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A Tale of Two Pipers (/maintenance-technical/item/1321-a-tale-of-two-pipers.html) //

28 March 2020 |

Published in Maintenance & Technical (/maintenance-technical.html)

Piper Aircraft Corporation's expansion in the mid-1950s led to the opening of a second facility at Vero Beach, Florida. The differences between Piper aircraft designed and built in Lock Haven, Pennsylvania, and those born in Vero Beach, Florida, are numerous and important for owners, operators, and mechanics to understand.

While many Piper pilots are aware on some level that Piper used to make aircraft in Lock Haven, Pennsylvania, and now makes them in Vero Beach, Florida, fewer understand the significance of that bit of Piper history.

It is not too much to say that Piper Aircraft in Lock Haven is almost a different aircraft manufacturer than Piper Aircraft in Vero Beach. The change of location led to significant design differences that need to be understood.

A history lesson

To appreciate the differences between the two Pipers and their respective product lines, a bit of history is in order.

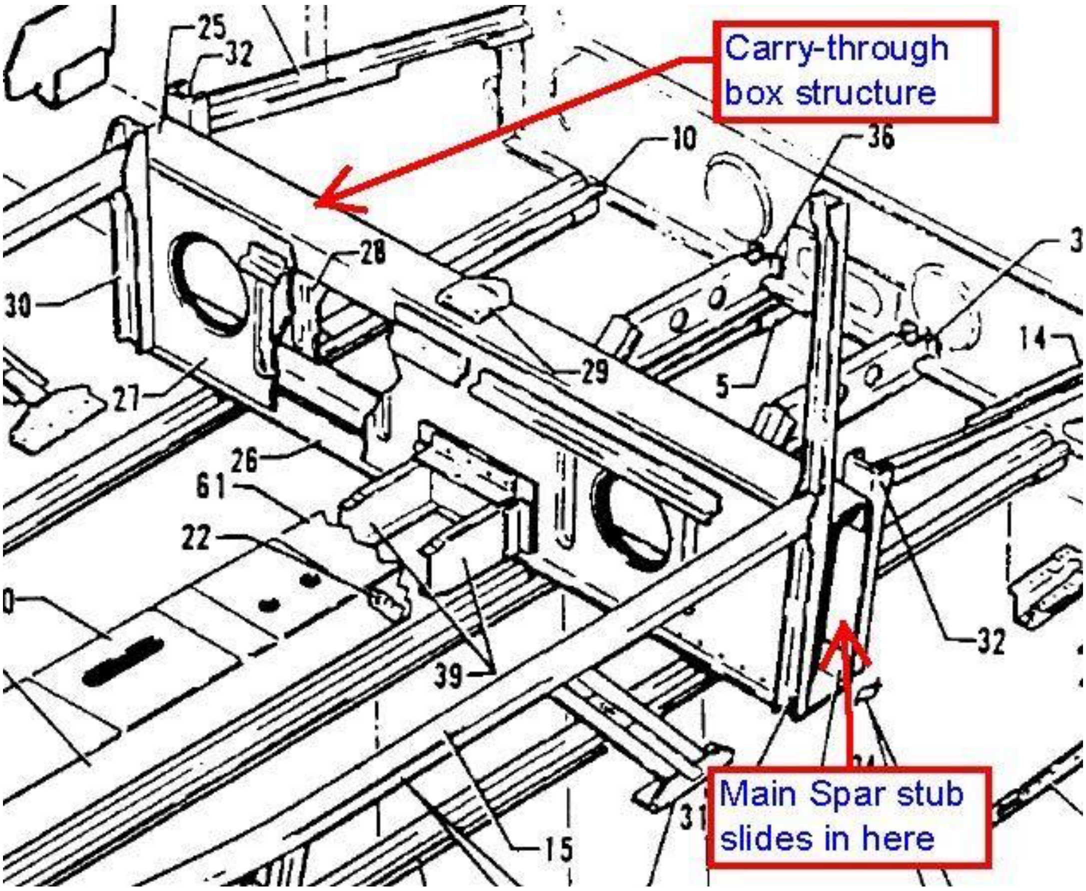
Most know that Piper got its start in Pennsylvania when William Piper, Sr. bought into Taylor Aircraft. Piper then bought Taylor out, and moved the company to Lock Haven, Pennsylvania, renaming it Piper Aircraft Corporation. This was back in the day of the Piper J-3 Cub, prior to World War II. (In "Piper Aircraft," historian Roger Peperell notes that W.T. Piper bought out Gilbert Taylor in 1935, moved to Lock Haven and officially changed the company's name in 1937. —Ed.)

From the beginning, W.T. Piper sought to be the Henry Ford of aviation, attempting to make aviation affordable to the masses. With the Piper Cubs and their derivatives, Piper arguably achieved that goal.

After World War II, airplane development turned from tube and fabric truss construction to aluminum, semi-monocoque designs.

