff from Runway 14 to avoid rapidly rising terrain. While in the turn, Lowell saw an uncommanded drop in manifold pressure from 36" to 20". Returning to Mountain Air for a landing seemed pretty much out of the question.

Keeping his cool, Lowell headed southeast toward Rutherford Country Airport (FQD) located in a valley 33 nm away at a field elevation of 1,078' with a 5,000' paved runway. The airplane was light—just the pilot aboard plus relatively little fuel—and managed to climb to 6,500'. But engine power continued to deteriorate and soon was no longer able to hold altitude.

Lowell continued toward FQD and entered a high-traffic pattern. He made a Mayday call on 122.8 unicom, announcing that he had suffered an engine failure and was going to make an emergency landing at FQD. A flight instructor on the ground replied, "The airport is yours."

On base leg, the engine made a loud noise and quit altogether, and the windshield became covered with engine oil. Lowell proceeded to make a perfect landing and emerged without a scratch on the airplane or him.

"The best thing about that flight," quipped Lowell when I spoke with him recently at the ABS Convention in Lexington, Kentucky, "was that my girlfriend wasn't aboard."

What happened?

Upon exiting the aircraft, Lowell noted two dents on the forward left part of the cowling. Opening the left cowling door revealed that the #6 connecting rod had failed and punched a large hole in the case just above the #6 cylinder. Some of the #6 cylinder hold-down nuts were missing, while others were loose and in the process of coming off.

N428LP was towed to the FQD maintenance shop called Plane Werks. Teledyne Continental Motors dispatched a technical representative to inspect the engine—a TCM factory rebuilt with 687 hours total time—after which the engine was removed from the aircraft and shipped to TCM in Mobile, Alabama, for a complete teardown inspection.

TCM ultimately issued an analytical report (Fig. 2) declaring Lowell's catastrophic in-flight engine failure to be a "FAILURE FOR UNKNOWN REASONS." However, a closer reading of the TCM report is quite revealing and instructive. After reading the report, it doesn't take a lot of imagination to determine the probable cause of the engine failure.

Let's take a look at what the report says:

> In flight heard loud noise followed by "humming." Landed, inspected crankcase to find large hole above #6 cylinder. Cylinder loose. Oil flooded windscreen. Landing was uneventful, no injury. Inspect engine for report. Remove for shipment to analytical in Mobile. Reported [cylinders] 2,4,6 were removed for repairs…

In fact, cylinders #2, #4 and #6 (on the left side of the engine) had been removed just 9.1 hours prior to the engine failure. Cylinders #2 and #6 were removed because of low compression readings; cylinder #4 was removed to facilitate access to #6.

> Made field visit to inspect the engine. Visual inspection confirmed loss-of-lubrication signatures to #5 and #6 [connecting] rods with subsequent rod failure. Noted evidence of loss of cylinder torque on #6 cylinder. Two missing cylinder base nuts were found in cowling. During cylinder borescope [inspection], noted #1 piston not moving in the cylinder. 7 quarts of oil in the sump. Moderate amounts of aluminum in the [oil] filter. Forward crankshaft bearings appear to have been displaced. Visual inspection results showed indication of spun bearings due to loss of cylinder torque.

TCM informed Lowell that there would be no warranty consideration, but that TCM would accept the destroyed engine for full core credit against purchase of a replacement factory-rebuilt engine. Lowell was also required to pay for the cost of shipping the engine to Mobile.

TELEDYNE CONTINENTAL MOTORS
A Teledyne Technologies Company

Engine Condition Report 100003775

Type of Call: Other

All recommended adjustments are subject to TCM final approval after review of TCM analytical inspection finding.

Part Number:	TSIO520UB17B	Description:	Catastrophic reported
Date:	**11/25/2007**	Serial Number:	527580
Date of Occurence *(mm/dd/yyyy)*:	11/25/2007	Model Number:	TSIO520UB17B
Claim Number:	Pending	Actual Total Hours:	687
Aircraft Make/Model:	Beech		
Reg:	N428LP	S/N:	EA693
Engine In-Service Date *(mm/dd/yyyy)*:	07/08/2002	New:	Rebuilt:
Component In-Service Date *(mm/dd/yyyy)*:	07/08/2002		
Dealer or FBO:	Russell Hyde, Airport		
Phone:	828-286-1474		
Address:	Rutherfordton, NC		
Fax:	C8284299356		
Owners Name:	Lowell Powers, Lima Golf Papa, LLC		
Phone:	401-849-3460		
Address:	207 Correy Lane, Middleton RI 02842		
Distributor:	Pending		
Engine Component:	ENGINE - GENERAL		
Engine Component 2:	CRANKCASE		
Engine Component 3:	FAILURE FOR UNKNOWN REASON		

Description of Engine Condition:
In flight heard loud noise followed by "humming". Landed, inspected crankcase to find large hole above #6 cylinder. Cylinder loose. Oil flooded windscreen. Landing was uneventful, no damage, no injury.

