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PROJECT 140 - PA-25, WING FRONT SPAR ADDITIONAL HOLE DESIGN REPORT

1 INTRODUCTION

1.1 This document provides the justification for the Engineering Orders at Ref [1].

1.2 The Piper Pawnee front wing spars have been known to fail due to poor repair quality resulting in fatigue cracks. As a result, the National Airworthiness Authority (NAA) ANAC Argentina has issued the Airworthiness Directives (ADs) at Ref [2] that references the acceptance and rejection criteria in the Service Bulletin 25-57-11, Ref [3].

1.3 The right hand wing passes the Service Bulletin acceptance / rejection criteria except for the following as shown in Ref [2], page 5……"*If more holes than the original design are found, the spar should be replaced*"….

1.4 The wing has had one additional hole drilled into the front spar upper rear flange as shown in Figure 1-1, located 23" from the wing root. See also Figure A10-1 for a plan view location of the additional hole.

1.5 The additional hole is 0.500" outboard of the original hole which is currently used to secure the leading edge skin. Both the original and the additional holes are per the design configuration, whereby they are drilled at nominal Ø3/32" and then fitted with the self tapping screw which has an outside thread Ø0.114".

1.6 The design configuration, Figure 1-2, shows that within each rib bay, quantity 4 screws are used to secure the leading edge skin to the upper spar cap and 4 screws into the lower spar cap.

Distribution	Internal				
Approvals	**Approved**				
Name/Sign.	B. Terrell (signed)				
Date	19 Oct 2025				

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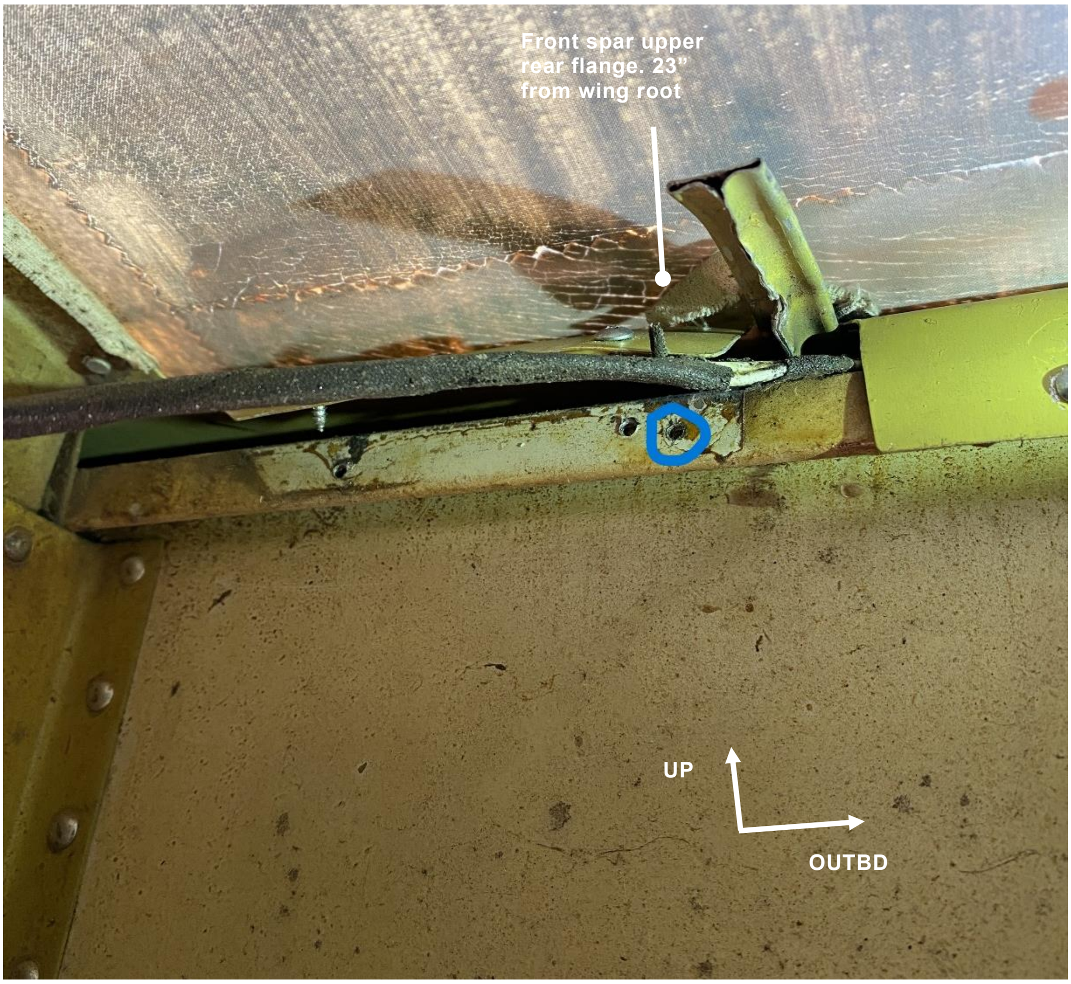
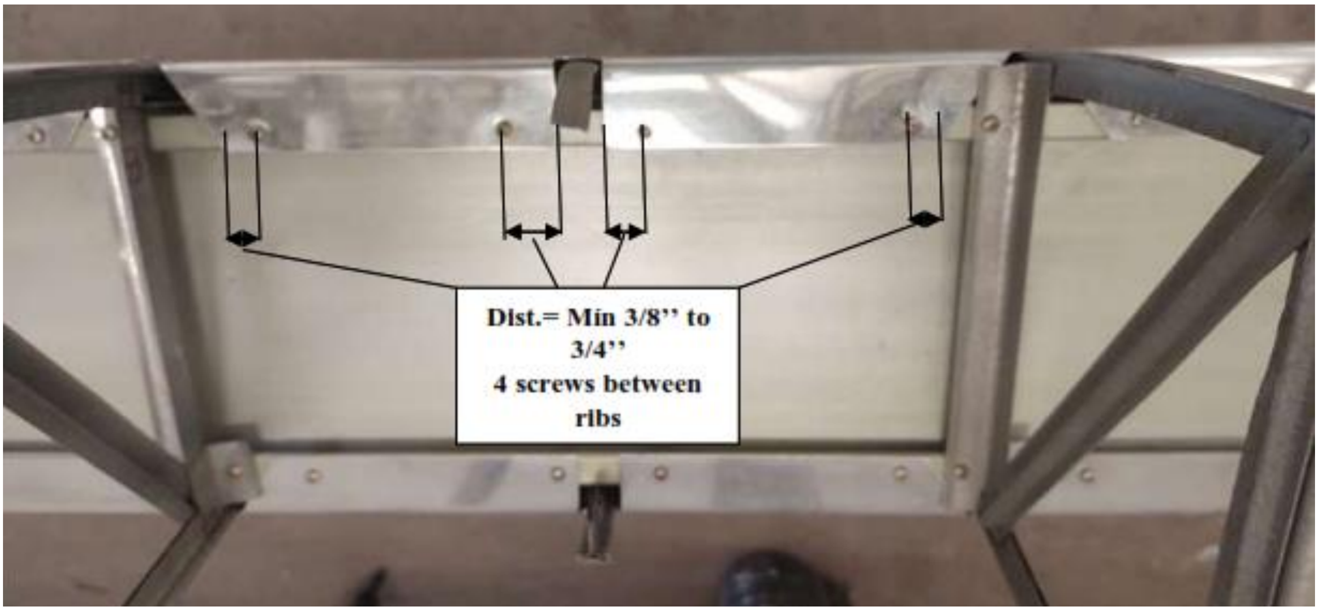


