REPORT NUMBER 144
MARCH 1965

FUSELAGE STRUCTURAL ANALYSIS
Volume IV
ENGINE INLET, THRUST SPOILERS,
PITCH FAN LOUVERS

XV-5A
LIFT FAN FLIGHT RESEARCH AIRCRAFT PROGRAM

CONTRACT NUMBER DA44-177-TC-715

GENERAL ELECTRIC
DDC AVAILABILITY NOTICES

1. Distribution of this document is unlimited.

2. This document is subject to special report controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of US Army Aviation Material Laboratories, Fort Eustis, Virginia 23604.

3. In addition to security requirements which must be met, this document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of USAAVLABS, Fort Eustis, Virginia 23604.

4. Each transmittal of this document outside the agencies of the US Government must have prior approval of US Army Aviation Material Laboratories, Fort Eustis, Virginia 23604.

5. In addition to security requirements which apply to this document and must be met, each transmittal outside the agencies of the US Government must have prior approval of US Army Aviation Material Laboratories, Fort Eustis, Virginia.

6. Each transmittal of this document outside the Department of Defense must have prior approval of US Army Aviation Material Laboratories, Fort Eustis, Va.

7. In addition to security requirements which apply to this document and must be met, each transmittal outside the Department of Defense must have prior approval of US Army Aviation Material Laboratories, Fort Eustis, Virginia 23604.

8. This document may be further distributed by any holder only with specific prior approval of US Army Aviation Material Laboratories, Fort Eustis, Va. 23604.

9. In addition to security requirements which apply to this document and must be met, it may be further distributed by the holder only with specific prior approval of US Army Aviation Material Laboratories, Fort Eustis, Virginia 23604.

DISCLAIMER

10. The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

11. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission, to manufacture, use, or sell any patented invention that may in any way be related thereto.

12. Trade names cited in this report do not constitute an official endorsement or approval of the use of such commercial hardware of software.
REPORT NUMBER 144

FUSELAGE STRUCTURAL ANALYSIS
VOLUME IV
ENGINE INLET, THRUST SPOILER, PITCH FAN LOUVERS

XV-5A Lift Fan
Flight Research Aircraft Program
Contract No. DA 44-177-TC-715

March 1965

ADVANCED ENGINE AND TECHNOLOGY DEPARTMENT
GENERAL ELECTRIC COMPANY
CINCINNATI, OHIO 45215
<table>
<thead>
<tr>
<th>SECTION</th>
<th>CONTENTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>ENGINE AIR INLET</td>
<td>3</td>
</tr>
<tr>
<td>3.0</td>
<td>THRUST SPOILER INSTALLATION</td>
<td>17</td>
</tr>
<tr>
<td>4.0</td>
<td>PITCH FAN LOUVER INSTALLATION</td>
<td>29</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION

The structural analyses of the engine air inlet, the thrust spoiler installation, and the pitch fan louver installation of the U.S. Army XV-5A Lift Fan Research Aircraft are presented in this report.
2.0 ENGINE AIR INLET

The engine air inlet installation provides the ducting for inlet air to the turbo jet engines, ducting for cooling air and provides the faired cover for the accessory and hydraulic compartments.

The engine inlet is constructed of Fiberglas, 181 cloth with polyester resin, per MIL-R-7575. The external skins are made up of three plys of 181 cloth reinforced along the attachment edges by eight additional layers. The inlet duct cylinders are of four ply construction.

The inlet installation is attached to the aircraft fuselage structure at the canted bulkhead aft of the cockpit, at two intermediate sub-frames, the engine forward support structure frame and along the lower edges to the fuselage upper longerons.

Critical design pressure loads are shown and the critical skin panel is analyzed for this loading. The attachments are investigated and shown to be adequate for inlet loading.

Material allowables for 181 cloth, polyester resin, Fiberglas are taken from MIL-HNDBK-17 and MIL-R-7575 and are shown below:

\[ F_{tu} = 40,000 \text{ psi} \]
\[ F_{cu} = 35,000 \text{ psi} \]
\[ F_{su} = 9,000 \text{ to } 20,000 \text{ psi} \]
\[ E = 2.5 \times 10^6 \text{ psi} \]
**FLIGHT CONDITION:**

\[ V_L, \text{ Sea Level} \]
\[ P = 850 \text{ psf} \]
\[ \alpha = 0 \text{ deg.} \]
\[ \beta = \pm 5 \text{ deg.} \]

**Inlet Loads & Pressure Distribution**

**Flange Design:**

*All pressures are ultimate acting in the direction shown.*

**Net Total Loads on Inlet**

\[ R = \pm 3000 \text{ # ult.} \]
\[ P_y = \pm 2800 \text{ # ult.} \]
\[ P_e = +5000 \text{ # ult.} \]
The above sketch represents an average cross-section of the outer skin panel between the two inlet transverse bulkheads. The panel is divided into three segments for analysis purposes as shown on the following pages. The end panels are essentially cylindrical segments and are analyzed as such. The upper panel is a flat membrane partially supported by two (not section) beams located approximately seven inches either side of the center line.

The membrane support is provided on the long sides by the bulkheads and on the short sides by the cylindrical end segments. The average upper surface pressure of 526 psi cantilevered to the beams and to the membrane according to the beam allowable bending strength which is equivalent to 2.11 psi. The remaining 3.14 psi pressure is applied to the membrane and maximum skin stresses and panel deflection are calculated. Because the end segments provide less rigid panel support than the bulkheads a fictitious membrane length is used which allows a short-end reaction approximately equal to the average end segment reactions. The major portion of the membrane loading is then reacted...
At the two bulkheads, the membrane maximum deflection is calculated on this basis and is shown to be compatible with the maximum allowable beam deflection.

\[ R_2 = 7.0(1.5) = 10.50 \text{ ft/in} \]
\[ R_1 = \frac{10.5}{\cos 42^\circ} = 14.13 \text{ ft/in} \]
\[ R_{X_3} = 14.13 \sin 42^\circ = 9.45 \text{ ft/in} \]
\[ R_3 = 1.5(20.0) - 9.45 = 20.55 \text{ ft/in} \]
\[ R_1 = 4.0(20.0) - 25.21 = 54.79 \text{ ft/in} \]
\[ \sigma_{max} = \frac{54.79}{0.030} = 1826 \text{ psi} \]

Average membrane end reaction:
\[ \frac{54.79 + 20.55}{2} = 37.68 \text{ ft/in} \]

Beams:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>( A )</th>
<th>( b )</th>
<th>( t )</th>
<th>( t_{max} )</th>
<th>( Aq )</th>
<th>( Aq^2 )</th>
<th>( I_z )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.075</td>
<td>0.015</td>
<td>0.012</td>
<td>0.0002</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>0.020</td>
<td>0.040</td>
<td>0.0080</td>
<td>0.0003</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0.038</td>
<td>0.030</td>
<td>0.0204</td>
<td>0.0167</td>
<td>0.00294</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>0.010</td>
<td>0.020</td>
<td>0.01020</td>
<td>0.02112</td>
<td>0.0294</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>0.0143</td>
<td>0.0226</td>
<td>0.02112</td>
<td>0.0294</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
BEAMS: CONT.

