

Chapter 4 Completing the Ailerons

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4.1 Introduction

The ailerons of the Lancair ES are high aspect ratio, having a short chord and long span. This makes for a thin cross section and not much room to work in the ailerons. You should always be aware of the narrow aileron and work more accurately than you have before; no oversized micro radii on these spars and ribs.

The Lancair ES uses a MAC S9 servo for electric roll trim. The roll trim servo is provided in the kit and is installed inside the aileron.

The aileron counterweights are totally inclosed in the wing, causing no airflow disruption when the ailerons are deflected. This method of counterweighting is obviously very aerodynamic, but again, care must be taken during construction because of the tight quarters in which to work.

The 1/4" thick, blunt trailing edge of the ailerons should be kept that way, blunt. This is an aerodynamic feature meant to increase roll response and lighten stick forces.

All drawings in this chapter show the left aileron. The right aileron is identical except for the lack of a trim servo.

Steps to Completion

- Install the aileron trim servo.
- Make the trim tab.
- Drill holes in the aileron ribs for the pushrods.
- Install the aileron bellcrank assembly.
- Install the aileron idler arm assembly.
- Make and install the pushrods.
- Balance the ailerons.

Caution!

Always perform the pre-fits that are recommended.

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.

4.2 Parts List

Ailerons

Item	Part Number	QTY	Description
1)	WTLD-HR	14	Lead weights for ailerons
2)	A2013L	1	Left aileron assembly
3)	A2013R	1	Right aileron assembly
4)	MS24693-S26	4	Screws
5)	MK1000-06	4	Nutplates
6)	AN426A3-5	16	Rivets
7)	MS20001	1	Extruded hinge for trim tab
8)			Safety wire

Servo

Item	Part Number	QTY	Description
1)	MAC S9	1	Electric servo with pushrod hardware
2)	TT-01	1	Trim tab arm

Bellcranks

Item	Part Number	QTY	Description
1)	AL201-01	2	Bellcrank bracket
2)	AL201-02	2	Bellcrank bracket
3)	AL208-01	2	Aileron bellcrank
4)	K1000-3	8	Nutplates
5)	MSC-37	16	Pop rivets
6)	AN3-5A	8	Bolts
7)	AN3-10A	4	Bolts
8)	AN960-10	6	Washers
9)	AN365-1032	6	Locknuts

Bellcranks

Item	Part Number	QTY	Description
10)	AN5-13A	2	Bolts
11)	AN960-516	2	Washers
12)	AN365-524A	2	Locknuts

Idler arms

Item	Part Number	QTY	Description
1)	3205-1	4	Aileron idler arm
2)	3205-2	4	Aileron idler arm bracket
3)	430	4	Bearing housing
4)	MBB-R-4-SRS	4	Bearings
5)	AN960-416	8	Washers
6)	AN470-AD4-8	12	Rivets
7)	MSC-36	16	Pop rivets
8)	K1000-3	8	Nutplates
9)	AN3-5A	8	Bolts
10)	AN4-12A	2	Bolts
11)			Nut to secure AN4-12A bolt
12)	AN960-10	4	Washers
13)	AN365-1032A	4	Locknuts

Pushrods – outboard

Item	Part Number	QTY	Description
1)	AL3202	2	1/2" dia. stainless steel
2)	AL3201	2	Rod end
3)	F34-14	2	Rod end bearing
4)	AN316-4	2	Checknuts



Pushrods – outboard

Item	Part Number	QTY	Description
5)	AN470AD4-12	4	Rivets
6)	AN3-10A	2	Bolts
7)	AN960-10L	4	Thin washers
8)	AN960-10	2	Washers
9)	AN36501932A	2	Locknuts

Pushrods – inboard

Item	Part Number	QTY	Description
1)	AL3202	2	7/8” dia. aluminum
2)	057-03	2	Rod end
3)	MD36-14	2	Rod end bearing
4)	AN316-6	2	Checknuts
5)	AN470AD4-20	4	Rivets



4.3 Construction Procedures

4.3.A Installing the Aileron Trim Servo

The MAC S9 electric servo is installed in the left aileron for roll trim control. The servo is connected to a simple, extruded hinge trim tab that is bonded into the trailing edge of the aileron. This method of roll trim is simpler than and just as reliable as a cable/pulley/spring system and is much lighter.

Steps...

1. Check the clearance of the small hole in the aileron spar for the threaded servo rod. If the servo rod binds against the spar, it can cause damage to the servo gears.
You can accurately find the location of the clearance hole by placing a piece of masking tape on the aft face of the spar while holding the servo against its mounting flange. Now connect the spar. The servo is tough, but be careful not to bind it against the spar, just run it so it touches. Run the servo the other way and remove it from the flange. You should see an impression where the servo rod has touched the masking tape. Use this as a reference to grind the clearance hole to the proper size through the aileron spar.
2. Place the servo into its flange and using the mounting holes of the servo to mark the hole locations.
3. Drill four #29 holes through the servo flange.
4. Drill out the mounting holes of the servo to the #29 size.
5. Countersink the metal flange of the servo so it can be mounted with screws, MS24693-S26.
6. Remove the servo and install four nutplates, MK1000-06, where you drilled the mounting holes.
7. Mount the nutplates to the flange using rivets AN426A3-5. Countersink the flange so the rivets are flush.

Figure 4.3.A.1 Aileron trim servo system

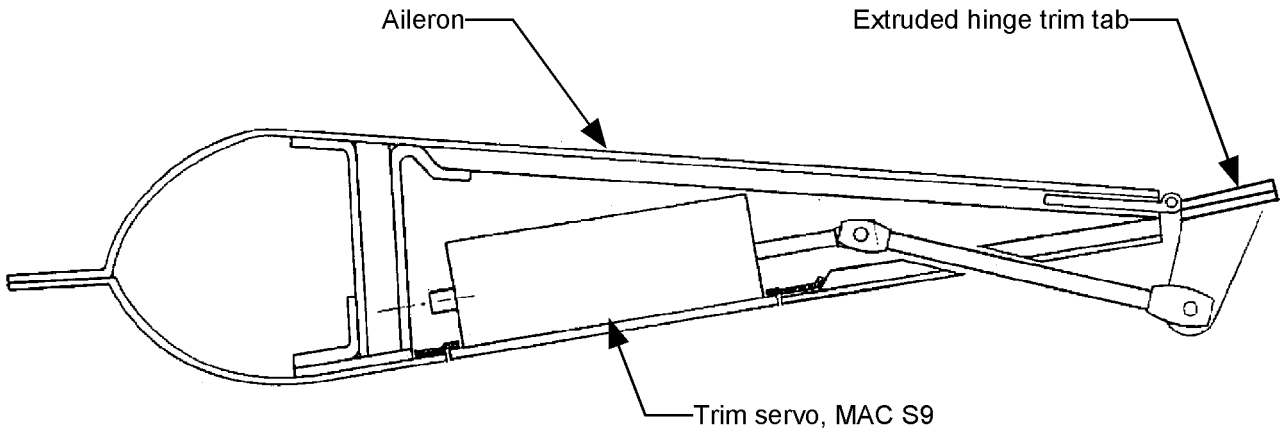
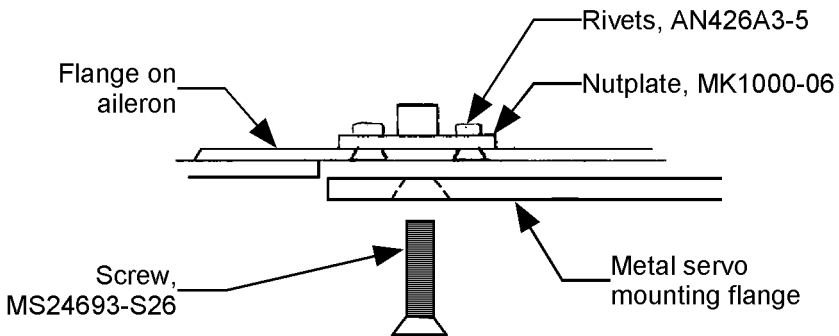


Figure 4.3.A.2 Mounting the servo to the flange



Making the Trim Tab

1. Cut the trim tab from the extruded hinge material (MS20001) supplied in the kit. Cut the hinge 12" (305 mm) long.
2. Drill numerous 3/16" (5 mm) dia. holes in one half of the trim tab hinge.
These holes will strengthen the mechanical bond when the hinge is potted into the aileron T.E.
3. Retain the hinge pin by drilling a #57 hole through each end of the forward hinge half, which is the half that will be bonded into the aileron T.E.
4. Shorten the hinge pin just enough so you can thread .040" safety through each hole. When the wire pieces are twisted and clipped, they will retain the hinge pin and make it removable for later maintenance.
5. Sand, using 40-grit, the trim tab hinge half you have just drilled.
6. Clean this half of the hinge with Acetone.
7. Rout out the core of the top aileron skin where the trim tab hinge will be mounted.
You'll notice that the core of the aileron is not the standard Nomex honeycomb but a foam-like Divinicell.
8. Clean the routed area.