Piper's first two all-metal aircraft were the Piper PA-23 Apache and the Piper PA-24 Comanche. These were both fine airplanes, but Piper's lower-end line was still represented by the tube-and-fabric PA-20 Pacer and PA-22 Tri-Pacer. These models were competing against Cessna's 170 and 172 series, which were more modern, all-metal aircraft. Piper needed a competitor to Cessna's offerings, and they wanted to be able to produce it more cheaply.

Piper faced a couple of limitations with building a less-expensive, all-metal competitor in Lock Haven. One limitation was that the Lock Haven plant had little room to expand. This made it difficult to add the facilities necessary to launch another line of aircraft.



Carry-through box structure
Main Spar stub slides in here
25
32
10
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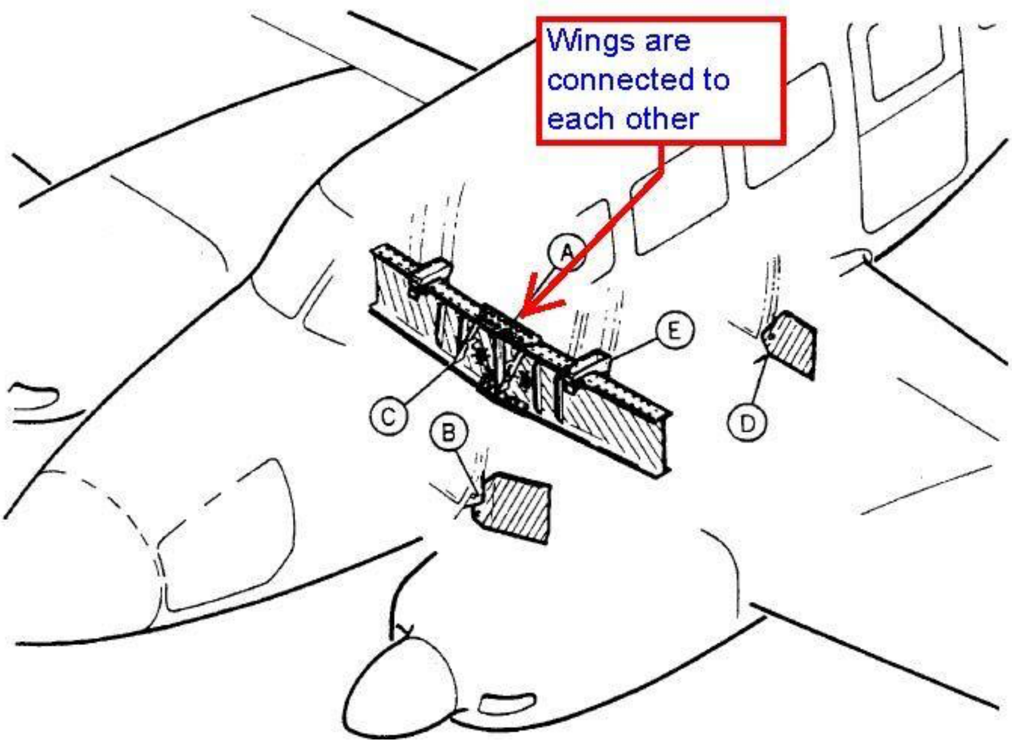
28
30
29
27
5
14
26
61
22
39
32
15
31



Wings are connected to each other
A
E
C
B
D

Additionally, the Lock Haven facility was largely unionized, which meant that labor costs were high, making the goal of a relatively inexpensive competitor to the Cessna 172 more difficult to realize.

Vero Beach expansion

In the mid-1950s, Piper opened a second engineering, and then manufacturing, facility in Vero Beach, Florida.

Piper hired outside engineers, Fred Weick, Karl Bergey, John Thorp, and others to design a new aircraft that would be a modern replacement for the PA-22 Tri-Pacer. There was little cross-pollination with the engineering department in Lock Haven.

The result was the Piper PA-28 Cherokee, which was certified in 1960. One goal was for the Cherokee to be relatively cheap to manufacture. The Cherokee had fewer than half the number of parts of a PA-24 Comanche and fewer than half the rivets. The Cherokee was a design that had little in common with those coming out of Lock Haven.

Evolutionary design and the Cherokee

Once a manufacturer has made a clean-sheet design, it is natural to extend the basics of the design to make new products or to improve existing ones. Evolutionary design is standard in the industry. It is much cheaper to scale up or down an existing design rather than start from scratch. It saves engineering time and it makes an aircraft easier to certify.

The Cherokee series and its many derivatives are a classic example.

The original fixed-gear, four-place PA-28 Cherokee design begat models ranging in horsepower from 140 to 235. The PA-28 got a new wing in the 1970s, which was itself only a modification of the existing wing.