Notes:

1. The screws have been removed from the leading edge skin and the skin has been lifted up to show access to the spar extrusion.
2. Spacing between holes is 0.410".
3. The additional hole is positioned 0.260" from the top of the spar and 0.250" from the edge of the bulb. The vertical position of the additional hole is within the limits of the Laviasa go-no-go gauge referenced in SB 25-57-11, Ref [3]. See also Figure 2-1.

Figure 1-1: Location of Additional Hole, (viewing looking forward on front spar)



Notes:

1. View is extract from SB 25-57-11, Ref [3], looking forward on front spar.
2. Quantity 4 screws (#4 x ¼", PN 15086) per rib bay are used to secure the leading edge skin to the upper and lower spar flanges.

Figure 1-2: Design Configuration- Typical Skin to Spar Screw Positioning in Rib Bay

1.7 HISTORY OF THE WING

1.7.1 A review of the aircraft log books show the following relevant to the right hand wing:

a. The aircraft was imported new from the USA. It was assembled and passed as airworthy on 24 March 1966 – location in Australia unknown but believed to be Jandakot.

b. 17 October 1981 – 6161 Hrs - THOMSON AERO SERVICES – "Removed both wings and stripped the fabric. Damaged ribs and one wingtip bow (not specified which wing) repaired/renewed. Cracked R/H flap bell-crank renewed. Inboard sections of T.E. repaired. Wings recovered in Ceconite 101 & Butyrate dope. Ag gear fittings deleted from wings".

c. 17 December 1992 – 9865.5 Hrs - CLEARVIEW AVIATION - "R/H wing L.E. patched".

d. 27 August 1993 - +- 10,100 Hrs - PANAMA JACKS – "Right wing removed, wing walk disassembled, all corroded parts repaired, new skins manufactured, new leading-edge cuff manufactured. All treated with anti-corrosive protection, painted and reassembled i.a.w. AC 43,13,1A and wing re-covered i.a.w. Stits proc manual No.1 & 5".

e. 1 September 1995 – 10,961.4 Hrs - PANAMA JACKS – "Right wing removed for ? (can't make out writing). New tip bow fitted. Repairs to ribs as necessary. Wing re-covered i.a.w. Stits manual. New wing struts (sealed type – Univar) fitted".

1.7.2 The additional hole is likely to be the result of the leading edge being replaced during one of the earlier re-builds. A visual inspection of the wing front spar did not find any repairs or damage near the additional hole site that would result in multi-repair interaction.

2 DESIGN JUSTIFICATION

2.1 STATIC STRENGTH

2.2 The wing front spar acts as a beam that carries wing bending loads which are shared between the front and rear spars. In the original design, the critical spar cross section occurs where the fasteners in the upper cap align with fasteners in the lower cap resulting in some lost area. With the addition of holes in the spar flange that have some spacing in the spanwise direction and are of equivalent (or lesser) hole diameter, there is no change to the original spar section properties through a given bending plane.

2.3 Where the leading edge skin attaches to the spar cap, it is secured using quantity 4 fasteners per rib bay. In the repair configuration for the subject wing, the same number of fasteners are used; quantity 4. However, the assumption is made that the screw attachment loads are negligible which is supported by the following:

a. The leading edge skin is not considered to form a torsion box; the two wing struts are assumed to react the wing torsion.

b. The leading edge skin is not considered to carry any of the wing bending loads because it has spanwise section breaks that are not joined using load carrying fasteners. Outboard of the strut attachment point, the leading skin doesn’t extend aft to the front spar. It simply helps provide an aerodynamic form for the fabric covering.

c. The leading skin has little stiffness in the vertical direction such that any airloads on the skin are carried by the wing ribs and half-ribs that shear the load into the spar flanges.

2.4 The critical cross section through the wing spar is in-line with the rib attachments due to the rib-to-spar shear connections that are both fore and aft of the spar. The second most critical cross section through the wing spar is in-line with the design configuration rivets attaching the leading edge skin to the spar flange. The cross section of spar through the repair configuration additional hole is by inspection less critical than the design configuration cross sections. A summary of these cross section configurations is shown in Figure 2-5.

2.5 As shown in Figure A10-2, the additional hole is located in a rib bay that does not have additional local loads such as lifting strut attachments. It is located near a jury strut attachment, however, these loads are considered to be negligible as the jury struts are to limit the Euler buckling of the wing strut in compression.

2.6 Based on the above, the static strength of the subject wing in the repair configuration, is considered to be equivalent to the original design configuration.