Figure 4.3.A.3 Extruded hinge for the aileron trim tab

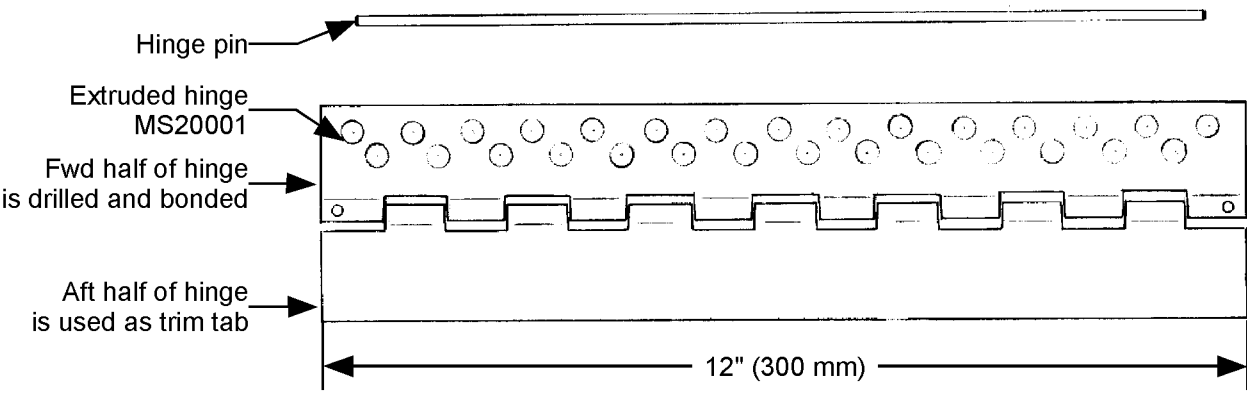
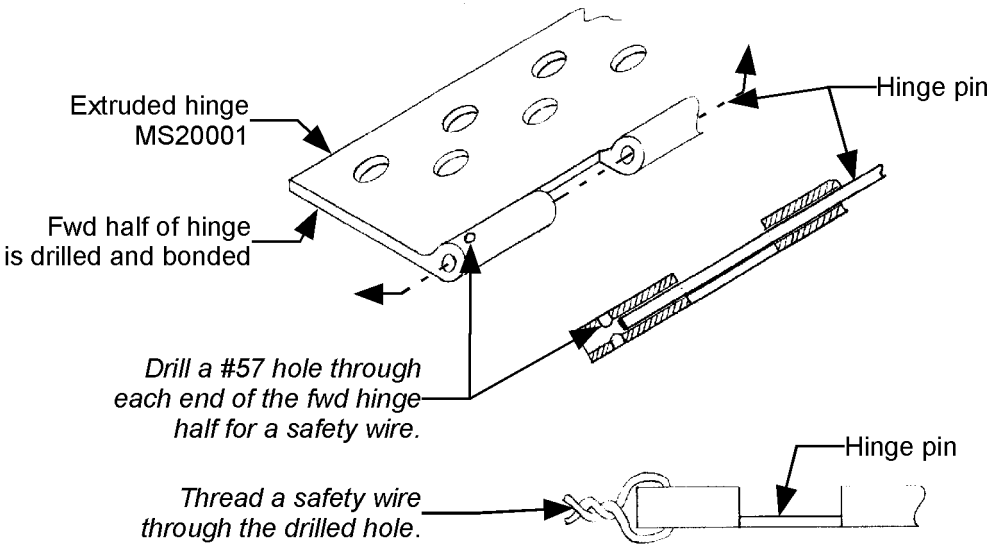


Figure 4.3.A.4 Drilling the hinge for the safety wire



9. Using epoxy/flox, bond the trim tab hinge into the top aileron skin T.E. Be sure not to get flox into the hinge pin area.
10. Position the trim tab on the bottom surface with the trim tab hinge in line with the threaded servo shaft (this position will also be perpendicular to the aileron T.E.).
11. Use rivets, AN426A3-5, to secure the trim tab arm to the trim tab. See Figure 4.3.A.8.
12. Grind a pushrod transit hole through the bottom aileron skin.
13. Connect the trim tab arm to the servo using the pushrod hardware provided in the MAC servo box.
14. Drill a 1/8" (3 mm) dia. hole through the aileron spar just forward of the servo. The two wires for the trim servo are routed forward of the aileron spar to the outboard end of the aileron.
15. Thread the two white wires of the servo through the spar hole and add wire and connectors as necessary (they are not included in the kit) to extend these wires out to the wing tip area.

Routing the Wires

The wires will be routed into the cabin through the plastic electrical tube that you will install.