\[ y = \frac{0.3226}{0.14} = 2.256 = \frac{C_t}{C_e} \]

\[ C_e = 1.0300 - 2.256 = 0.8044 \text{ in.} \]

\[ I = 0.02112 - (2.256)(0.03226) + 0.00294 = 0.0168 \text{ in}^4 \]

\[ M_w = \frac{1.25F_eI}{C_e} = \frac{1.25(3500)(0.0168)}{0.8044} = 914 \text{ in} \cdot \text{lb} \]

\[ M_{max} = \frac{wL^2}{8} \text{ where } w = \rho d \text{ and } d = 12.0 \text{ in} \]

\[ P_w = \frac{6M_w}{12L^2} = \frac{8(914)}{12(17)^2} = 21.11 \text{ psi} \]

\[ \delta_{max} = \frac{5wL^4}{384EI} = \frac{5(0.0168)(12)(17)^4}{384(2.5)(10)^6} = 10.574 \times 10^{-6} = 0.000656 \text{ in.} \]

MEMBRANE:

[Ref: Seelye & Dimaio, Airplane Structure, Analysis & Design]

\[ \rho = 5.25 - 2.11 = 3.14 \text{ psi} \quad \alpha_{th} = 3.82 \]

\[ a = 24 \text{ (Assume = 65) } \eta_1 = 0.070, \text{ Defl @ Center} \]

\[ \lambda = 17 \quad \eta_5 = 0.025, f_t \text{ Short Side} \]

\[ t = 0.030 \quad \eta_6 = 0.240, f_t \text{ Long Side} \]

\[ f_t = \eta\left[\frac{p^2E}{\alpha^2}\right]^{1/3} \]

\[ = \eta\left[3.14^2(2.5)(10)^4\left(\frac{65^2}{0.5^2}\right)\right]^{1/3} = \eta\left[115.60(10)^2\right]^{1/3} \]

\[ = \eta\left[4.87(10)^4\right] = \eta(48,700) \text{ psi} \]

\[ f_t \text{ Short Side } = 0.025(48,700) = 1218 \text{ psi } f_t \text{ Long Side } = 0.240(48,700) = 11,688 \text{ psi} \]

\[ S_{cnt} = \eta\frac{E}{f_t} \left[\frac{\alpha}{L}\right]^{1/3} = 0.070(65)\left[\frac{3.14^2(65)}{2.5\times10^5(0.030)}\right]^{1/3} \]

\[ = 4.55\left[\frac{65}{271}\right]^{1/3} = 4.55(0.140) = 0.637 \text{ in.} \]
MEMBRANE: CONT.

UPPER PANEL LOAD IS APPLIED TO THE BEAMS BY MEMBRANE ACTION OF THE SKIN PANELS.

\[ R_{w,1} \quad I \quad U \quad I \quad R_{w,2} \]

\[ R_{w,1} = 5.25 \text{ psi} \]

\[ R_{w,2} = 10 \]

\[ R_{w,2} = 12.0 \]

\[ R_{w,1} = 37.68 \text{ ft/in} \text{ - Assume panel length to approximate this end loading.} \]

**Panels I & II**

\[ P = 5.25 \text{ psi [ULT]} \]

\[ \omega_{2} = 0.58 \text{ [ULT]} \]

\[ \omega_{2} = 5.0 \text{ (Assume = 100)} \]

\[ \omega_{2} = 14.0 \text{ (Assume = 100)} \]

\[ Z = 17.0 \]

\[ t = 0.030 \]

\[ \eta_{1} = 0.05 \]

\[ \eta_{5} = 0.014 \]

\[ \eta_{6} = 0.18 \]

\[ \eta_{7} = 0.06 \]

\[ f_{t} = \eta \left[ \frac{P^{2} E \omega_{2}^{2}}{t^{3}} \right]^{1/3} \]

\[ f_{t} = \eta \left[ \frac{(5.25)^{2} (2.5)(10)(100^{2})}{(0.030)^{3}} \right]^{1/3} = \eta \left[ \frac{765.55(10)^{12}}{12} \right]^{1/3} \]

\[ f_{t} = \eta (91,500) \]

\[ f_{t \text{ short side}} = 0.14 (91,500) = 12,811 \text{ psi} = 38.43 \text{ ft/in [ULT]} \]

\[ f_{t \text{ long side}} = 0.18 (91,500) = 16,470 \text{ psi} = 49.40 \text{ ft/in [ULT]} \]

\[ f_{s \text{ short side}} = 0.06 (91,500) = 549.0 \text{ psi} \]

Max. Membrane Stress: 16,470 psi

\[ M.S. = \frac{35,000}{16470} = 2 \text{ High} \]
INLET ATTACHMENTS:

TYPICAL FIBERGLASS

Panel Edge Attachment

BUILT UP TO 11 PLYS
1/1 CLOTH, POLYESTER RESIN

NAS 1068A
Nut Plate

- NAS 664-1/2 BOLT
- NAS 1169.004-16 WASHER

Shear-out:

\[ A = 2 \times (5.5)(11) = 0.121 \]

\[ P_{aw} = 0.121 \times (9000) = 1089 \text{#/FASTENER} \]

\[ * \text{ Min. Shear Allow} \]

Bolting:

\[ A = 0.45(0.9) = 0.041 \]

\[ P_{aw} = 0.041 \times (35,000) = 1455 \text{#/FASTENER} \]

\[ **(P_0) \]

Assume \( P_x \) (300 \# ULT) reacted by fasteners into 143F082

Attachments not critical.

Assume \( P_y \), Segment II (1800 \# ULT) reacted by fasteners
across top surface at F.S. 160.0 \& F.S. 208.0. Induced
\( M_x \) moment reacted by fasteners into blocks at F.S.
177.20 \& F.S. 193.46 as shear couples.

\( P_y \) loads on segments I, II \& III reacted by panel edge
attachment. Attachments are critical.
Inlet Attachments: Cont.

Assume $P_2$ (5000 lb) reacted by fasteners into blocks at stations 177.2, 193.46, and 193.5062 frame.
Equal reactions equal BB # 1 frame side.
Two shear fasteners at each frame are sufficient.
Attachments not critical.

