

Chapter 7 Aileron Controls

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7.1 Introduction

In this chapter you will complete the aileron controls, all of which is installed inside the fuselage. This includes all the sub-assemblies to connect the control stick to the aileron pushrod that exits the wing. Then in Chapter 8 the elevator connection to the control stick is installed. At the end of Chapter 8 you will check the aileron travel and the elevator controls.

Steps to Completion

- Build and install the forward bellcrank support.
- Install the inboard bellcrank.
- Create a hole in the fuselage for the wing’s aileron pushrod.
- Install the forward support for the aileron torque tube.
- Install the aileron torque tube.
- Connect the inboard bellcranks to the aileron pushrods.
- Make and install the aileron torque tube/inboard bellcrank pushrod.
- Make and install the aileron crossover pushrod.
- Install the control sticks.
- Install the control stops.
- How to rig the ailerons.

Caution!

Always perform the pre-fits that are recommended.
Before you start this chapter the following must be completed:

- Wings

A Word about Sanding and Cleaning

The instructions in this chapter refer to preparing a surface or preparing a bonding area. When we recommend preparing a surface or a bonding area, we expect each of the following steps to be completed every time.

1. Sand the area using 40-grit sandpaper.
2. Vacuum all sanded areas.
3. Clean all sanded surfaces with Acetone.

7.2 Parts List

Blueprints needed for this chapter include:

- 3502 – Inboard aileron bellcrank installation
- 3503 – Torque tube installation

Aileron torque tube assembly

Item	Part Number	QTY	Description
1)	AL407	4	Bearing block support
2)	4080	2	Control stick support
3)	3203-01	1	Left torque tube
4)	3203-02	1	Right torque tube
5)	AN3-6A	8	Bolts
6)	AN960-10	8	Washers
7)	AN365-1032A	8	Locknuts (for securing bearing block support)
8)	AN365-428A	4	Locknuts (for securing torque tube in place)

Inboard bellcrank

Item	Part Number	QTY	Description
1)	3207	2	Aileron inboard bellcrank
2)	GM468	4	Spacers
3)	AN4-37A	2	Bolts
4)	AN960-416	4	Washers
5)	AN365-428A	2	Locknuts

Aileron pushrods

Item	Part Number	QTY	Description
1)	3202A	1	Stainless steel tube
2)	AL3201	4	Rod ends
3)	AN316-4	4	Checknuts

Aileron pushrods (Continued)

Item	Part Number	QTY	Description
4)	F34-14	4	Rod end bearings
5)	AN470AD4-12	8	Rivets
6)	6061-875-057	1	Aileron crossover tube
7)	057-03	4	Rod ends
8)	AN316-6	4	Checknuts
9)	MD35-14M (MD36-14)	4	Rod end bearings
10)	AN470AD4-20	8	Rivets
11)	AN3-10A	8	Bolts
12)	AN960-10	8	Washers
13)	AN365-1032A	8	Locknuts

Control stick

Item	Part Number	QTY	Description
1)	CS401	2	Control stick
2)	AN4-16	2	Bolts
3)	AN960-416	4	Washers
4)	AN310-4	2	Castle nuts
5)	MS24665-151	2	Cotter pins
6)	301-09	1	Aluminum plate .063 x 4 1/2" x 3"



7.3 Construction Procedures

First you will install the forward bellcrank support and the bellcrank. This bellcrank is where the aileron pushrod from the wing connects into the control system in the fuselage. As a part of this installation, you will need to temporarily install the wings and cut openings in the fuselage for the aileron pushrod to enter.

Then you will complete one assembly:

- Two, a right and a left, aileron torque tubes with the control sticks. The left and right sides are identical except for the aileron torque tube. See Figure 7.3.0.1.

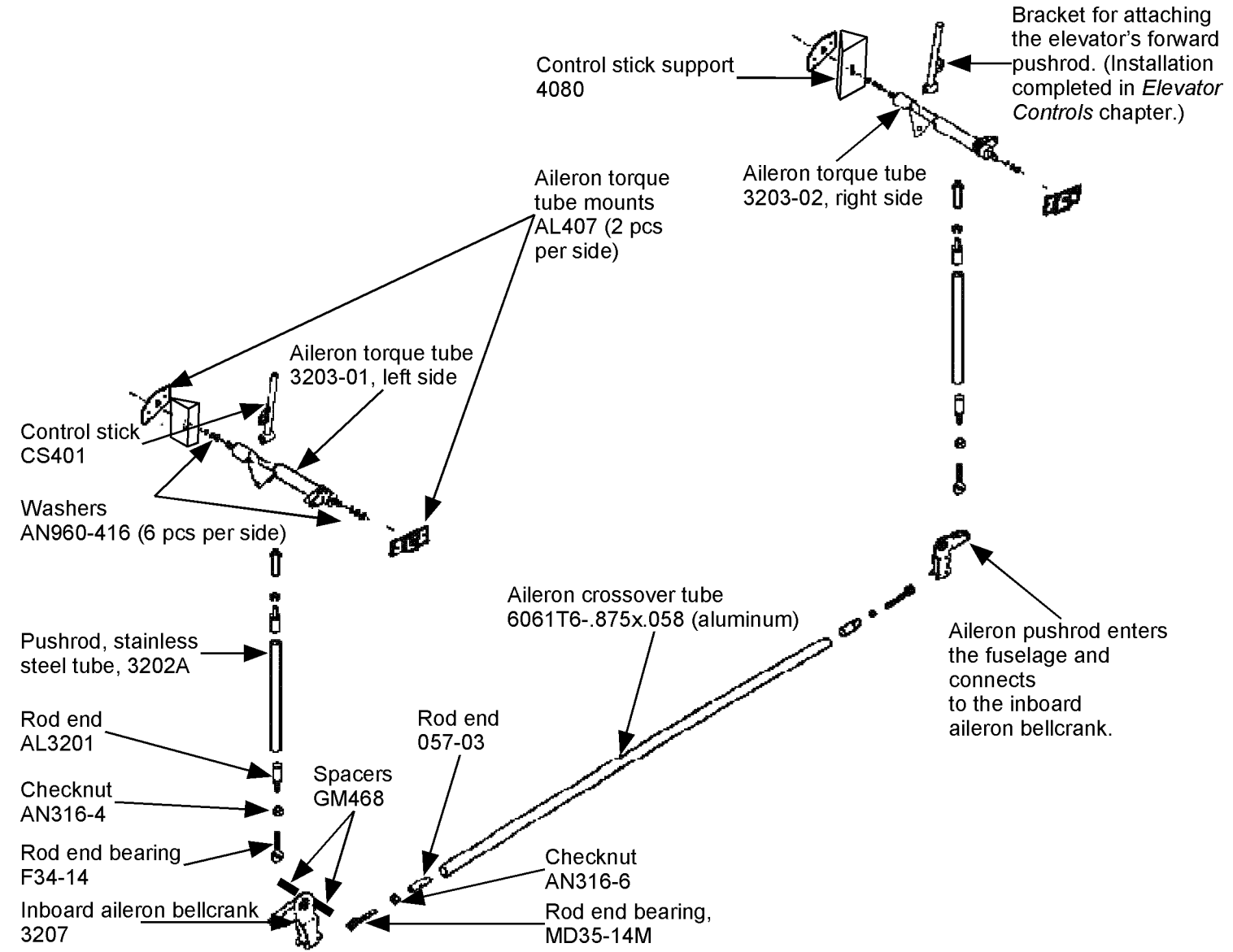
You will make two pushrods from stainless steel tubing and one from aluminum tubing. Then you will assemble all the bearing rod ends. The pushrod assemblies are:

- Two forward pushrods that connect the aileron torque tube to the bellcrank. See part 3202A in Figure 7.3.0.1.
- One pushrod, the aileron crossover tube, that runs between the bellcranks.

The following connections are temporary:

- Aileron pushrod to the inboard aileron bellcrank – connect this only while you have the wing in place.

Figure 7.3.0.1 Overview of the aileron controls



7.3.A Installing the Inboard Bellcrank

As the aileron pushrod enters the fuselage, it connects to the inboard aileron bellcrank. The inboard bellcrank is a pre-assembled item, like the outboard bellcrank (mounted to the BL 145.5 rib).

The inboard bellcrank is supported by the forward bulkhead and a bellcrank support, which you need to make and install. Refer to blueprint 3502 for this section.

Steps...

1. Cut the inboard aileron bellcrank supports out of a 2 PPS 1/4" (6 mm) thick prepreg panel.

Use blueprint 3502 and fit the pattern to your airplane before you cut the prepreg. You have been supplied with two copies of blueprint 3502 so you can make a pattern for both sides of the fuselage.

2. Remove the laminate and core from the forward side as shown in Figure 7.3.A.1.

Now the support will tend to curl in the area where the laminate and core has been removed. To ensure that the support is straight, glue a piece of wood to the aft face of the support. After you have reinforced the bellcrank support with the 5-BID, remove the wood support and you should have a straight support.

3. Prepare the bonding surfaces for the 5-BID reinforcement.
4. Reinforce the forward side of the bellcrank support with 5-BID as shown in Figure 7.3.A.2. Overlap the BID 1" (25 mm) onto the original laminate.

Figure 7.3.A.1 Aileron bellcrank support

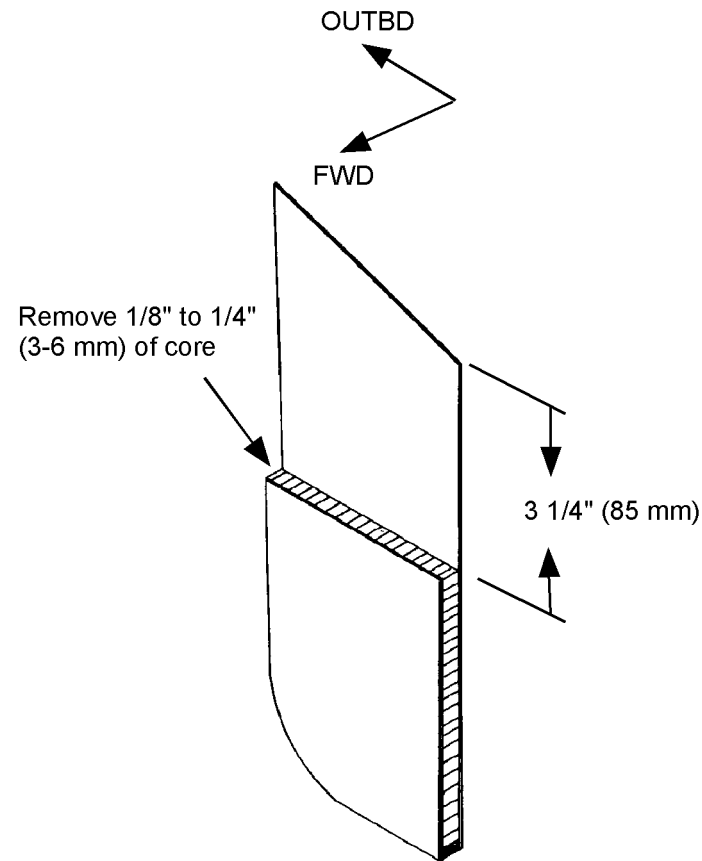
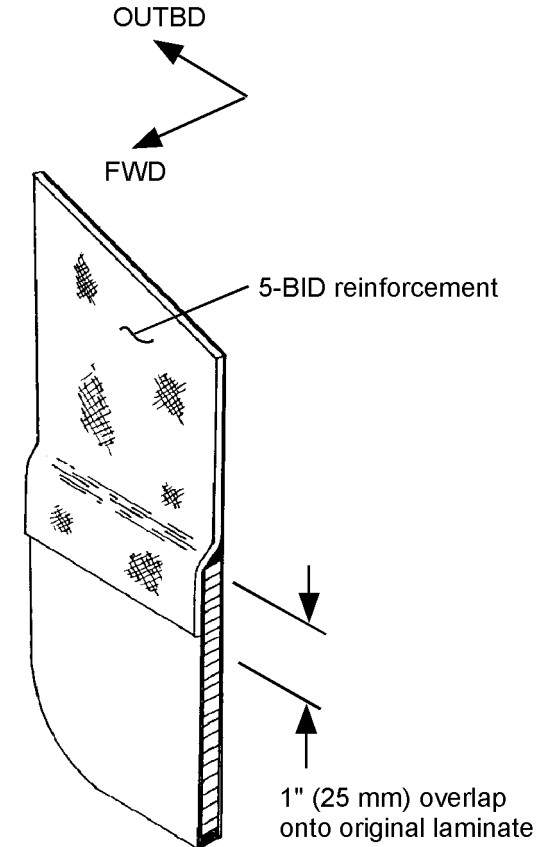