Figure 4.3.A.5 Trim tab connected to the aileron, showing the servo flange

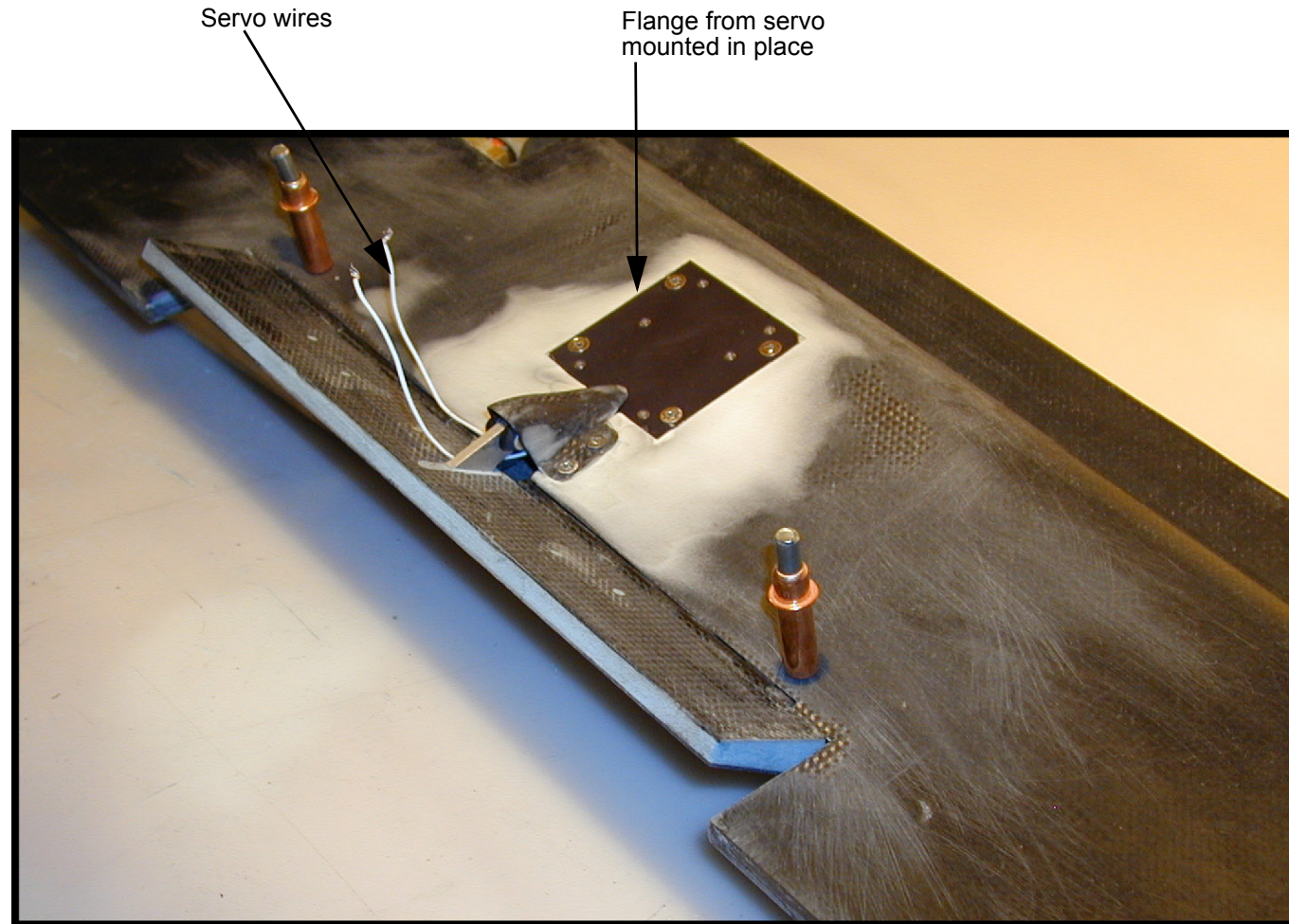


Figure 4.3.A.6 Securing the trim tab arm to the tab

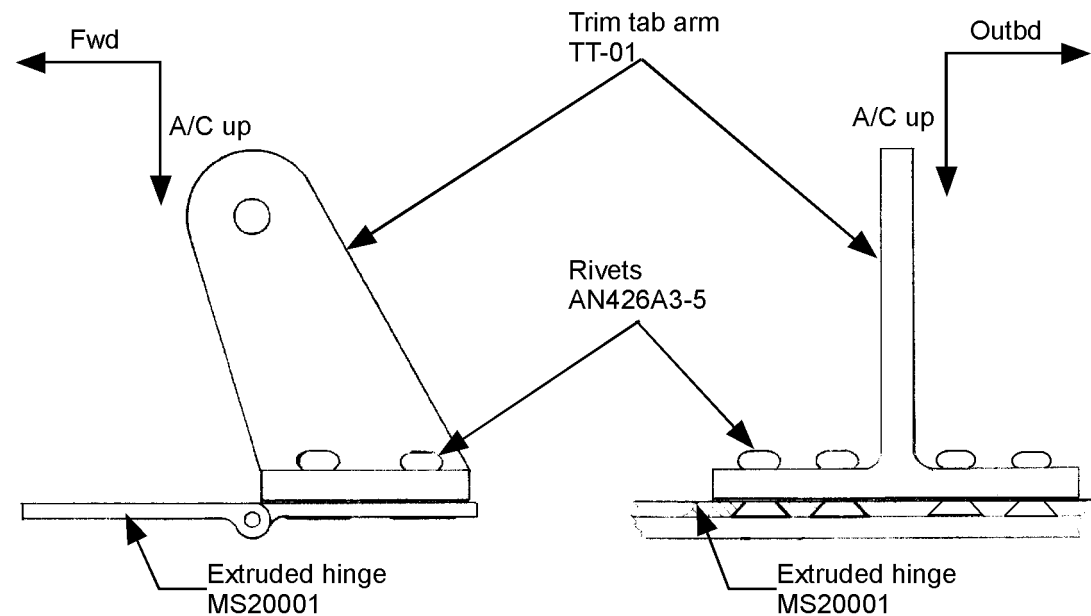


Figure 4.3.A.7 Trim tab arm with extruded hinge

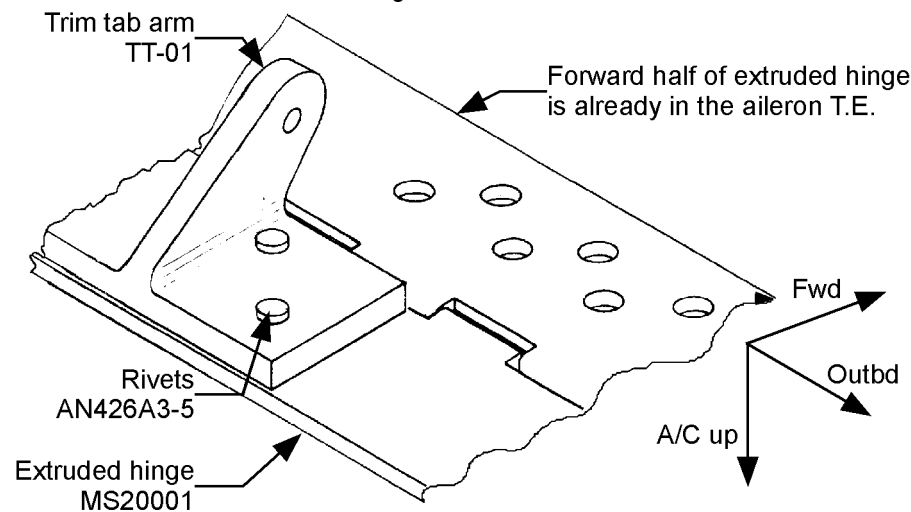
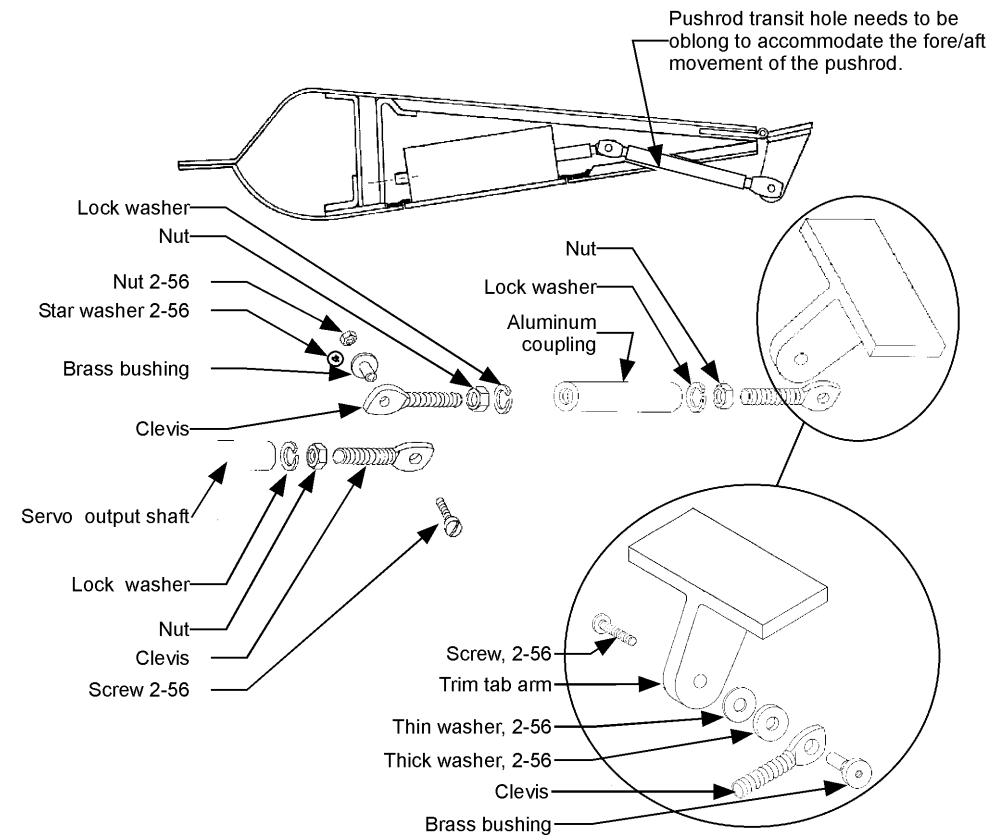


Figure 4.3.A.8 Connecting the pushrod to the servo



4.3.B Completing the Wing's Aileron Control

A steel pushrod connects the aileron actuator arm to the aileron bellcrank on the BL 145.5 rib. The geometry of the aileron bellcrank provides for accurate aileron travel and differential allowing for coordinated flight without the use of rudder pedals. An aluminum pushrod connects the aileron bellcrank to the aileron idler arm on the BL 75 rib. Another aluminum pushrod connects the bellcrank to a pushrod in the fuselage.

Steps...

1. Drill the initial holes through the aileron's ribs for the pushrod using the following steps to align the holes. Later you will correctly size each hole to provide adequate clearance.

Locate the holes by:

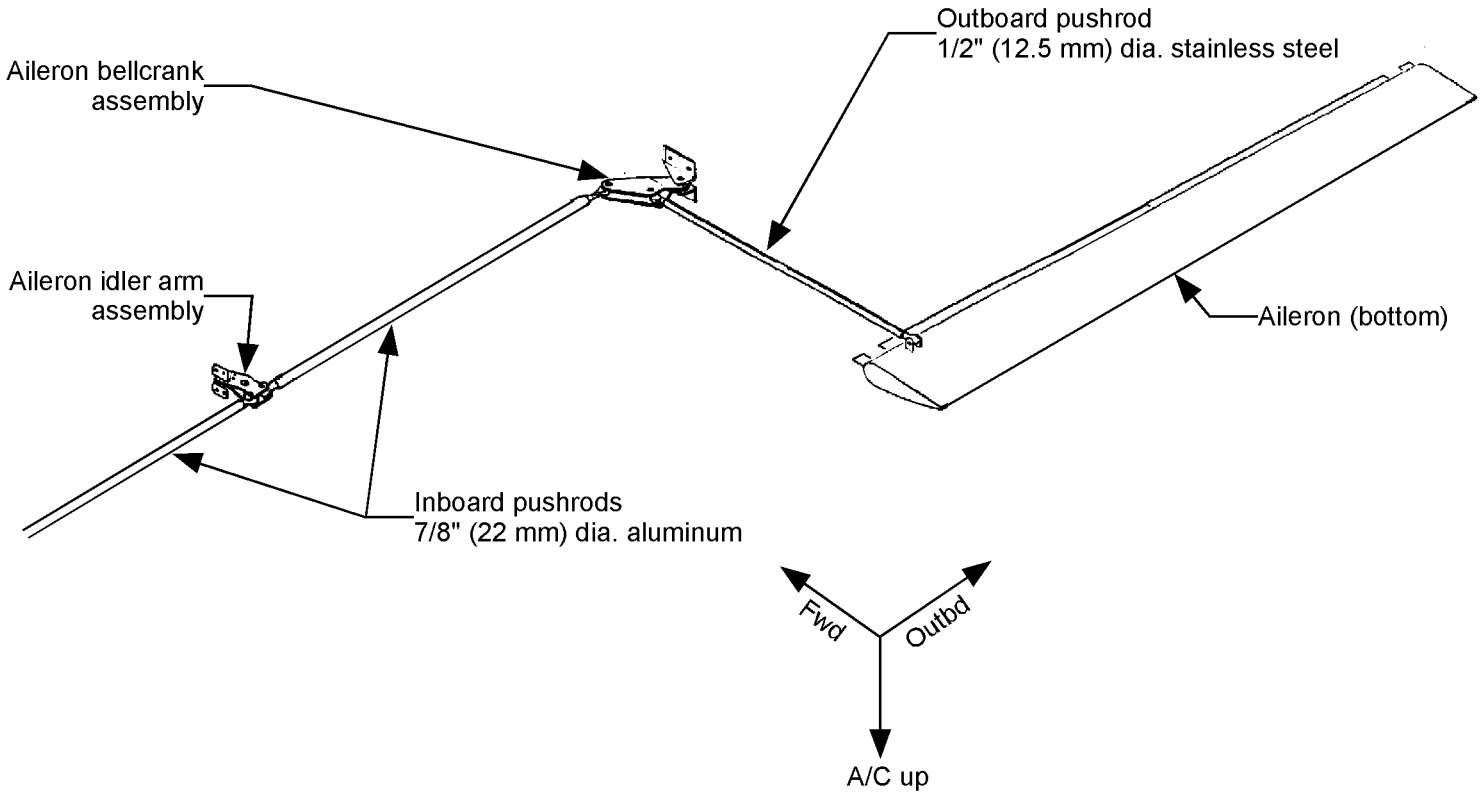
- Draw vertical lines aft of the L.E. of the wing using the following dimensions:

Rib	Distance from Rib to center of hole
27.25	5.25" (130 mm)
39	5.4" (140 mm)
54.5	5.7" (145 mm)
75 thru 139.5	6.0" (150 mm)

- Mark the center line of the rib height wise. The intersection of the two lines will be the center of the initial hole.
- Drill 1 1/2" (40 mm) diameter holes in ribs BL 27.25 through BL 139.5. A hole saw works well.
- Look through the holes from the inboard rib to check that they are all aligned.

The holes are now large enough for the initial alignment. Later when all the hardware is installed and the ailerons hooked up you will increase the size of the holes so there is a minimum of 1/4" (6 mm) clearance between the pushrod and the ribs and shear web at any point through the travel range.

Figure 4.3.B.1 Overview of the aileron actuator mechanism



The bellcrank is centered height wise on the rib. It is necessary to reinforce the BL 145.5 rib at the bellcrank location.

Steps...

1. Remove the outboard laminate and core on the outboard side of the BL 145.5 rib as shown in Figure 4.3.B.3. You will need to cut into the capstrip reinforcements and the BID securing the rib to the upper wing skin.
2. Remove the core on the forward and aft edges of the coreless area and form a micro radius around the perimeter.
3. Prepare the BL 145.5 rib for the 8-BID.

Figure 4.3.B.2 Location of coreless area

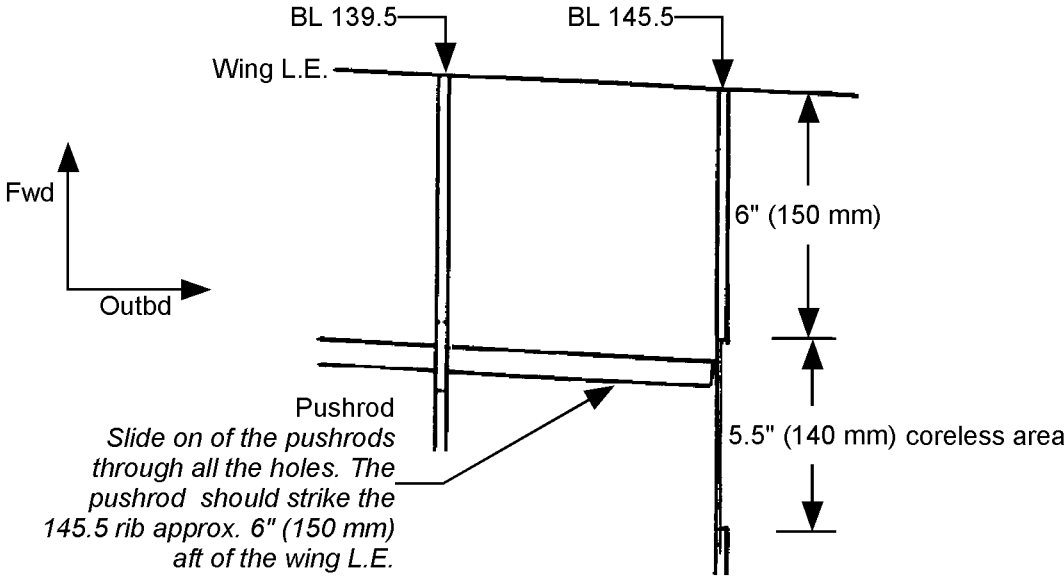
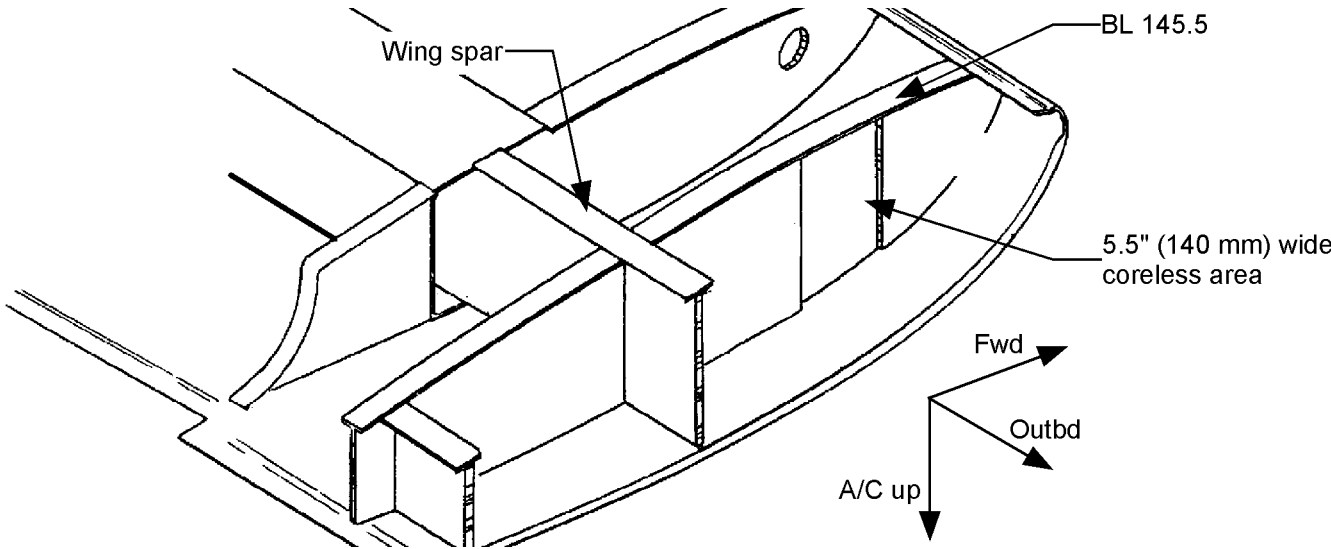