Top Cooling Air Inlet:

In order to reduce the effect of ingestion on cooling air supplied to the electrical, hydraulic, and engine compartments, an alternate inlet is provided on the upper surface of the engine air inlet. The upper inlet is located in the area of high pressure loading on the skin and is therefore framed with a ring capable of transferring skin membrane stresses.
### Inlet Ring Bending Moments

<table>
<thead>
<tr>
<th>$\theta$</th>
<th>$P_0$</th>
<th>$P_{15}$</th>
<th>$P_{30}$</th>
<th>$P_{45}$</th>
<th>$P_{60}$</th>
<th>$P_{75}$</th>
<th>$P_{90}$</th>
<th>$P_{105}$</th>
<th>$P_{120}$</th>
<th>$P_{135}$</th>
<th>$P_{150}$</th>
<th>$P_{165}$</th>
<th>$P_{180}$</th>
<th>$\Sigma M_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-493</td>
<td>-221</td>
<td>-377</td>
<td>78</td>
<td>104</td>
<td>63</td>
<td>38</td>
<td>41</td>
<td>29</td>
<td>-31</td>
<td>-92</td>
<td>-140</td>
<td>-164</td>
<td>-820</td>
</tr>
<tr>
<td>30</td>
<td>-41</td>
<td>-221</td>
<td>-442</td>
<td>-170</td>
<td>-23</td>
<td>34</td>
<td>38</td>
<td>68</td>
<td>104</td>
<td>93</td>
<td>46</td>
<td>-40</td>
<td>-104</td>
<td>-196</td>
</tr>
<tr>
<td>45</td>
<td>103</td>
<td>-40</td>
<td>-202</td>
<td>-572</td>
<td>-127</td>
<td>-14</td>
<td>21</td>
<td>61</td>
<td>115</td>
<td>140</td>
<td>110</td>
<td>50</td>
<td>-41</td>
<td>-196</td>
</tr>
<tr>
<td>60</td>
<td>185</td>
<td>100</td>
<td>-37</td>
<td>-170</td>
<td>-277</td>
<td>-75</td>
<td>-8</td>
<td>34</td>
<td>104</td>
<td>155</td>
<td>166</td>
<td>126</td>
<td>51</td>
<td>+348</td>
</tr>
<tr>
<td>75</td>
<td>205</td>
<td>180</td>
<td>92</td>
<td>-31</td>
<td>-127</td>
<td>-163</td>
<td>-67</td>
<td>-14</td>
<td>58</td>
<td>140</td>
<td>184</td>
<td>180</td>
<td>123</td>
<td>+760</td>
</tr>
<tr>
<td>90</td>
<td>185</td>
<td>201</td>
<td>166</td>
<td>78</td>
<td>-23</td>
<td>-75</td>
<td>-102</td>
<td>-75</td>
<td>-23</td>
<td>78</td>
<td>166</td>
<td>201</td>
<td>185</td>
<td>+962</td>
</tr>
<tr>
<td>105</td>
<td>123</td>
<td>180</td>
<td>184</td>
<td>140</td>
<td>58</td>
<td>-14</td>
<td>-47</td>
<td>-163</td>
<td>-127</td>
<td>-31</td>
<td>92</td>
<td>180</td>
<td>205</td>
<td>+760</td>
</tr>
<tr>
<td>120</td>
<td>51</td>
<td>120</td>
<td>166</td>
<td>155</td>
<td>106</td>
<td>34</td>
<td>-8</td>
<td>-75</td>
<td>-277</td>
<td>-170</td>
<td>-37</td>
<td>100</td>
<td>185</td>
<td>+348</td>
</tr>
<tr>
<td>135</td>
<td>-41</td>
<td>50</td>
<td>110</td>
<td>140</td>
<td>115</td>
<td>61</td>
<td>21</td>
<td>-14</td>
<td>-127</td>
<td>-372</td>
<td>-202</td>
<td>-40</td>
<td>103</td>
<td>-196</td>
</tr>
<tr>
<td>150</td>
<td>-103</td>
<td>-40</td>
<td>46</td>
<td>93</td>
<td>104</td>
<td>68</td>
<td>38</td>
<td>34</td>
<td>-23</td>
<td>-170</td>
<td>-442</td>
<td>-221</td>
<td>-41</td>
<td>-657</td>
</tr>
<tr>
<td>165</td>
<td>-144</td>
<td>-100</td>
<td>-37</td>
<td>39</td>
<td>61</td>
<td>63</td>
<td>61</td>
<td>53</td>
<td>-31</td>
<td>-202</td>
<td>-481</td>
<td>-226</td>
<td>-890</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>-164</td>
<td>-140</td>
<td>-92</td>
<td>-31</td>
<td>29</td>
<td>41</td>
<td>38</td>
<td>68</td>
<td>14</td>
<td>78</td>
<td>-37</td>
<td>-221</td>
<td>-493</td>
<td>-820</td>
</tr>
</tbody>
</table>

$M_p = C_m R \Delta P$

$M_{max} = -890 \text{ in.-lb [ULT] Comp inside}$

$M_{max} = +962 \text{ in.-lb [ULT] Tens inside}$
**SECTION B - B:**

![Diagram of section B-B with dimensions and notes]

**INLET RING BENDING:**

Assume conservatively that the .050 CHANNEL & .030 TOP SPADE carry total ring bending moments.

<table>
<thead>
<tr>
<th>Item</th>
<th>A</th>
<th>x</th>
<th>A_x</th>
<th>A_x^2</th>
<th>I_o</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.0161</td>
<td>.020</td>
<td>.0033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.0280</td>
<td>.070</td>
<td>.01092</td>
<td>.00236</td>
<td>.0011</td>
</tr>
<tr>
<td>3</td>
<td>.0302</td>
<td>.106</td>
<td>.02893</td>
<td>.03968</td>
<td>.0005</td>
</tr>
<tr>
<td>4</td>
<td>.0437</td>
<td>.050</td>
<td>.03714</td>
<td>.05157</td>
<td>.0043</td>
</tr>
<tr>
<td></td>
<td>.1163</td>
<td></td>
<td>.07732</td>
<td>.06551</td>
<td>.0059</td>
</tr>
</tbody>
</table>

\[
\bar{x} = \frac{.07732}{.1163} = .6648 = C_{\text{outside}}; C_{\text{inside}} = .6152
\]

\[
I = .06551 - .6648(.07732) + .0059 = .0200 \text{ in}^4
\]

\[M = -870 \text{ in} \cdot \text{lb; tens. outside}\]

\[f_{bd} = .890(648) = 29,580 \text{ psi}\]

\[F_{bd} = 10,000 \text{ psi}\]

\[M_s = \frac{40,000}{29,580} = 1.35\]
INLET RING BENDING: CONT.

\[ M = +962 \text{ in.-lb} \quad \text{COMP. OUTSIDE} \]

\[ f_{dc} = \frac{962 \times (6648)}{0.0200} = 31,980 \text{ psi} \]

\[ F_{dc} = 35,000 \text{ psi} \]

\[ M.S.C. = \frac{35,000}{31,980} - 1 = \frac{1.09}{1} \]

SKEIN SPICE TO CHANNEL:

\[ P_{dc} = 175 (1.06)(900) = 6750 \text{ lb/in} \]

\[ P_{max} = 494.1 \text{ lb/in} \]

\text{NOT CRITICAL}
BLANK PAGE
3.0 THRUST SPOILER INSTALLATION (Drawing 143P069)

The thrust spoilers consist of a pair of doors located aft of the tailpipe nozzles and supported by the fairing structure below the fuselage box structure. The tailpipe exhaust impinges on the doors when they are extended. The doors are operated by a single hydraulic actuator located on the airplane centerline. The actuator drives a rod which is connected to the door support links. Longitudinal movement of rod and door supports joint causes the doors to pivot about the door hinges located at the forward end. The rod/door supports joint motion is guided by a track. An idler link at the actuator/rod joint reacts vertical loads so that the guide track is not loaded.