Figure 7.3.A.2 5-BID reinforcement to decored bellcrank support



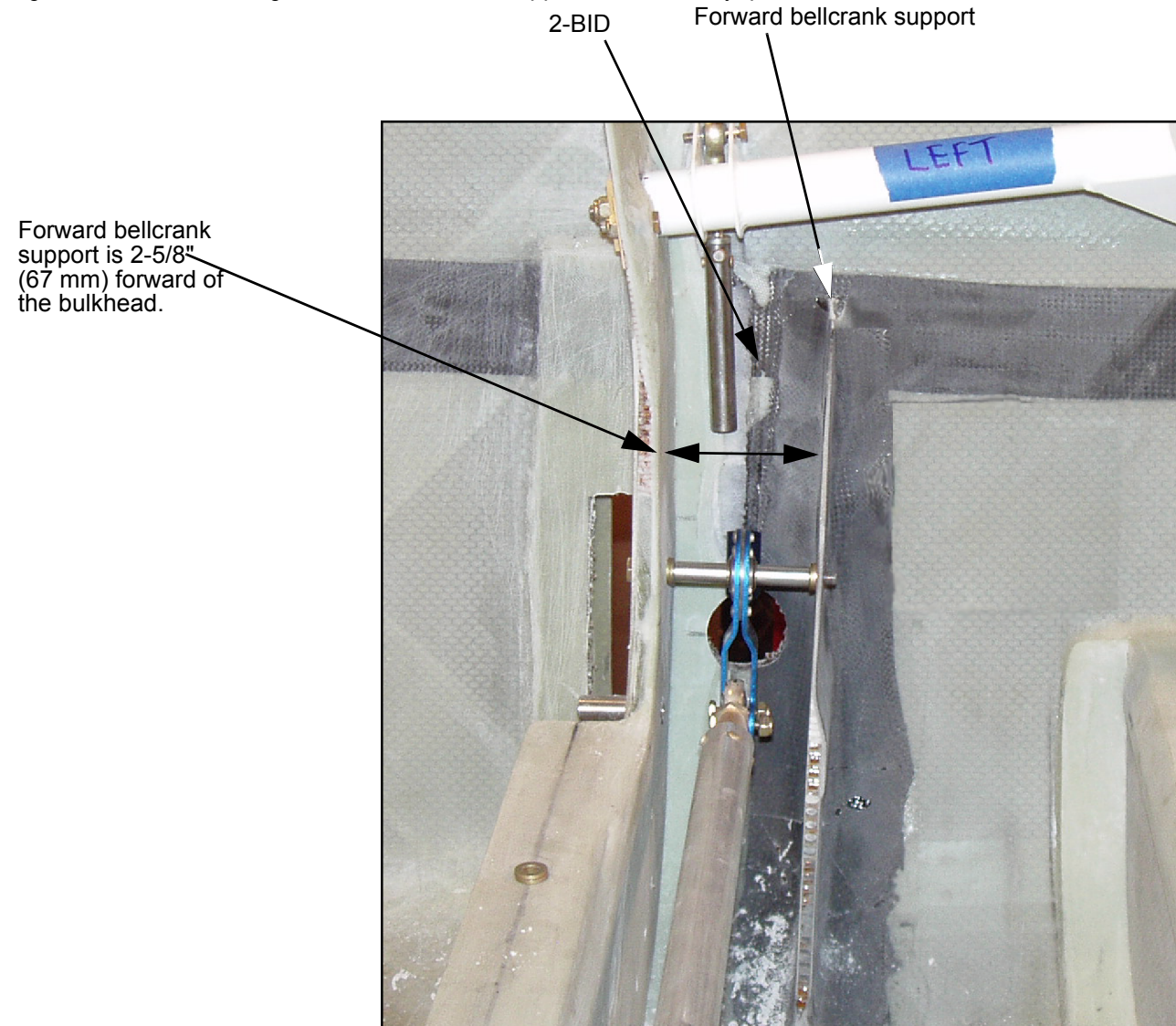
5. Remove 1/8-1/4" (3-6 mm) of core around the perimeter of the support.
6. Locate the forward bellcrank supports 2-5/8" (67 mm) forward of the bulkhead.
This spacing is important in order for the bellcrank to fit. The bellcrank support must be parallel to the bulkhead.
7. Prepare all the bonding surfaces for installation of the forward bellcrank support.
8. Pot the bellcrank supports in place with a thick epoxy/micro mixture.
9. Form micro radii between the fuselage and the support.
10. Secure the support to the fuselage with 2-BID as shown in Figure 7.3.A.3.

The 2-BID covers the entire face of the support in the area where you removed the core. All other areas are reinforced with 2" (50 mm) wide 2-BID.

Locating the Aileron Opening and the Bolt Hole

1. Slide the wing into position if you have not already.
2. Using the inboard end of the wing as the pattern, mark the fuselage for the aileron pushrod opening.

Figure 7.3.A.3 Positioning of forward bellcrank support and 2-BID layup



3. Cut the holes in the fuselage. See Figure 7.3.A.5. Start the hole small and align with the other side using a straight rod and a level.
4. Center the pushrod in the opening of the new hole and hold the bellcrank (3207) in position. Simulate the movement the bellcrank will make and verify it clears the side of the fuselage.
5. Slide a bolt (AN4-37A) through the bellcrank and mark the bolt's location on the bulkhead using the following positioning goals:
 - 2.5" above the wing bolt
 - as far outboard as possible
 Also refer to Figure 7.3.A.4 for dimension guidelines.

Figure 7.3.A.4 Bulkhead dimensions to locate the bellcrank bolt

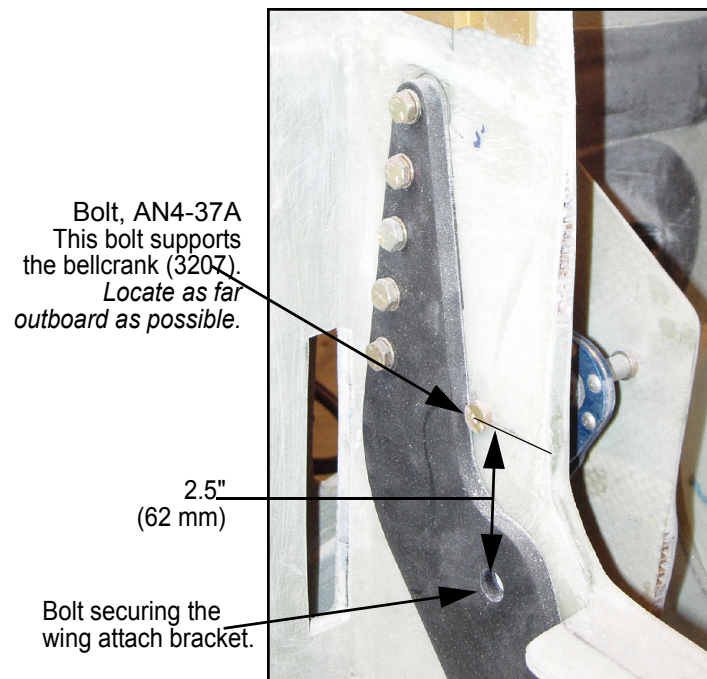
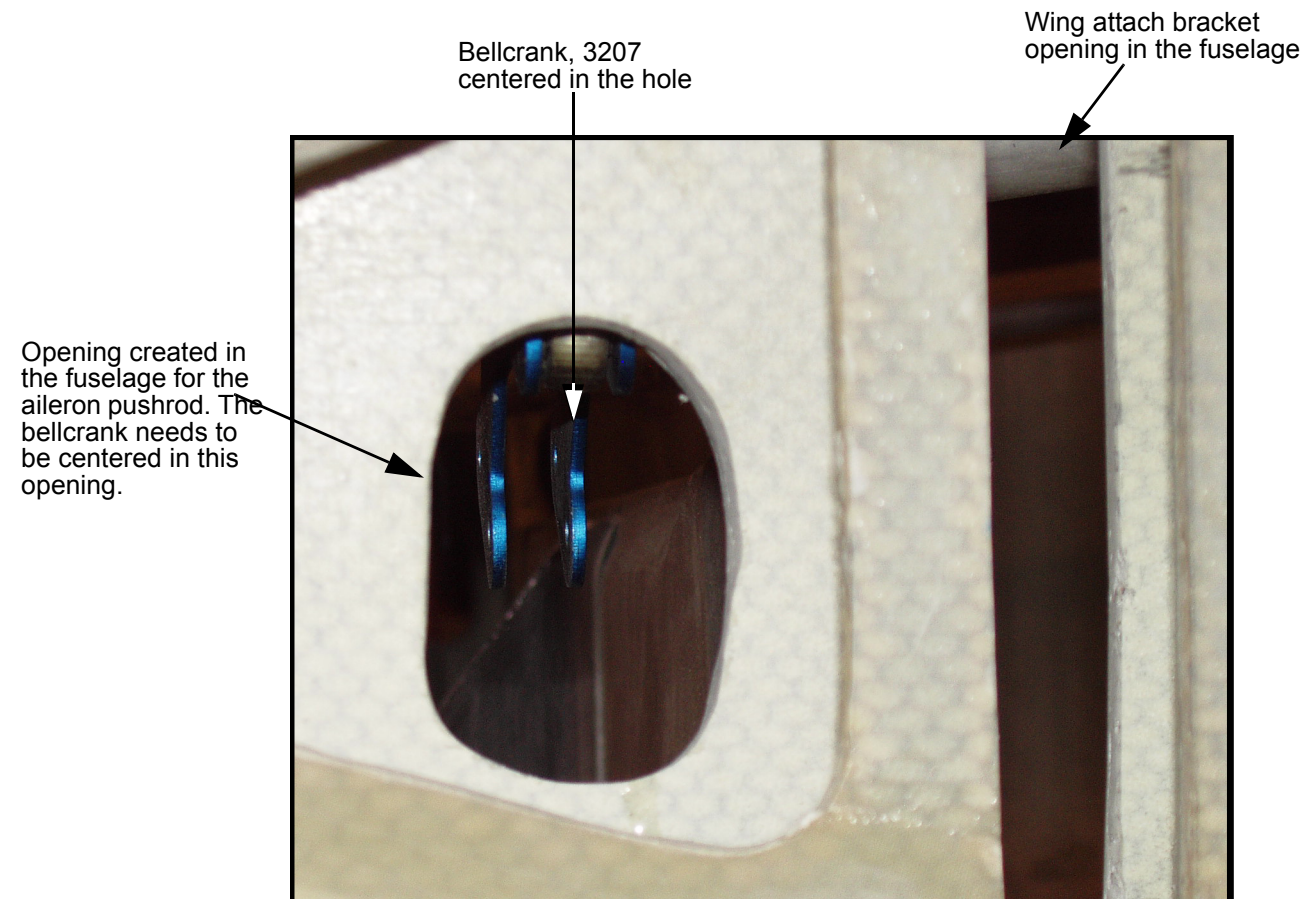


