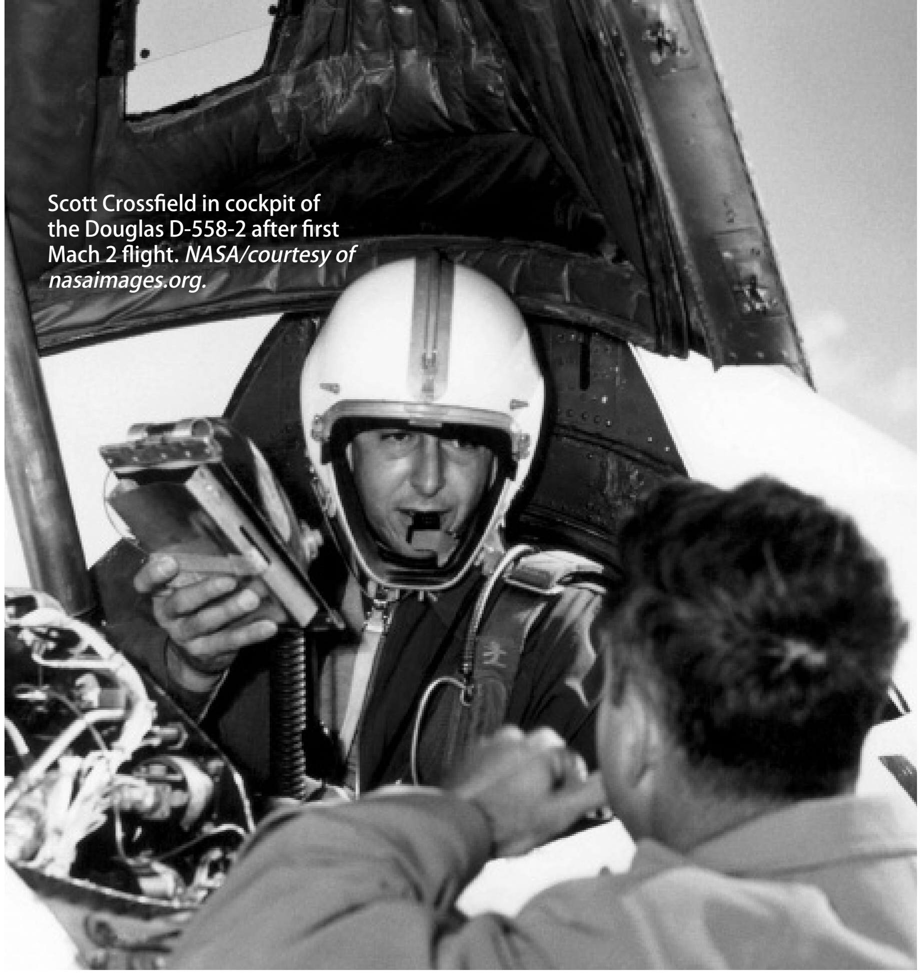


Scott Crossfield in cockpit of the Douglas D-558-2 after first Mach 2 flight. *NASA/courtesy of nasaimages.org.*

Scott Crossfield Edition:

World's Most Reliable Piston Engine?

Employing cryogenic technology, the Scott Crossfield Edition engine may be the most reliable in general aviation. • By Bill Cox

Those pilots privileged to know Scott Crossfield regarded him as one of aviation's most durable good guys. In a career that spanned some six decades, Scotty flew a little of everything, from the Wright Flyer to the X-15, and he somehow managed to survive them all.

Sadly, we lost Scott Crossfield in April 2006 to an inflight breakup in a Georgia thunderstorm, but not before he initiated development of the Crossfield Edition engine. Scotty lived every day of his 84 years, and much of that time was spent flying the world's most exotic rocket planes. At one point in the late 1950s, Crossfield had more rocket time than any other test pilot on Earth.

Scotty was more than just a talented test pilot, however. In his own words, he was first and foremost an engineer, and he regarded his flight test talents as secondary. Crossfield flew the X-1, X-4, X-5, XF-92, D-558-I and D-558-II before transitioning to the ultimate rocket research plane, the X-15.

Having flown at ridiculous speeds and altitudes (Scotty was the first man to exceed Mach 2.0 and the first to survive flying faster than Mach 3.0), Crossfield knew that everything from guitar strings, golf clubs and shotgun barrels to NASA test aircraft and spacecraft have been treated cryogenically to harden them for the rigors of their respective disciplines.

In the case of spacecraft, cryogenic treatment helps guard against high speeds, low pressure, high/low temperatures and other rigors of high altitude flight. Why couldn't piston aircraft engines benefit from the same process?

Enter Victor Sloan of Victor Engines in Palo Alto, California. Victor has been providing some of the world's most highly regarded, balanced, blueprinted piston mills for more than 30 years, with some customers even having their airplanes flown in from Europe for installation.

Crossfield had flown behind a Victor Black Edition engine in his Cessna 210A for several years. The engineer had great respect for Victor and felt a collaboration could produce a truly durable powerplant.