Figure 4.3.B.3 BL 145.5 Rib core removal area



4. Reinforce the BL 145.5 rib with an 8-BID, extending 1" (25 mm) onto the following areas:
 - wing skin
 - capstrips
 - fore and aft of the coreless area

Refer to Figure 4.3.B.4.

5. Drill 3/16" (4.75 mm) mounting bolt holes in each bellcrank bracket, parts AL201-01 and AL201-02.
Drill a straight hole to a tight tolerance. You will later use these holes as guides for drilling the holes through the BL 145.5 rib.

Figure 4.3.B.4 BL 145.5 8-BID reinforcement

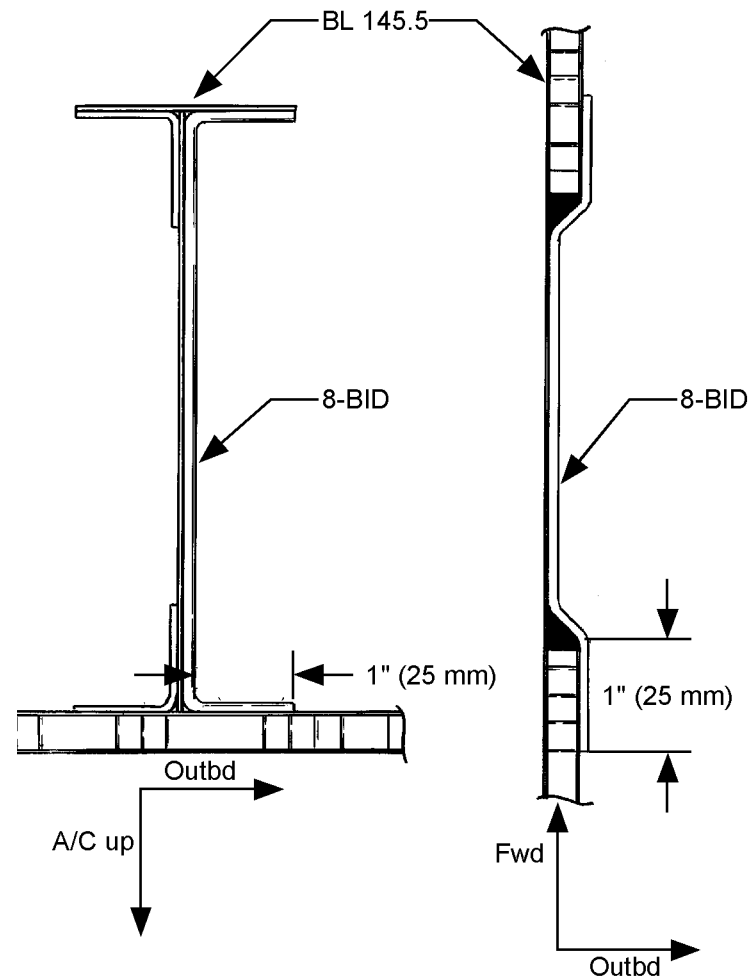
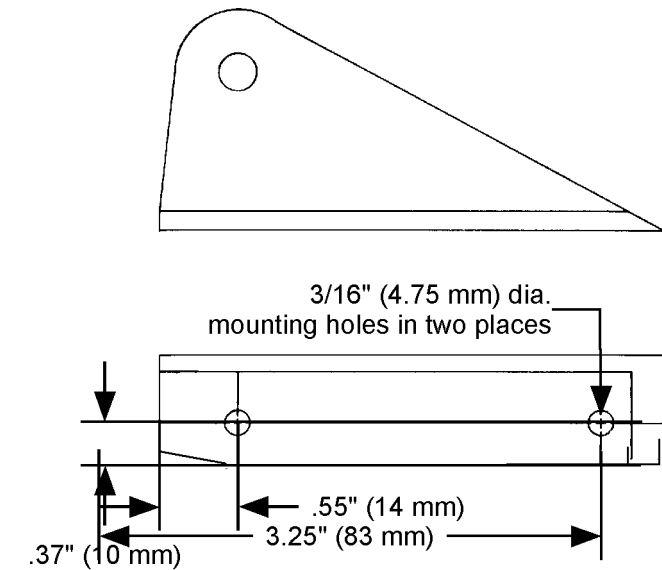


Figure 4.3.B.5 Bellcrank bolt holes



6. Bolt the bellcrank between the two bellcrank brackets as shown in Figure 4.3.B.7.

Notice that the bellcrank brackets are mirror images of each other, the bottom bracket on the left aileron bellcrank is used as the top bracket on the right aileron bellcrank.

7. Align the bellcrank as shown in Figure 4.3.B.6.

The alignment criteria are:

- The forward edges of the aileron attach brackets must be 6" (150 mm) from the L.E. of the wing.
- The assembly must be centered height wise on the rib.
- The assembly should be mounted at approximately 3° off from horizontal as shown.

Figure 4.3.B.6 Aligning the aileron bellcrank

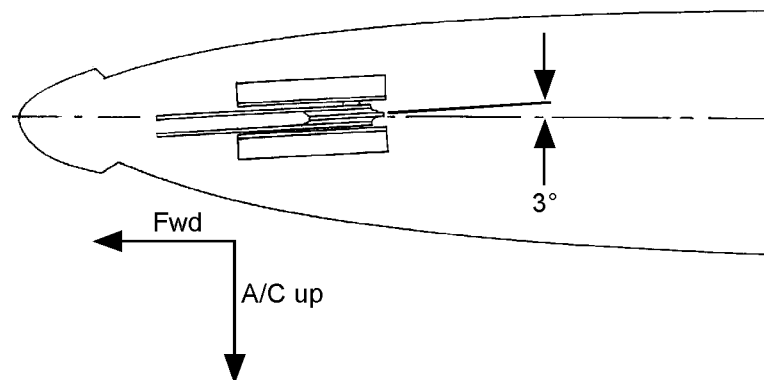
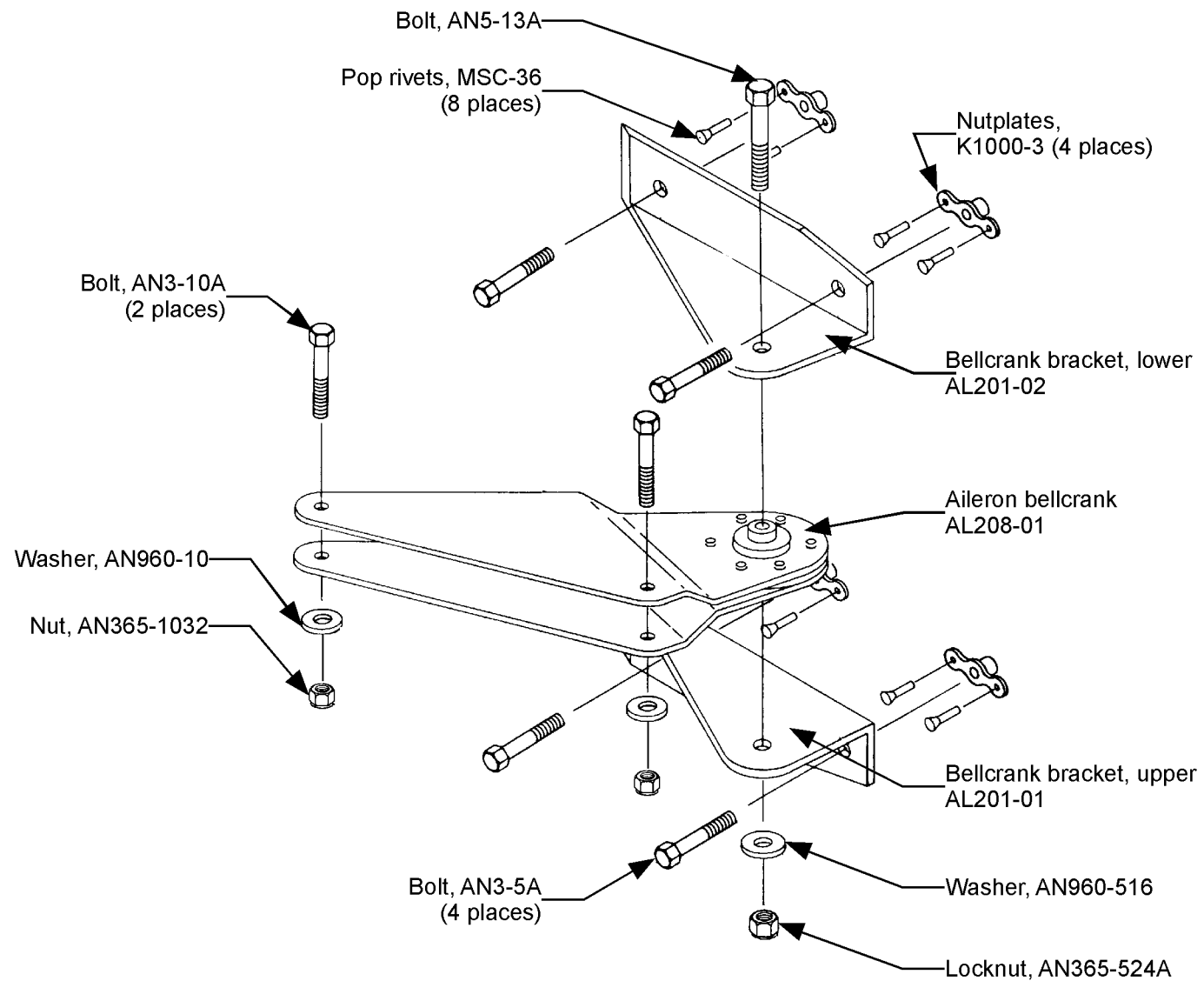


Figure 4.3.B.7 Bellcrank assembly



Before you start drilling in the next step, make sure the assembly will not move in the process by using superglue or clamps.