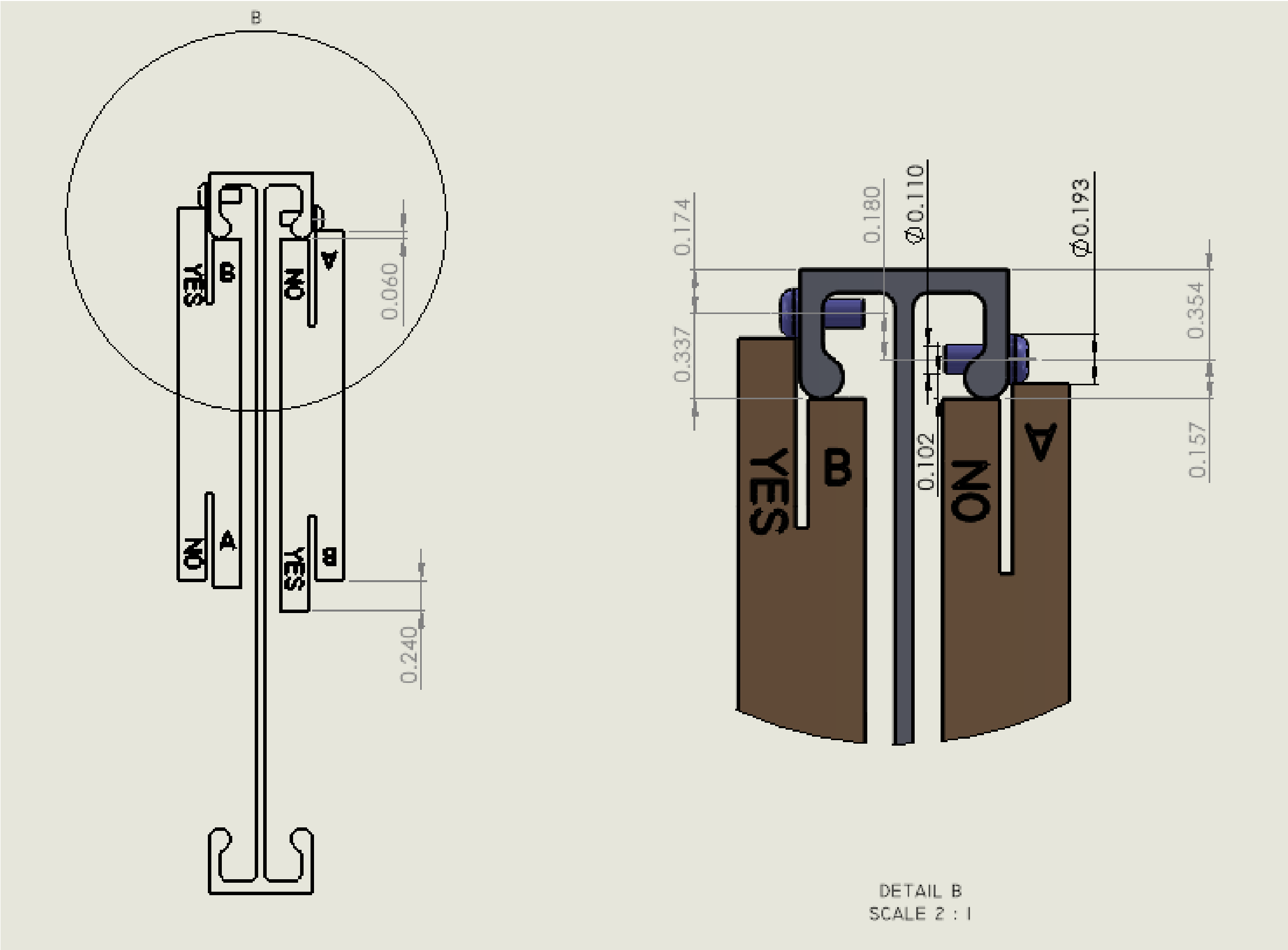


Figure 2-1: Design Configuration – Allowable Vertical Positions for Screws

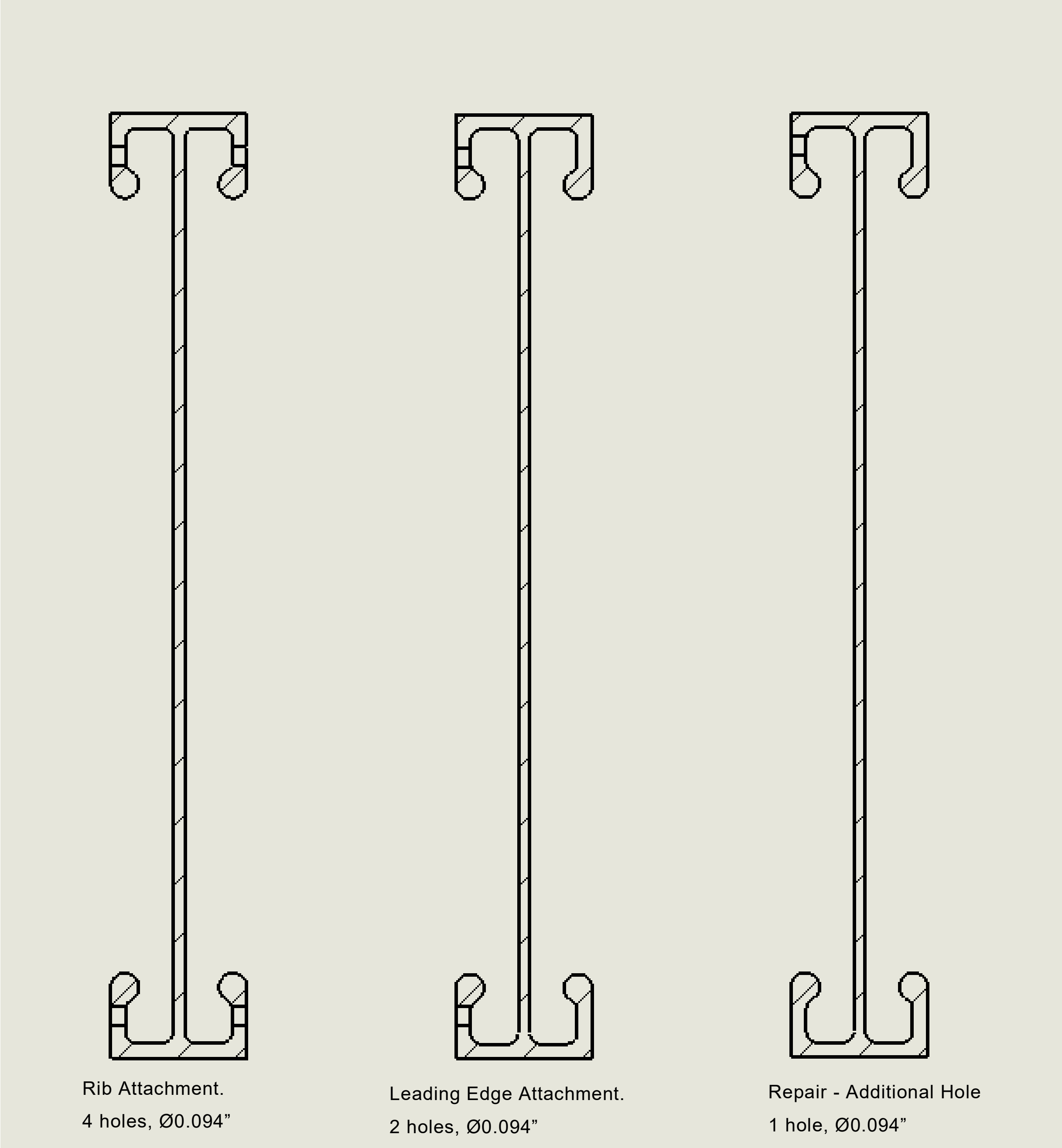


Figure 2-2: Design and Repair Configurations – Typical Spar Cross Section at Rib Attachment

2.7 FATIGUE STRENGTH, SAFE -LIFE

2.8 When the spar flange is in spanwise tension, the peak stress concentration occurs at the top and bottom boundaries of the screw hole and results in a stress concentration of ~kt = 3.0. The presence of an additional hole in the spanwise direction results in a minor reduction to the hole boundary peak stress concentration as calculated below using the method of ESDU 67023, Ref [4]:

Hole diameter, d = 0.114” (r = 0.057”)	From screw drawing 15086
Hole pitch, p = 0.410”	measured on wing, VH-CSN
r/p = 0.057/0.410 = 0.139	
Angulear alignment of holes = 11 degrees	Figure 2-5
Assuming $f_2/f_1 = 0$	
$f_m/f_1 = 2.87$ at 0 degrees	From ESDU 67023, Figure 1. See also this document, Figure 2-3
$f_m/f_1 = 2.95$ at 15 degrees	From ESDU 67023, Figure 1. See also this document, Figure 2-4

So, kt ≈ 2.93(f_1) at an angle of 11 degrees, which is less than the original configuration where kt ~3.0 (for tension loads).

