AVRO AIRCRAFT

TECHNICAL REPORT

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

ANALYZED

AIRCRAFT: C-105

REPORT No. 7-0558-79

FILE No.

No. OF SHEETS: 54

TITLE: OVERBOARD AIR BLEED CUTOUT & SUPPORT STRUCTURE

STA. 630 → 634.8

~~CONFIDENTIAL~~

Classification cancelled / Changed to UNCLASS
By authority of AVRS
Date 30 Sept 86
Signature [signature]
Unit / Rank / Appointment AVRS

PREPARED BY K. IDDON, G. ISAACS, J. NEEDHAM, G. COILEY — DATE 24 MAY 1956

CHECKED BY — DATE

SUPERVISED BY — DATE

APPROVED BY — DATE

ISSUE No.	REVISION No.	REVISED BY	APPROVED BY	DATE	REMARKS

FORM 1316A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT NO. 7-0558-79	SHEET NO. 1		
AIRCRAFT: C-105	OVERBOARD AIR BLEED CUTOUT & SUPPORT STRUCT.	PREPARED BY: G. ISAACS	DATE: 22 MAY 1956
		CHECKED BY:	DATE:

CONFIDENTIAL

— INDEX —

FORM 1319A

AVRO AIRCRAFT LIMITED, MALTON - ONTARIO, TECHNICAL DEPARTMENT		REPORT NO. 7-0556-79	
		SHEET NO 2	
AIRCRAFT:		PREPARED BY	DATE
C-105	OVERBOARD AIR BLEED CUTOUT & SUPPORT STRUCT.	K. IDDON, G. ISAACS	23 MAY 1956
		CHECKED BY	DATE

GENERAL

DISCUSSION

This report on the AIR BLEED is a study of the lateral support for the ducts & also the effects on the skin hole cutout. The object of the bleed is to discharge air from the compressor when the aircraft is throttled back. High temperature is envisioned and hence no metal to metal contact of pipe to structure has been permitted. Provision is made to withdraw the pipe from the engine to facilitate engine removal.

METHOD OF ANALYSIS

There are four(4) loads to consider on the structure ~

(a) Loads due to change of shape and direction of the pipe which on the ENGINE PIPE must be carried to the ENGINE FLANGE. On the SLIDING PIPE this does not exist due to constant shape; likewise for the INNER & OUTER DUCT.

(b) Loads due to curvature of VANES ~ Since the VANES deflect the airstream aftward they resist a dynamic pressure ($\frac{1}{2}\rho V^2$) across their curved portions causing them to act as simple beams & to transmit the resulting shear via the INNER & OUTER DUCT to load normally on the SKIN & DOUBLER.

(c) Spring loads produced by ENGINE PIPE deflection transmits load from CAN DUCT via the SPRINGS to the CAN DUCT & thence into OUTER DUCT to finally be reacted by the SKIN panels.

(d) Existing shear in SKIN around cutout due to concurrent flight condition that causes portal bending on the SKIN & DOUBLER assembly.

Initially, each of these four (a, b, c, & d) will be treated separately and the final reactions determined from their summation. Each part will then be examined using the combined effects of all the loads neglecting any reliefs. It will be assumed throughout that the ENGINE has moved max. outb'd. so as to compress the SPRINGS.

Local bending due to the offset of the SPRING ℄ from the side of the INNER PIPE will be assumed carried by the INNER PIPE. The loading on the FILLER will be pure shear between the INNER & OUTER DUCTS. Reserve factors on the normal load to skin & resulting RIVET tensions will be kept high for fatigue purposes ~

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT: C-105	OVERBOARD AIR BLEED CUTOUT & SUPPORT STRUCT.	REPORT No. 7-0558-79	SHEET No. 3
		PREPARED BY: K. IDDON, G. ISAACS	DATE: 23 MAY 1958
		CHECKED BY:	DATE:

GENERAL ~ Continued

ASSUMPTIONS

1. Engine is in max. outboard position.
2. Vanes act as simply supported beams.
3. Moments due to offsets of springs need be considered as local only.
4. Engine can does not support ducts.

REFERENCES

1. DRAWINGS
   7-0158-333(3) "AIRBLEED OUTLET OUTB'D."

2. LOADS REF.
   Pressure loads received from Aerodynamics Group

3. PUBLICATIONS
   "FORMULAS FOR STRESS & STRAIN", by ROARK
   "ANALYSIS & DESIGN of AIRPLANE STRUCT.", by BRUHN
   ANC-5, dtd. MARCH, 1955

LOADS FOR STRESSING CASES (ULT.)

CASE I: Engine static pressure = 69.0 p.s.i.
" II: Dynamic press. = 18.7 p.s.i, 9.35 p.s.i, on ctr. & outer vanes, resp.
" III-a: Shroud pressure = 24.85 p.s.i.
" III-b: Shroud pressure = 0
" IV-a: Spring loads = 18.7# compression total/four
" IV-b: Spring load = 0# total
" V: Skin shear-flow = 1275 #/inch around cutout