The new “Warrior” wing was a longer, tapered version of the original “Hershey Bar” wing, so called because of its rectangular shape and resemblance to the candy bar.

The new wing was of the same airfoil and had the same wing area. The change took the outer portion of the wing and tapered and lengthened it.

The fuselage was stretched, and a bigger engine installed to make the PA-32 Cherokee Six, but the general structure and the design details remained essentially the same.

Retractable landing gear was added to the PA-28-180 Cherokee 180 to make the PA-28R Cherokee Arrow. The same retractable landing gear system was added to the Cherokee Six to make the PA-32R Lance/Saratoga line.

The PA-32 Cherokee Six was modified to make the PA-34 Seneca by using two smaller engines on the wings in place of a single big one in the nose. A similar modification to the PA-28R-201 Arrow IV design resulted in the PA-44 Seminole.

Throughout all these changes, the structure remained fundamentally the same; the landing gear—fixed or retractable—remained the same; the control system remained essentially the same, and so on.

Lock Haven design characteristics

The same sort of design extension is true for Piper in Lock Haven and other manufacturers. However, Lock Haven did not stretch any of its designs as far as Vero Beach did with the original Cherokee.

There are certain hallmarks of a Lock Haven design. They always used the same basic design for how the wings and the fuselage met. They used the same hydraulic landing gear system in the

Apaches, Aztecs, Navajos and Cheyenne series. They used bladder fuel tanks in most models, whereas Vero Beach did not.

Manufacturers' similarities

Anyone familiar with the single-engine Cessnas will see the design similarities throughout. The same can be said of the twin-engine Cessnas (until you get into the Citation line of jets). Beechcraft got a lot of mileage out of the basic Bonanza design, which stretches back to the 1940s. And a Mooney is a Mooney is a Mooney.

When comparing different lines of aircraft from the same manufacturer, many of the design details and the way of doing things show their common origins (assuming they're from the same engineering center).

The departures between the Lock Haven Pipers and the Vero Beach Pipers are fairly dramatic and it is worth keeping that distinction in mind. A Piper is not always the same animal, just because it is a Piper.

An instructor experienced in a PA-28R Arrow will know nothing about a PA-24 Comanche by dint of his/her Arrow experience alone. A mechanic that has worked on PA-28 Cherokees most of his career will be lost at sea when presented with his first PA-23 Aztec.

When dealing with Pipers, keep in mind that there were essentially two different Piper Aircraft companies.

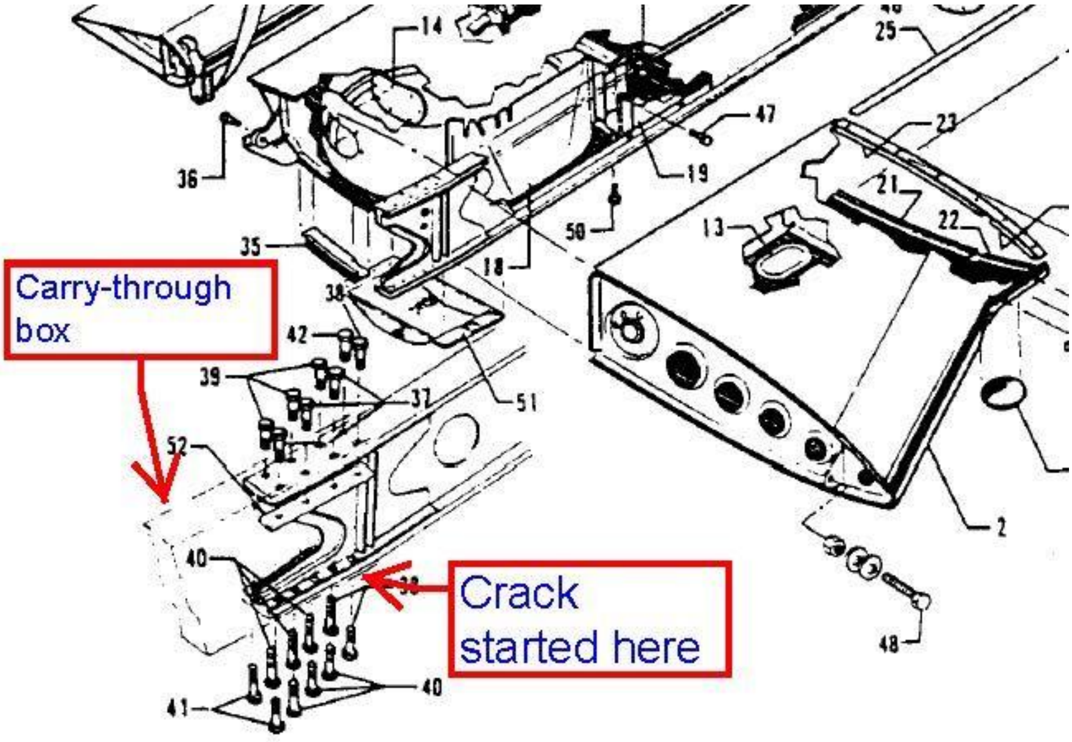
Piper wing attachment designs

In the wake of the in-flight breakup of the Piper Arrow, operated by Embry-Riddle Aeronautical University, some Piper owners or prospective owners/pilots have expressed concern about the structural integrity of all Piper aircraft. In that accident, the left wing separated at the root.