8. Drill the 3/16" (4.75 mm) attach bracket mounting holes through the rib using a 90° drill attachment.

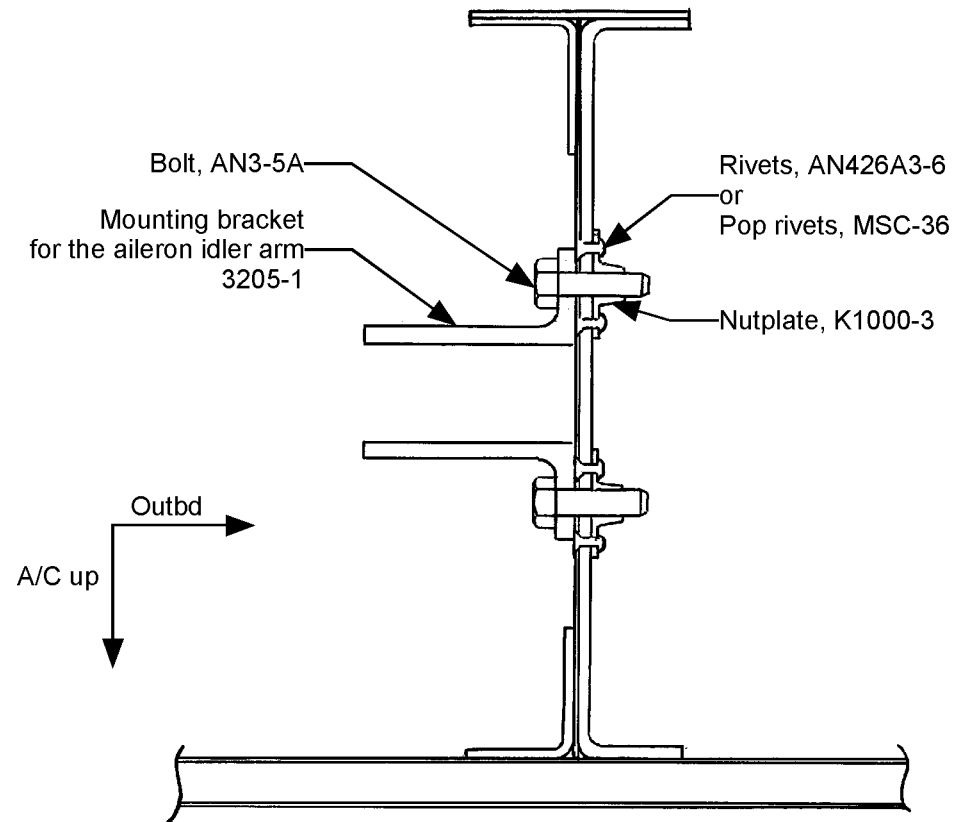
Drill one hole at a time and slide the appropriate bolt through. It is a good idea to label the left and right bellcrank assemblies at this time as the holes may vary slightly in the two assemblies.

9. Remove the bellcrank brackets from the rib and mount the K1000-3 nutplates as shown in Figure 4.3.B.8.
10. Apply a small dab of structural Hysol™ adhesive around the nutplate flanges. This insures that the nutplates will never loosen.

Tip: Don't get structural adhesive Hysol in the threads of the nutplates.

11. Reinstall the aileron bellcrank and bellcrank brackets.

Figure 4.3.B.8 Installing the aileron bellcrank



Assembling the Aileron Idler Arm

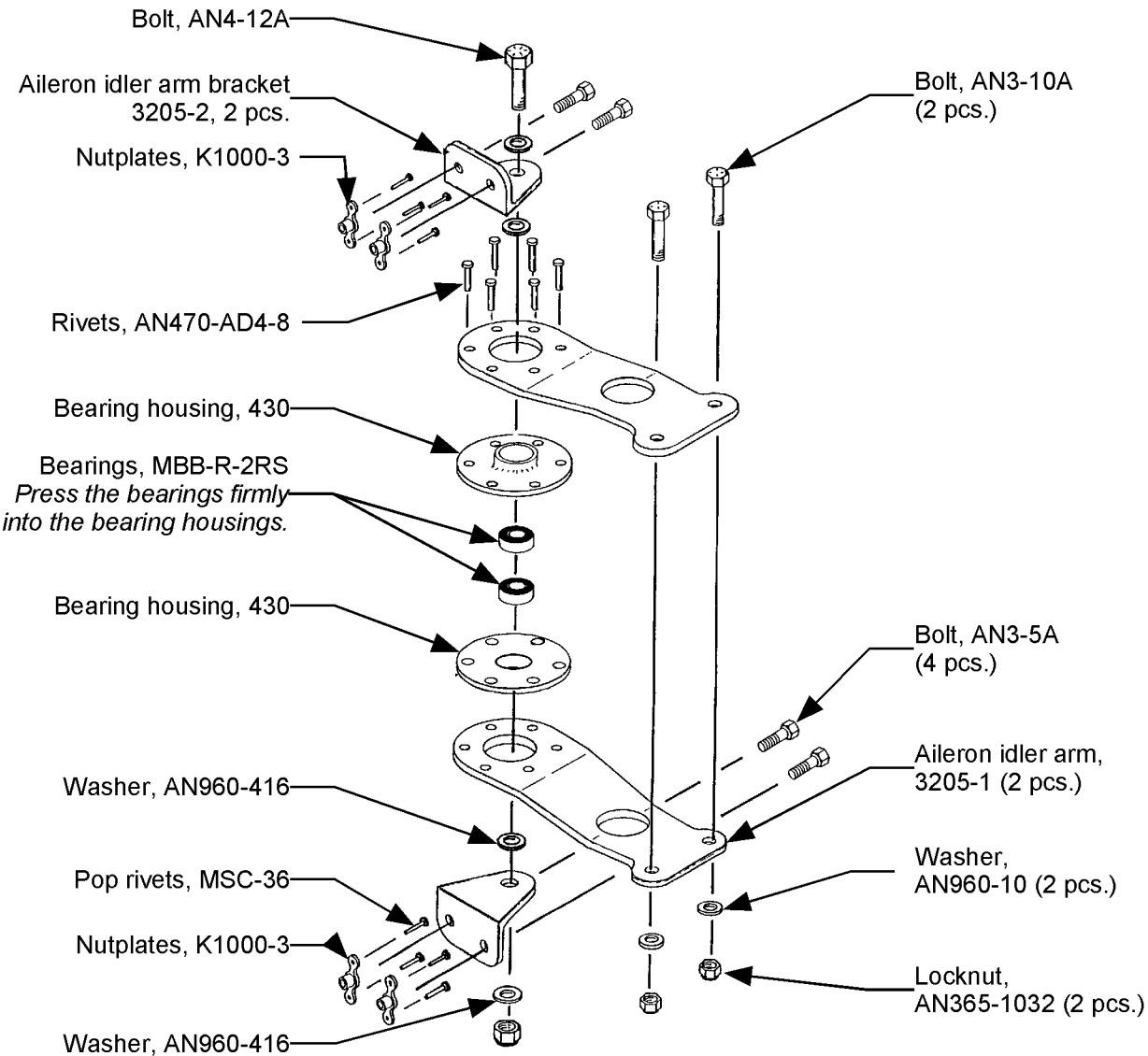
The aileron idler arm is mounted in much the same way as the aileron bellcrank. It is mounted to the outboard face of the BL 75 rib. First the aileron idler arm needs to be assembled.

Steps...

1. Assemble the aileron idler arms as shown in Figure 4.3.B.9.
2. Cut a scrap piece of 1/8" (3 mm) thick aluminum or steel to fit on the outboard side of the BL 75 rib in the idler arm mounting area.

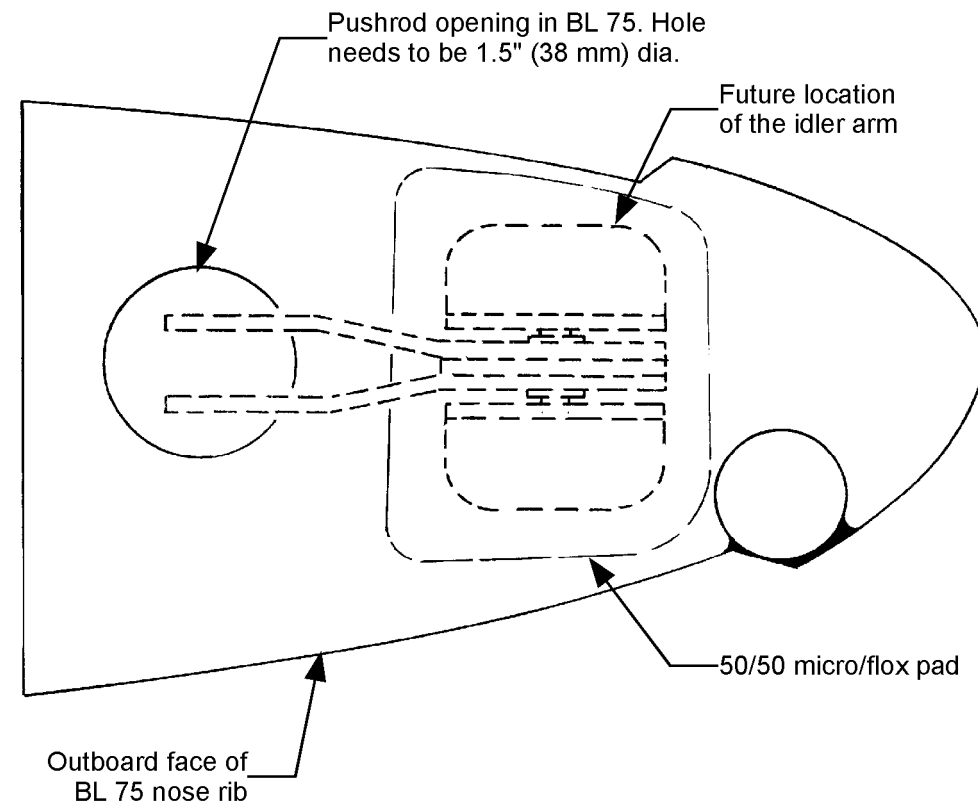
This is used to create a flat surface and then it is removed. It is a good idea to trial fit the idler arm to get an idea of the location for the micro/flox pad. The exact orientation of the idler arm is not critical, but it must be located in the center of the holes.