The spoilers are designed for operation under the following condition:

100 kts., hot day, 2500 ft., 9200 lbs. gross weight, full flaps, 98.6% RPM

Ultimate load per spoiler = 1553 lbs.

Load is normal to the deflected plane and c.p. is at the center of area.

Unsymmetrical loading due to differential engine RPM of ± 0.5% if ± 40 lbs.

Design temperature for links and operating mechanism = 300°F

Materials used in the construction of the thrust spoilers are 19-9 DL and A-286 steel alloys.

Material properties used in stress analysis are shown below. (Reference: MIL-HNDBK-5, AMS55525A and Allegheny Ludlum Data Sheets)

<table>
<thead>
<tr>
<th>Property</th>
<th>R.T. Mat'l Allowable KSI</th>
<th>300°F Mat'l Allowable KSI</th>
<th>1200°F Mat'l Allowable KSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{tu}$</td>
<td>95</td>
<td>140</td>
<td>86.4</td>
</tr>
<tr>
<td>$F_{ty}$</td>
<td>45</td>
<td></td>
<td>39.6</td>
</tr>
<tr>
<td>$F_{cy}$</td>
<td>45</td>
<td></td>
<td>41.4</td>
</tr>
<tr>
<td>$F_{su}$</td>
<td>60</td>
<td></td>
<td>50.4</td>
</tr>
<tr>
<td>$F_{brue/D} = 2.0$</td>
<td>225</td>
<td></td>
<td>184.5</td>
</tr>
<tr>
<td>$E$</td>
<td>29,000</td>
<td>29,000</td>
<td>27,260</td>
</tr>
</tbody>
</table>
MECHANISM GEOMETRY
Ref: Dwg # 113P069

Door shown in 51 degree open position
Door Free Body:
51 Degree Open Position

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>9.9</td>
<td>7.35</td>
<td>4.87</td>
<td>72.32</td>
</tr>
<tr>
<td>II</td>
<td>15.53</td>
<td>9.19</td>
<td>1.79</td>
<td>88.95</td>
</tr>
<tr>
<td>III</td>
<td>15.65</td>
<td>7.52</td>
<td>-.78</td>
<td>117.68</td>
</tr>
<tr>
<td>IV</td>
<td>100.02</td>
<td>54.75</td>
<td>1.91</td>
<td>87.99</td>
</tr>
<tr>
<td>Tot.</td>
<td>154.80</td>
<td>1.91</td>
<td>-6.7</td>
<td>97.96</td>
</tr>
</tbody>
</table>

Total Surface:

\[
\bar{x} = \frac{979.86}{154.80} = 6.33 \text{ in.}
\]

\[
\bar{y} = \frac{647}{154.80} = .41 \text{ in.}
\]

\[
\bar{p} = \frac{1593}{154.80} = 10.29 \text{ psi}
\]

Area Outboard (Aft) of \( A - A \):

\[
\bar{x} = \frac{879.93}{100.02} = 8.75 \text{ in.}
\]

\[
d = 8.75 - 4.10 = 4.65 \text{ in.}
\]

\[
M_{A-A} = 4.65(100.02)(10.29) = 4786 \text{ in. lb}
\]
Section A-A @ Support Line Hinge, Lower Beam:

-9 \( t = 0.020 \)

-21 & -23 Doubles Omitted

-13 \( t = 0.025 \)

-3 \( t = 0.025 \)

<table>
<thead>
<tr>
<th>ELEM</th>
<th>A</th>
<th>X</th>
<th>Ay</th>
<th>Ay^2</th>
<th>Ic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0200</td>
<td>3.40</td>
<td>0.0280</td>
<td>0.0070</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.3750</td>
<td>7.55</td>
<td>0.0281</td>
<td>0.0211</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.0125</td>
<td>0.12</td>
<td>0.0002</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.0312</td>
<td>6.21</td>
<td>0.0193</td>
<td>0.0120</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.0150</td>
<td>1.18</td>
<td>0.0177</td>
<td>0.0209</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.0500</td>
<td>3.00</td>
<td>0.0400</td>
<td>0.0320</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.0250</td>
<td>1.00</td>
<td>0.0275</td>
<td>0.0166</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.0250</td>
<td>1.00</td>
<td>0.0275</td>
<td>0.0166</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.0100</td>
<td>-0.10</td>
<td>-0.0001</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>2262</strong></td>
<td><strong>1.957</strong></td>
<td><strong>2044</strong></td>
<td><strong>0.0277</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* \( F_{ec} \times KF = 3.64 \times (1.56)(10)^4 \times (0.025) = 42,200 \) psi

\[
M = \frac{1364}{2300} (4786) = 2611 \text{ ft.-lb} \\

f_{pcu} = \frac{2611 \times 0.865}{0.0628} = 36,795 \text{ psi} \text{ limit} = 24,530 \text{ psi limit} \\
f_{p_{elu}} = \frac{2611 \times 0.715}{0.0628} = 29,727 \text{ psi} \text{ limit} = 19,818 \text{ psi limit} \\

M_{S_e} = \frac{36,795}{24,530} - 1 = \frac{0.26}{L} \\
M_{S_e} = \frac{29,727}{19,818} - 1 = \frac{0.23}{L} 

SECTION B-B, LOWER BEAM

\[ \begin{array}{|c|c|c|c|c|c|}
\hline
\text{ELEM} & A & y & A_y & A_y' & I_o \\
\hline
1 & 0.010 & -0.25 & -0.0025 & 0.0006 & \\
2 & 0.015 & -0.01 & -0.0001 & - & \\
3 & 0.038 & 0.40 & 0.0152 & 0.0061 & 0.0114 \\
4 & 0.016 & 1.30 & 0.0208 & 0.0270 & \\
5 & 0.016 & 0.01 & 0.0002 & - & \\
6 & 0.022 & 0.55 & 0.0121 & 0.0066 & 0.0022 \\
7 & 0.012 & 1.00 & -0.0120 & -0.0120 & \\
8 & 0.051 & 0.52 & 0.0265 & 0.0138 & 0.0166 \\
9 & 0.040 & 1.25 & 0.0500 & 0.0425 & \\
10 & 0.025 & 0.05 & 0.0212 & 0.0181 & \\
\hline
\end{array} \]

\[ Y = \frac{1554}{2945} = 0.534 \]

\[ C_1 = 0.094 + 0.50 = 1.34 \]

\[ C_2 = 1.500 - 0.34 = 1.166 \]

\[ I_0 = 0.187 - (0.34 \times 0.162) + 0.0302 \]

\[ = 0.0784 \text{ in}^4 \]

\[ M = \frac{1364}{2500} (4786) = 2611 \text{ in}-\text{lb} \]

\[ f_{bcu} = \frac{2611 (1.134)}{0.0784} = 37,767 \text{ psi LIMIT} = 25,178 \text{ psi LIMIT} \]

\[ f_{bcu} = \frac{2611 (0.864)}{0.0784} = 28,840 \text{ psi LIMIT} = 19,227 \text{ psi LIMIT} \]

\[ M.S.C. = \frac{31,050}{25,178} - 1 = +0.23 \]

\[ M.S.C. = \frac{26,840}{19,227} - 1 = +0.44 \]
Door Hinge Lugs:  
View C-C

Total lug thickness is made up of -19 double 4-

-11 channel, t = .025

tf = .075 per lug, two lugs are hinge.