The NTSB has just made a final determination as to the cause. It confirms that fatigue cracks propagated from the outboard bolt holes in the lower spar cap. Additional inspections of Embry-Riddle's fleet of Arrows found another to be cracked in the same location. The FAA has proposed an Airworthiness Directive requiring eddy current NDT testing of the bolt holes looking for fatigue cracks.

The NTSB final report focuses on the numerous landing cycles that these aircraft experienced, which, in the case of the Embry-Riddle aircraft, was in excess of 30,000 landings, and the fact that these aircraft spent their operational life bouncing around at low altitudes. The NTSB report goes on to state that private-use aircraft are not subject to the same magnitude of repetitive stresses. (The final report was published by the NTSB on Sept. 3, 2019. For a link to this 30-page document, visit the PA-28 board under "Piper Models" at PiperFlyer.org/forum. —Ed.)

The Vero Beach Piper PA-28 Cherokee series and its derivatives, including the Arrow, all use the same structural design to attach the wings to the fuselage. The Cherokee uses a carry-through box structure that is built into the fuselage. The main spar of each wing has a stub portion that slides into the carry-through box, and then eight bolts go through the box and upper spar cap and 10 bolts go through the box and lower spar cap.



In contrast, the Lock Haven Piper design attaches the wings together in the center and then attaches the fuselage to the wings. The Lock Haven design has no carry-through structure built into the fuselage. Instead, the main spar of each wing extends out beyond the wing surface a distance approximately equal to half of the width of the fuselage. The main spar of each wing is attached to the other wing main spar with substantial splice plates on both the top and bottom, plus two channels on the front and back of the spar webs. The fuselage is then attached to the wing structure.

The engineering merits of the two types of structures can be debated. However, what is clear is that the failure mode that happened to the PA-28R-201 Arrow (and back in the 1980s to a PA-28-181 Archer) will not happen to the Lock Haven-designed aircraft such as the PA-23 Apache, PA-24 Comanche, PA-23-250 Aztec, PA-30 Twin Comanche, PA-31 Navajo, and the PA-42 Cheyennes.

From the PA-24 Comanche in-flight breakups which I have studied, it appears that the center sections on these aircraft do not fail and do not develop the same type of fatigue cracks as have occurred in the PA-28 series.

The in-flight breakups of which I am aware in the Lock Haven birds involved massive overloading usually caused by flying into a thunderstorm. Even then, it has not generally been the center section of the wings that broke, but rather an outboard section of the wing broke.

It should also be noted that the structure attaching the two halves of the wing together on the Lock Haven aircraft is easy to visually inspect. The Vero Beach Cherokee attachment system requires either sophisticated testing or removal of the wings.

We are all waiting for the other shoe to drop with the Cherokee wings in the form of an expected AD. It should be kept in mind that the aircraft which suffered the wing failures were all high-cycle aircraft. The first in the 1980s had thousands of hours of pipeline patrol flying; bumping along in summer turbulence day in and day out. The Embry-Riddle Arrow had over 6,000 hours of flight training use.

Keep in mind that the proposed AD does not require an inspection on an aircraft which has not had 100-hour inspections until something like 85,000 hours. The fact that the AD applies primarily to aircraft that have a long commercial use history suggests that it is not a factor for the average owner.

Kristin Winter has been an airport rat for almost four decades. She holds an ATP-SE/ME rating and is a CFIAIM, AGI, IGI. In addition, Winter is an A&P/IA. She has over 8,000 hours, of which about 1,000 are in the Twin Comanche and another 1,000 in the Navajo series. She owns and operates a 1969 C model Twinkie affectionately known as Maggie. She is a recognized authority on Piper Comanche aircraft. Currently she is serving as Director of Operations for a commuter airline in Southeastern Alaska. Send questions or comments to editor@piperflyer.org.

From Piper Flyer 1019

Read more... (/maintenance-technical/item/1321-a-tale-of-two-pipers.html)

(/maintenance-technical/item/1284-piper-pa-28-and-pa-32-wing-spar-nprm-2018-ce-049-ad.html)

Piper PA-28 and PA-32 Wing Spar NPRM 2018-CE-049-AD (/maintenance-technical/item/1284-piper-pa-28-and-pa-32-wing-spar-nprm-2018-ce-049-ad.html)

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04 April 2019 |

Published in Maintenance & Technical (/maintenance-technical.html)

01/15/21 Editor's note: The final Airworthiness Directive has been issued and differs from this proposed version.