Figure 7.3.A.5 Opening in the fuselage for the aileron pushrod



6. Drill a hole in the bulkhead at the marked location. Verify the following positioning of the bellcrank before drilling the hole:

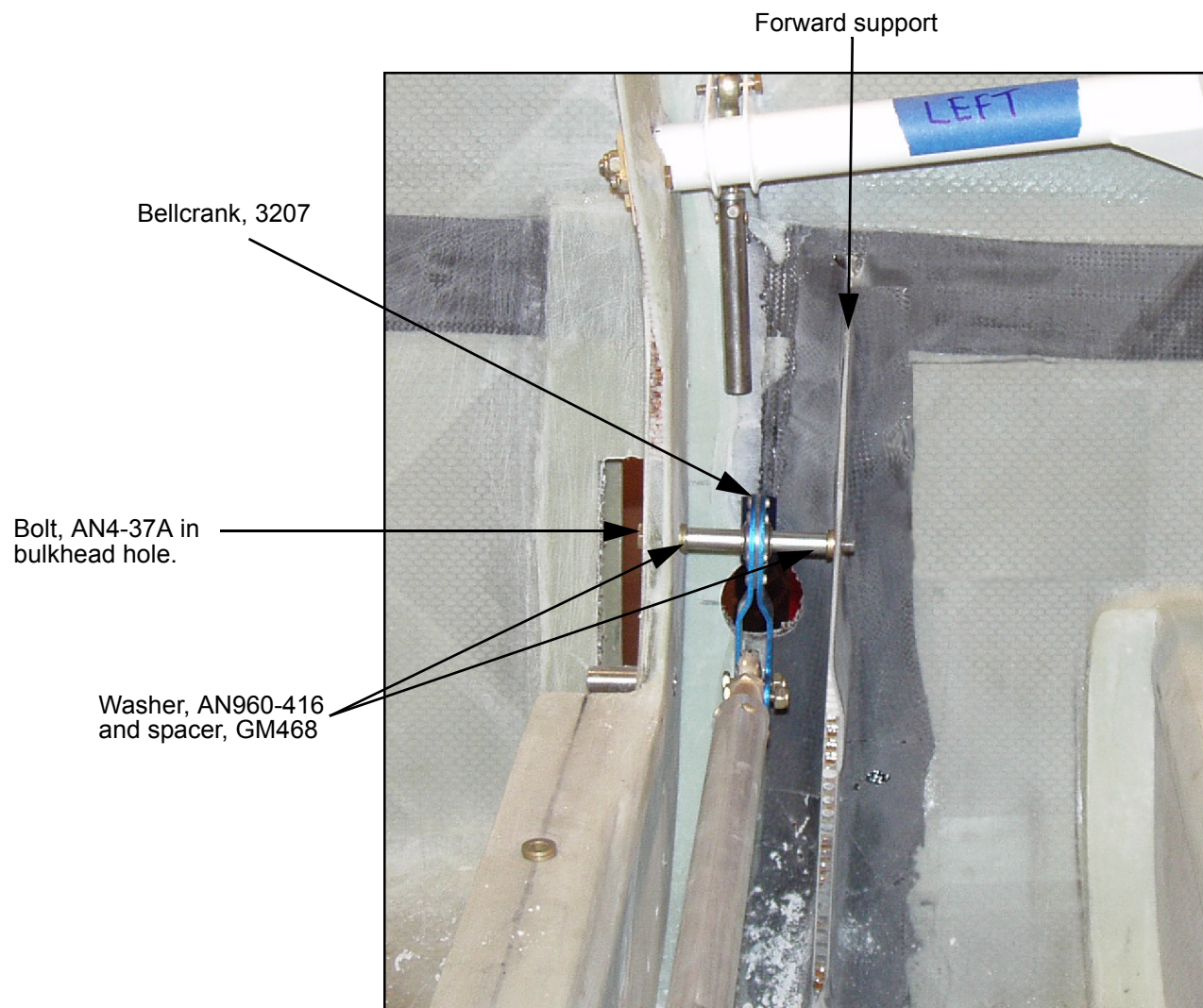
- must be level
- end that connects to aileron must be centered on the hole in the side of the fuselage
- range of movement clears the inside of the fuselage

Note: You may want to take review the information in Chapter 9 where the opening is located in the wing fairing. See Figure 9.3.D.1 in *Chapter 9 Wing Fairings*.

7. Mark and drill the bolt hole through the forward support.
8. Install the bellcrank (3207) by sliding a bolt (AN4-37A) through the bulkhead, a washer (AN960-416), a spacer (GM468), the bellcrank, followed by another spacer and washer, through the forward support and secure with a locknut (AN365-428A).

Note: The seat belt also attaches to the aft side of the bulkhead support. In order to keep your seat belt clean, we suggest you install the seat belt later. See *Chapter 15 Assembling and Installing the Seats* for the seat belt installation.

Figure 7.3.A.6 Installed bellcrank

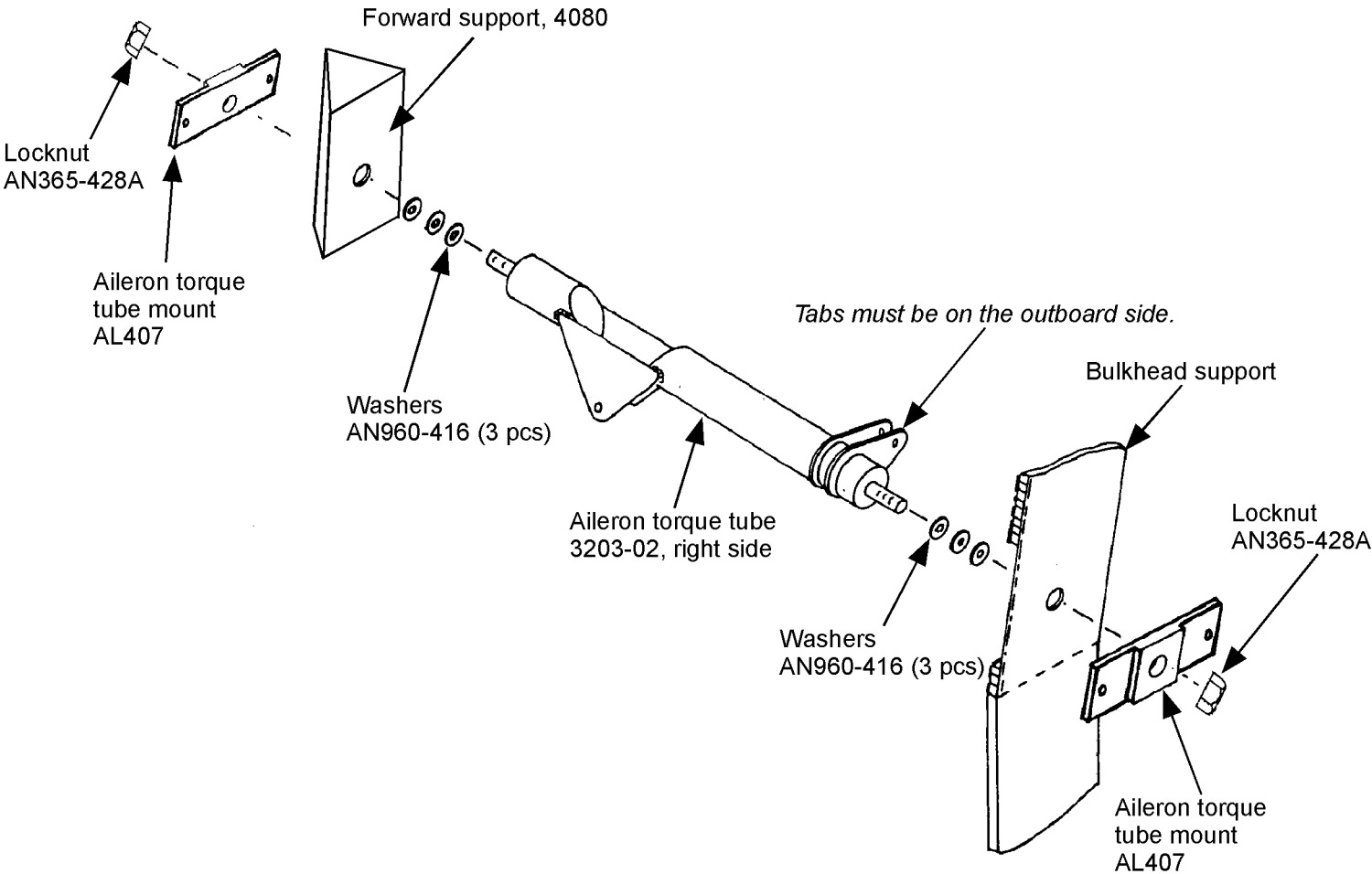


7.3.B Installing the Aileron Torque Tubes

The aileron torque tubes are mounted on each side of the fuselage. They transfer the control stick's left to right movement to the inboard aileron bellcrank.

In this section, the instructions will describe the installation of the right aileron torque tube. Both sides are installed in the same manner, as a mirror image of each other. Refer to blueprint 3503 for this section.

Figure 7.3.B.1 Right aileron torque tube



Steps...

1. Add a 2" (50 mm) wide 3-BID to the areas of the bulkhead support that are not covered with factory-applied BID.
2. Locate the hole for the bolt on the bulkhead support.
The center of the hole should be 10-1/4" (260 mm) above the AN8-17 bolt securing the wing attach bracket and 2-1/2" (63.5 mm) from the side of the fuselage. Refer to Figure 7.3.B.2 or Figure 7.3.B.5 to view the dimensions.
- Tip:** The torque tube can be lowered as much as 1-1/2" (40 mm) so the control stick will be closer to the armrest.
3. Drill a 3/4" (20 mm) diameter clearance hole through the bulkhead support as shown in Figure 7.3.B.2.
- Tip:** The location of the aileron torque tube and the rudder cables can vary from builder to builder. In some cases the rudder cables and the torque tube may interfere. If this is the situation, install the torque tube farther inboard to avoid any interference.
4. Center the aileron torque tube mount (AL407) on the 3/4" diameter hole you just drilled and clamp it in place.
5. Mark the two bolt holes used to secure the torque tube mount.
6. Drill 3/16" (4.75 mm) diameter holes using the marks you just made of the torque tube mount holes as guides.
7. Secure the torque tube mount using two bolts (AN3-6A), two washers (AN960-10) and two locknuts (AN365-1032A).