Of course, the first question is why cryogenics? If Crossfield was an expert on the subject, Victor wasn't unfamiliar with the concept. An avid motorcycle racer in his younger days, Sloan was conversant with most of the go-fast techniques in bike and auto racing, and he knew that NASCAR and NHRA teams had long been experimenting with cryogenic treatment to toughen brake and suspension systems, two of the most abused components in racing.

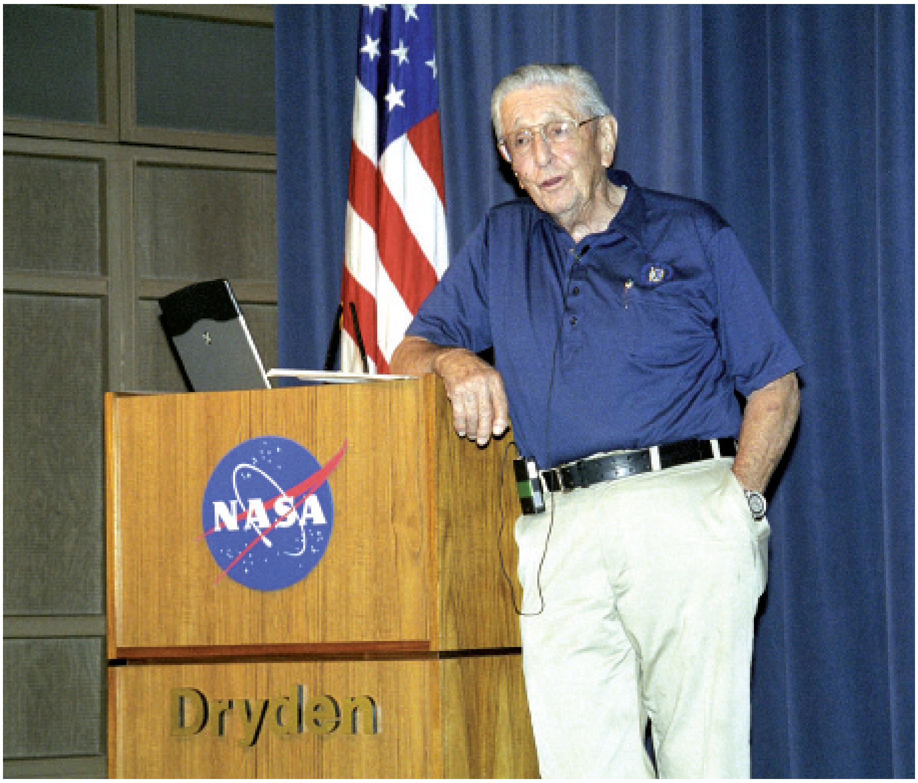
OK, so what exactly is cryogenic tempering? Cryogenic temperatures are typically those below -244 degrees F, well below mere "cold" treatment that demands only -125 degrees F. A typical cryogenic cycle includes placing the parts in an airtight cryonic chamber, gradually lowering the temperature using nitrogen, holding at -300 degrees F and then slowly returning the parts to room temperature. In some cases, a short tempering cycle completes the process. Cryogenic treatment typically requires 48 hours, 12 hours to bring the metal parts down to the proper temperature, 24 hours to cure and another 12 hours to bring them back to room temperature. It can demand up to 70 hours, depending upon the composition and amount of material to be treated.

The result of the treatment is a remarkable transformation of the molecular structure of the parts. In addition to relieving residual stresses within the metal and hardening the material exponentially, it's suspected of actually refining and realigning the crystalline structure of the metal.

The bottom line is a level of hardness otherwise uncommon in the engine overhaul business. An engine consists of a number of components, so tougher metal components alone are no guarantee against problems, but the cryogenic process definitely does harden the target.

Accordingly, Victor selected the most complex and powerful flat engine in general aviation, a Lycoming IO-720-A1A, as his test article for the Crossfield Edition cryogenic application. In general aviation terms, the 400 hp Lycoming is the peak of the pyramid with a flat engine. (There are a number of round engines with seven or more cylinders that produce more horsepower, but none remain in production. In the mid-'60s, Lycoming introduced the IO-720 as the ultimate piston mill, and even today, it's the most powerful horizontally-opposed powerplant available.)

For better or worse, the only production airplane to use the King Kong Lycoming was the PA-24 Comanche, perhaps the most hard core Piper ever to wear an N-number. There are a number of conversions – Aero Commander, Beech Queen Air – but Ted Smith Aerostar was the only other manufacture to experiment with a production model 800 that would have featured twin IO-720s. Smith dropped the project.



Scott Crossfield speaking at the Centennial of Flight Colloquium held at the NASA Dryden Flight Research Center in October, 2003. *Photo by Tom Tschida/NASA/courtesy of nasaimages.org.*

Ultimate speed and performance were the goals for the Comanche 400. The original Comanches of the mid-'60s were wide, comfortable machines, blessed with pleasant handling, a docile stall and reasonable economy. Despite what you may have heard about the invincible V-tail Bonanzas, the 250 and 260 hp Comanches weren't that far behind the Beech or the Bellanca 260, and they were about even with the four-seat Cessna 210. In the early 60s, all four airplanes used 260 hp engines to cruise in the 160-170 knot range.

