# Featured Article: Riveting Research

## From the Tech' Desk

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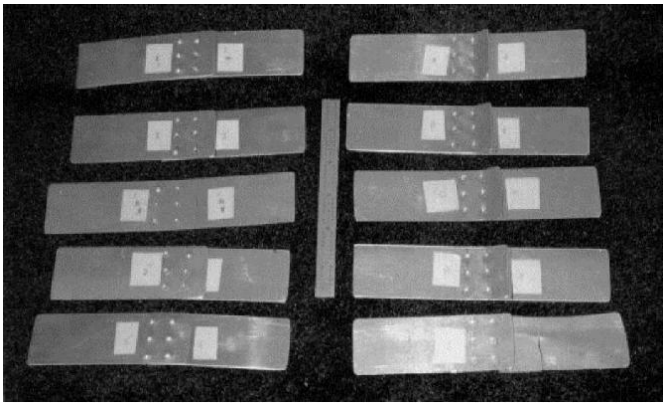
Two days ago I got around to doing something that I had planned last year -- actual pull tests on riveted aluminum coupons to see how critical it is to drive rivets to the correct height. All of us building . . . have had to wonder which imperfect rivets to drill out and which are OK. The answer is obvious when there is a severe cosmetic problem, but when strength is at issue, how much does a slightly under or over-driven rivet affect strength? How much does a grossly under or overdriven rivet affect it? Frankly, I had made the decision that the risk of damage from drilling out a flush rivet is greater than the benefit of doing so, unless an obvious cosmetic defect or really bad rivet is at issue. Now I have some hard data to go by.

What I did was to make up 10 test coupons. Each of these consisted of two pieces of .032 2024-T3 sheet 1.5 inches wide and 4 inches long. These two pieces were overlapped by 1.5 inches and riveted together with two parallel rows of 3 rivets each. Of the 10 total coupons, five involved the use of universal head AN 470 AD3 rivets and the other 5 used AN 426 AD3 flush rivets. In the latter case, both pieces of aluminum were dimpled at each rivet location, as is routinely done in Van's airplanes.



In fact, the coupon construction is similar to the double rivet line where the lower outboard wing skin overlaps the lower inboard wing skin. This joint is loaded in tension normally for positive G flight and gave me the idea to mimic it for the pull tests.

Before getting into the results, let me ask you a question. Please think about the answer before proceeding. Just how many pounds of force do you think it would take to destroy one of the sheets used in making up the coupons? Remember this is .032, 2024-T3 sheet 4 inches long and 1.5 inches wide with no holes or rivets in it. Think about grabbing and suspending it at one end with some sort of clamp across the entire 1.5 inch width and then hanging weights on the other end from another clamp. How much weight would it take to break this .032 inch thick sheet? Would a 100 pound set of barbells do it? A 500 pound set? A 1200 pound small car? A gross weight RV8 at 1800 pounds? A gross weight Grumman Tiger at 2400 pounds? More than that? Come up with some sort of gut feel before proceeding. I was surprised by the answer. You may or may not be, depending on your knowledge in this area.

Since some of you will cheat and read on, I'll hold the answer for a moment! Each of the 5 test coupons, both with the universal head rivets and the flush head rivets, was riveted to a different degree. One was grossly under driven, one was slightly under driven, one was correct per the rivet gauge, one was slightly over driven and the last was grossly over driven. The slightly under driven and slightly over driven rivets were such that you would probably need a rivet gauge to detect them -- I did this because I suspect that most of the rivets in our planes fall into this category. The grossly over and under driven rivets were really gross. The over driven were squashed nearly flat and the under driven were barely set at all. I did this to see just how poorly a joint make of this sort of gross error would hold up. You would easily see these and know there was a problem immediately. You'll find the results interesting.....

The idea was to put each coupon in a pull test machine and expose the riveted joint to a slowly increasing force until it yielded. This was done at a structural test lab in Paramount (a Southern CA city) that works mostly with civil engineering construction materials. A stress/strain graph was running and we monitored it to see the first indication of joint failure as indicated by a decrease in force required as the coupon stretched, cracked, broke in two, sheared or tipped rivets, etc. I was interested in the force required to cause the initial failure, as well as the nature and appearance of that initial failure; ie, what actually happened first. We agreed to stop the machine at the incipient indication of failure, thus preserving the coupon in its early failure state without destroying the joint completely. I was very curious as to how things would fail and really had no idea other than the thought that the dimpled, flush riveted joint would probably be stronger than the undimpled one with the 470 universal head rivets. In contrast, one of the owners of the lab came in to watch and thought the opposite would be true. In his 50 years in the business, he had never seen this test done. What do you think would hold best?