Figure 4.3.B.9 Assembly of the aileron idler arm



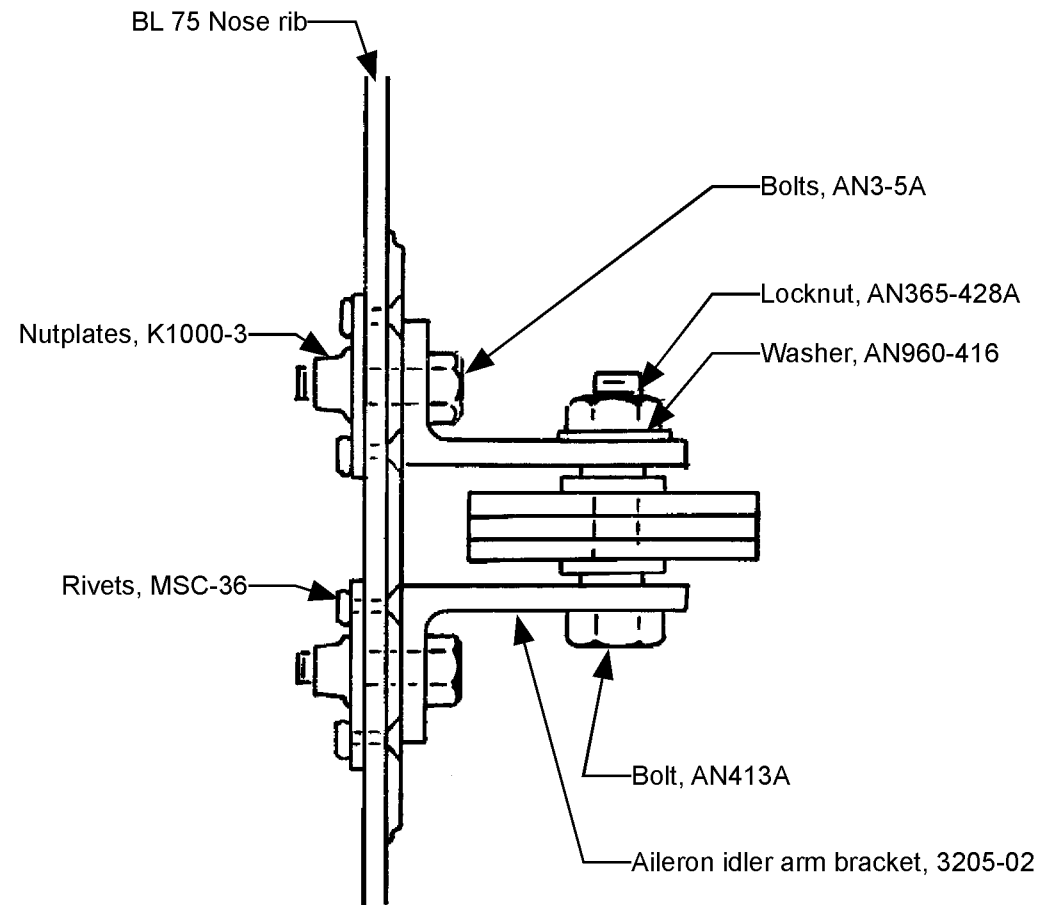
3. Cover the flat aluminum piece with release tape or wax and make sure the aluminum doesn't ride up on the radii where the ribs join the capstrip and the top wing skin.
4. Prepare the outboard face of the BL 75 rib for a flox/micro pad.
5. Apply a thin 50/50 micro/flox mixture to the are of the release.
Don't use too much micro/flox, a thin 0.04" (1 mm) coating is sufficient.
6. Clamp the aluminum release plate in position on the rib.
Don't clamp the aluminum release plate too tightly, you may bend or warp it so the resulting surface would be uneven.
7. Bolt the aileron idler arm between the two bellcranks.
Before you mount the aileron idler arm assembly to the BL 75 rib you must have a flat surface on the rib for the brackets to mount.
8. Align the aileron idler arm on the outboard face of the BL 75 rib as shown in Figure 4.3.B.10.

Figure 4.3.B.10 Micro/Flox mounting pad for aileron idler arm



9. Drill the 3/16" (4.75 mm) attach bracket mounting holes through the rib using a 90° drill attachment.
Before drilling, make sure the assembly will not move in the process (use superglue or clamps). Drill one hole at a time and slide the appropriate bolt through.
10. Remove the aileron idler arm assembly from the rib and install the K1000-3 nutplates (as shown in Figure 4.3.B.11). To assure yourself that the nutplates will never loosen up on the rib, apply a small dab of HysoTM structural adhesive around the nutplate flanges.

Figure 4.3.B.11 Mounting the aileron idler arm bracket



Aileron Pushrods

There are three aileron pushrods in each wing.

- Inboard pushrod – connects the inboard aileron bellcrank to the aileron idler arm.
- Next pushrod outboard – connects the aileron idler arm to the aileron bellcrank.
- Outboard pushrod – connects the aileron bellcrank to the aileron actuator arm.

Since you won't know the exact length of the inboard pushrod until you have mounted the wings in the fuselage, you will only rivet the outboard rod end to the pushrod at this time.

For this section the ailerons should be mounted.

Mounting Guidelines...

- The pushrods are installed with the aileron bellcrank and the aileron idler arm in the neutral position (refer to the above figure).
- The ailerons must also be set neutral (or at 0° deflection).
- The aileron bellcrank will travel roughly 1 1/4" (30 mm) inboard and outboard of the neutral point.
- The aileron idler arm will have the same amount of travel as the aileron bellcrank. You will have to open up the hole in the BL 75 rib for the idler arm to fit through.

Note: The aileron travel is 20° up and 13° down.

The aileron rigging is completed in *Chapter 7 Aileron Controls*.

Figure 4.3.B.12 Centering the aileron idler arm

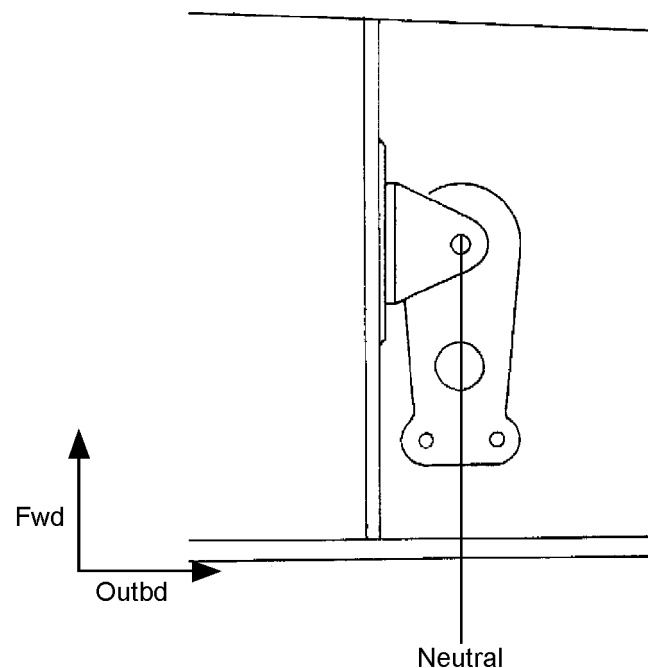
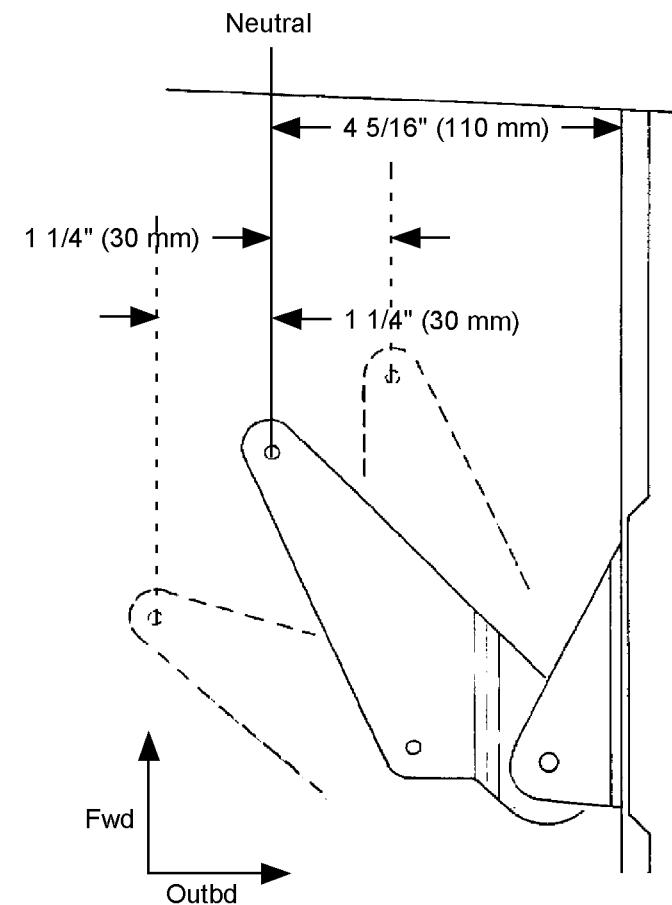