Figure 7.3.B.2 Bulkhead location for the torque tube mount

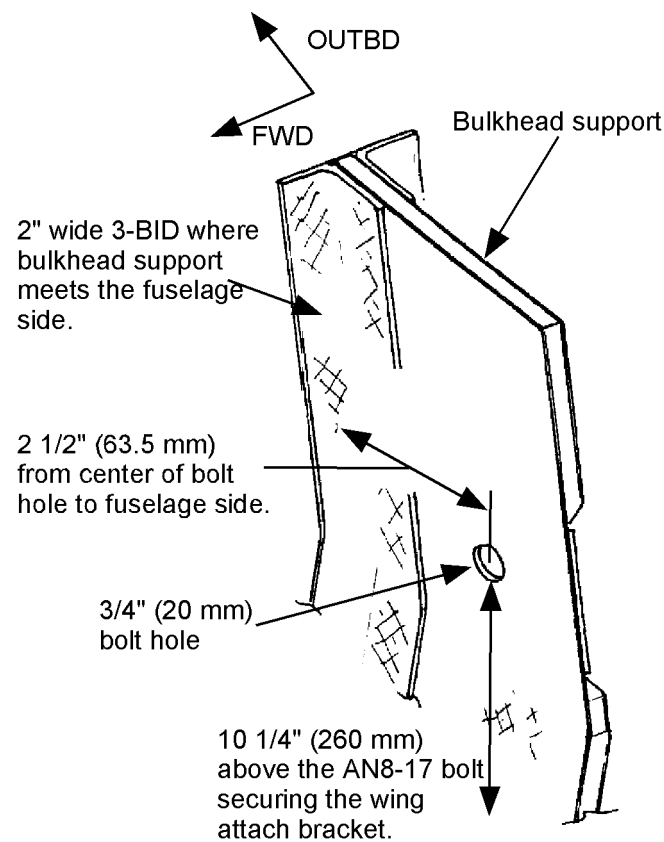
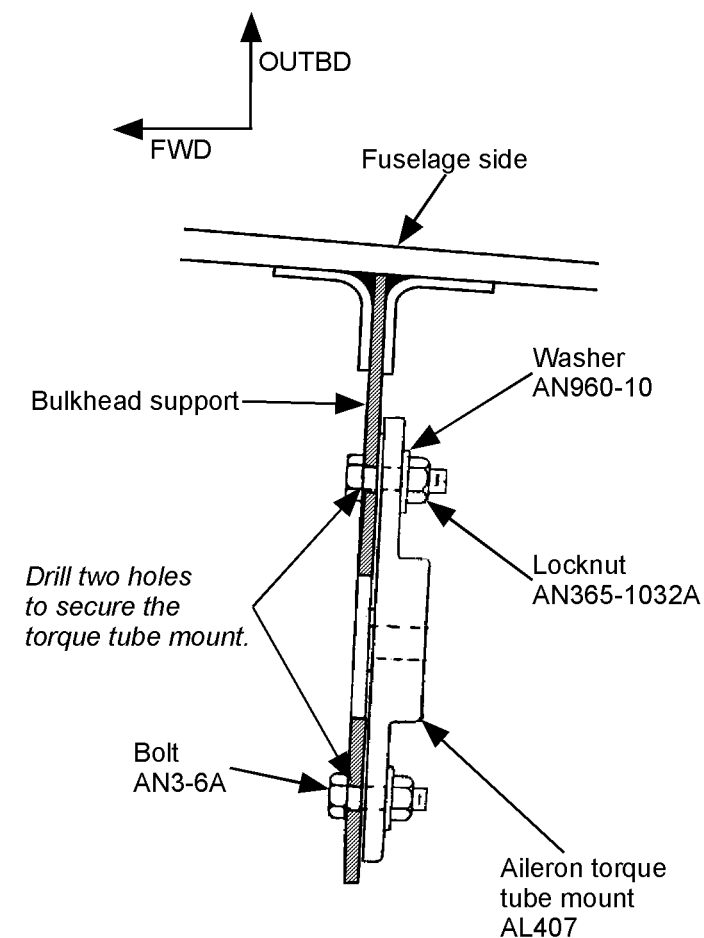


Figure 7.3.B.3 Top down view of securing the bulkhead torque tube mount



8. Drill a 3/4" (20 mm) diameter clearance hole through the forward support (4080). Center the 3/4" hole vertically on the part and 2-3/4" (70 mm) from the side that will be bonded to the fuselage.
9. Super glue the torque tube mount (AL407) to the support, centered on the hole you drilled.



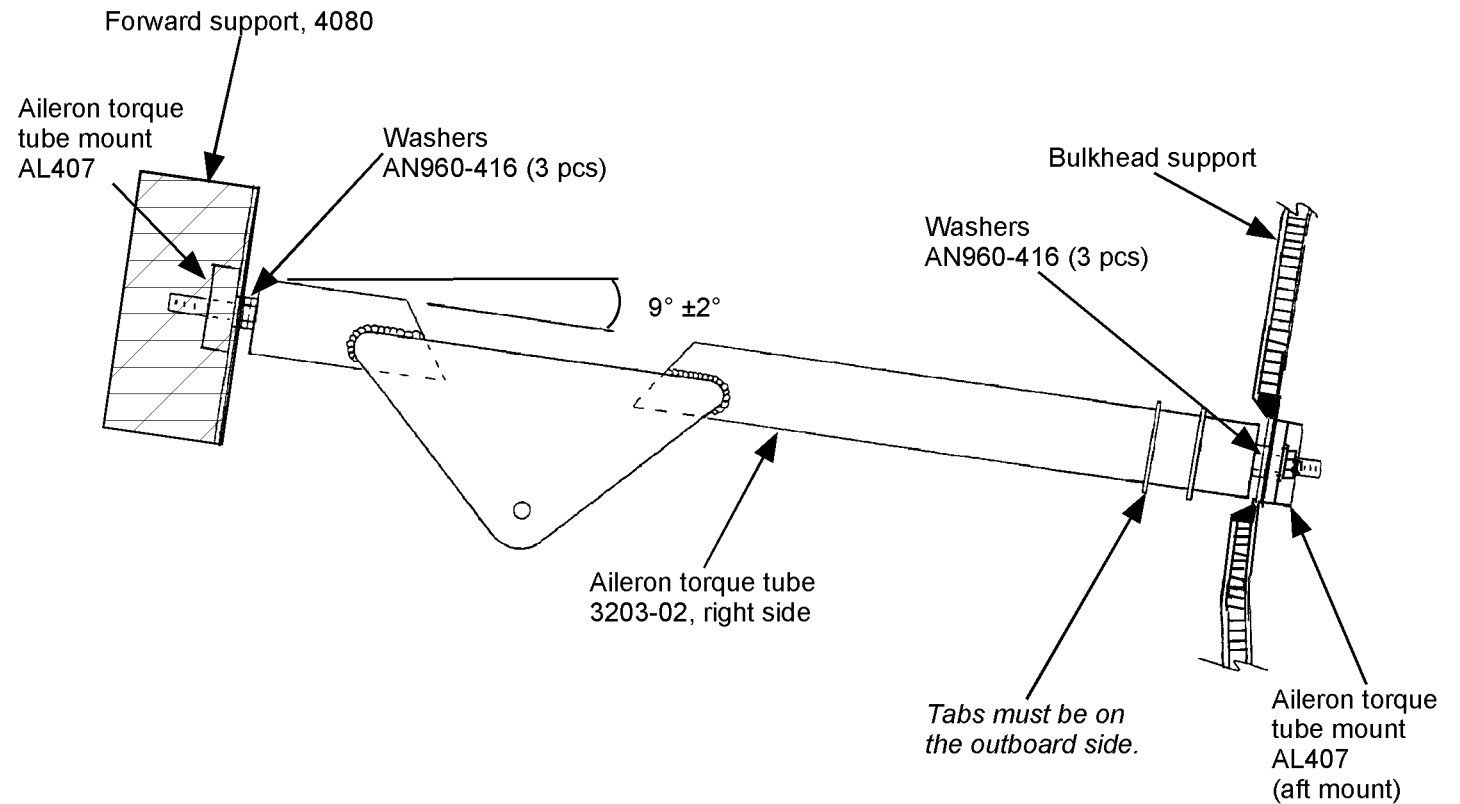
The following instructions describe the trial run for fitting the aileron torque tube in the torque tube mounts.

10. Add three washers (AN960-416) to the bolt extending from the aft end of aileron torque tube (3203-02).
11. Install the aft end of the torque tube (3203-02 for the right side and 3203-01 for the left side) into the mount on the bulkhead support.
12. Slide three washers (AN960-416) onto the forward end of the torque tube
13. Slide the forward support against the three washers.
 - The forward support should fit the following criteria:
 - The washers should be up against the bearings in the torque tube mounts.
 - The angle of the torque tube should be 9° off horizontal.
 - The forward support should be perpendicular to the torque tube.

This will give you the proper location for the forward support.

14. Set the torque tube to within $\pm 2^\circ$ of 9° .
15. Mark the location on the fuselage for the forward support.
16. Prepare the fuselage for bonding the support in place.
17. Install the forward support with a thick epoxy/micro mixture. Check that the torque tube is still set at the proper angle. Check that there is no gap between the washers and the bearings.

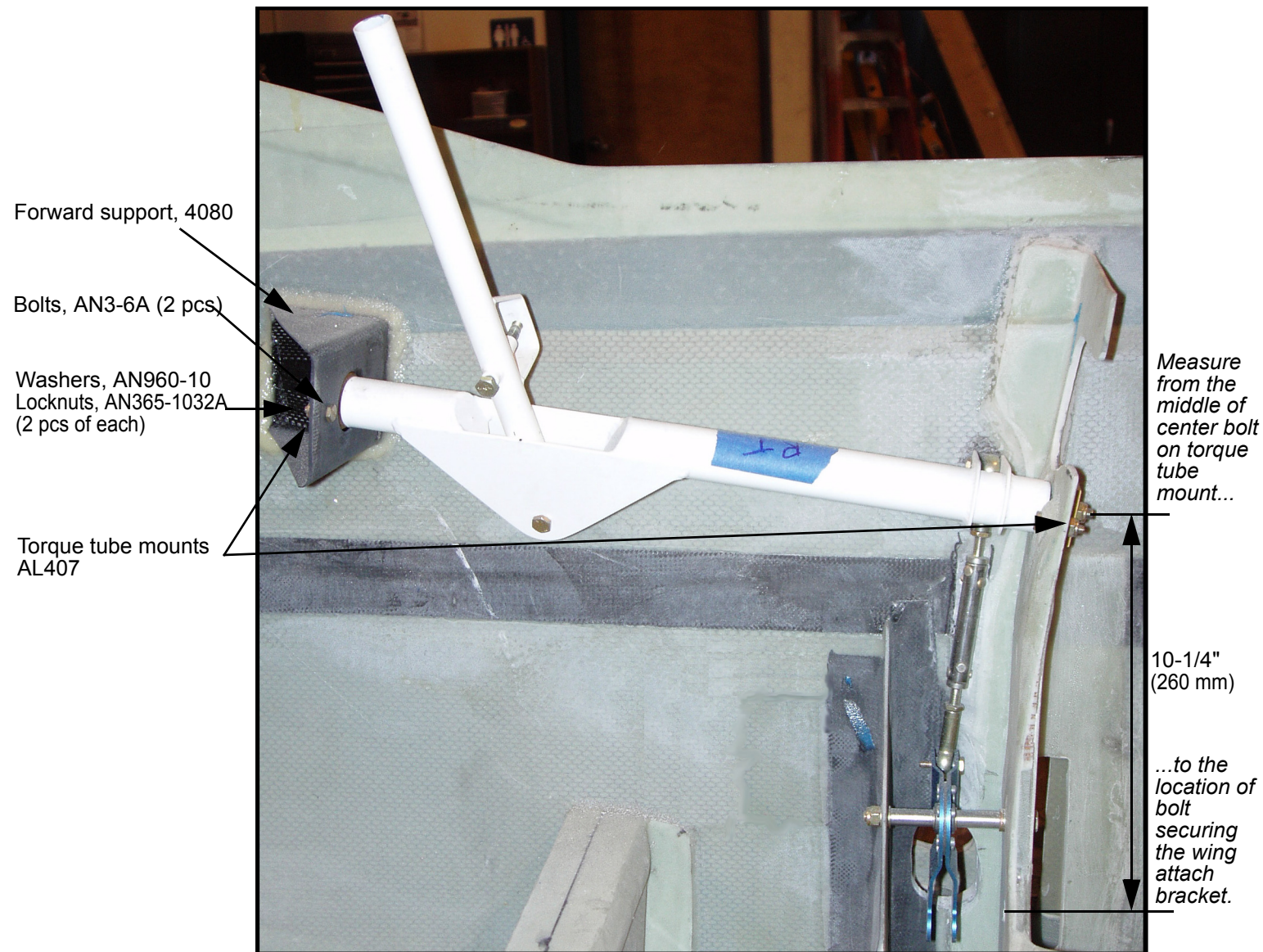
Figure 7.3.B.4 Temporarily securing the forward mount



Steps after cure...