2.9 Based on the above, the fatigue strength (based on the safe life methodology) of wing, VH-CSN, in the repair configuration, is considered to be equivalent to the original design configuration.

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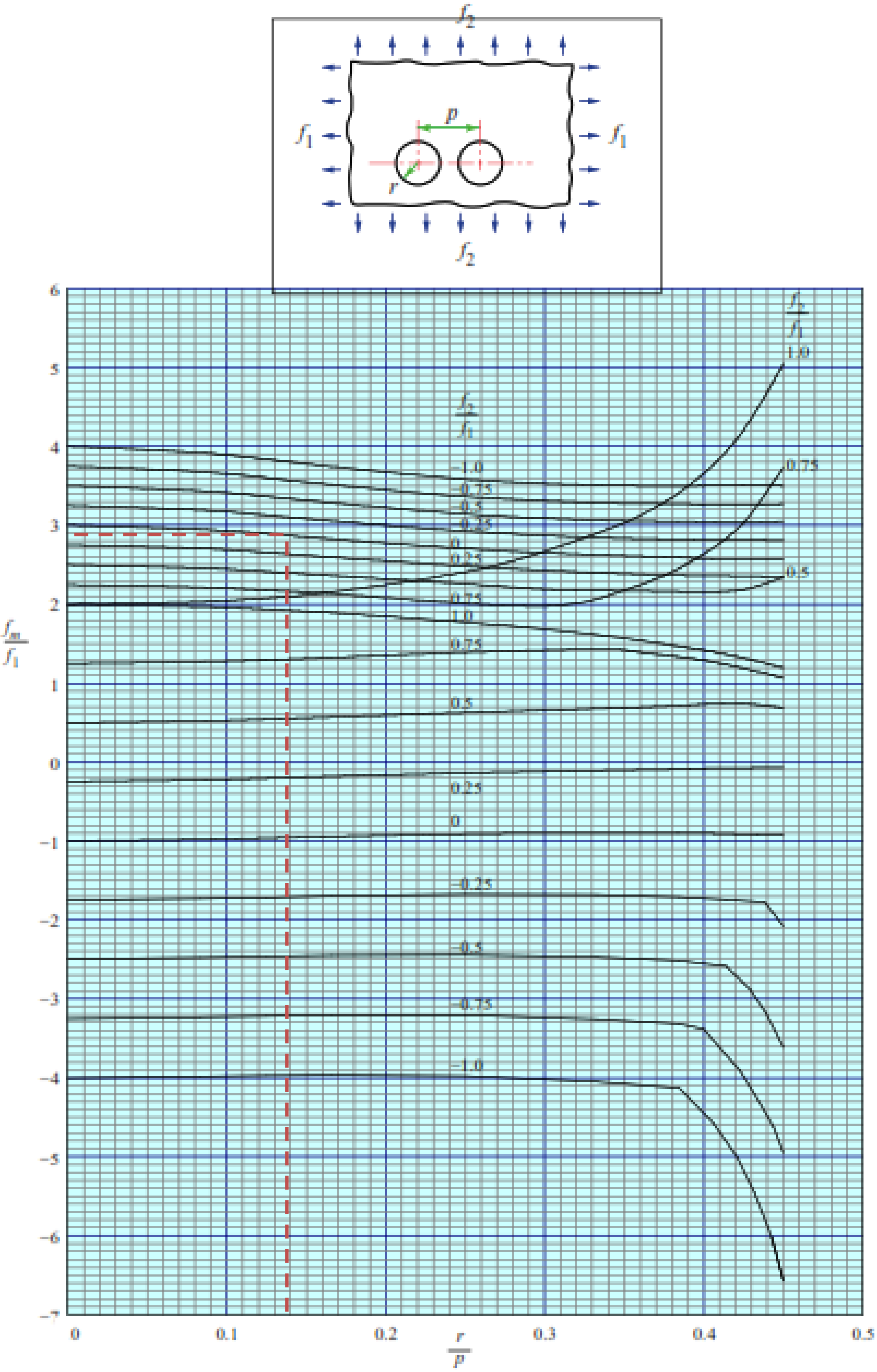