A proposed AD requires an inspection of the lower wing spar cap on airframes with high-load or unknown usage history (as determined by a formula). STEVE ELLS shows you how to calculate your airplane's "factored service history" and details the compliance steps and costs involved.

Dec. 21, 2018, the Federal Aviation Administration published a Notice of Proposed Rulemaking (NPRM), to define the proposed protocol for an inspection process to address the possibility of cracks in the lower wing spar cap of Piper PA-28 and PA-32 series airplanes.

After the crash of an Embry-Riddle Aeronautical University (ERAU) Piper PA-28R Arrow due to a wing separation on April 4, 2018, I researched and wrote a story about the accident, and looked back at the history of PA-28 and PA-32 wing cracks. The story appeared in the July 2018 issue oraf Piper Flyer. (See Resources for more information. —Ed.)

The importance of this proposed eddy current inspection is detailed in this sentence from the NPRM:

We are issuing this AD to detect and correct fatigue cracks in the lower main wing spar cap bolt holes. The unsafe condition, if not addressed, could result in the wing separating from the fuselage in flight.

The NPRM process

In my experience, the FAA often issues important NPRMs and Airworthiness Directives (ADs) just before a long weekend. This NPRM, 2018-CE-049-AD, was published Friday, Dec. 21, 2018. (See "Aviation Safety Alerts" on page Page 54 of this issue. —Ed.)

The NPRM proposal specifies that the AD will apply to the following Piper single-engine aircraft:

Model PA-28-140, PA-28-150, PA-28-151, PA-28-160, PA-28-161, PA-28-180,

PA-28-181, PA-28-235, PA-28R-180, PA-28R-200, PA-28R-201, PA-28R-201T, PA-28RT-201, PA-28RT-201T, PA-32-260, and PA-32-300 airplanes.

An NPRM is a preview of a proposed AD. The NPRM is an opportunity for owners, operators and other interested parties to respond to the proposal with comments, corrections and suggestions.

The comments must have depth, breadth and be constructive. It's important that the comments and corrections be based in experience and be factual. Comments that amount to nothing more than raging about cost or how the AD will decimate the fleet are of scant value.

The comment period is 45 days from the date of issuance. Feb. 4, 2019, is the end of the comment period for 2018-CE-049-AD.

“Factored service hours”

This proposed AD is unusual in that it requires owners and technicians to calculate “factored service hours.” The NPRM says:

This proposed AD would require calculating the factored service hours for each main wing spar to determine when an inspection is required, inspecting the lower main wing spar bolt holes for cracks, and replacing any cracked main wing spar.

The NPRM cites the discovery of a crack in the lower wing spar cap of a Piper PA-28R-201 as the reason for the proposal. It goes on to say:

An investigation revealed that repeated high-load operating conditions accelerated the fatigue crack growth in the lower main wing spar cap. In addition, because of the structural configuration of the wing assembly, the cracked area was inaccessible for a visual inspection. Model PA-28-140, PA-28-150, PA-28-151, PA-28-160, PA-28-161, PA-28-180, PA-28-181, PA-28-235, PA-28R-180, PA-28R-200, PA-28R-201T, PA-28RT-201, PA-28RT-201T, PA-32-260, and PA-32-300 airplanes have similar wing spar structures as the model PA-28R-201.

100-hour inspections as an indicator of high-load operations

Factored service hours are derived by researching the aircraft records to determine (1) the number of 100-hour inspections and (2) the total airframe hours, also called time in service (TIS).

The factored service hours for each airframe are calculated by plugging the number of 100-hour inspections and TIS hours an airplane has accumulated into an equation.

The rationale for using factored service hours (rather than total airframe time) is because the FAA believes that PA-28 and PA-32 airplanes used in flight schools, for-hire operations and other high-load environments such as low-altitude pipeline patrol, for example, are the airplanes that are subject to the heavy loading necessary for cracking to occur.

The NPRM says further:

Only an airplane with a main wing spar that has a factored service life of 5,000 hours, has had either main wing spar replaced with a serviceable main wing spar (more than zero hours TIS) or has airplane maintenance records that are missing or incomplete, must have the eddy current inspection.

How to determine factored service hours

The following is a summary of the formula for determining an airplane's factored service life, published in the NPRM.

Step 1: Review the maintenance records (logbooks) to determine: a) the number of 100-hour inspections and b) total hours on the airplane since new or since any new wing or new wing spar replacement.

Note: If a used spar or wing has been installed; or if the aircraft's maintenance records are unclear as to the number of hours on the airplane, the bolt hole eddy current inspection must be done since it is impossible in those cases to determine how long the wing has been in service.

Step 2: Calculate the factored service hours for each main wing spar using the following formula: (N x 100) + [T-(N x 100)]/17 = Factored Service Hours, where N is the number of 100-hour inspections and T is the total hours TIS of the airplane.