1. Mark the holes for securing the torque tube mount.
2. Drill 3/16" (4.75 mm) diameter holes using the torque tube mount holes as guides.
3. Secure the torque tube mount using two bolts (AN3-6A), two washers (AN960-10) and two locknuts (AN365-1032A).
4. Re-insert the aileron torque tube in its torque tube mounts.
Don't forget the three washers on each end of the aileron torque tube before it is inserted into its mounts.
5. Secure the torque tube with a locknut (AN365-428A) on each end.

Figure 7.3.B.5 Forward support for the torque tube mount bonded in place



7.3.C Completing the Aileron Pushrods

Three more pushrods are needed to complete the aileron control system. Two of these pushrods are identical and connect the aileron torque tubes to the inboard aileron bellcranks. These are made of 1/2" (13 mm) diameter stainless steel rods. The last pushrod is called the aileron crossover tube and it connects the two inboard aileron bellcranks. It allows both control sticks to work as one. It is made of 7/8" (22 mm) diameter aluminum tube.

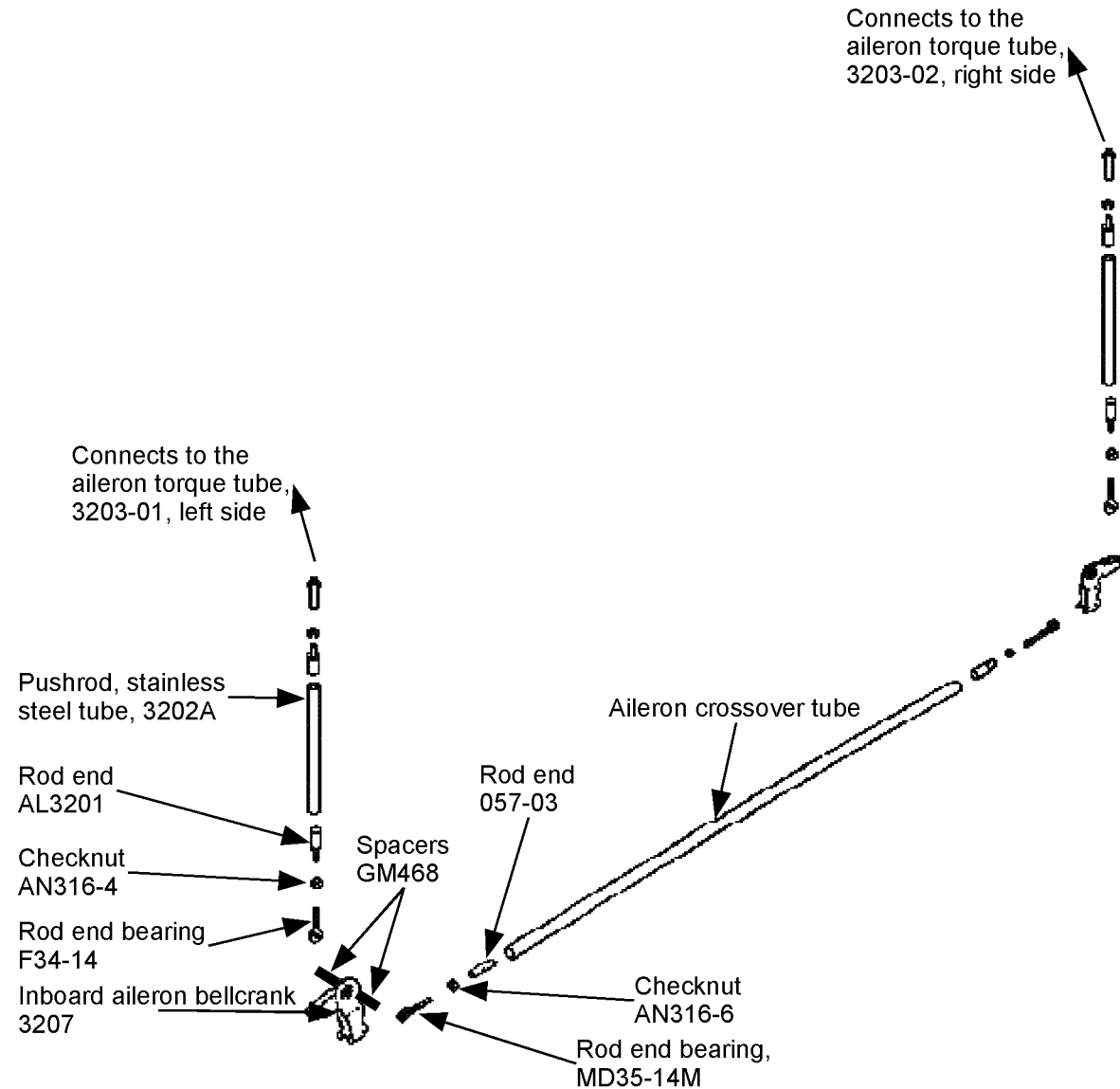
Connecting the Two Inboard Bellcranks to the Wing Pushrods

When you measure the aileron pushrod that extends from the wing, work with only one wing attached to the fuselage at a time. We recommend this so the other side of the fuselage is available for moving the long rods into position and for removing the rods.

Steps...

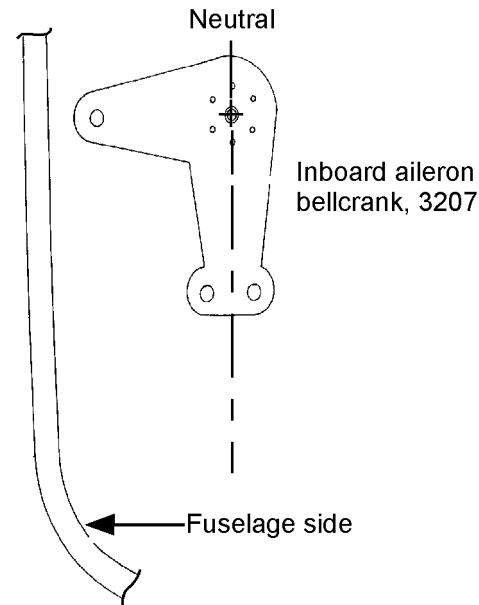
1. If you have not already done so, hook up the aileron pushrods in the wing. See Chapter 4, 4.3.B *Completing the Wing's Aileron Control*.
2. The ailerons also need to be connected to the outboard bellcranks so you can move both ailerons by pushing and pulling the long pushrods. Again, refer to Chapter 4.
3. Slide the wings into the fuselage.
If necessary, increase the size of the holes in the fuselage for adequate clearance. Make sure you keep the bellcrank centered in the opening.
4. Complete the wing installation by sliding the wing bolts through the bushings and install the bolts securing the wing attachment bracket.

Figure 7.3.C.1 Aileron pushrods inside the fuselage



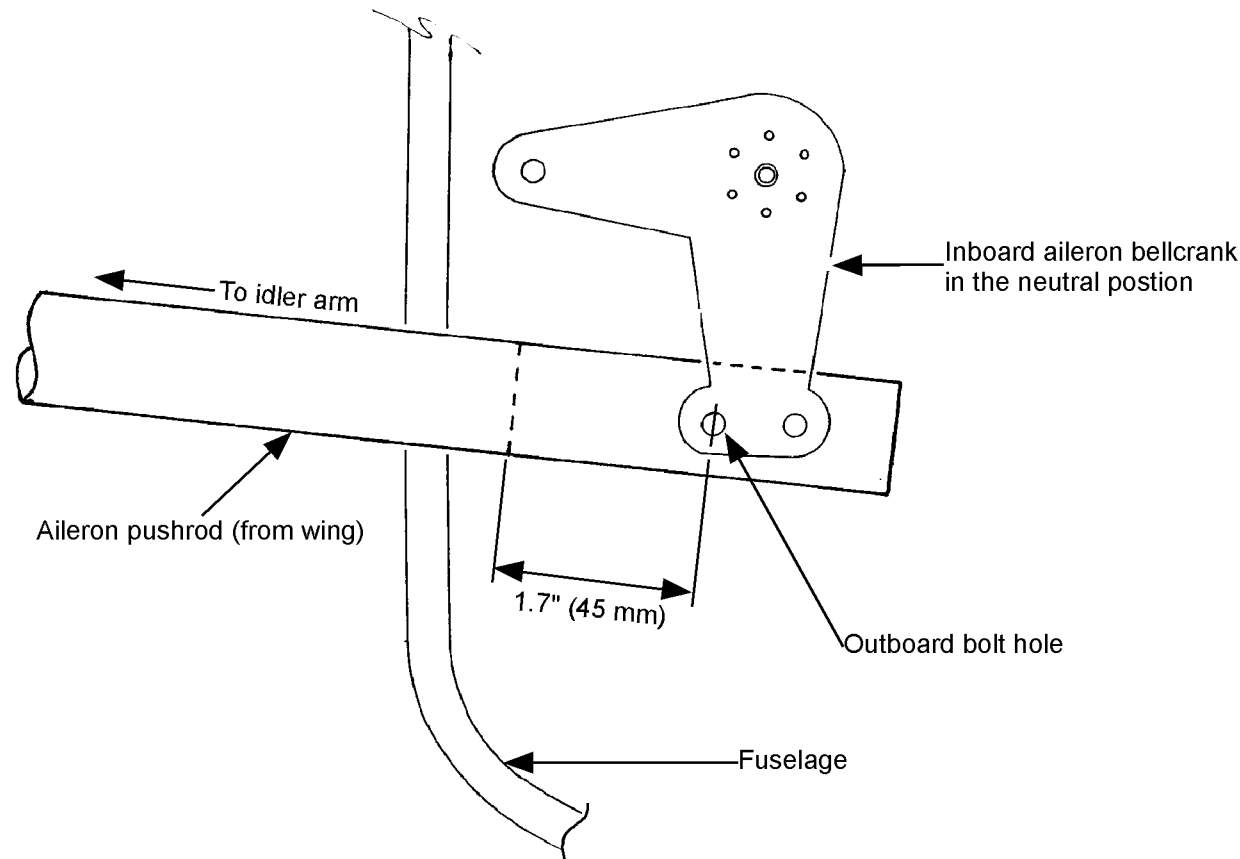
5. Set the ailerons, idler arms, and the inboard aileron bellcranks in the neutral position. Refer to Figure 7.3.C.2 to set the inboard bellcrank in the neutral position. Use duct tape to hold the bellcrank in the neutral position.