Figure 2-3: Extract from ESDU 67023, Figure 1

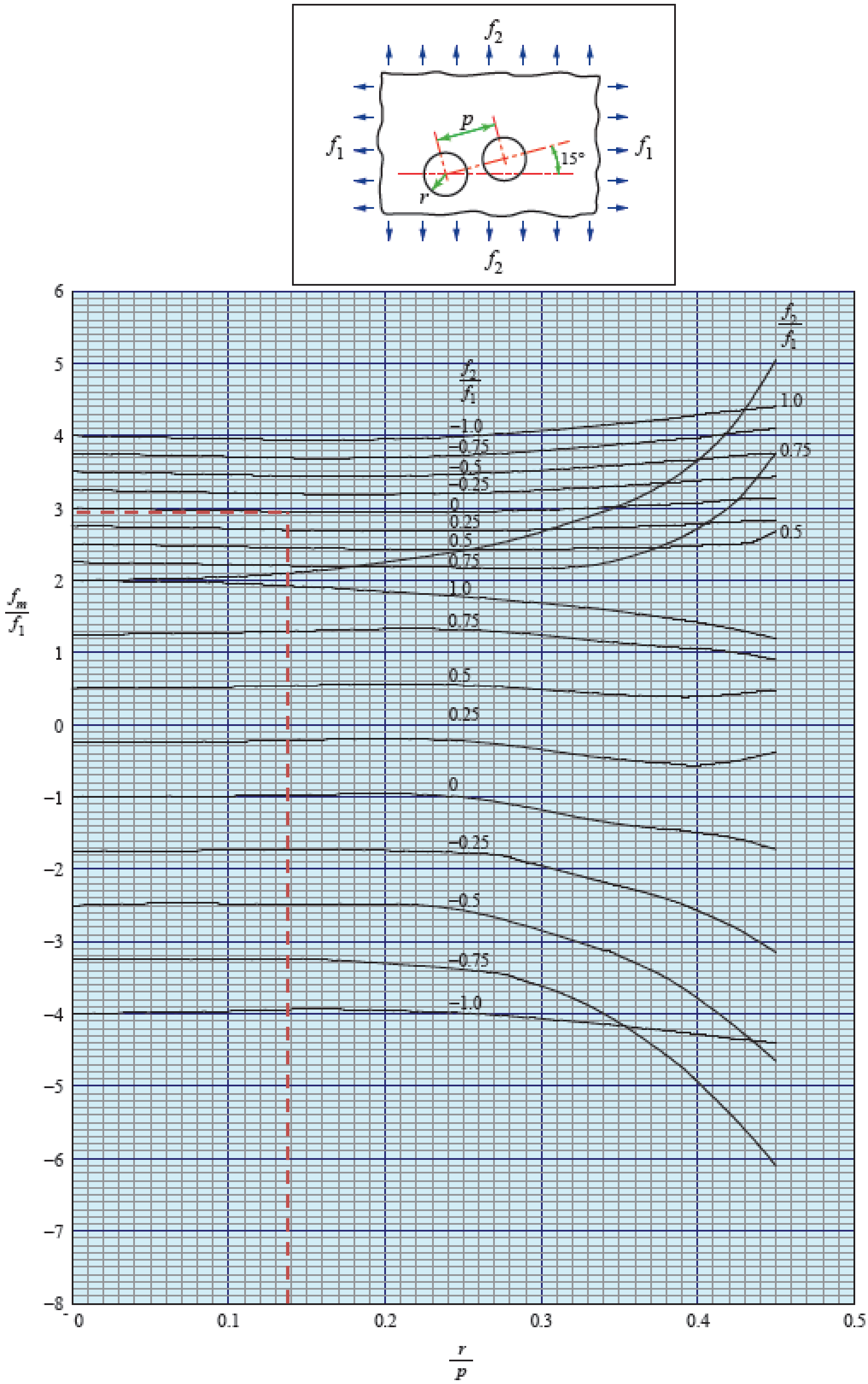

Figure 2-4: Extract from ESDU 67023, Figure 2

2.10 FATIGUE STRENGTH, SAFETY BY INSPECTION

2.11 The AD 2024-05-01, Ref [2], introduces an eddy current inspection to be conducted at a frequency of every annual inspection or every 100 hours, whichever occurs first. It seems unlikely that the type certificate holder has adopted a fatigue safety-by-inspection scheme using a calculated critical crack growth rate based on the detectable flaw size for eddy current surface scan. It is more probable that eddy current surface scan was identified as a convenient and effective method of crack detection and the frequency of every 100 flight hours was identified as being very conservative. However, without the benefit of an independent crack growth model, the justification for the repair configuration will be based on equivalence.

2.12 For the subject wing, the location of the additional hole is at ~23” from the wing root which is within the eddy current inspection zone (~19” to 41” from the wing root) as mandated by the AD 2024-05-01, Ref [2]. The repair design does mandate that the eddy current inspection is extended to include the additional hole.

2.13 The additional hole position for the repair configuration for the subject wing is shown in Figure 2-5 and the approximate crack growth paths are shown. The following assumptions are made:

a. Based on spanwise tensile load conditions in the spar cap, the cracks will propagate from the boundary of the holes at the points of highest stress concentration.

b. The crack growth path will be in the bending plane, perpendicular to the spanwise tensile load direction.

c. The holes are sufficiently spaced apart in the spanwise direction such that, by inspection, crack interaction will not occur and hence not undermine any previously calculated growth rate (if it exists).

2.14 Based on the above, the fatigue strength (based on the safety by inspection methodology) of the subject wing in the repair configuration, is considered to be equivalent to the original design configuration.

2.15 Recommendation - If a dedicated crack growth assessment was developed, it is likely that the repeat inspection interval could be extended significantly beyond every 100 hours.

2.16 INSTRUCTIONS FROM CASA

2.17 CASA issued Design Advice 2025-08418 conforms the design is major and states to continue with approval subject to conditions. Those conditions were incorporated into the EO instructions.

2.18 The design also states that CASA will issue an AMOC.

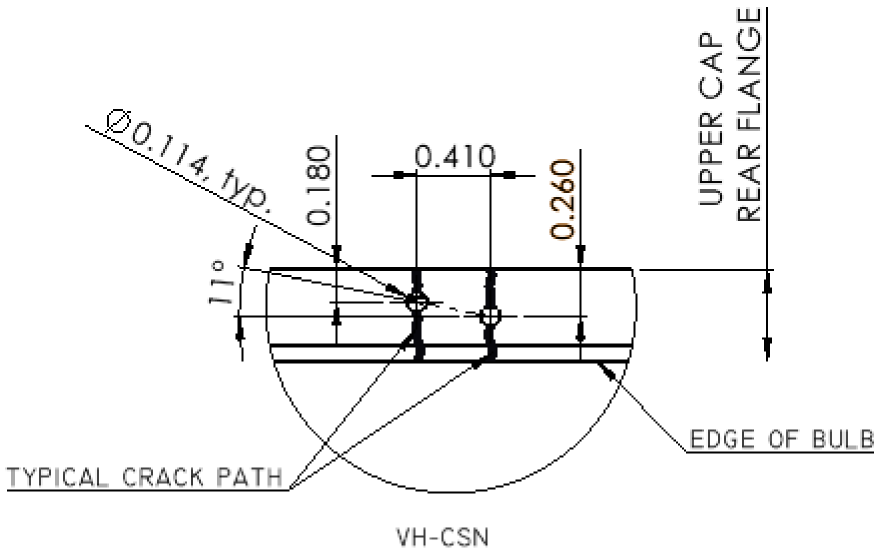

Figure 2-5: RH Wing, VH-CSN, Repair Configuration Holes, Predicted Crack Growth Paths

2.19 CONSIDERATION OF EXISTING MAINTENANCE DATA AND ICA

2.20 The design at Ref [1] acknowledges the intent of the AD at Ref [2]. While the repair site is outside of the Airworthiness Directive inspection zone, the same eddy current method and frequency of inspection has been applied. This is a conservative approach that will not impact the existing maintenance schedule.

2.21 The repair design does undermine or otherwise affect the Airworthiness Directive at Ref [2].

2.22 WEIGHT AND BALANCE

2.23 The design has no effect on aircraft W&B.

2.24 CONSIDERATION OF FAILURE MODE

2.25 Failure or partial performance of the design (additional screw hole) may result in undetected cracking within the wing spar. The consequence of failure is assessed as HIGH.