Shear Take out: (Assume acting on min. shear-out area)

\[ \frac{f_s}{S} = \frac{503}{.503} \]

\[ A_{s_{\text{min}}} = 4 \times (32 \times 2197) \times (0.075) = .0300 \text{ in}^2 \]

\[ f_s = \frac{503}{.0300} = 16,766 \text{ psi ULT} \]

\[ f_{u_{2000F}} = 33,600 \text{ psi} \]

\[ \frac{M.S. = 33,600}{16,766} - 1 = 1.00 \]

Bearing:

\[ \frac{P_{bc}}{A_{bc_{\text{min}}}} = \frac{503}{(2 \times (4.385)) \times (0.075)} = .066 \text{ in}^2 \]

\[ f_{bc_{\text{min}}} = \frac{503}{.066} = 7621 \text{ psi} \]

\[ \text{not critical} \]
**Top Link:**

- **59 Tube:**
  - ½ Dia x 0.025 in
  - **Matl.:** A286
  - $E_{\text{ho}} = 280000$ MPa
  - $\sigma_{\text{UTS}} = 400$ MPa
  - $P_c = \frac{\pi^2 E I}{(L_e)^2} = \frac{\pi^2 (28 \times 10)^4 (0.001)}{(7.90 \text{ in})^2} = 4865$ lbs
  - Tube not critical

- **57 Channel:** Lower lug, net tension section
  - **Matl.:** 025
  - **DL (2 thicknesses):** $A_e = (0.080) (0.84 + 0.089) = 0.020$ in$^2$
  - $F_{\text{ult}} = 86100$ lbs
  - $P_c = 0.020 (86100) = 1732$ lbs
  - Tension not critical
**Idler Link:**

**Lower Lug, Section D-D, Compression Allowable**

\[ F_{cr} = KE \left( \frac{L}{b} \right)^2 \]

Where \( K = 1.00 \), \( \alpha_b = 1.00 \), ends pinned sides face

\[ F_{cr} = 18.56 \times (10)^{6} \text{ psi} \]

\[ P_{cr} = 0.050 \times 0.84 \times (16,370) = 687 \text{ lb/lug} \]

**Shear Tear-out: Lower Lug**

\[ P_3 = 875 \text{ lb/lug} \]

\[ A_s = 2 \times (0.42 - 0.2193) \times 0.050 = 0.020 \text{ in}^2 \]

\[ f_s = \frac{875}{0.020} = 43,750 \text{ psi} \]

\[ F_{u300} = 50,400 \text{ psi} \]

\[ M.S. = \frac{50,400}{43,750} - 1 = 0.15 \]
Door Support Links:

Section LE-LE

\[ C_e = C_c = 0.55 \text{ in}. \]
\[ I = 2 \left( \frac{1.00^3 \times 0.025}{12} \right) + \frac{2(1.00)(0.025)(0.025)}{12} = 0.0174 \text{ in}^4 \]
\[ A = 2(1.05 + 1.00)(0.025) = 0.1025 \text{ in}^2 \]

\[ M_{C,C} = 1.22(375) - 8.35(N) = 1631 \text{ in.-lb} \]

\[ f_b = \frac{1631(0.55)}{0.0174} = 46,240 \text{ psi} \]
\[ \text{ULT} = 30,827 \text{ psi limit} \]

\[ f_c = \frac{1631}{0.0174} = 92,680 \text{ psi} \]
\[ \text{ULT} = 92,680 \text{ psi limit} \]
Door Support Links:

**Section E-E**

\[ \Sigma f_c = 60,142 \text{ psi} \]
\[ F_{cc} = KE \left( \frac{t}{k} \right)^2 \]
\[ = 3.64 \times (27.26 / 10)^6 \left( \frac{0.025}{0.75} \right)^2 = 69,644 \text{ psi} \]
\[ F_{cy} = 41,400 \text{ psi} @ 300^\circ F \]
\[ M.S.c = \frac{41,400}{40,095} - 1 = 0.03 \]

-45° LIG ATTACHMENT TO SUPPORT

**THE 1425° ULS SUPPORT LOAD IS TRANSFERRED TO THE -45° LUG THROUGH 10 SPOT WELDS PER MIL-W-6858 @ .5 SPACING.**

\[ t_{weld} = .025 \]
\[ P_{90°/spot} = 425 \text{ lb/spot} \]
\[ P_{90°/spot} = 425 \text{ lb/spot} \]
\[ P_{90°/spot} = 425 \text{ lb/spot} \]
\[ P_{90°/spot} = 425 \text{ lb/spot} \]
\[ \Sigma P_{90°/spot} = 10 (230) = 2300 \text{ # ULS} \]

\[ M.S. = \frac{2300}{1425} - 1 = 0.61 \]
Door Support Line Lug:
View IF-IF

Shear Tear Cut:

\[ F_S = 1375 \, \text{lbs.} \]
\[ A_S = 2 \times (0.7 - 0.251) \times 0.085 = 0.037 \, \text{in}^2 \]
\[ f_{S}_{II} = \frac{1375}{0.037} = 37,162 \, \text{psi} \]
\[ F_{su} = 50,400 \, \text{psi} \]

\[ M.S. = \frac{50,400}{37,162} - 1 = 0.36 \]

Lug Bending NOT CRITICAL
4.0 PITCH FAN INLET LOUVER INSTALLATION

The pitch fan inlet louver installation (Ref. Dwg. 143P010) consists of two independently operated sets of four louvers, one set on each side of the aircraft centerline, at the inlet to the pitch fan. The louvers are designed for flight operations in two positions only. Fully closed they provide a faired upper surface over the pitch fan and fully open they allow inlet air to enter the pitch fan and guide the flow of the inlet air.

The louvers are attached to the inlet through the louver support vanes, which are integral parts of the inlet, by means of full length piano hinges. Louver actuation is accomplished through a series of push rods between the louver bellcranks by a single electrical actuator for each set of four louvers. The actuator (Ref. Dwg. SCDE0066) is designed to preload the louver system against the centerline bellcrank stop throughout the range of relieving louver loads and is load limited to preclude overloading of the mechanism.

A sketch of the installation of one set of the louvers is shown in Figure 1.

The louver installation is designed to withstand normal pressure loading in the closed position for any conventional flight condition. Critical design loads occur in the open position at maximum design speeds of 125 knots fan power on and 180 knots fan power off with the aircraft in a + 15 degree sideslip flight condition. These loads, in terms of louver hinge moments are shown in the accompanying pages.