Figure 7.3.C.2 Neutral position for the inboard aileron bellcrank



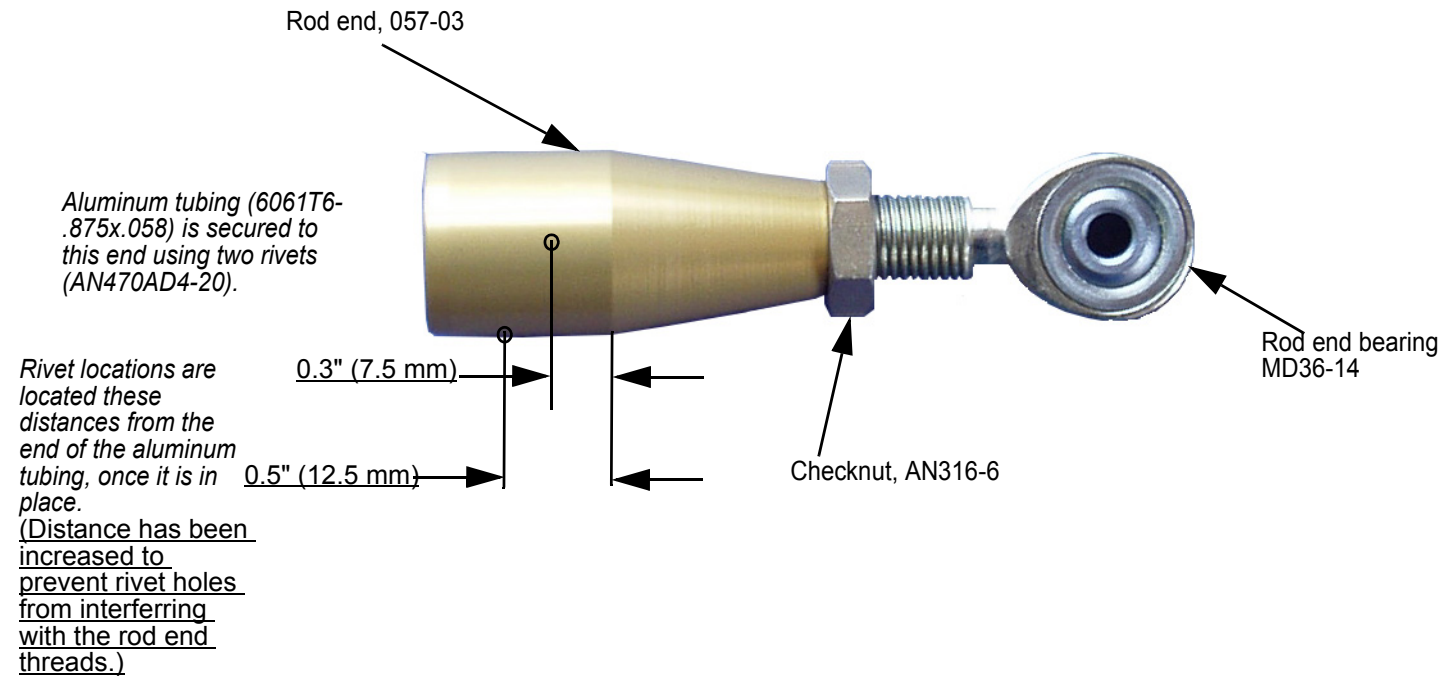
6. Mark the pushrod 1.7" (45 mm) outboard of the bolt hole as shown. Make sure you measure from the outboard bolt hole.

Figure 7.3.C.3 Measuring for inboard pushrod length



7. Pull the wings out and cut the pushrods on the mark you made in the previous step.
8. Install the rod ends (057-03) in the pushrods using two rivets (AN470AD4-20) to secure each rod end.
Use a size #30 drill for drilling the rivet holes. Use Locktite in the holes to prevent rattling.
9. Install the rod end bearings (MD36-14) and checknuts (AN316-6).
10. Secure the rod end bearings to the inboard bellcrank, the outboard bolt hole, using bolt (AN3-10A), washer (AN960-10) and a locknut (AN365-1032A).

Figure 7.3.C.4 Installing rod ends in the pushrods

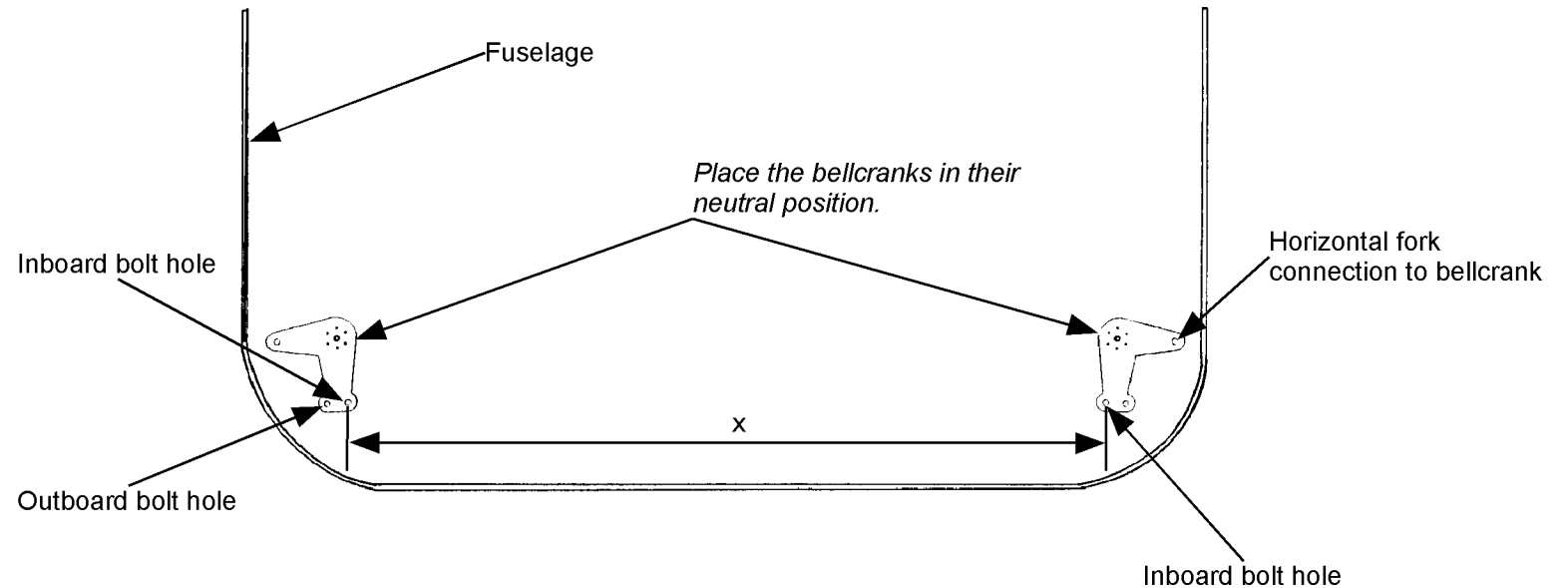


Connecting the Aileron Crossover Tube to the Inboard Bellcranks

Steps...

1. Measure the distance between the two inboard holes of the bellcranks. See Figure 7.3.C.5 and take the measurement for X.
2. Calculate the length you need to cut the 7/8" (22 mm) diameter aluminum tubing.
 $\text{Length} = X - 3.4"$
– or –
 $\text{Length} = X - 86 \text{ mm}$
3. Cut the aluminum tubing to the calculated length.
4. Install the rod ends (057-03) in the pushrod using two rivets (AN470AD4-20) to secure each rod end. Use a size #30 drill for drilling the rivet holes. Use Loctite in the holes to prevent rattling.
5. Install the rod end bearings (MD36-14) and checknuts (AN316-6).
6. Secure the rod end bearings on the aileron crossover tube to the inboard aileron bellcrank, the inboard bolt hole, using bolt (AN3-10A), washer (AN960-10) and a locknut (AN365-1032A).

Figure 7.3.C.5 Calculating the length and installing the aileron crossover tube



Connecting the Torque Tube to Bellcrank Pushrods

The final two pushrods of the aileron control system are the two 1/2" (13 mm) diameter stainless steel pushrods. These connect the inboard aileron bellcranks to the aileron torque tubes on each side of the fuselage. In order to cut the pushrods to the correct length, you need to set the aileron torque tubes and the bellcranks to the neutral position.

Steps...

1. Set the aileron torque tubes in the neutral position as shown in Figure 7.3.C.7.

1. Measure the distance between the two inboard holes of the bellcranks. See Figure 7.3.C.7 and take the measurement for X.
2. Calculate the length you need to cut the 1/2" (13 mm) diameter aluminum tubing.

$$\text{Length} = X - 3.9"$$

– or –

$$\text{Length} = X - 99 \text{ mm}$$
3. Cut the aluminum tubing to the calculated length.

Figure 7.3.C.6 Aileron torque tubes in the neutral position

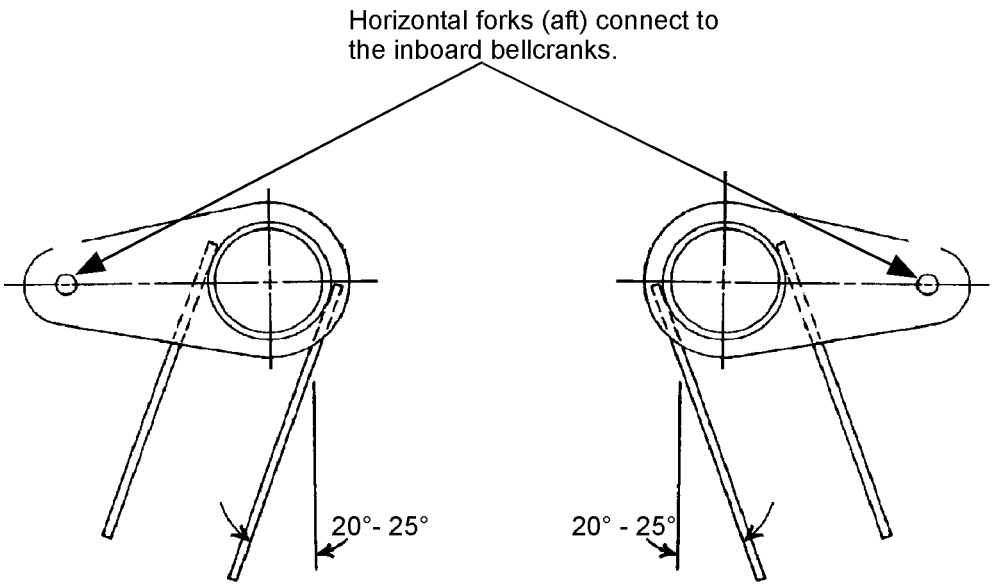
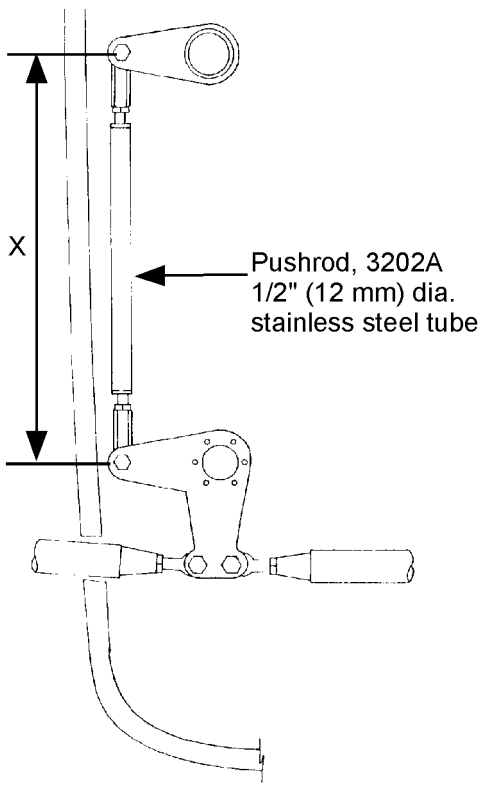


Figure 7.3.C.7 Calculating the length for the torque tube to bellcrank pushrods



4. Fill the rod ends (AL3201) with an epoxy/flox mixture.
5. Install a rod end in each end of the two pushrods by drilling through the pushrod and the rod end and using two rivets (AN470AD4-12) to secure each rod end. Use a size #30 drill for drilling the rivet holes.
6. Install the rod end bearings (F34-14) and checknuts (AN316-4).
7. Secure the pushrod's upper rod end bearing to the aileron torque tube using a bolt (AN3-10A), three washers (AN960-10) and a locknut (AN365-1032A).
8. Secure the pushrod's lower rod end bearing to the bellcrank using bolt (AN3-10A), washer (AN960-10) and a locknut (AN365-1032A).