Thereafter, after each annual inspection and 100-hour TIS inspection, recalculate the factored service hours for each main wing spar until the main wing spar has accumulated 5,000 or more factored service hours.

The same formula is used to determine the factored service hours for all PA-28 and PA-32 airplanes. It works for those that have had only 100-hour inspections, those that have had no 100-hour inspections and airplanes that had some (but not all) 100-hour inspections over the life of the airplane.

Factored service hour calculations

Now, let’s do a few. Remember N is the number of 100-hour inspections and T is the total hours TIS of the airplane.

Picking numbers out of the air, let’s say our sample airplane has been used exclusively as a trainer for a well-known flight school for 4,662 hours and has had 46 100-hour inspections. What are the factored service hours of this airplane?

The formula for factored service hours is given in the NPRM as (N x 100) +

[T – (N x 100)]/ 17

For this airplane, that’s (46 x 100) + [4,662 – (46 x 100)]/17

Simplified, (4,600) + [4,662 – (4,600)]/17

And finally, 4,600 + 3.657, which means this airplane has 4,603.65 factored service hours.

The inspection isn’t due yet, but will be soon, once the airplane reaches 5,000 factored service hours.

What about a privately-owned Piper PA-28-180 Cherokee 180 with complete maintenance records that has never had a 100-hour inspection?

Here’s an example straight out of the NPRM for determining factored service hours for an airplane with no 100-hour inspections.

The airplane maintenance records show that the airplane has a total of 12,100 hours TIS, and only annual inspections have been done. Both main wing spars are original factory-installed. In this case, N = 0 and T = 12,100.

Use those values in the formula as follows: (0 x 100) + [12,100 - (0 x 100)]/17 = 711 factored service hours on each main wing spar.

Despite the high number of airframe hours, this airplane has relatively few factored service hours and thus won't need the inspection for quite some time.

Then, there are airplanes that have been used by a flight school, yet are now privately-owned. Here's an example for an airplane that has 5,500 hours TIS and 25 100-hour inspections.

Use the same formula: (25 x 100) + [5,500 – (25 x 100]/17 equals 2,676 factored service hours.

This airplane is a little more than halfway to needing the inspection.

Math whizzes will recognize that the factored service hours formula is written based on an engineering calculation that wing spars in airplanes used for hire are 17 times more likely to have a spar crack than those that haven't been flown for hire.

My friend Mike Busch remarked:

The idea is that factored service hours are the sum of "abusive hours" and one-seventeenth of "non-abusive hours," where "abusive hours" are defined as those hours during which the airplane was engaged in operations requiring 100-hour inspections (i.e., ops that included carrying passengers for hire and/or giving flight instruction for hire).

The only gotcha is for airplanes that have incomplete or approximated airframe hours instead of actual airframe hours. For instance, if an aircraft maintenance record (logbook) was lost or if one of the continuous record logs is missing, that airplane must have the wing spar bolt hole eddy current inspection specified in Paragraph (h) (1) and (2) of the NPRM and the inspection protocol in Appendix 1 of the AD.

Inspection timeline and ongoing inspection requirements

The AD, as proposed, will require each airplane affected to have its number of inspections and TIS hours recalculated using the formula in the AD at each annual or 100-hour inspection to determine if it has gotten to the 5,000-hour factored service time point.

Airplanes that get to 5,000 factored service hours per the formula, or airplanes with unknown airframe or wing hours TIS must have the eddy current inspection done within the next 100 hours time in service or 60 days, whichever occurs later.

According to figures in the NPRM, the eddy current inspection should take 1.5 man-hours.

Reporting inspection results

The AD will require a written report within 30 days following each inspection. Here’s how it’s explained:

Within 30 days after completing an inspection required in Paragraph (h) of this AD, using Appendix 2, "Inspection Results Form," of this AD, report the inspection results to the FAA at the Atlanta ACO Branch. Submit the report to the FAA using the contact information found in Appendix 2 of this AD.

Interim action

We consider this proposed AD interim action. The inspection reports will provide us additional data for determining the cause of the cracking. After analyzing the data, we may take further rulemaking action.

Based on these calculations, affected airframes that have never been operated where 100-hour inspections were required, seem to have little to be concerned about.

Airframes that have a factored service life of 5,000 hours or more will need to find a facility that can do a bolt hole inspection in accordance with the guidelines in Appendix 1 of the AD.

If cracks are found, the wing spar will need to be replaced. The AD estimates that that repair will take 32 work hours and estimates that, at a labor cost of $85/hour the total cost will be $2,720 in labor. The FAA projects the part cost at $5,540, for a total cost of $8,260.

However, since many of affected airframes are approaching 60 years' time in service, I suspect that there will be owners and operators that elect to get the bolt hole eddy current inspection done regardless of the number of factored service hours on the airframe. It's the only way to make sure there are no cracks.