2.26 The design did not require detailed analysis or significant engineering judgment; it is based on basic structural engineering principles to demonstrate equivalence. Therefore, the probability of failure of the inspection is assessed as LOW.

2.27 Risk Assessment – Based on the above, the risk of the inspection to technical airworthiness is assessed as LOW.

3 PROJECT REQUIREMENTS

3.1 The applicable Type Certificate and certification basis are shown in Table 3-1 and Table 3-2 defines the Means of Compliance (MOC) that can be utilised to demonstrate compliance. The requirements compliance assessment is provided in Table 3-3.

Table 3-1: Type Certificate and Certification Basis

Notes 1: From referenced TCDS.

The contemporary requirements of FAR Amdt 23-62 were used in lieu of the dated CAR 8 requirements.

Aircraft	Australian TC	Referenced Foreign TCDS	Certification Basis[1]
PA-25	None	FAA TCDS 2A10 Issue 29, 14 July 2021	CAR 8.10(b) dated Oct 1950

Table 3-2: Means of Compliance (MOC)

Type of Compliance	Means Of Compliance (MOC)	
Engineering Evaluation	0 = Compliance Statement 1 = Design Review, Technical Description	2 = Calculation/Analysis 3 = Safety Assessment
Tests	4 = Tests 5 = Ground Tests	6 = Flight Tests 8 = Simulation
Inspection	7= Compliance Inspections (Design Inspection/Audit)	
Equipment Qualification	9 = Equipment Qualification, Vendor Data	

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Table 3-3: Requirements Compliance Assessment

Regulation/Requirement	Compliance Statement	MOC	Document Reference	Authorised Person and Engineering Speciality	References, Remarks, Guidance Material
CLIENT REQUIREMENTS					
From the customer purchase order requirements: Provide an EO that allows the right hand wing removed from VH-BMF to have an additional hole in the spar upper cap.	C – Complies	1	This document.	Ben Terrell – Structures	The design allows the additional hole to remain without further reinforcement.
OPERATIONAL REQUIREMENT					
Pursuant to CASA AC 21-08, the proposed design solution must not impact applicable operational approvals (CASR Subpart 91, FAR 91, 121, 125, 135)	C – Complies	1	This document.	Ben Terrell – Structures	No impact on these operational requirements.
The proposed design solution must not impact basic operational requirements for aircraft equipment defined by CAO 20.18 (Aircraft Equipment – Basic Operational Requirements).	C – Complies	1	This document.	Ben Terrell – Structures	No impact on these operational requirements.
AIRWORTHINESS REQUIREMENTS					
Pursuant to CASR 21.437 Clause (2)(b), the proposed design solution must comply with the applicable airworthiness standards.	C – Complies	1	This document.	Ben Terrell – Structures	Refer to the Cert Basis Standards below.
Pursuant to CASA AC 21-08, the proposed solution must not impact airworthiness requirements additional to the Type Certification Basis defined by CASR Subpart 90.	C – Complies	1	This document.	Ben Terrell – Structures	CASR Subpart 90 requirements have no impact.
Pursuant to CASA AC 21-08, the proposed solution shall not impact on the requirements of any applicable Airworthiness Directive (AD), including any defined exclusions or alternative means of compliance.	C – Complies	1	This document.	Ben Terrell – Structures	The design does impact the AD 2024-05-01, R1. CASA guidance will be sought.
AIRWORTHINESS – CERTIFICATION BASIS STANDARDS					
23.305, Amendment Number: 23-45, Effective Date: 09/07/1993 **TITLE:** Strength and deformation. **SECTION RULE:** (a) The structure must be able to support limit loads without detrimental, permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation. **[**(b) The structure must be able to support ultimate loads without	C – Complies	1	This document.	Ben Terrell – Structures	Refer to static strength Section 2.

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Regulation/Requirement	Compliance Statement	MOC	Document Reference	Authorised Person and Engineering Speciality	References, Remarks, Guidance Material
failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the three second limit does not apply.**]**					
23.307, Amendment Number: Initial, Effective Date: 02/01/1965 **TITLE:** Proof of structure. **SECTION RULE:** (a) Compliance with the strength and deformation requirements of Sec. 23.305 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated. (b) Certain parts of the structure must be tested as specified in Subpart D of this part.	C – Complies	1	This document.	Ben Terrell – Structures	Refer to static strength Section 2.
23.571, Amendment Number: 23-62, Effective Date: 01/31/2012 TITLE: Metallic pressurized cabin structures. SECTION RULE: For normal, utility, and acrobatic category airplanes, the strength, detail design, and fabrication of the metallic structure of the pressure cabin must be evaluated under one of the following: (a) A fatigue strength investigation in which the structure is shown by tests, or by analysis supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected in service; or (b) A fail safe strength investigation, in which it is shown by analysis, tests, or both that catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structures are able to withstand a static ultimate load factor of 75 percent of the limit load factor at V_C, considering the combined effects of	C – Complies	1	This document.	Ben Terrell – Structures	Passed by Equivalence. Refer to fatigue strength Section 2.

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Regulation/Requirement	Compliance Statement	MOC	Document Reference	Authorised Person and Engineering Speciality	References, Remarks, Guidance Material
normal operating pressures, expected external aerodynamic pressures, and flight loads. These loads must be multiplied by a factor of 1.15 unless the dynamic effect of failure under static load are otherwise considered. (c) The damage tolerance evaluation of Sec. 23.573(b). (d) If certification for operation above 41,000 feet is requested, a damage tolerance evaluation of the fuselage pressure boundary per Sec. 23.573(b) must be conducted.					
23.572, Amendment Number: 23-48, Effective Date: 03/11/1996 TITLE: [Metallic] wing, empennage, and associated structures. SECTION RULE: [(a) For normal, utility, and acrobatic category airplanes, the strength, detail design, and fabrication of those parts of the airframe structure whose failure would be catastrophic must be evaluated under one of the following unless it is shown that the structure, operating stress level, materials and expected uses are comparable, from a fatigue standpoint, to a similar design that has had extensive satisfactory service experience: (1) A fatigue strength investigation in which the structure is shown by tests, or by analysis supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected in service; or] (2) A fail safe strength investigation in which it is shown by analysis, tests, or both, that catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structure is able to withstand a static ultimate load factor of 75 percent of the critical limit load at V_C. These loads must be multiplied by a factor of 1.15 unless the dynamic effects of failure under static load are otherwise considered. (3) The damage tolerance evaluation of Sec. 23.573(b). (b) Each evaluation required by this section must: (1) Include typical loading spectra (e.g. taxi, ground-air-ground cycles, maneuver, gust); (2) Account for any significant effects due to the mutual influence of aerodynamic surfaces; and	C – Complies	1	This document.	Ben Terrell – Structures	Passed by Equivalence. Refer to fatigue strength Section 2.