Figure 7.3.C.8 Pushrod's upper rod end connection

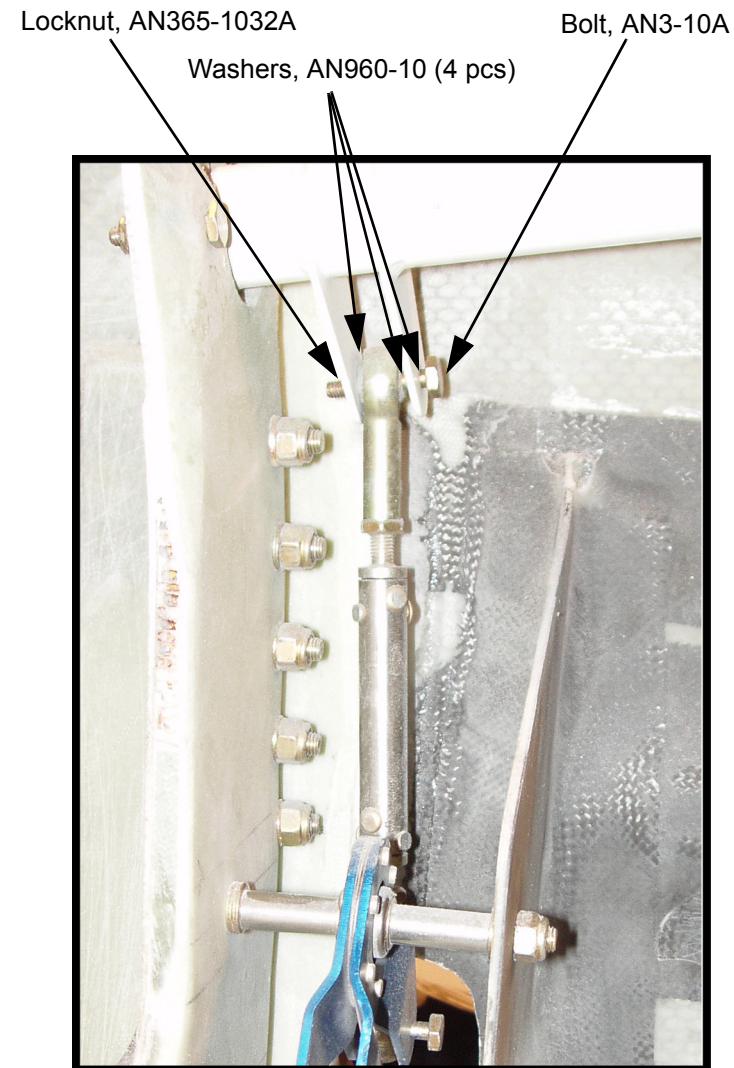
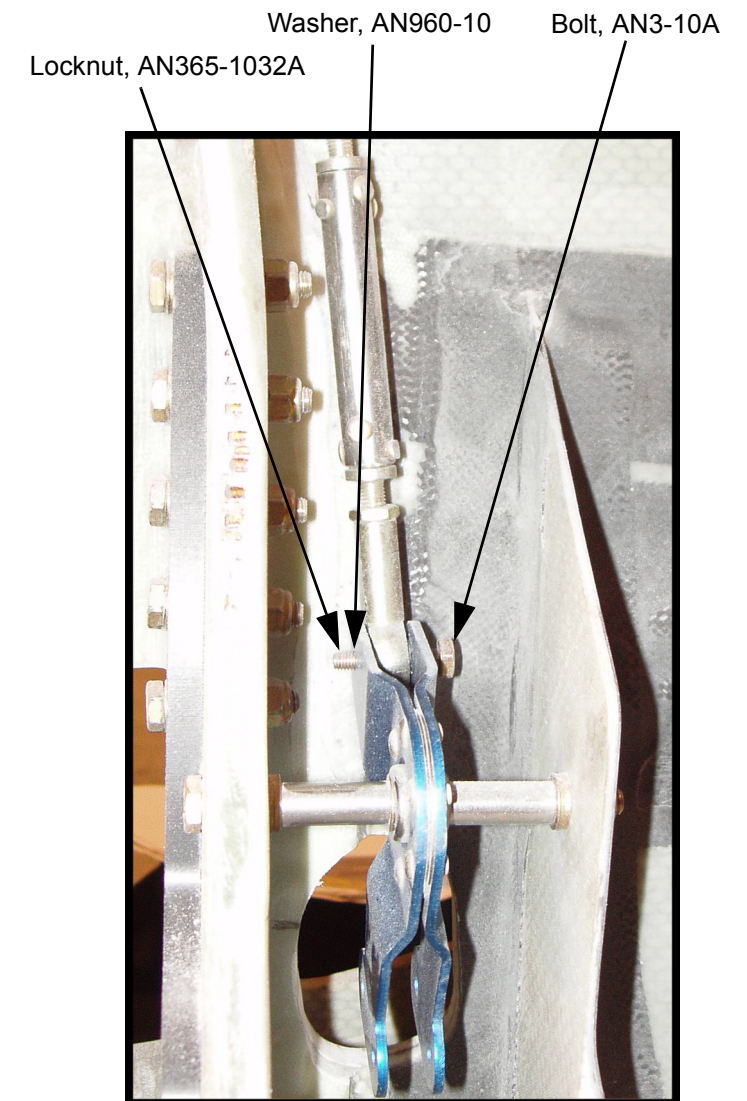


Figure 7.3.C.9 Pushrod's lower rod end connection



7.3.D Installing the Control Sticks

Although the control sticks are not needed at this time, you can install them just to say your aileron control system is complete. Like the aileron torque tubes and bellcranks, both control sticks are installed in the same manner.

Steps...

1. Place the control stick into the aileron torque tube.
The elevator reinforcement bracket should be on the outboard side.
2. Secure the control sticks to the torque tubes with a bolt (AN4-16), washer (AN960-416), a castle nut (AN310-4) and a cotter pin (MS24665-151).
Tighten the castle nuts until there is no slop in the sticks, but they can be easily moved without binding.

You may want to hold off on inserting the cotter pins until later in construction because you'll probably remove and install the sticks a few times. Remember to secure the castle nuts with the cotter pins before the first flight!

Now you can move the control stick and watch as one aileron goes up and the other goes down.

Figure 7.3.D.1 Control stick assembly – includes installed bearings

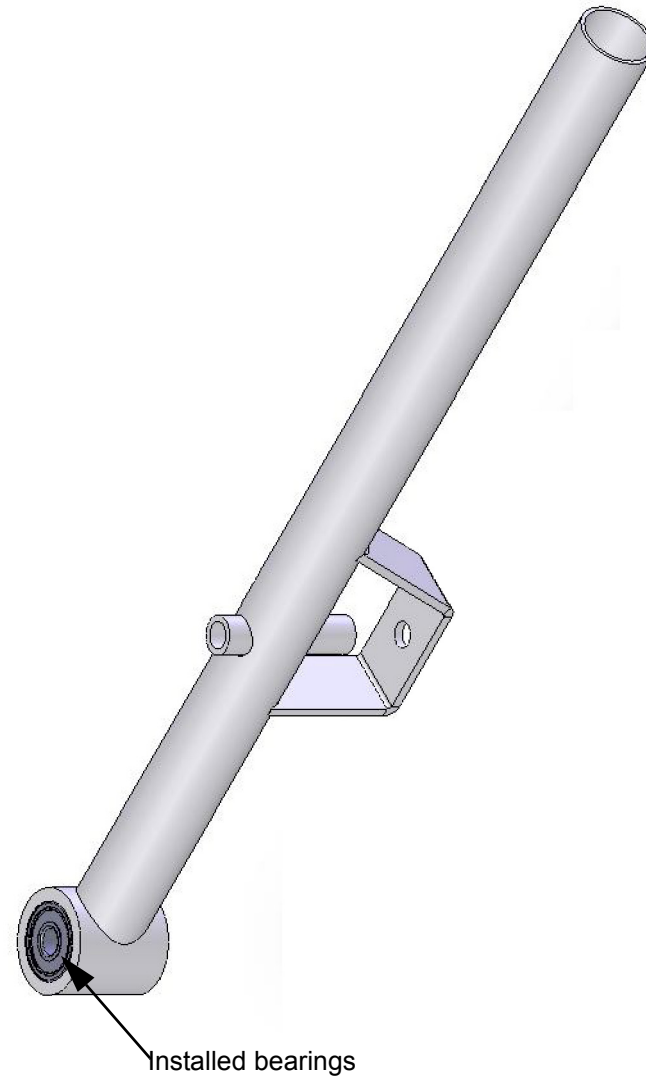
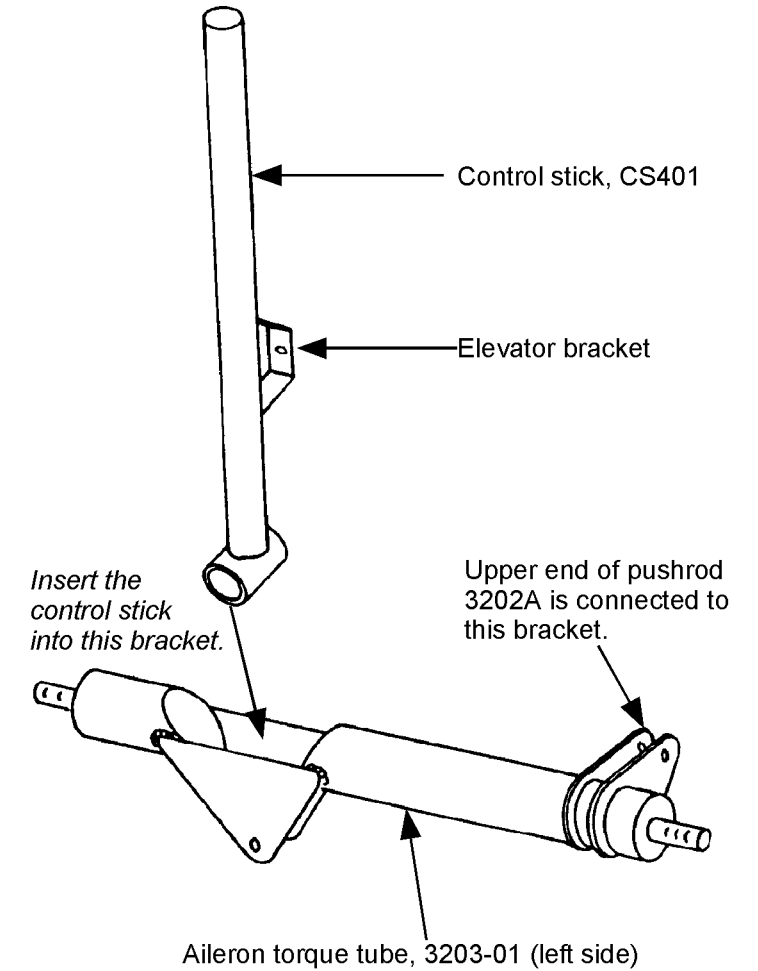


