

# A Stronger Weld

## Research shows what to consider when welding 4130

**Ron Alexander and Scott Helzer**

Last month we described an experiment to determine ways to maximize the strength of a weld involving 4130 chromoly tubing. The research questions addressed in this study were grouped into three general categories of process, filler, and post-weld heat treatment.

For the welding process, we wanted to determine which process is the best. We wanted to determine whether there are significant differences in the part performance from different welding processes. We also wanted to consider which process would be easiest for an amateur welder to use with success.

When considering which filler material is the best, we wanted to see if there were significant differences in part performance with different fillers, as well as what filler material would be easiest for an amateur to use.

Next we looked at pre- and post-weld heat treatment. We wanted to know if pre-heat is required or if post-weld heat treatment is required. If so, we wanted to know how much was required and for how long. The bottom line is whether pre- or post-weld heat would create

a difference in the final weldment.

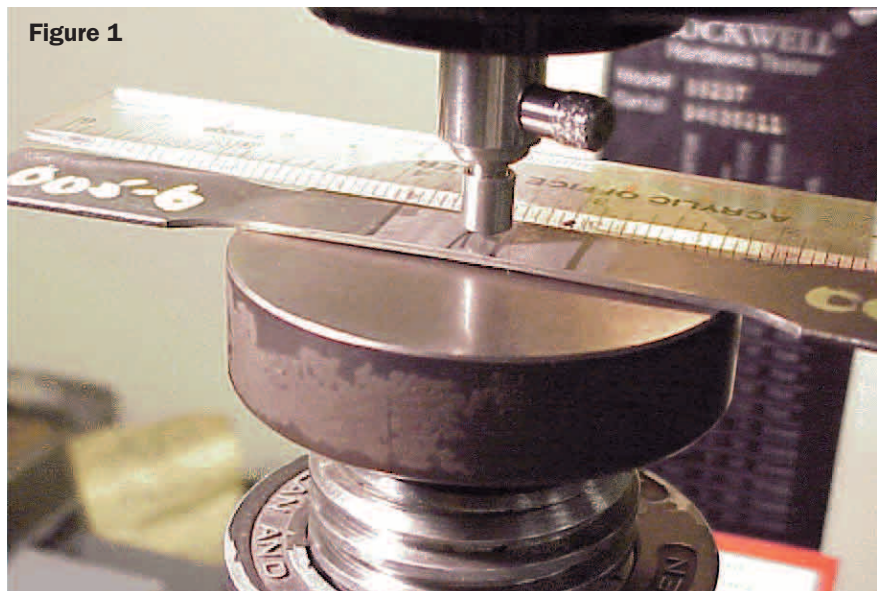
We carried out a program of testing under controlled conditions. No attempt was made to compare the results of using flat specimens to tube-type connections. The outcomes are intended as a base line reference to further the work in tube connections, but the base line of materials, processes, and filler metals needs to be conducted to examine interactions of the three primary variables. Further considerations included stress-

relieved and non-stress-relieved test coupons to determine the effectiveness of the process.

### How the Study Worked

This study is limited to the testing of 4130 steel in the flat position, with the process and filler metals listed. Test specimens were prepared and welded by certified personnel under the prescribed conditions. Test specimens from the same group of weldments were alternately stress-relieved and not stress-relieved to

**Figure 1**



examine the effectiveness of the post-weld heat treatment. Tests were conducted on certificated machines in a manner consistent with industry practice. No other thicknesses of material were tested other than .050-inch material.

The samples were prepared and tested for hardness in the base metal, in the heat-affected zone, in the weld metal, in the heat-affected

zone on the other side, and lastly in the unaffected base, as shown in Figure 1.

The hardness test that was used was the Rockwell hardness test on the "A" scale. Hardness and tensile strengths are relational, and so it is possible to draw some estimates about tensile strengths from the hardness values. Hardness and brittleness are also loosely correlated

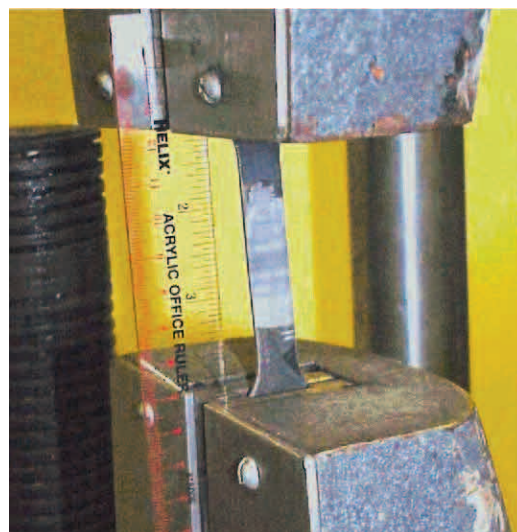


Figure 2

to each other in that as hardness increases so does brittleness. Brittle failures in welds are fast-opening displacements with little warning of failure until fracture has occurred.