Recommended Adjustment:
Inspect engine for report. Remove for shipment to analytical in Mobile. Reported 2,4,6, were removed for repairs past April 2007.
LOG BOOK MUST ACCOMPANY RETURNED ENGINE! NULL

By: Loren W. Lemen, Jr

Attach File/Image:

Type of Adjustment: Other

AV18 Notes:

NOTE 1: Made field visit to inspect the engine. Visual inspection confirmed loss of lubrication signatures to no 5 and 6 rods with subsequent rod failure. Noted evidence of loss of cylinder torque on no 6 cyl. Two missing cyl base nuts were found in cowling.

NOTE 2: During cyl borescope noted no 1 piston not moving in the cyl. 7 qts oil in sump. Moderate amounts AL in the filter. Forward C/S bearings appear to have been displaced. Visual insp. results showed indications of spun bearings due to loss of cyl torque.

NOTE 3: Engine will be accepted for full core value against the order of a replacement engine from TCM. Engine will be routed to analytical for inspection. Shipping will be the owners responsibility. No warranty applies at this time.

Fig2: TCM's analytical report on the catastrophic engine failure of B36TC N428LP on November 7, 2007.

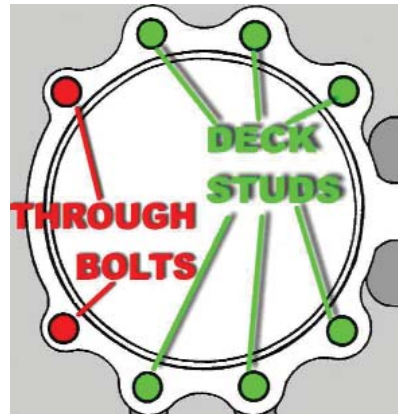

Fig3: Each cylinder is held in place by six deck studs and two through-bolts.

Fig4: Eight through-bolts hold the crankcase halves firmly together.

What *really* happened?

The maintenance shop in New England that performed the annual inspection on Lowell's B36TC removed all three cylinders on the left side of the engine. Removing each cylinder requires removal of the eight cylinder hold-down nuts that secure the cylinder base flange to the crankcase. Six of those hold-down nuts are threaded onto short deck studs that are mounted in threaded holes in the crackcase. The other two hold-down nuts are threaded onto a pair of long through-bolts that pass all the way through the crankcase. (Fig. 3.)

To understand the cause of this catastrophic engine failure, you need to know something about how the engine is put together. The left and right banks of cylinders are staggered so that each pair of through-bolts run from the front hold-down nuts on a left-bank (even-numbered) cylinder to the rear hold-down nuts on a right-bank (odd-numbered) cylinder. The engine has four pairs of these through-bolts (Fig. 4), and they are primarily responsible for holding the two crankcase halves firmly together.

The crankcase contains precisely machined semicircular main bearing saddles that hold the main bearings that support the crankshaft. The main bearings are semicircular shells (Fig. 5) that consist of steel back plates laminated to bearing surfaces made of a softer material called "babbit" that won't scratch the crankshaft journals. The main bearing shells have

Fig5: Main bearings are semicircular shells held in place by through-bolt torque.

oil supply holes that must line up precisely with oil passages machined into the crankcase halves.

When the engine is assembled, the ends of the main bearing shells stick out slightly above the mating surfaces of the crankcase bearing saddles. As the case halves are mated during engine assembly by torquing the through-bolts, the bearing shells are forced firmly into the crankcase saddles in an operation known as "crushing." Once the bearings are crushed in place during engine assembly, it is absolutely essential that they not be disturbed.

If a mechanic removes all three cylinders from one side of the engine by removing all 24 cylinder hold-down nuts (8 per cylinder), this results in loss of torque on six of the eight through-bolts that hold the two crankcase halves together. If the mechanic rotates the crankshaft while the engine is in this precarious state—to position each successive piston to bottom-dead-center to facilitate removal of the associated cylinder—there is a serious risk that the main bearings will shift in their saddles.

If the bearings shift, the oil holes in the bearing become misaligned with the oil passages in the crankcase, partially cutting off the oil supply to the bearing. If the engine is then put back into service, the reduced oil supply to the bearing causes increased heat and friction that can result in the bearing shifting more, further reducing its oil supply. Ultimately, the bearing can shift enough to cause the oil supply to be cut off completely, and the result is invariably a catastrophic failure of exactly the kind that Lowell's engine suffered. This phenomenon is usually referred to as a "spun bearing."

After reading the TCM analytical report several times, talking to Lowell, and looking at the photos he took of the engine after his forced landing, there's no doubt in my mind that this is exactly what happened to his TSIO-520-UB engine. In my opinion, this was a classic maintenance-induced failure.

Robert Bernstein of Oshkosh, Wisconsin, won a free Savvy Owner seminar at the 2008 ABS Convention. Mike Busch generously donated this prize for a random drawing from convention seminar evaluations submitted by ABS members. Thanks, Mike, and congratulations to Bob Bernstein.