Figure 7.3.D.2 Installing the control stick



7.3.E Aileron Control Stops

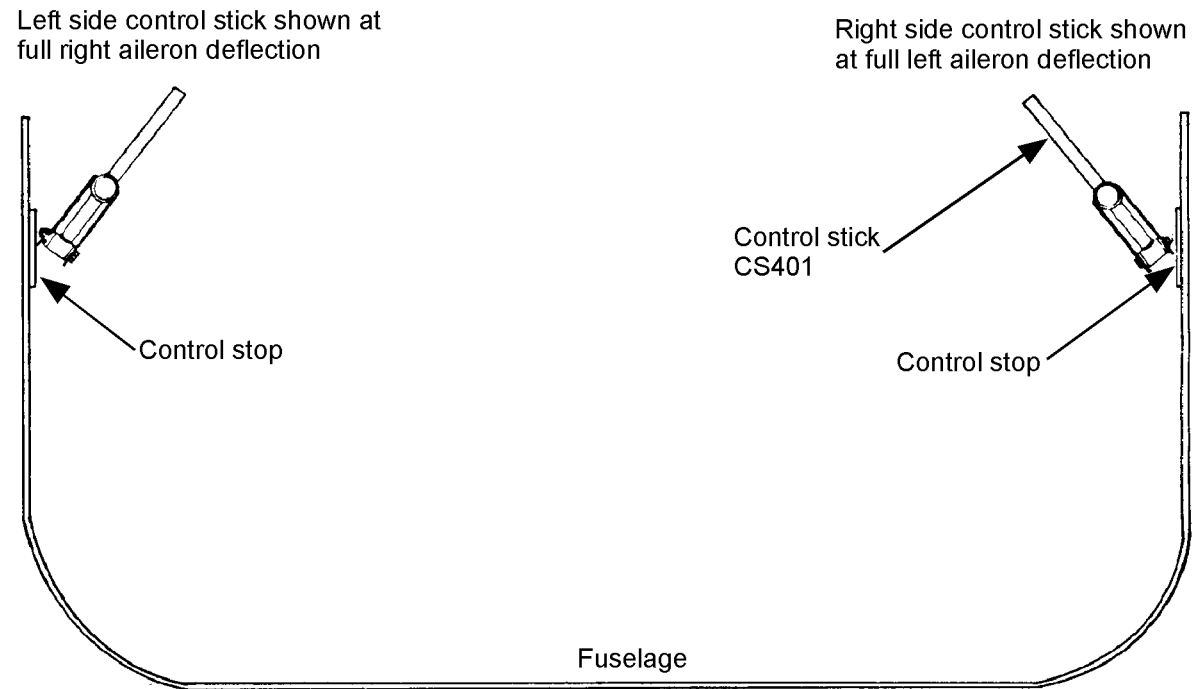
The aileron stops are bonded to the left and right sides of the fuselage. The aileron stops are made of 0.06" (1.5 mm) aluminum. At full aileron deflection the vertical forks of the aileron torque tubes hit the stops. The stop on the left side limits the right aileron travel and the stop on the right side limits the left aileron travel.

The ailerons and all the pushrods must be hooked up and set correctly for aileron stop installation. You should follow the instructions, 7.3.F Rigging the Ailerons on page 7.21 before starting this section.

Steps...

1. Drill holes in the 0.06" (1.5 mm) aluminum piece (301-09) provided in the kit.
The holes serve the purpose of providing a better bonding surface.
2. Cut the aluminum piece in half.
3. Using a Smart Level™ check the gap between the fork and the side of the fuselage.
Deflect one aileron to 20° up and check the gap between the tip of the fork and the side of the fuselage. Repeat for the other side.
4. Determine the method you will use to install the plate based on the information from the previous step.
Method 1 – If you have a gap of at least 0.06" (1.5 mm), it is not necessary to remove the inner laminate and core. See Figure 7.3.E.2.
Method 2 – If you have a gap less than 0.06" (1.5 mm) and you need more room, remove the inner laminate of the fuselage and the core. Reinforce with a 3-BID as shown. See Figure 7.3.E.3.

Figure 7.3.E.1 Aileron control stops



5. Install the plate. The orientation of the control stop is not critical.
6. Prepare the surface of the control stop and the fuselage for bonding.
7. Mix up a small batch of Hysol, enough for bonding in one of the stops at a time.
8. Apply a thin coat of Hysol to the side of the fuselage and to the outboard surface of the control stop. Mix flox in with the Hysol to form a thick mixture.
9. Mound up Hysol/flox on the side of the fuselage where the control stop will be bonded in place.
10. Put the control stop in place and slowly move the aileron on the respective side up to 20° travel. This will push the control stop in the correct distance.

Drop a few drops of instant glue between the control stop and the forks to keep the control stop from slipping. The aileron must also be kept in place.

Repeat for the other side.

Note: The travel is limited to 20° of travel on the ailerons. This translates to between 12-14° of "down" travel on the opposite aileron.

Figure 7.3.E.2 Method one for the control stop installation

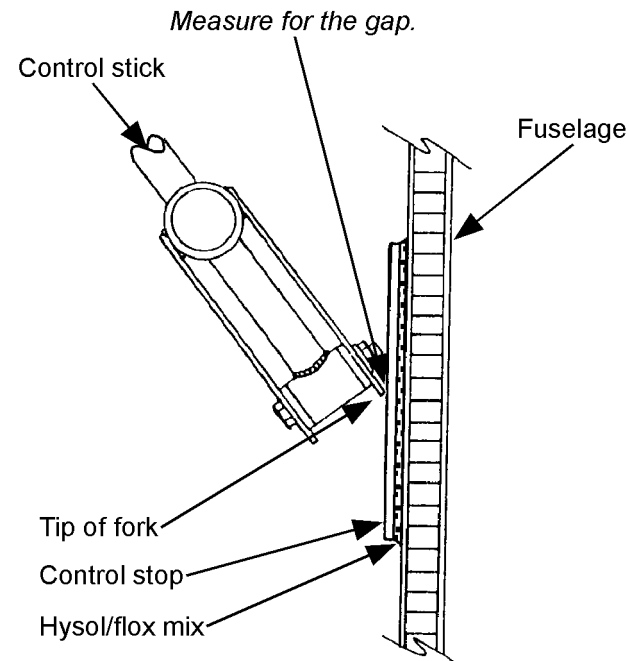
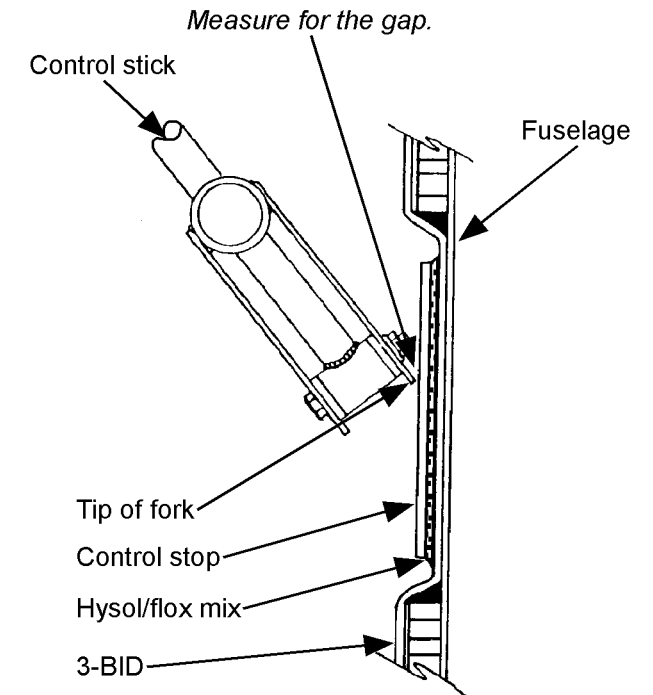


Figure 7.3.E.3 Method two for the control stop installation



7.3.F Rigging the Ailerons

Always start this process on the pilot side. Only the pilot side can have possible interference with the door latch hardware against the elevator control tube.

Steps...

1. Make sure you have enough free travel available with each aileron: 20° up and 13° down. Extra travel is better and you will install stops on the sticks.
2. Make a template for travel out of posterboard or cardboard and tape it on each side of the plane between the aileron and the wingtip.
3. Draw lines on the cardboard at each of the following locations:
 - 20° up
 - neutral
 - 13° down

This should be easy to do with no pushrods connected. It is helpful if you can see these lines from the cockpit as you work the sticks.

4. Starting inside the airplane with just one stick, the pilot side first, set it to 20° (70 on the smart level). This will be neutral. Now adjust the small pushrod until the bellcrank below the control stick is oriented at 90°.

You may be able to use line-of-sight, looking down to see if the two pushrod bolt holes are evenly split between the main bearing of the bellcrank.

5. Rig something to hold the control stick at the 20° (neutral).
6. Go to the first pushrod that connects the inside bellcrank to the idler. Leaving the stick at 20°, set the pushrod length so the idler is neutral.
Remember, neutral is when the idler is parallel to the centerline on the airplane.
7. Go to the next pushrod, outboard, which connects the idler to the outer bellcrank. This bellcrank may have a sticker above it showing neutral, up and down. This is a starting point, but the positions will not be exact. There is a small flat spot on this bellcrank. Set the pushrod length so the flat spot on the bellcrank is 90° to the centerline of the airplane.
Do not worry about it being exact since you will make adjustments later.
8. Clamp the aileron into neutral and adjust the final pushrod length to connect the bellcrank to the aileron.
9. Go inside the airplane again and start working the stick.

Look at the travel template you set up and see if the aileron is making it to the up and down lines on the template.

Now the fun starts.

There are several things that can limit travel. If you are sure the aileron was able to make full travel when it was not connected, most likely the stick is hitting something that limits travel.

You will need to do one or the other, or perhaps both, of the following to provide more room for the stick to travel:

- Either cut a larger area for the stick to travel,
– And/Or –
- Adjust the stick to begin at a different degree for neutral.

For example, these adjustments can be made by:

- de-coring the inside of the fuselage where the stick is hitting the inside wall
– And/Or –
- plus adjust neutral to be 28° instead of 20°.

In this example, when the sticks are in neutral, they are angled a little more to the inside. Both sticks are angled the same. This was done because at full left deflection the pilot side tube was banging against the door latch hardware.

Tips

When you change the starting (neutral) point at the stick to a different degree you have to go back and set all of the bellcranks and idlers back to neutral. Do *not* be tempted to simply adjust the outboard aileron pushrod because this will not work. The best way to adjust the neutral spot of the stick is with the small pushrod that connects to the stick only. Leave everything else alone as those lengths do not need to change.

If you are not getting enough travel and you are not hitting anything, something is rigged incorrectly. Probably it is the outside bellcrank that connects to the aileron pushrod.

Once you get travel established, full up and full down, do the same procedure on the copilot side. Although the door latch is not an issue, you may find other problems so the same procedure needs to be followed.

When full travel is established on both sides, individually, and the sticks are beginning from the same degree for neutral, connect the crossover tube with the sticks and ailerons in neutral. Clamp the ailerons in neutral to help with this.

With any luck you are done. But maybe not. Again, check for full travel with both sides connected. There may be some adjustment needed. For example:

The up travel on one side is limiting the down on the opposite side. This relationship is all dealt with by the outer bellcrank. To fix this, simply hold the idlers in neutral, lengthen the outboard pushrod and shortened the aileron pushrod to achieve more down travel, without disrupting the "neutral" position of the sticks.



Revisions

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Aileron Controls

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