The test coupons used in the project were prepared as follows. After the materials were procured, we sheared the coupons and machined the sheared edges. The coupons were pre-cleaned. We then welded the coupons and stress-relieved the selected coupons.

After welding them, we visually inspected the welds, photographed the coupons, and began the testing regimen.

The tensile specimens that were pulled were pulled transverse to the weld in what is known as a flat bar specimen as shown in Figure 2. The tensile strength was then calculated by dividing the load in pounds by the area of the specimen in square inches, thus the final units of pounds of loading per square inch, or PSI.

Lastly, the tensile specimens once broken were measured to see how much they stretched or elongated before they fractured or broke. This was done by using a gauge length of 1 inch and then measuring the final gauge length when the tensile is complete as shown in Figure 3, expressed as percentage elongation.



## Answer: Yes you do!\*

\* Question: Do I need one of these?  
Find out why at:  
[www.ellison-tbi.com](http://www.ellison-tbi.com)

**ELLISON**  
*Carburetors You Can Bank On!*

Ellison Fluid Systems Inc. • 350 Airport Way • Renton, WA 98055 • 425-271-3220

# FREE Catalog!

# FREE Cash!

# FREE Call!



## \$5 OFF

Any Order

Hurry! Call **1-800-248-0638** We'll rush you a Free \$5.00 gift certificate and a brand new **Aircraft Tool Supply Catalog** stuffed with over 3500 essential aircraft items and tools. Your Free Cash is good on any size order from our catalog or website at [www.aircraft-tool.com](http://www.aircraft-tool.com).

**Over 3500 Essential Aircraft Items & Tools Plus...**

- Free UPS Ground Shipping on all Orders Over \$100
- Free Aircraft Technical Support
- Life Time Guarantee on all Hand Tools
- Same Day Shipping

**Do it Now! Call 1-800-248-0638**



**AIRCRAFT TOOL SUPPLY**

The program of testing was carried out under controlled conditions. No attempt was made to compare the results of using flat specimens to tube-type connections. The outcomes are intended as a base line reference to further the work in tube connections, but the base line of materials, processes, and filler metals needs to be conducted to examine interactions of the three primary variables. Further considerations included examining whether stress-relieving the coupons was a useful and effective process.

It should be noted that the tests used for the coupon evaluation are relative in and unto the specimens themselves only. First, hardness tests are relative to the material and the weld being tested. When testing the weld, it should be acknowledged that the weld metal does not generally yield, as does the base. So discussing yield of the tensile coupons and elongation is not relevant for the comparison of base metal tensile and elongation in the final weldment.

There is no best method of welding. All of the processes tested could be used to weld chromoly for the tests as conducted. Certain processes are easier to learn, some are more forgiving, others are cleaner, and still others are more advanced technically. We do not consider any one method "best" because the best weld is often the result of a process you already own, or the process that you already are proficient at.

If there is a preferred combination to be put forward for consideration, it would be to use TIG welding with a power source that exhibited a stable and smooth arc that would "light off" at low amperages with a small diameter tungsten and that would be user friendly to set up. The torch body would be small and flexible with light cables and small diameter gas nozzles, so the welder could manipulate the arc and see the puddle. Lastly, the filler


would be easy to manipulate and flow into the puddle with a quiet addition into the puddle so that the integration of base and filler had little or no turbulence.

### Recommendations

For filler metal, we found the hand-fed processes of GTAW (TIG) and OFW (gas welding) were most

compatible with the filler ER-80-S-D2. ER-80-S-D2 developed strengths approaching that of the base metal, with a minimum amount of turbulence as the molten filler entered the arc.

RG-45 and the RG-60 produced welds that fell outside the parameters of acceptability for welding on 4130. The RG series of filler materials lack



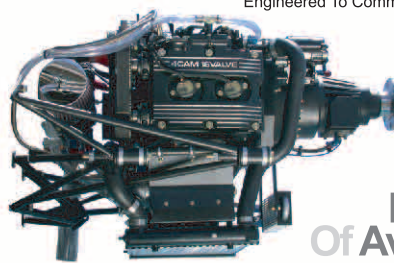
T 519.925.5255      713 Industrial Road  
F 519.925.5633      Shelburne | Ontario  
E info@crossflow.com      Canada | L0N 1S4  
i www.crossflow.com

Engineered To Command The Skies™

## High Performance Aviation Solutions

Offering a suite of high performance aviation products and services for kitplane applications in the 200hp - 350hp range.