Because of the similarity of components which make up the separate louvers and mechanism units, stress analysis and margins of safety are shown for the critical component only.
Pitch Fan Inlet Louver Installation:

Ref: Dwg 118 P10

9 Louver No. 2

11 Louver No. 3

13 Louver No. 4

15 Bellcrank

21 Bellcrank

Support Vane No. 1

Support Vane No. 3

Support Vane No. 4

71 Rod (L)

75 Rod (R)

-97 Hinge

-107 Stop Block

45 Bellcrank

69 Pin 7 Places

-19 Bellcrank

-5 Linkage R.H.

3 Bellmouth

S.D. E0046 Activator

W.L. 100.00

B.L. 0.00

S.H. 59.00

W.L. 100.02

B.L. 24.05

113 F127, Actuator Mounting Bracket

View Looking Forward, L.H. Side

Figure 1
Inlet Louver Linkage Geometry and Loading

View Looking Forward, L.H. Side

Figure II
**Mechanism Unit Loads:** Actuator loaded: louvers open

Push rod and & crank stop loads for a one pound tension load in the actuator, no other loads applied, louvers open. + indicates tension.

\[
R_4 = +1.00 \text{ #} \\
R_3 = \frac{1.93}{1.84} R_4 = +1.05 \text{ #} \\
R_2 = \frac{1.36}{2.97} R_3 = +0.56 \text{ #} \\
R_1 = \frac{1.54}{1.76} R_2 = +0.48 \text{ #} \\
R_3 = \frac{1.63}{1.18} R_1 = +0.66 \text{ #}
\]

For a compression load in the actuator, the push rod loads above would be minus (compression) and the stop load, \( R_3 \), becomes zero.

**Loupers Loaded:**

For positive lower hinge moments, reactions are supplied by both the & crank stop and the actuator. Preliminary analysis showed the following division of load to these reactions to be representative of the distribution due to flexibility of the linkage mechanism. Negative hinge moments are reacted by the actuator alone.

<table>
<thead>
<tr>
<th>Hinge Moment</th>
<th>No. of Equal Springs to</th>
<th>Load Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actuator</td>
<td>Stop</td>
</tr>
<tr>
<td>+M_1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>+M_2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>+M_3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>+M_4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>-M_1-M_4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Mechanism Unit Loads:**

**Louvers Full Open & Landed**

Hinge moments equal one inch pound, all other loads.

<table>
<thead>
<tr>
<th>R</th>
<th>+M₁</th>
<th>+M₂</th>
<th>+M₃</th>
<th>+M₄</th>
<th>-M₁</th>
<th>-M₂</th>
<th>-M₃</th>
<th>-M₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>R₁</td>
<td>-1.2</td>
<td>+3.4</td>
<td>+1.9</td>
<td>+0.5</td>
<td>+1.61</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R₂</td>
<td>-1.4</td>
<td>-2.6</td>
<td>+1.6</td>
<td>+0.6</td>
<td>+1.70</td>
<td>+1.66</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R₃</td>
<td>-2.6</td>
<td>-4.8</td>
<td>-4.3</td>
<td>+1.1</td>
<td>+1.30</td>
<td>+1.21</td>
<td>+1.42</td>
<td>0</td>
</tr>
<tr>
<td>R₄</td>
<td>-2.5</td>
<td>-4.6</td>
<td>-4.1</td>
<td>-4.1</td>
<td>+1.24</td>
<td>+1.15</td>
<td>+1.69</td>
<td>+0.52</td>
</tr>
<tr>
<td>R₅</td>
<td>+0.6</td>
<td>+1.7</td>
<td>+1.9</td>
<td>+0.7</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

---

**Inlet Louver Loads:**

The following table shows maximum estimated hinge moments applied to the louvers for two critical flight conditions with the louvers in the fully open position. Positive hinge moments tend to open the louvers.

<table>
<thead>
<tr>
<th>Hinge Moment</th>
<th><strong>Limit Hinge Moment, Inch Pounds Per Louver.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Fan Power on, V = 125 K.</strong></td>
</tr>
<tr>
<td></td>
<td>β = +15</td>
</tr>
<tr>
<td>M₁</td>
<td>-125</td>
</tr>
<tr>
<td>M₂</td>
<td>-75</td>
</tr>
<tr>
<td>M₃</td>
<td>-60</td>
</tr>
<tr>
<td>M₄</td>
<td>-30</td>
</tr>
<tr>
<td></td>
<td><strong>Fan Power Off, V = 180 K.</strong></td>
</tr>
<tr>
<td></td>
<td>β = +15</td>
</tr>
<tr>
<td>M₁</td>
<td>-170</td>
</tr>
<tr>
<td>M₂</td>
<td>-150</td>
</tr>
<tr>
<td>M₃</td>
<td>-120</td>
</tr>
<tr>
<td>M₄</td>
<td>-60</td>
</tr>
</tbody>
</table>
**Mechanism Loads: Limit**

**Flight Cond. IV, Fan Angle Off, V=180 K, β= +15 Deg.**

This condition applies critical negative hinge moments (closing moments) which increase tension loads in the push rods in the actuator.

<table>
<thead>
<tr>
<th>LOAD</th>
<th>( M_1 = )</th>
<th>( M_2 = )</th>
<th>( M_3 = )</th>
<th>( M_6 = )</th>
<th>Actuator Load</th>
<th>Total Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_i )</td>
<td>+103.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+96.0</td>
<td>+144.0</td>
</tr>
<tr>
<td>( R_k )</td>
<td>+119.0</td>
<td>97.5</td>
<td>0</td>
<td>0</td>
<td>+112.0</td>
<td>+168.0</td>
</tr>
<tr>
<td>( R_s )</td>
<td>+221.0</td>
<td>+181.5</td>
<td>+68.4</td>
<td>0</td>
<td>+240.0</td>
<td>+315.0</td>
</tr>
<tr>
<td>( R_{\text{act}} )</td>
<td>+210.8</td>
<td>+172.5</td>
<td>+82.8</td>
<td>+31.2</td>
<td>+200.0</td>
<td>+300.0</td>
</tr>
<tr>
<td>( R_s )</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Actuator load is higher than maximum actuator operating load of 300#, which means that the actuator could not operate the counters in this condition. Actual actuator ultimate static load is ±1000#, however, so it would maintain lower position.*

**Flight Cond. V, Fan Power Off, V=180 K, β= -15 Deg.**

This condition applies critical positive hinge moments (opening moments) which tend to relieve pre-tension loads in the push rods and in the actuator. Note that the actuator preload is not reversed in any linkage component at a minimum actuator preload of 200#.