Regulation/Requirement	Compliance Statement	MOC	Document Reference	Authorised Person and Engineering Speciality	References, Remarks, Guidance Material
(3) Consider any significant effects from propeller slipstream loading, and buffet from vortex impingements.					
23.573, Amendment Number: 23-48, Effective Date: 04/11/2008 TITLE: Damage tolerance and fatigue evaluation of structure. SECTION RULE: (a) *Composite airframe….* [(b) Metallic airframe structure. If the applicant elects to use Sec. 23.571(c) or Sec. 23.572(a)(3), then the damage tolerance evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage.] The determination must be by analysis supported by test evidence and, if available, service experience. Damage at multiple sites due to fatigue must be included where the design is such that this type of damage can be expected to occur. The evaluation must incorporate repeated load and static analyses supported by test evidence. The extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand critical limit flight loads, considered as ultimate, with the extent of detectable damage consistent with the results of the damage tolerance evaluations. For pressurized cabins, the following load must be withstood: (1) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in this part, and (2) The expected external aerodynamic pressures in 1g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load. (c) [Removed.]	C – Complies	1	This document.	Ben Terrell – Structures	Passed by Equivalence. Refer to fatigue strength Section 2.

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Regulation/Requirement	Compliance Statement	MOC	Document Reference	Authorised Person and Engineering Speciality	References, Remarks, Guidance Material
23.603, Amdt. 23-23, Materials and workmanship. [(a) The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must-- (1) Be established by experience or tests;] (2) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; [and (3) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.] (b) Workmanship must be of a high standard. (g) An applicant may use other material design values if approved by the Administrator.	C – Complies	1	This document.	Ben Terrell – Structures	No new materials added.
23.605, Amdt. 23-23, Fabrication methods. [(a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed under an approved process specification. (b) Each new aircraft fabrication method must be substantiated by a test program.]	C – Complies	1	This document.	Ben Terrell – Structures	No new processes used.
23.609, Amdt. 23-0 Protection of structure. Each part of the structure must-- (a) Be suitably protected against deterioration or loss of strength in service due to any cause, including-- (1) Weathering; (2) Corrosion; and (3) Abrasion; and (b) Have adequate provisions for ventilation and drainage.	C – Complies	1	This document.	Ben Terrell – Structures	No changes to structural protection.
23.1529, Amdt. 23-26 Subpart G – Operating Limitations and Information **Maintenance Manual** SECTION RULE: The applicant must prepare Instructions for Continued Airworthiness in accordance with Appendix G to this Part that are acceptable to the Administrator. The instructions may be	C – Complies	1	This document.	Ben Terrell – Structures	ICA for the supplementary spar inspection is provided.

Regulation/Requirement	Compliance Statement	MOC	Document Reference	Authorised Person and Engineering Speciality	References, Remarks, Guidance Material
incomplete at type certification if a program exists to ensure their completion prior to delivery of the first airplane or issuance of a standard certificate of airworthiness, whichever occurs later.]					
AIRWORTHINESS – CONTINUED AIRWORTHINESS REQUIREMENTS					
Continued Airworthiness and supportability requirements of the proposed design solution have been identified and/or produced as ICA and comply with applicable airworthiness standards.	C – Complies	1	This document.	Ben Terrell – Structures	ICA for the supplementary spar inspection is provided.
The proposed design solution is not in conflict with the currently promulgated aircraft/equipment CAR 37 Approved Minimum Equipment Lists (MEL). If the proposed design solution conflicts with the requirements MEL, such conflict is identified and advised to the owner/operator.	C – Complies	1	This document.	Ben Terrell – Structures	The design has no impact on MELs.
The proposed design solution is not in conflict with the currently promulgated aircraft/equipment CAR2A Approved Maintenance Data and CAR 42M Approved System of Maintenance. If the proposed design solution conflicts with the requirements of either Approved Maintenance Data or the System of Maintenance, such conflict is identified and advised to the owner/operator.	C – Complies	1	This document.	Ben Terrell – Structures	The design has no known conflict with the Approved Maintenance Data or the System of Maintenance.
AIRWORTHINESS – ENVIRONMENTAL PROTECTION REQUIREMENTS					
The proposed repair solution shall not affect the environmental impact of the aircraft/equipment.	C – Complies	1	This document.	Ben Terrell – Structures	Repair does not affect environmental impact of the aircraft. Further verification not required.
SAFTEY REQUIREMENTS – UNSAFE FEATURES AND CHARACTERISTICS					
Pursuant to CASR 21.437 clause (4)(d), the proposed design solution shall have no feature or characteristic that makes the affected aviation product of the design unsafe for its intended use.	C – Complies	1	This document.	Ben Terrell – Structures	Passed by Inspection.

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4 CONCLUSION

4.1 The following conclusions are applicable to this document:

a. The inspection has been adequately verified against the requirements identified in Section 3.

5 REFERENCE

[**1**] EO-DAC-PA25-57-00-122, Project 140 – PA-25, Wing Front Spar Additional Hole – Engineering Order

[**2**] ANAC, Airworthiness Directive, 2024-05-01, R1, dated 18 Dec 2024

[**3**] Laviasa Service Bulletin, 25-57-11, Rev 00, Dated 23 Aug 2024

[**4**] ESDU 67023_Amdt B, Geometric stress concentrations, Two equal unreinforced circular holes in infinite flat plate, dated March 2024

6 FIGURES

7 TABLES

8 REVISIONS

Rev No.	Section or Page Affected	Description of Changes
0	--------------------------	Initial issue.

9 ANNEXES

[A] Repair Location Overview.