> [www.crossflow.com](http://www.crossflow.com)





## The Future Of Aviation

Q

Quality, Service, Experience =

**The NEW DUATS Golden Eagle FlightPrep® Software**

CSC DUATS along with Stenbock and Everson FlightPrep® bring you a powerful new flight planning, filing and weather briefing tool. The new DUATS Golden Eagle FlightPrep® software has these features:


- Flight planning using Relief or IFR Charts
- NEXRAD Overlay on both Relief and IFR Chart
- Graphical TFRs on both Relief and IFR Chart
- 8 Zoom levels
- Navigational overlay information selectable by Zoom Level. This includes:
  - VORS      – AIRPORTS      – SUA
  - Obstructions      – CLASS B, C, D, and E Airspace
  - INTERSECTIONS/AIRWAYS
- Lat/Long Easy locator on charts
- Radial/DME Pointer
- DUATS Weather Briefings
  - Standard      – Outlook      – Abbreviated
- DUATS Flight Planner and Filing
- Golden Eagle FlightPrep® Offline Flight Planner

DUATS Technical Support and  
Order Line: 1.800.345.3828 by  
e-mail [duats@duats.com](mailto:duats@duats.com)

[www.duats.com](http://www.duats.com)

Computer Sciences Corporation  
Federal Sector  
15000 Conference Center Drive  
Chantilly, VA 20151-3808

CSC.COM    CONSULTING    SYSTEMS INTEGRATION    OUTSOURCING



EXPERIENCE. RESULTS.

the strength to be compatible with the base material.

For processes, as mentioned above, we found that any of the processes could be used to weld 4130. However, there are certain processes that could be construed as having preferred characteristics. One of the desires of welding is that the base and filler metal combinations “match” so that minute amounts of the base material are thermally affected.

**Figure 3**



All of the processes produced acceptable welds for the applications

of amateur aircraft building.

When we looked at post-weld heat treatment, we found that it did make a difference in the controlled experiment as conducted. However, in practice the oxy fuel rosebud heating tip—or worse yet a cutting torch—is many times employed as the heating source. These may or may not be adjusted to a neutral flame, and the heat may or may not be applied evenly. That means they may or may not produce the desired reduction in hardness and the increase in toughness and ductility.

As an aside, consider that all metallurgical reactions are dependent on time and temperature. The complex carbides that form in chromoly steels are difficult to disassociate and dissolve. If there were only an average four-point reduction in hardness in 25 minutes at 1,025° F, it is doubtful that oxy fuel will have a significant affect in the 5-7 minutes that it takes to heat the joint to a dull cherry red.

In the end, it's your project with your body strapped into it, whether it's a plane, roll cage, or a glider. Practice welding before you begin the project. Develop welding procedure specifications like the ones in this article. You could even consider having an AWS certified welding inspector look at your welds or have an independent testing lab destructively test some of your best practice welds.

It's up to you to decide how you will demonstrate that you are qualified to produce the welds in your project. It's also up to you to make sure you can reliably produce welds that make your project as safe as it can be.



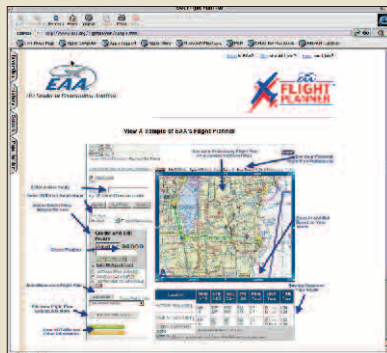
## INTRODUCING EAA Flight Planner™

EAA, in an agreement with AeroPlanner.com, is pleased to announce an exciting new Membership benefit for EAA Members...**EAA Flight Planner**. Take advantage of the newest Member benefit by heading over to [www.eaa.org](http://www.eaa.org). Click on the “Register Now” link, get registered, and log onto Flight Planner to plan your next flight.



### FREE FOR EAA MEMBERS EAA Flight Planner:

- Files, stores and retrieves your flight plans with or without DUATS
- View and print IFR approach plates
- Displays your flight plan on an interactive sectional map
- Provides a flight planning “Wizard” for more flexibility
- “Auto-route” based on your preferences
- Checks NOTAMs, TFRs and MOAs along your route
- Checks weather along your route
- Calculates weight and balance
- Stores multiple aircraft profiles



**Maximize Your Membership...  
Check Out the EAA Flight Planner  
at [www.eaa.org](http://www.eaa.org) Today!**