No big surprise, then, that Piper elected to up the ante on the Comanche by employing weapons grade horsepower. In 1964, Piper mounted the monster, eight-cylinder, Lycoming on the nose of a Comanche to create the Comanche 400, producing what was, at the time, the fastest normally-aspirated production single in the world.

Though the king-sized engine is definitely more than a pair of four-cylinder, 200 hp, IO-360s welded together, it does offer a total of 720 cubic inches of displacement and 400 hp. Trouble is, more cylinders and horsepower are supposed to be anathema to reliability. Increase the number of moving parts inside an engine by 33 percent and you'll nearly always lower TBO and increase the incidence of premature failure.

Piper incorporated a number of changes to handle the big engine on the Comanche airframe. Most prominently, the tail was modified to increase rudder and elevator authority. There's essentially no commonality between the empennage on the lesser-powered Comanches and the 400.

The additional power also dictates that the 400's rudder be aerodynamically balanced in a manner similar to that of the Twin Comanche. Also, the Comanche 400 doesn't employ the lead external balance weights of the lower-powered single-engine Comanches.

Conversely, all the Comanche's fly above the same 36 foot span airfoil. The Comanche 400's fuselage is a foot longer

Photo courtesy of www.victor-aviation.com.

than the original Comanche 180s, but the airplanes have a startling resemblance parked side-by-side on the ramp.

Victor went looking for a Comanche 400 demonstrator for the Crossfield Edition engine and found one in the Midwest. A farmer in Des Moines, Iowa had a reasonably nice 400 parked in a barn adjacent to his private grass strip, Victor purchased it as was, relicensed it and flew it to California for a complete overhaul.

"The point of the Crossfield Edition isn't necessarily more power," Victor comments. "You can't legally produce more than rated power, anyway. But the exhaust system and all the accessories drain away some power, so we wanted an engine that would deliver the maximum allowable horsepower to the prop."

At a gross weight of 3600 pounds and with 400 horsepower on tap, the airplane enjoys a power loading of 9.0 pounds per horsepower, the lowest of any general aviation, production airplane outside the aerobatic category. Power loading isn't the only measure of takeoff acceleration, but it's one of the most important.

Flying from Victor Engine's home base of Palo Alto, California, with Sloan in the right seat and Pilot Peggy in back, the Comanche 400 left little doubt that it was not your grandfather's Comanche. To fly the finished Crossfield Edition demonstrator is to experience what seems a gradual tsunami of thrust.

Push the left knob to the wall, and the engine pulls like a team of rabid Malamutes. It's not exactly the same as dropping the clutch on a ZR1, but among four-place, cross country airplanes, it's an experience you're not liable to match.

Perhaps contrary to what you might expect, however, the Crossfield Comanche doesn't feel drunk with power. Acceleration does seem to go on and on as the Comanche seizes the bit in its teeth and inhales altitude with enthusiasm, but the Comanche 400 is easily manageable in the pattern.

In keeping with the airplane's considerable power, I used about 120 knots cruise climb and still scored an initial 1400 fpm uphill as we cleared the class B airspace to the west of Palo Alto and lofted out over the coastal hills into unrestricted airspace.

I saw 10,500 feet on the altimeter in a little under nine minutes. This is one airplane that's not dependent on a turbocharger for reasonable climb. The book spec for service ceiling suggests 19,500 feet, so there's plenty left at a typical cruise height.

The big question, of course, is cruise performance. The book number for 75 percent is 185 knots at 8000 feet. In 1964, that made the PA-24-400 the world's fastest normally-aspirated production single. Victor's Crossfield Edition Comanche generated more like 190 knots on the same power, though with only 40 hours on the tach, the new mill was just getting broken in. Sloan is confident he'll see another two or three knots of speed when the engine is running at optimum. An obvious benefit is that the Crossfield Comanche can generate the same horsepower at higher altitude, so better speed is almost a given in the thinner air.

Remember, however, that 75 percent of 400 hp is still 300 hp. Specific fuel consumption is fairly immutable, about .43 pounds/hp/hr. Do the math, and the result is about 22 gph, so the top Comanche isn't liable to win favor with the Sierra Club. That means the standard airplane's 100 gallon tanks are worth about 3+30 plus reserve. Tip tanks can add 15 gallons a side for a total of 130, worth about five hours endurance at max cruise.

As this is written, the Crossfield Edition Cryogenic Engine has seen less than 100 hours use in Victor Aviation's Comanche 400. Standard TBO is listed as 1800 hours. With the benefit of cryogenic tempering, logic suggests it should last considerably longer than that, perhaps well over 2000 hours.

If I'm still here when that time comes, I'll keep you informed.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