Know your FAR/AIM and check with your mechanic before starting any work.

Steve Ells has been an A&P/IA for 45 years and is a commercial pilot with instrument and multi-engine ratings. Ells also loves utility and bush-style airplanes and operations. He's a former tech rep and editor for Cessna Pilots Association and served as associate editor for AOPA Pilot until 2008. Ells is the owner of Ells Aviation (EllsAviation.com) and the proud owner of a 1960 Piper Comanche. He lives in Templeton, California, with his wife Audrey. Send questions and comments to editor@piperflyer.org.

Eddy Current Inspection Procedure

A. Equipment

1. Equipment Requirements

(i) Equipment used must provide impedance plane diagrams.
(ii) Probes may be either absolute or differential coil configurations.
(iii) For manual bolt hole probing: use probe collars at an increment of every 1/64 inch to ensure the uniform depth of rotation and to aid in reducing lift-off effects.
(iv) Automated scanning systems may be used.
(v) Bolt hole probes must match as closely as possible, but not exceed, the bolt hole diameter. Split core probes may be expanded to a maximum of 0.050 inch beyond the probe's nominal diameter (in accordance with on the probe manufacturer's instructions). The fill factor must be 80 percent minimum.
(vi) A right angle (90 degree) surface probe may be used for further detail indication, if needed.

2. Equipment Examples

The following optional inspection equipment has been shown to be adequate to conduct this procedure and is provided as examples only. Other equipment meeting the requirements in A.1. may be used.

(i) Nortec 500D Series Portable Eddy Current Flaw Detector – Olympus
(ii) Bolt hole probe, 0.375 inch with 0.062 inch shielded coil – Olympus
(iii) Right angle (90 degree) surface probe with 0.062 inch shielded coil – Olympus
(iv) Calibration standard (NIST traceable) for bolt holes and surface: Air Force General Purpose Eddy Current Standard
  (a) Bolt hole: 0.030 x 0.030 inch corner notch, 0.030 inch radial notch
  (b) Surface: 2024-T3: 0.008, 0.020, and 0.040 inch depth EDM notches
  (c) Frequency 300 KHz, EDM notch set at five (5) divisions screen height

B. Reference Standard

(1) Use a reference standard of the same conductivity 2024 T-3 within +/-15% IACs. It must have electrical discharge machining (EDM) notches for simulating defects as calibration references.
(2) The surface finish must be 63 RHR or better.
(3) The reference standard must have a corner notch size of 0.030 x 0.030 inch (screen set at minimum of three divisions vertical with a phase signal of between 45 and 120 degrees separation from the horizontal liftoff).
(4) Use a frequency between 100 and 500 kHz.
(5) The calibration must be checked in the beginning and end and every 30 minutes of inspections.

C. Personnel Qualifications

Personnel doing the eddy current inspection must have NAS 410 Level II or Level III certification.

D. Material Required

NOTE: Hardware part numbers and torque values are contained in the Aircraft Maintenance Manual and Illustrated Parts Catalogue for the specific airplane model.

For each wing inspected:

(1) Two (2) wing to spar attach bolts
(2) Two (2) wing to spar attach nuts
(3) Two (2) wing to spar attach washers
(4) Cleaning cloth
(5) Isopropyl alcohol or mineral spirits

E. Conduct Inspection

For each wing to be inspected:

(1) Locate the two (2) lower outboard main spar attach bolts, as shown in Figure 1 of Appendix 1, installed on the lower cap of the main spar, on the forward and aft sides of the spar web.