10 ANNEX [A] – REPAIR LOCATION OVERVIEW

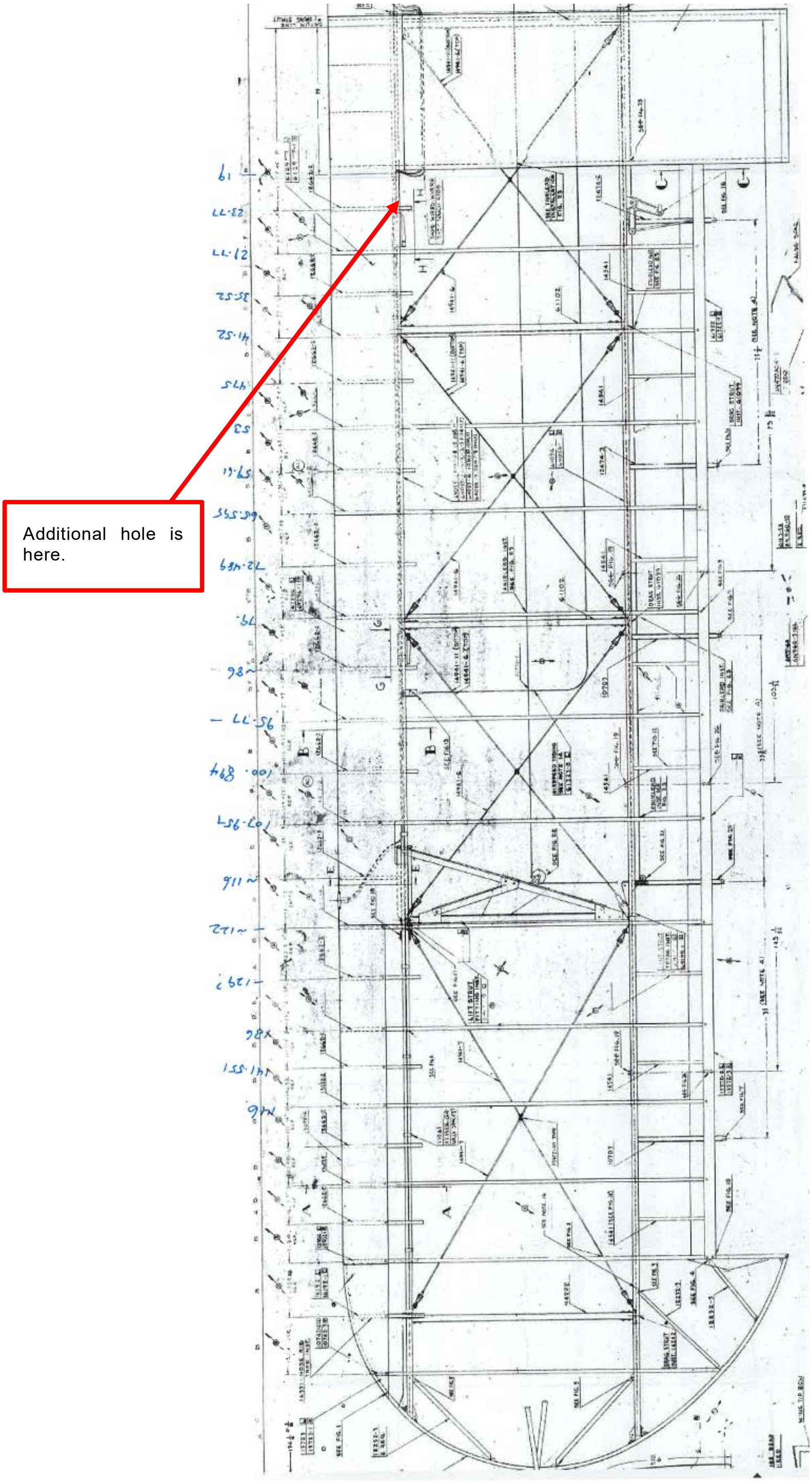

Figure A10-1: Wing Plan View

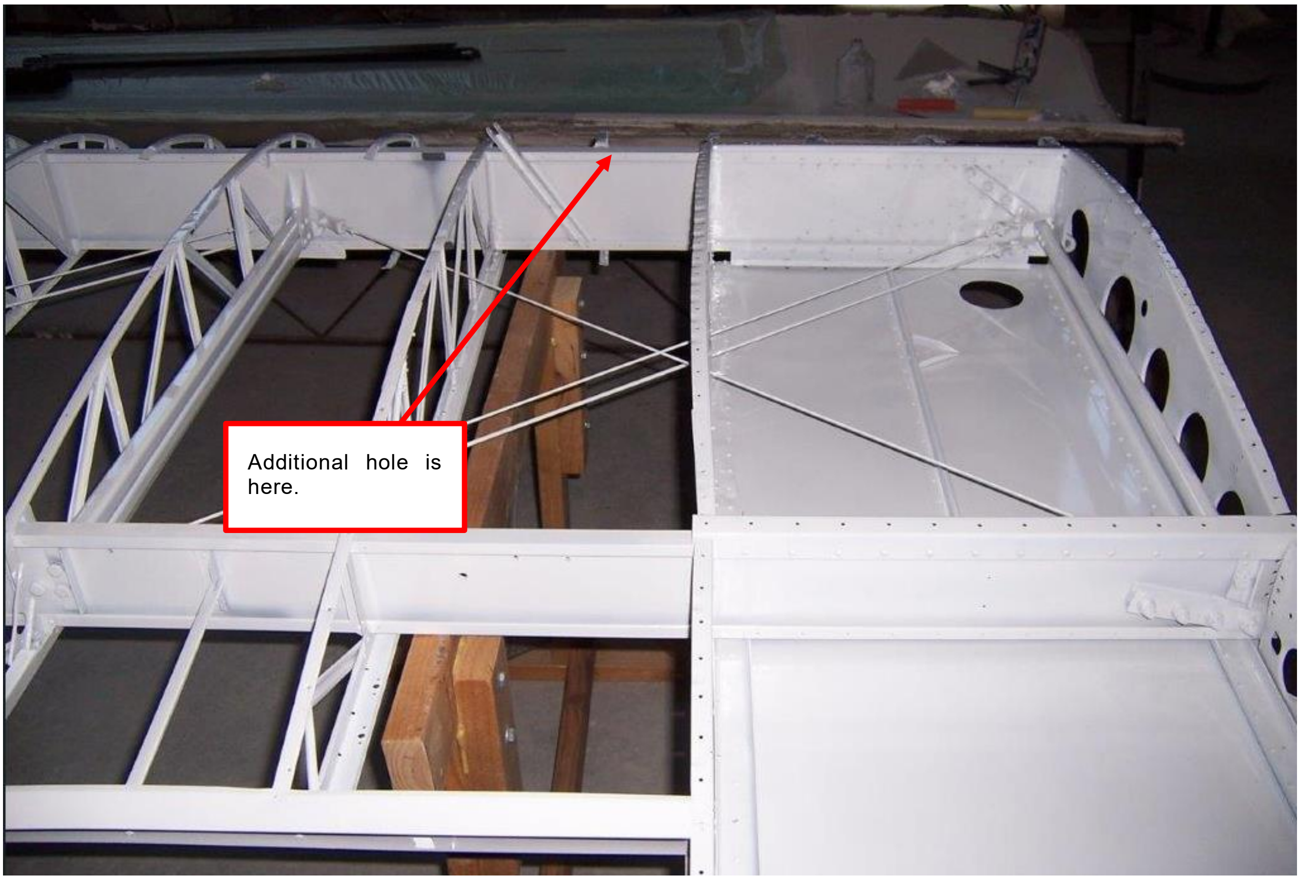

Figure A10-2: Fabric Removed, View looking Forward (Pictorial only; not the subject wing)