

# S51D Builder's Guide

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## Foreword

Congratulations in joining the community of S-51D builders! I think you will find that for the most part the quality, fit and finish of your kit is excellent. Of course there are still a few things that could be improved. These will be pointed out as they arise in the construction sequence.

The primary purpose of this manuscript is to guide builders around problems which frequently arise during construction. This includes a recommended construction sequence which should prevent you from "riveting yourself into a corner". In some cases suggestions are made as to the tools that work best for various tasks, how best to hold or clamp pieces during assembly, sources are suggested for parts not furnished with the kit, etc. There are a few areas in which builders frequently misinterpret the plans. These are also identified.

There are probably as many ways of assembling S51 kits as there are builders. What follows is based on my experience, as aided by conversations with Jim and Jerry at Stewart 51 and with other builders. I cannot say that the individual procedures described represent the best way of accomplishing the assembly, simply that they seem satisfactory to me. My observations indicate that the experience and expertise of S51 builders vary widely. In reading the following, the experienced builder will no doubt find obvious points belabored at times. On the other hand, the narrative assumes a knowledge of basic metal fabrication techniques (riveting, etc) that the novice may not have. Nevertheless, I hope everyone will find enough useful information to make the experience worthwhile.

This outline applies to a pop-rivet kit with added auxiliary tanks. It is based primarily on my experience with kit #162, most of which was fabricated in late 1997. I know that some earlier kits are missing some features incorporated in this one, particularly some of the access holes in wing ribs. Some of these are absolutely necessary if you are to successfully follow the order given in the following narrative. Presumably they can be cut in the earlier kits. On the other hand, some of the recommended modifications to my kit are standard in those now manufactured.

The assembly sequence outlined below is mostly from memory. I'm not guaranteeing it is correct and of course take no responsibility for any problems it might cause you if you follow it. *This outline is not a substitute for thinking ahead, studying the plans or seeking advise where necessary from Jim or your local S51 wizard.* In my experience Jim is very happy answer questions on assembly of the kit, so if in doubt by all means ask. For obvious reasons he is less willing to entertain questions regarding structural modifications. Nevertheless, if you are contemplating such, you really owe it to yourself to keep him informed.

By way of background, this is the first aircraft I've built. I have done quite a bit of maintenance on aircraft, however, and have a fair amount of machine shop experience. My experience with sheet metal is limited to a few practice projects I did while waiting for the kit to arrive. I have ready access to a couple of well equipped machine shops, and have found this to be very helpful if not absolutely necessary. If the following narrative sounds academic, it's because I'm a mechanical engineering professor.

## "Improvements"

Probably every kitplane builder that ever lived has incorporated some "improvements" into his project. You are urged to think carefully before you do so. A great deal of effort, expertise and experience went into the S51 design, and the reason that some things were done as they are may not be obvious. As an example, consider the flap torque tube assembly.

The second kitbuilt S51 suffered a sudden retraction of the flaps when on approach to landing. The airspeed at which this occurred is not known. Although disconcerting to the relatively inexperienced pilot, the landing was completed normally.

The flaps on the S51 are actuated by a screwjack attached to a torque tube mounted on the front of the rear seat. The torque tube has three arms welded to it; one on each end for the individual flap push-pull tubes and one towards the middle for the screwjack. This particular problem was caused by the failure of the weld that secured the screwjack arm. Consequently, both flaps retracted to the full up position.

It is tempting to "improve" the design by strengthening this weld. What, if anything, is wrong with this?

Every mechanical assembly will fail if enough force is put on it. This occurs at the weakest point. One design consideration is what will happen as the result of this failure. In this case weakest point was the screwjack lever arm, which was designed to withstand the force exerted at the maximum recommended flap speed. Suppose you decide to strengthen this part of the assembly. Now some other part, perhaps one of the end levers, becomes the weakest point. Failure of this "improved" assembly would result in a split flap condition. Which would you rather deal with?

This example illustrates how strengthening one part of an assembly can make it possible to overstress a more critical part, with more severe consequences. So, we urge you to think carefully before you improve. Better yet, check with the designer, who has probably already thought about it!

## Order of construction

In this manual, we discuss the wing construction first, then the fuselage, and finally those tasks that can be accomplished only after the wings and fuselage are mated. Of course the order of construction is up to you. Many builders choose to tackle the fuselage first. In making your decision, the following observations may be of help:

- The wings go together much faster than the fuselage, primarily because you need do no metal forming and only a little trimming. Unless you are adding auxiliary tanks, you just ream out the holes, deburr and prime, then countersink and install AN rivets. You do have to install fuel fittings, and of course sealing the tanks is not the most pleasant of tasks. On the other hand, a lot of systems must be installed in the fuselage before you can complete the riveting. This is quite time consuming. The radiator scoop and cowling require considerable fitting and trimming, and you will have to do some metal forming on the cowl and canopy skirt. All in all, you can ex-

pect to spend 2-4 times as long to complete the fuselage as the wings.

- The thinner the skin, the more any riveting errors will show. The skin thickness on the wings ranges from 0.040 to 0.063". The fuselage skin is mostly 0.040", and the control surfaces are mostly 0.025". Unless you are an experienced riveter, it is not a good idea to start on the control surfaces. They are by far the most difficult to do a good job on.
- If you store the completed wings in the original crate, they take up far less floor space than the fuselage. The (unmated) wings are short enough to easily be stored in a garage. The fuselage with engine mount and cowl installed will be too long to fit in many garages.
- Most of the extra cost items go in the fuselage. These include instruments and avionics, circuit breakers, oxygen system, etc. It makes sense to postpone these purchases as long as possible.

## Updates

This manuscript is reformatted from its electronic form, which for a time was freely available via the world wide web. It is no longer distributed over the web. In the present version a few changes have been made and many typos fixed, but basically it's pretty much the same as the earlier version.

In some cases you will find that the printed pictures are too small to show as much detail as you would like. Those of you with computers who are reading this from a CD are in luck. The graphics are actually stored in full resolution, and will appear clearer when you zoom in on the area of interest.

Updating this guide takes a significant amount of work, and is therefore done irregularly. It is not unusual for the design of some components to change between updates, either to improve the part or to simplify its manufacture. So, if your parts do not suffer from some of the problems described here, it's probably because the design has been fixed.

## Distribution

This copyrighted document is intended for S-51D builders. As a builder, you may copy it for your own use and to provide copies to others, however no part of it may be sold or used for any commercial purpose.

## Disclaimer

In proceeding further, you should understand that the information provided is not approved by Stewart 51, Inc. *As the aircraft manufacturer, you should review all of the suggested procedures critically before use, and must accept sole responsibility for the outcome.* Jim Stewart remains the most authoritative source of information regarding the airframe. He can be contacted at (516) 778-0051 and is happy to answer questions from builders. We urge you to utilize this resource. Powerplant, cooling and fuel systems questions should be directed to PAE.

I originally wrote this guide as a service to S51D builders. Although it is now distributed by PAE, they are not in a position to vouch for each and every statement in it. I myself disclaim any special expertise in building aircraft or responsibility for any problems resulting from the use of the following procedures. Now on to the interesting part!