<table>
<thead>
<tr>
<th>LOAD</th>
<th>( M_1 = )</th>
<th>( M_2 = )</th>
<th>( M_3 = )</th>
<th>( M_4 = )</th>
<th>Actuator Load</th>
<th>Total Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_i )</td>
<td>-20.9</td>
<td>+51.0</td>
<td>+16.8</td>
<td>+3.0</td>
<td>+96.0</td>
<td>+144.0</td>
</tr>
<tr>
<td>( R_k )</td>
<td>-23.8</td>
<td>-39.0</td>
<td>+19.2</td>
<td>+3.6</td>
<td>+112.0</td>
<td>+168.0</td>
</tr>
<tr>
<td>( R_s )</td>
<td>-44.2</td>
<td>-72.0</td>
<td>-51.6</td>
<td>+6.6</td>
<td>+210.0</td>
<td>+315.0</td>
</tr>
<tr>
<td>( R_{\text{act}} )</td>
<td>-42.5</td>
<td>-69.0</td>
<td>-49.2</td>
<td>-24.4</td>
<td>+200.0</td>
<td>+300.0</td>
</tr>
<tr>
<td>( R_o )</td>
<td>+115.6</td>
<td>+70.5</td>
<td>+22.8</td>
<td>+4.2</td>
<td>+132.0</td>
<td>+198.0</td>
</tr>
</tbody>
</table>
### Mechanism Unit Loads, Louvers Open & Loaded

#### & Crank Stop Unloaded

<table>
<thead>
<tr>
<th>R</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>-0.61</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R2</td>
<td>-0.70</td>
<td>-0.65</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R3</td>
<td>-1.20</td>
<td>-1.21</td>
<td>-0.72</td>
<td>0</td>
</tr>
<tr>
<td>R4</td>
<td>-1.24</td>
<td>-1.15</td>
<td>-0.69</td>
<td>-0.52</td>
</tr>
<tr>
<td>P2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Mechanism Loads: Limit

**Right Cond. VI, Fan Averind Off, V = 180K, B = -15 Deg**

This condition applies critical positive whole moments (opening moments) when the louvers are open but not against the & crank stop. This applies critical compression loads in the push rods and actuator.

<table>
<thead>
<tr>
<th>Load</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>Actuator Load</th>
<th>Total Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-200#</td>
<td>200#</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-300#</td>
<td>300#</td>
</tr>
<tr>
<td>P2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P1(A)</td>
<td>-210.8</td>
<td>-172.6</td>
<td>-82.8</td>
<td>-31.2</td>
<td>-200.0</td>
<td>-300.0</td>
</tr>
<tr>
<td>R4</td>
<td>-221.0</td>
<td>-181.5</td>
<td>-86.4</td>
<td>-210.0</td>
<td>-315.0</td>
<td>-488.9</td>
</tr>
<tr>
<td>R3</td>
<td>-119.0</td>
<td>-97.5</td>
<td>0</td>
<td>0</td>
<td>-112.0</td>
<td>-168.0</td>
</tr>
<tr>
<td>R2</td>
<td>-103.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-96.0</td>
<td>-144.0</td>
</tr>
<tr>
<td>R1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-96.0</td>
<td>-144.0</td>
</tr>
</tbody>
</table>

* Actuator load exceeds maximum actuator operating load of 300#, which means the actuator could not operate the louvers in this condition. Static actuator capability of ±1000# assures that the actuator will maintain this louver position.
No. 1 (Center Line) Louver

-7 Louver, -15 Bellcrank

**Limit Loads:**

<table>
<thead>
<tr>
<th>Condition</th>
<th>$M_1$</th>
<th>$R_1$</th>
<th>$P_3$</th>
<th>$P_1$</th>
<th>$R_{H1}$</th>
<th>$R_{Z1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV, $\theta = +15$&lt;br&gt;FULL OPEN</td>
<td>-170</td>
<td>+103.7</td>
<td>0</td>
<td>+52.8</td>
<td>-157.8</td>
<td>+6.5</td>
</tr>
<tr>
<td>V, $\theta = -15$&lt;br&gt;Against Stop</td>
<td>+170</td>
<td>+196.4</td>
<td>+411.1</td>
<td>-54.8</td>
<td>+240.8</td>
<td>-172.0</td>
</tr>
<tr>
<td>VI, $\theta = -15$&lt;br&gt;Not Against Stop</td>
<td>+170</td>
<td>-103.7</td>
<td>0</td>
<td>-54.8</td>
<td>+157.8</td>
<td>-6.5</td>
</tr>
</tbody>
</table>

Critical Louver Member & Torsion:

**Section A - A**

\[ \text{Mult} = 1.5 \times (1.6) \times (54.8) = 131.5 \text{ in-lb} \]

\[ I = 2(0.75)(163)^2 + 10 \left( \frac{25}{12} \right)^3 = 0.0041 \text{ in}^4 \]

\[ f_b = \frac{131.5 \times 0.20}{0.0041} = 6415 \text{ psi} \]

\[ \text{Malt: } 7075 - 7651, F_{c4} = 77,000 \text{ psi} \]
No. 1 (Centriline) Louver

Louver Torsion:

Maximum torsional moment in the louver blade occurs at mid length at the crank.

\[ M_t = 3.14 \left( \frac{3}{2} \times 8 \right)(1.5) = 127.4 \text{ in-lb (ult)} \]

\[ A = 6.0(45) = 2.70 \text{ in}^2 \]

\[ t = 0.020 \text{ 2024-T4 Alum.} \]

\[ fs = \frac{127.4}{2(2.70)(0.020)} = 1,180 \text{ psi} \]

Angle of Twist:

\[ L = 23.0 \text{ in.} \]

\[ \varepsilon = \frac{12}{G} = 600 \]

\[ \theta = \frac{127.4(23.0)(600)}{4(7.29)(10)(10)} = 0.015 \text{ rad} = 0.86 \text{ deg (ult)} \]
**No. 2 Louver:**
- 9 Louver, -17 Bellcrank

**Limit Loads:**

<table>
<thead>
<tr>
<th>Condition</th>
<th>$M_2$</th>
<th>$R_1$</th>
<th>$R_2$</th>
<th>$P_2$</th>
<th>$P_{y2}$</th>
<th>$R_{2z}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV, $\theta = +15^\circ$ Full Open</td>
<td>-150</td>
<td>+103.7</td>
<td>+216.5</td>
<td>+48.4</td>
<td>-147.5</td>
<td>+71.0</td>
</tr>
<tr>
<td>V, $\theta = -15^\circ$ Against Stop</td>
<td>+150</td>
<td>+196.4</td>
<td>+128.0</td>
<td>-48.4</td>
<td>+121.0</td>
<td>+4.0</td>
</tr>
<tr>
<td>VI, $\theta = -15^\circ$ Not Against Stop</td>
<td>+150</td>
<td>-103.7</td>
<td>-216.5</td>
<td>-48.4</td>
<td>+199.5</td>
<td>-71.0</td>
</tr>
</tbody>
</table>
No. 3 Louver
-11 Louver, 1-19 Bellcrank

Limit Loads:

<table>
<thead>
<tr>
<th>Condition</th>
<th>$M_3$</th>
<th>$R_2$</th>
<th>$R_3$</th>
<th>$P_3$</th>
<th>$R_{y3}$</th>
<th>$R_{z3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV $\beta = +15$&lt;br&gt;Full Open</td>
<td>-120</td>
<td>+216.5</td>
<td>+488.9</td>
<td>+38.7</td>
<td>-274.0</td>
<td>+138.5</td>
</tr>
<tr>
<td>V $\beta = -15$&lt;br&gt;Against Stop</td>
<td>+120</td>
<td>+128.0</td>
<td>+153.8</td>
<td>-35.7</td>
<td>+8.0</td>
<td>-4.5</td>
</tr>
<tr>
<td>VI $\beta = -15$&lt;br&gt;Not Against Stop</td>
<td>+120</td>
<td>-216.5</td>
<td>-488.9</td>
<td>-38.7</td>
<td>+274.0</td>
<td>-138.5</td>
</tr>
</tbody>
</table>

Louver Hinge:
Critical Hinge Resistant Reaction:

$R_h = 1.5 (274.0^2 + 138.5^2)^{1/2} = 460.5$ kN (ult)
Assume total hinge reaction at crank.