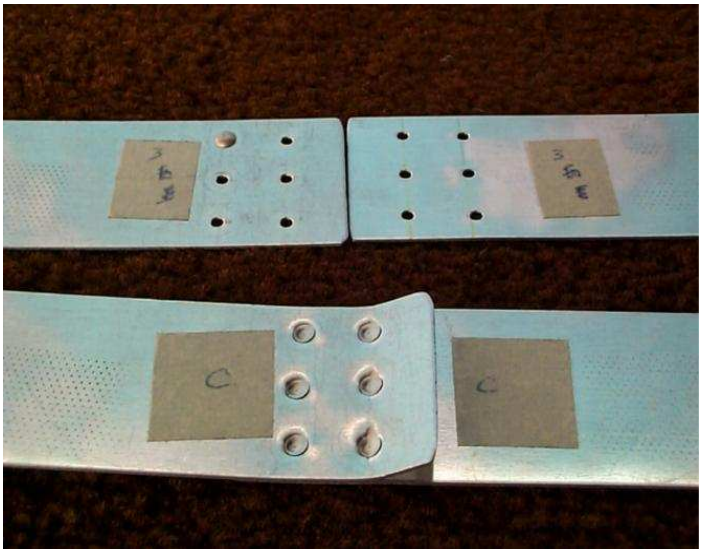
That said, here is the answer to my prior question. A force of 2300 pounds was required to break the test material with no rivets or holes in it. It failed catastrophically shortly after some initial stretching was noted. I had no idea that a cross section of this 2024 T3 sheet, .032 inches thick and 1.5 inches wide, would sustain anywhere near that load. Frankly, I was surprised when it passed 1000 pounds and still going strong.
Before showing you the numbers, I will give a brief summary of them:

1. The dimpled, flush riveted construction was stronger, but not by as much as I had thought. However, and this is really important, initial failure of the dimpled construction

# Riveting Research Continued...

was generally not catastrophic and occurred as rivet tipping and rivet head distortion. In contrast, initial failure of the AN 470 undimpled construction was generally catastrophic by rivet shear. I am really happy Van uses the flush riveted, double dimpled joints throughout most of the airplane!

2. Slightly under driving or slightly over driving a rivet makes an observable and thus measurable difference in the joint strength.
3. Slightly over driving is stronger than slightly under driving and results (in my opinion) in an insignificant difference in strength as compared to properly driven rivets.
4. In the one test of slightly over driven AN 470 rivets, the joint was actually stronger than with properly driven rivets. This may have just been the luck of the draw for this single sample, so I wouldn't put any real faith in it.
5. A joint made of grossly over driven rivets is stronger joint than a joint make of grossly under driven ones.
6. A grossly under driven AN 470 joint is much weaker than a grossly under driven AN 426 joint.
7. No joint was as strong as the parent material itself.



To summarize the summary, try for properly driven rivets but realize that minor over driving is preferable to minor under driving and results in nearly the same strength as does the condition of the properly driven rivets.

**AN 426 AD 3 Table**

| Condition | Force at failure | Nature of failure |
|---|---|---|
| Gross under | 1650 | Rivet tipping, head distortion |
| Slight under | 1775 | 23 |
| Correct | 2025 | Same |
| Slight over | 1975 | Same |
| Gross over | 1825 | Sheet tear at rivet line |

**AN 470 AD 3 Table**

| Condition | Force at failure | Nature of failure |
|---|---|---|
| Gross under | 1100 | Rivet tip plus one sheared rivet |
| Slight under | 1600 | 5 sheared rivets!! |
| Correct | 1625 | 6 sheared rivets! |
| Slight over | 1750 | 6 sheared rivets! |
| Gross over | 1500 | Rivet tip plus sheet tear at rivet line |

Anyway, those are some real numbers for an area we have undoubtedly thought about at one time or another. My opinion, FWIW: I think that an occasional rivet that is slightly under driven or slighlt over drive is utterly no big deal and can be safely ignored We all have some of these flying in formation in our airplanes. A line of them would be another matter. Even an occasionally grossly over driven rivet is probably OK, especially if getting rid of it would cause damage. And if under driven too much, just whack it again. Hope you learned something from this. I certainly did.

*. . try for properly driven rivets but realize that minor over driving is preferable to minor under driving and results in nearly the same strength as does the condition of properly driven rivets.*

# President's Message Continued...

systems, integrated with auto-pilot systems that can be controlled remotely from the ground; and the list goes on. The current bill has topped 1.4 million dollars Can.

Transport Canada requires a pressurized turbo-prop to have an approved manufacturer's maintenance and operating procedure. The manufacturer of this 4P (an amateur builder in the US), has no such thing. Today I learned that the Minister has rejected this aircraft's exemption. Someone may have a huge problem on their hands.

The outcome of this meeting was the unanimous decision to recommend to the Minister that a CARAC appointed working committee be set up to evaluate the initiation of a new class of non-certified aircraft that could accommodate just such an example. It can be argued that with the development of newer high-tech aircraft such as this and the Legend, Comp Air and Comp Air Jet, the Epic and Epic Jet, the amateur-built class no longer fits. If a person wishes to build the 4P example above as a homebuilt, (providing he fulfills the intent and Rules of the Amateur-built class), he could do so. On the other hand, if he wanted to have the same aircraft presented to him without his involvement in manufacture, he could do so in this new non-certified classification. This latter case would no doubt require ongoing airworthiness to fall into the A & P category.

The added benefit to this 'new classification' approach is the concept of keeping the Amateur-built aircraft class "pure". Amateur aircraft have evolved phenomenally since our first tube and fabric, and wooden homebuilts, of the 1950's. Nevertheless our freedoms remain precious, and the 'non-commercial, 51% major-portion' rule is our mitigating defense against liability, both for the builder and the kit sup-