Figure 4.3.B.13 Centering the aileron bellcrank



Finding the Outboard Pushrod Length

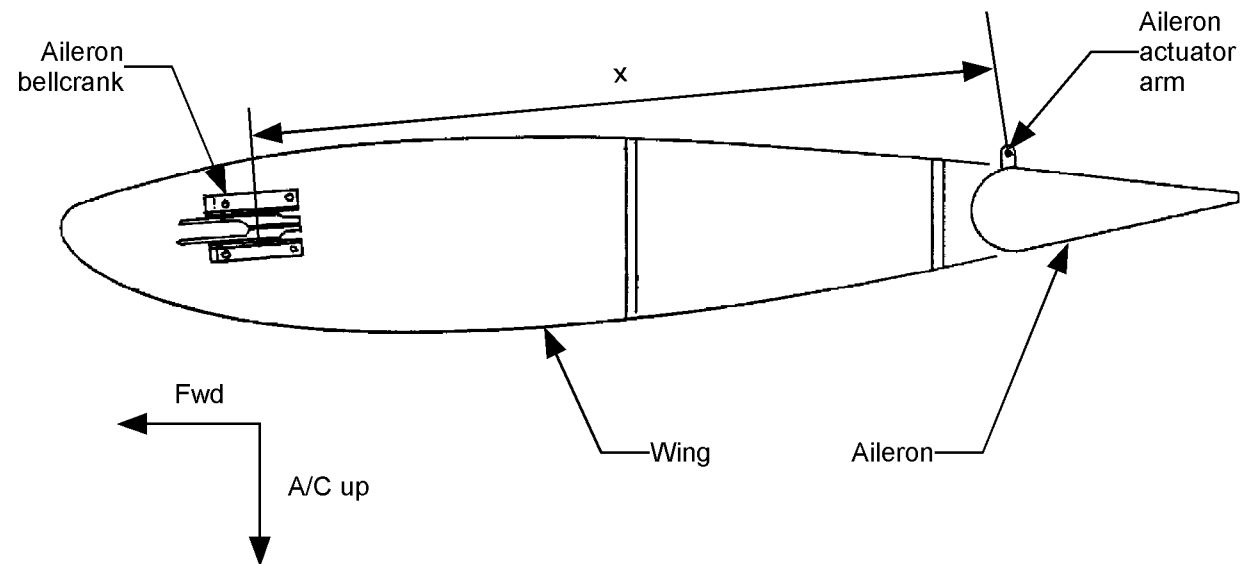
The outboard pushrod is 1/2" dia. stainless steel rod (AL3202). It connects the aileron actuator arm to the aileron bellcrank.

To Determine the Length...

1. Measure the distance between the aileron actuator arm and aileron bellcrank, as shown in Figure 4.3.B.14.
You will need to cut a notch in the outboard shear web and wing skin.
2. Drill a hole in the outboard spar closeout for the pushrod to fit through.
Make sure the aileron is at 0° deflection and the bellcrank is in the neutral position as shown in Figure 4.3.B.13.
3. Start with a 1/4" (6 mm) hole and run a string line through to determine which way you need to open it up.
4. Calculate the length you need to cut the tubing.
 $\text{Length} = X - 3.9"$
– or for metric –
 $\text{Length} = X - 99 \text{ mm}$
5. Cut the tubing to the calculated length.
6. Check that the pushrods are the correct length by securing the rod ends with a couple of drops of superglue, then install them.
Do not cover the rod ends in glue and then slop them into the tube as the bond would be impossible to break.
7. Once you determine the pushrod tube is the proper length, break the rod ends free and clean them up.

If you need instructions on installing the rod ends, see Chapter 2, 2.3.G *Control Systems* on page 2.21 or to see a photo of a rod end see Chapter 13, page 13.14.

Figure 4.3.B.14 Determining the outboard pushrod length

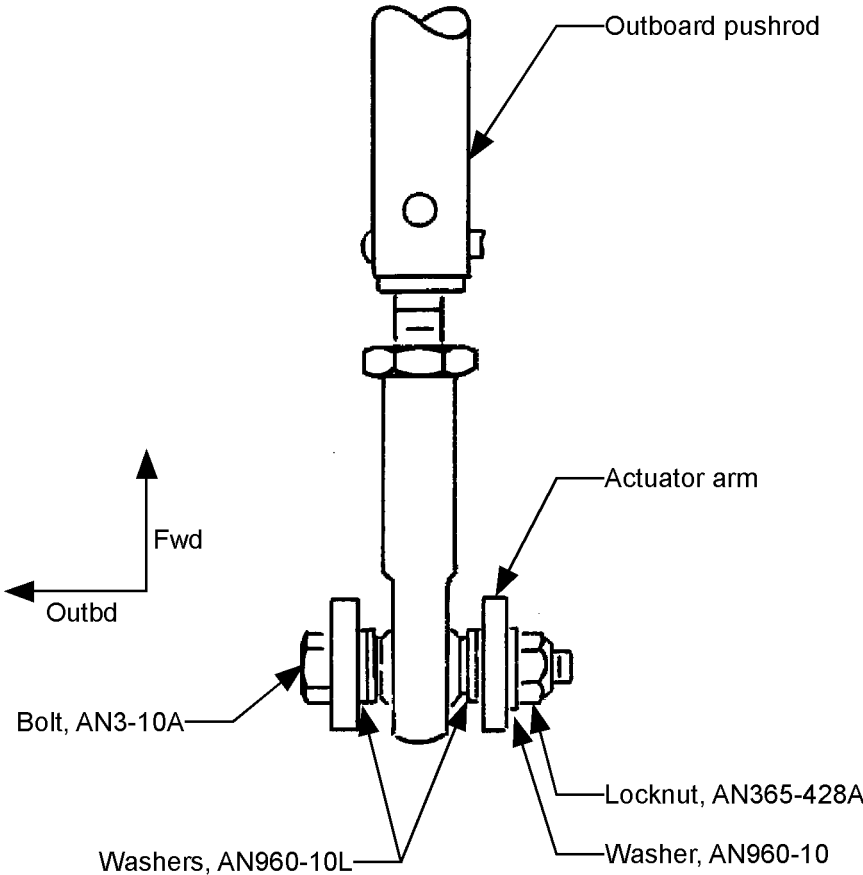


Installing the Outboard Pushrod

Steps...

1. Install the rod ends in the outboard pushrod.
It is important that once you have adjusted all your pushrods, you must tighten the checknuts. Tighten the checknut against the rod end bearing for the outboard pushrod.
2. Grind clearance in the shear web as required.
3. We suggest you make a small fairing to cover the pushrod where it protrudes through the wing skin. Simply shape a piece of foam to the desired shape. See the photo on page 4.6 for an example of the fairing.
Make sure the fairing is large enough to accommodate the pushrod through its range of travel.
4. Apply 3-BID to the piece of foam. Leave a 1" (25 mm) flange for bonding the fairing to the wing skin.

Figure 4.3.B.15 Installing the outboard pushrod's rod end to the actuator arm



Finding the Inboard Pushrod Length...

The two inboard pushrods are 7/8" (22 mm) dia. aluminum (6061T6-.875x058). The inboard pushrods can be left to full length since they will be cut to length after you have installed the inboard aileron bellcranks in the fuselage Chapter 7.

Tip: Do this section twice to calculate the length separately for each wing. It is very likely that the left and right wings are slightly different.

To Determine the Length...

1. Measure the distance for the pushrod that connects the aileron idler arm to the aileron bellcrank, from bolt hole to bolt hole.

Once again, make sure both the idler arm and the aileron bellcrank are in the neutral position as shown on page 4.16.

2. Calculate the length you need to cut the tubing.

$$\text{Length} = X - 3.4"$$

– or for metric–

$$\text{Length} = X - 86 \text{ mm}$$

3. Cut the tubing to the calculated length.
4. Install the rod ends in the 7/8" (22 mm) diameter pushrods. Only install one rod end in the pushrod connecting the idler arm to the inboard aileron bellcrank. Use Loctite to prevent the rod end from rattling and two rivets (AN470AD4-20) per rod end.
5. Install the rod end bearings. There is no tag wire hole in this type of rod end bearing. The rod end bearing must be at least 0.45" (11 mm) into the rod end or eight turns.
6. Install the pushrods.

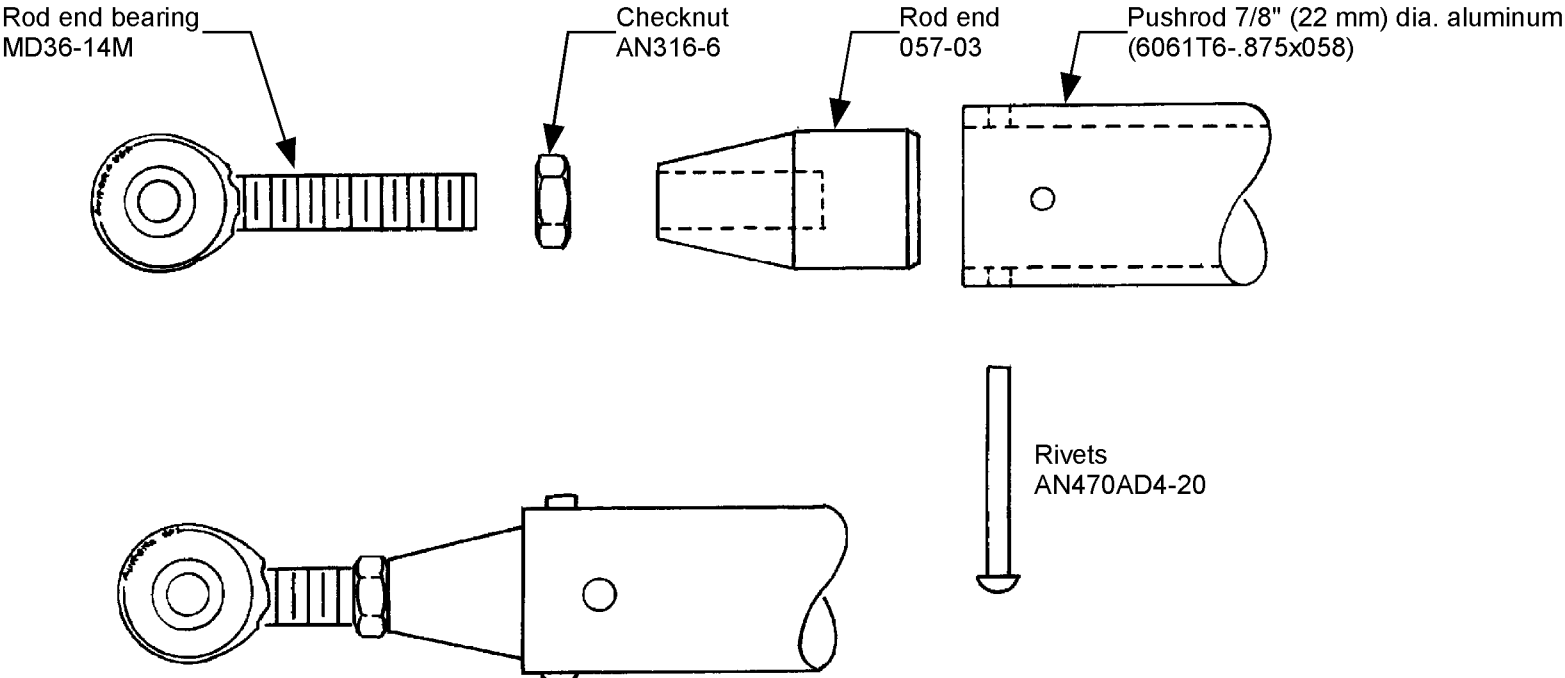
Don't let these numbers scare you. They simply correspond to the outside diameter of the threads of the rod end bearing plus 1/16" (1.5 mm) which is the accepted safety factor.