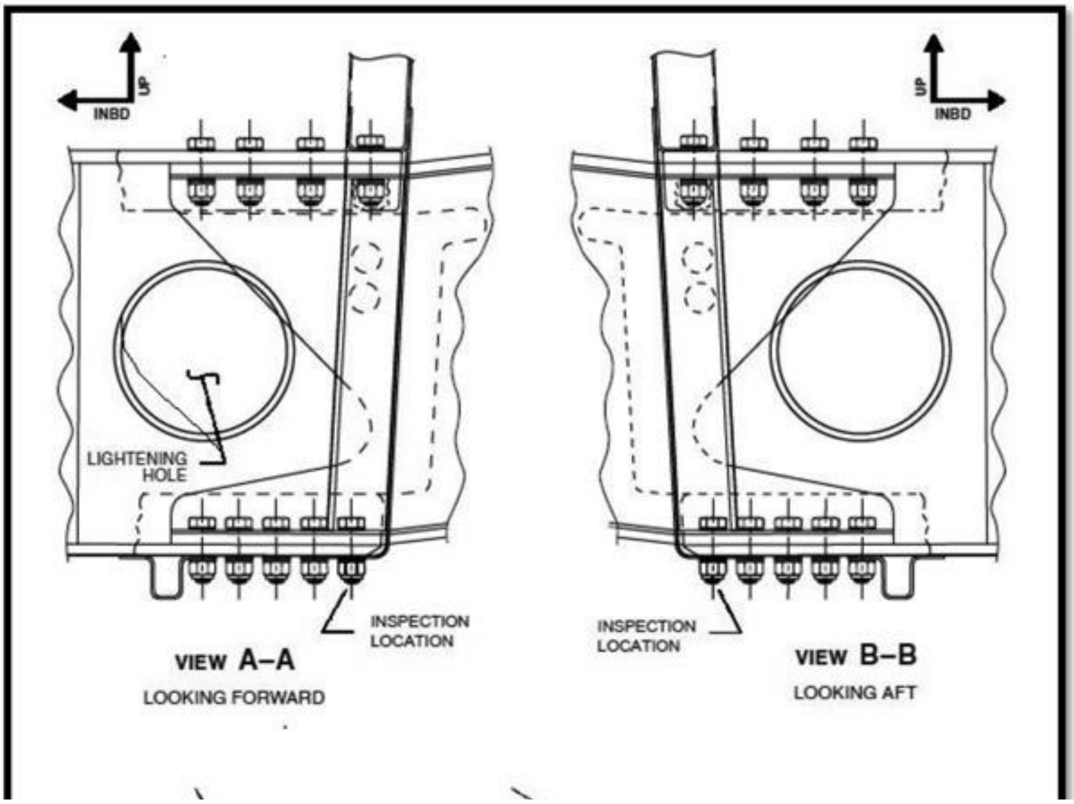
CAUTION: The interior surface of the bolts holes can be easily damaged during bolt removal and installation. Do not drive out spar to fuselage attach bolts.

(2) Clean the inspection surfaces using a cloth dampened with isopropyl alcohol or mineral spirits.

(3) Use eddy current surface and bolt hole examinations to detect surface and shallow subsurface cracking and discontinuities on the left and right lower outboard spar bolt holes. Use SAE ARP4402, "Eddy Current Inspection of Open Fastener Holes in Aluminum Aircraft Structure," or another FAA-approved eddy current inspection method to do these inspections.

F. Accept/Reject Criteria

A crack or crack-like indication with an amplitude equal to or greater than 50 percent of the reference level signal must be rejected and documented. Such an amplitude reading indicates that the spar does not meet type design.



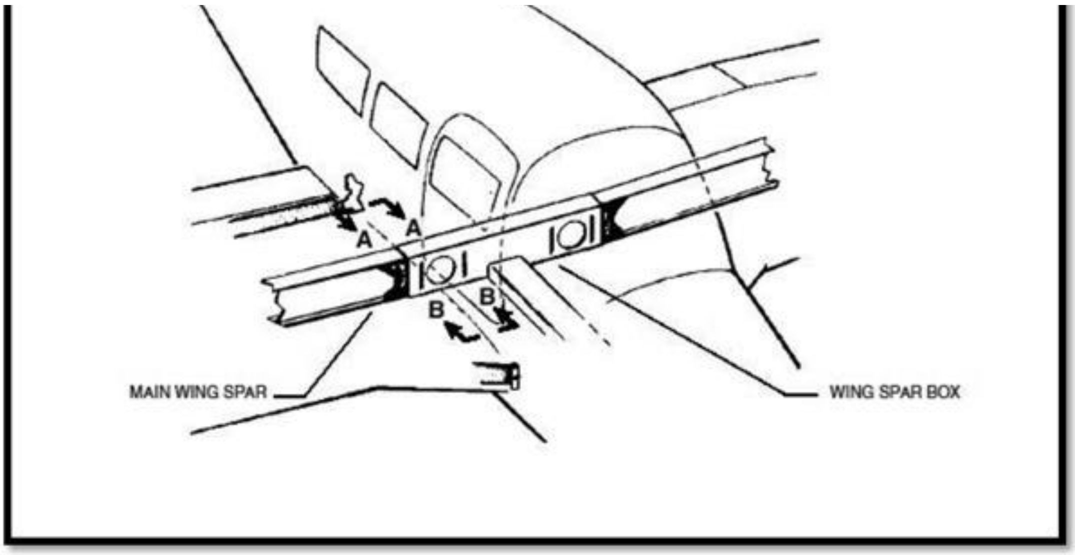


Figure 1. Main Spar Attach Bolt Locations (RH Side Shown)

RESOURCES >>>>>

PIPER FLYER ARTICLES

“PA-28 and PA-32 Wing Spar Cracks: What You Should Know”

by Steve Ells, July 2018

NPRM 2018-CE-049-AD

Federal Aviation Administration

federalregister.gov/documents/2018/12/21/2018-27577/airworthiness-directives-piper-aircraft-inc-airplanes (https://www.federalregister.gov/documents/2018/12/21/2018-27577/airworthiness-directives-piper-aircraft-inc-airplanes)

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