Hinge pin dia. = .090
Matl: Corrosion Resistant Steel, $F_{tu} = 40,000$ psi, min.
$P_3 = 230.3$ kN (ult) per shear force
$A_s = .0064$ in$^2$<br>$f_s = \frac{230.3}{.0064} = 35,984$ psi $M_S = \frac{460.5}{35,984} = .011$
No. 4 LOUVER:
-13 LOUVER, 21 BALL CRANK

Limit Loads:

<table>
<thead>
<tr>
<th>Condition</th>
<th>M₄</th>
<th>R₃</th>
<th>R₄</th>
<th>P₄</th>
<th>R₅</th>
<th>R₂₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV, β = +15° &lt;br&gt; Full Open</td>
<td>-60</td>
<td>+485.7</td>
<td>+477.3</td>
<td>+25.0</td>
<td>+137.0</td>
<td>+233.0</td>
</tr>
<tr>
<td>V, β = -15° &lt;br&gt; Against Stop</td>
<td>+60</td>
<td>+153.8</td>
<td>+114.7</td>
<td>-25.0</td>
<td>+95.0</td>
<td>+19.0</td>
</tr>
<tr>
<td>VI, β = -15° &lt;br&gt; Not Against Stop</td>
<td>+60</td>
<td>-485.7</td>
<td>-477.3</td>
<td>-25.0</td>
<td>-137.0</td>
<td>-233.0</td>
</tr>
</tbody>
</table>

Section B-B:
Critical Crack Bending:
- Material: 7075-T651, Fₑᵤ = 77,000 psi
- I = \( \frac{.231 \times (30)^3}{12} = 100051 \text{ in}^4 \)
- M = .32(497.3)(.5) = 238.7 in-lb (ult)
- \( M^2 = 238.7^2 \times .00057 = 70,205 \text{ psi} \) (ult)
No. 4 LOUVER:

SECTION B-B, CONT:

\[ A = 0.231 \times 30 = 0.69 \text{ in}^2 \]
\[ F_p = 1.5 \times 600 = 900 \text{ ft lb (MFT)} \]
\[ f_c = \frac{600}{0.069} = 8695 \text{ psi (MFT)} \]

\[ R_{ke} = \frac{70,305}{1.2(77,000)} = 0.760 \quad R_e = \frac{8695}{77,000} = 0.118 \]

\[ M.S. = \frac{1}{0.760 + 0.118} = 1.14 \]

CRANK ARM - ACTUATOR ATTACHMENT:

SHEAR TEAR-OUT:

\[ R_{max} = 0.25 \]
\[ D_{max} = 0.194 \]
\[ t_{min} = 0.097 \]

\[ P = (1.5) \frac{873}{2} = 373 \text{ ft lb (MFT) / Lb} \]
\[ A_S = 2 \times (0.25 - 0.097)(0.099) = 0.030 \text{ in}^2 \]

\[ f_S = \frac{373}{0.030} = 12933 \text{ psi (MFT)} \]
\[ F_S = 16,000 \text{ psi } \text{ not critical} \]

-69 ANU:

\[ D = 0.189 \]
\[ M.A.F. = 17 \times 56 \text{ ft lb, cond. A} \]
\[ A_S = 2 \times \left( \frac{1890^2}{9} \right) = 0.0561 \text{ in}^2 \]

\[ P = 1.5 \times (497.3) = 746 \text{ ft lb} \]

\[ f_S = \frac{746}{0.0561} = 13,300 \text{ psi } \text{ not critical} \]
**A. R. O. D. S:**

**Critical Push Rod is Rod - 75 (R3)**

\[ P_{c, \text{max}} = 1.5(488.9) = 733.4 \text{ # (ult.)} \]

**Ref:** Theory of Elastic Stability, Timoshenko

- \( L = 5.60 \text{ in.} \) (includes rod ends)
- \( c = 1.00 \) (pinned rod ends)
- **Material:** 8130 steel, \( E = 29,000 \text{ psi} \)
- \( a = 0.50 \)
- \( a/l = \frac{150}{5.60} = 0.268 \)
- \( I_1/I_2 = \frac{0.00064}{0.00192} = 0.333 \)
- \( m = 7.42 \)
- \[ P_{cr} = 7.42 \left( \frac{29.0 \times 10^6 \times 0.00192}{5.60^2} \right) = 1317 \text{ #} \]

\[ M.S. = \frac{1317}{733.4} - 1 = 0.80 \]

---

**-107 Step Block:**

**Material:** Fiberglass cloth & 538 DTA resin

\[ F_{tu} = 17,000 \text{ psi} \text{ min.} \]
\[ F_c = 15,000 \text{ psi} \text{ min.} \]
\[ F_{su} = 6,000 \text{ psi} \text{ min.} \]

**Ref:** MIL-HDBK-17, MIL-R-9500 epoxy resin

\[ P_2 = 1.5(411.1) \cos 22° = 1.5(411.1)(.9272) = 571.8 \text{ # (ult.)} \]
\[ A_S = .60(1.00) = .60 \text{ in}^2 \]

\[ F_{SU} = \frac{571.8}{.60} = 953 \text{ psi} \]

**NOT CRITICAL**
LOOPER ACTUATOR MOUNTING BRACKET

Ref: DAC, NA F/27, 193 F/28

MAX: 2024 - T351

\( F_{u} = 59,000 \) psi, \( F_{b} = 118,000 \) psi, \( F_{s} = 37,000 \) psi

\( R = \pm 746 \) # uln

\( R_{1} = 450 \) # uln
\( R_{2} = 597 \) # uln

LUG SHEAR CUT:

\( A_{s,\text{min}} = 2 \times 0.080 \times 0.246 = 0.090 \text{ in}^2 / \text{lug} \)

\( R_{u} = 373 \) # /side

\( f_{s} = \frac{373}{0.090} = 9325 \text{ psi} \)

\( f_{t} = 50,222 \text{ psi} \)

LUG BENDING:

Assume transfer, if lug load to bracket sides by lug bending and lug axial load alone.

\( I_{\text{min}} = \frac{0.080 \times (0.246)^2}{6} = 0.0046 \text{ in}^3 \)

\( A_{\text{min}} = 0.080 \times (0.246) = 0.047 \text{ in}^2 \)

\( M_{\text{A}} = 1.25 \times (167) = 209 \text{ in} \cdot \text{lb} \)

\( f_{c} = \frac{209}{0.047} = 45,134 \text{ psi} \)

\( f_{t} = \frac{225}{0.047} = 4788 \text{ psi} \)

\( M_{5} = \frac{59,000}{50,222} - 1 = 0.17 \)