The exploded view of the aileron idler arm, Figure 4.3.B.9, and the aileron bellcrank, Figure 4.3.B.7, show the appropriate hardware.

Aileron Travel and Pushrod Clearance

1. Check for pushrod clearance.
The clearance for the two outboard pushrods:
 - Move the ailerons through the entire travel range from +20° to -13°.
 - Make sure you have at least 1/4" (6 mm) of clearance between the pushrods and the ribs and shear web.
2. Open up the hole for the idler arm. Remove 1/8" - 1/4" (3-6 mm) of core around the perimeter of the holes and fill with an epoxy/micro mixture.

Figure 4.3.B.16 Rod ends for the 7/8" (22 mm) pushrods



Tip: There is no tag wire hole in this type of rod end bearing. The rod end bearing must be at least 0.45" (11 mm) into the rod end or eight turns.

4.3.C Balancing the Ailerons

Like the elevator, the ailerons are 100% mass balanced with lead weights. Since there is no counterweight arm to mount the lead within, half-round lead weights are bonded to the L.E. flange of the aileron. These weights are provided in the kit. This counterweight system has no drag penalty and is simple to build.

Steps...

1. Trim the aileron L.E. flange as shown in Figure 4.3.C.1.
2. Suspend the aileron using safety wire by inserting the hinge bolts into the aileron hinges and threading the wire around the bolts. Attach the three wires to a straight board (or a length of steel or angle iron) so the aileron hangs level underneath. Support the straight board at each end with sawhorses.

It is important that the aileron hangs level for proper balancing, and that the top skin is UP.

3. Position the lead weights. It will take about seven to eight half-round weights to balance each aileron.
The left aileron, that has the trim servo, will require more weight than the right aileron.
4. Flatten the weights with a hammer (a carpenter's hammer with the rough striking surface works well) until they are half their original thickness.
5. Temporarily install the lead weights along the entire leading edge. You will have to cut the weights to fit. A few drops of superglue will hold them in place.
6. Continue adding weights on top of the other weights until you have achieved the condition depicted in Figure 4.3.C.3 with the T.E. about 1/2" (12 mm) higher than level at the middle of the aileron).

This will allow for the added weight of primer and paint. Then after the aileron is finished you will need to perform a final balance by drilling holes through the flange and lead weights. The aileron must not be under balanced!

Figure 4.3.C.1 Trimming the aileron's L.E. flange

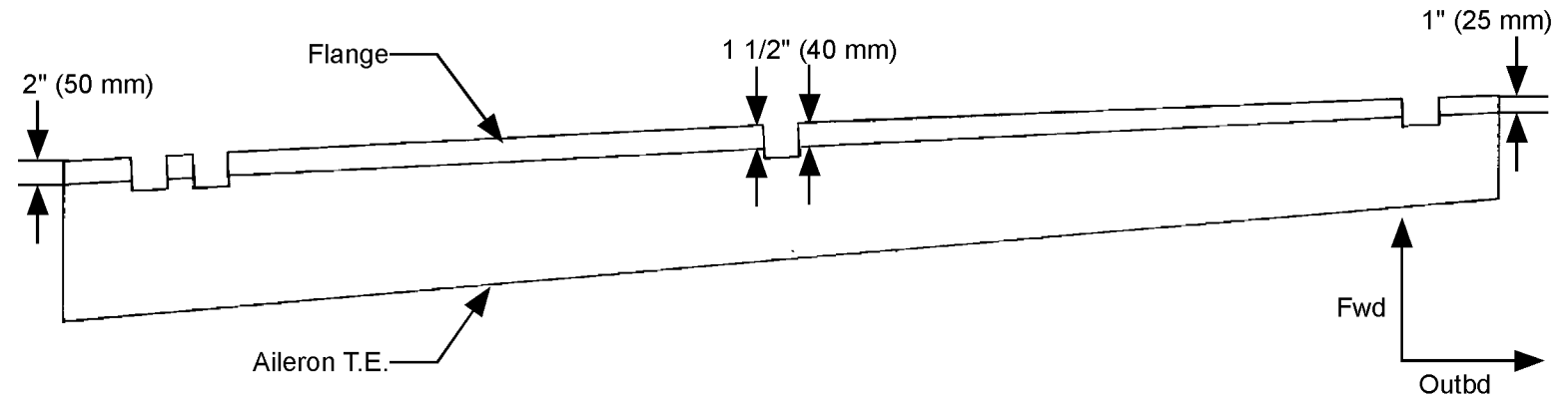
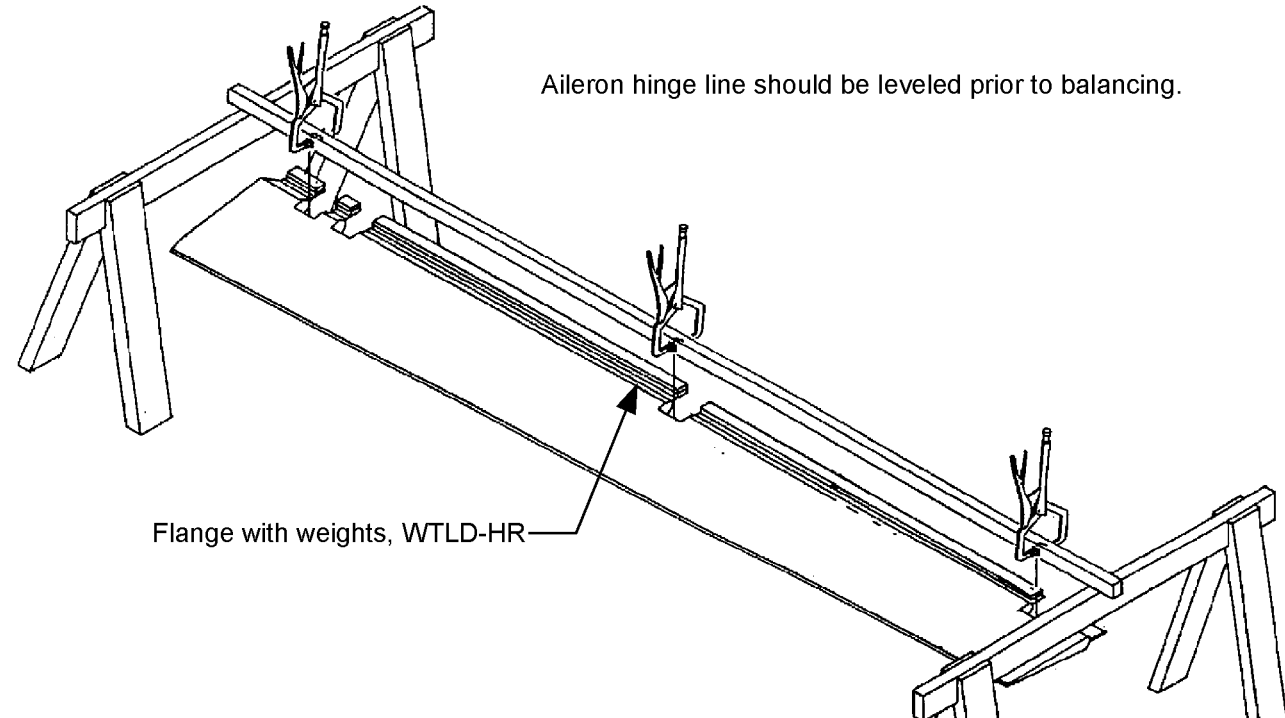


Figure 4.3.C.2 Suspending and balancing the aileron



7. Rotate the aileron through its travel range and check that the lead counterweights do not strike the inside of the top wing skin before the aileron has reached its full travel.
8. Lay the bottom wing skin in position and again check the aileron for freedom throughout its travel range.
9. Sand or file a radius on the lead weights or aileron L.E. flange if either interferes with the aileron's travel limits. Once you are satisfied the lead counterweights will fit, you can flex them in place.

Tip: The wing core may be in the way of achieving full aileron travel. You may remove the core in this area and apply a 2-BID reinforcement.

10. Also, while you still have the aileron mounted on the wing:
 - Move the aileron to its full down travel of 13° down.
 - Draw a line along the aileron L.E. radius at the trailing edge of the wing skin.
 - Repeat this process for the extreme up travel.

The purpose of this line is so you will know how far to extend the 3 BID securing the counterweights onto the L.E. radius.

11. Secure the lead counterweights to the aileron L.E. flange with floc and 3 BID.

There's no need to remove the lead weights from the flange, just push the floc into the gaps and crevasses so the cloth will lay nicely over the rough lead surface. Extend the 3 BID to within 1/4" (6 mm) of the line you drew in the previous step.

WARNING: Make sure you have sanded and cleaned the surfaces you are bonding to. Failure of the counterweights, meaning the weights falling off, could be extremely dangerous.

Figure 4.3.C.3 Balancing the ailerons

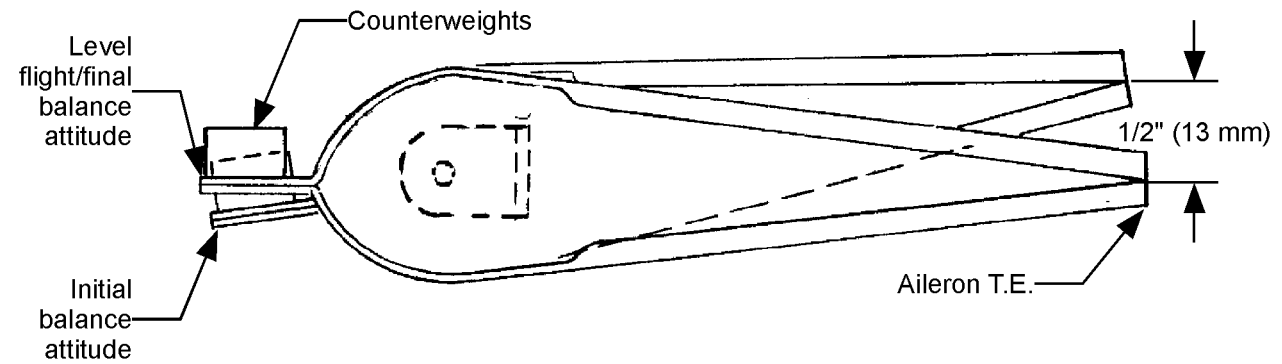


Figure 4.3.C.4 Checking for counterweight clearance