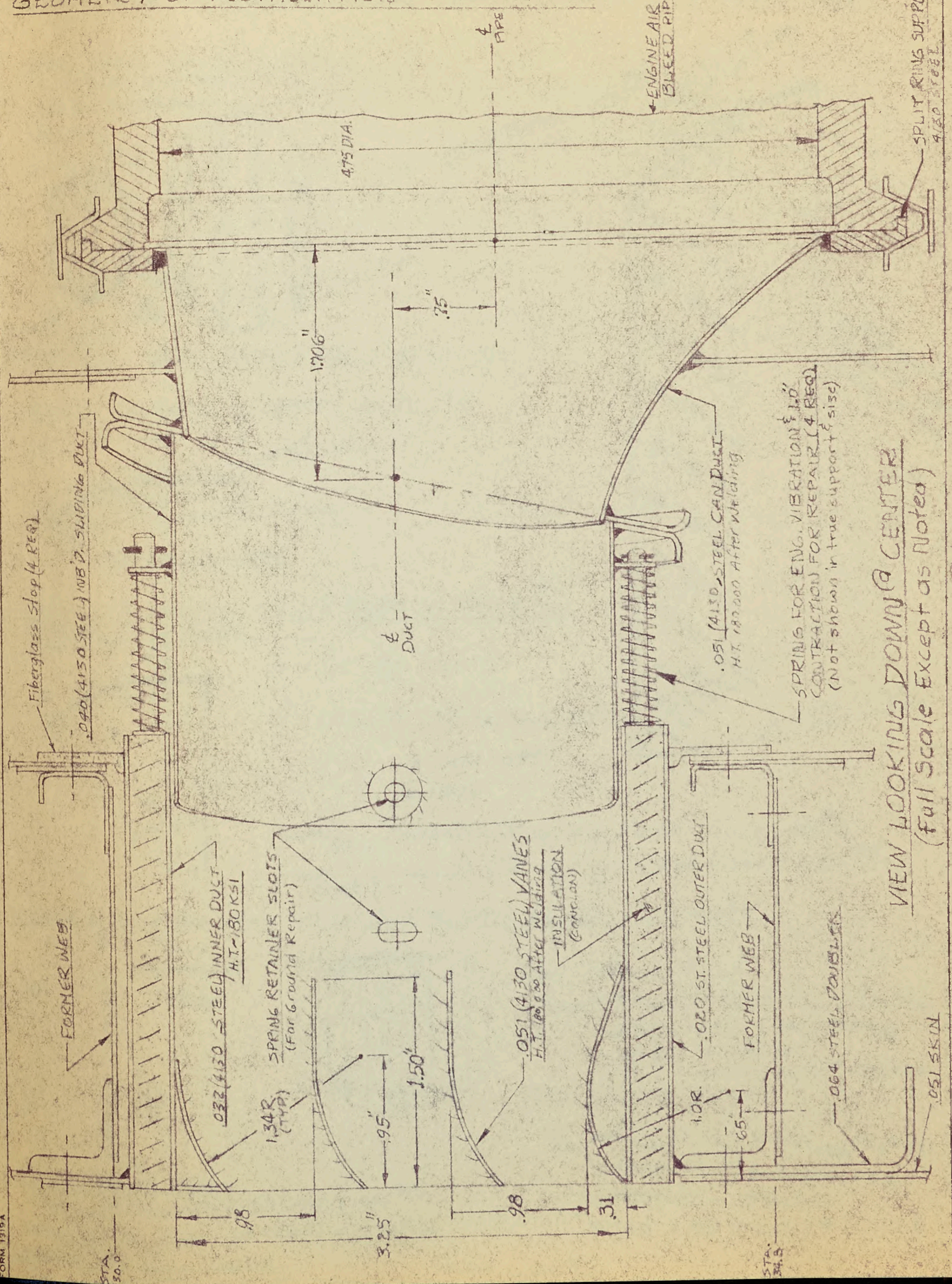
Note: Temperature within engine pipe & ducts = 495°F.
Temperature within shroud (surrounding the pipes) = 265°F.

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	REPORT No. 7-0558-79	SHEET No. 4
		PREPARED BY: G. ISAACS	DATE: 3-21-56
		CHECKED BY:	DATE:

GEOMETRY OF INSTALLATION



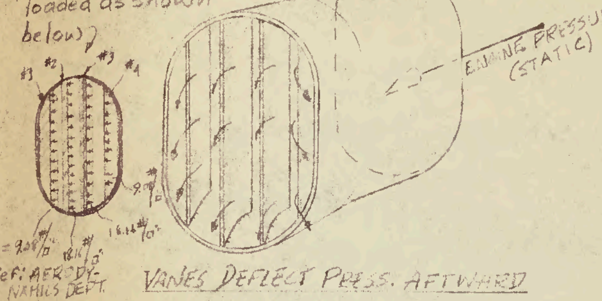
FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

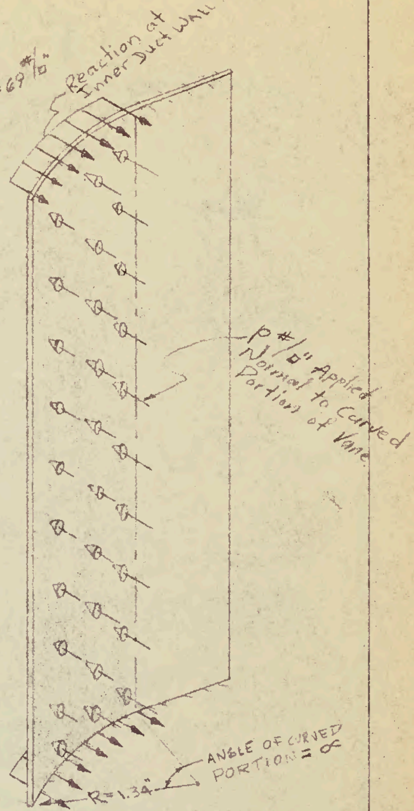
AIRCRAFT:		REPORT No. 7-0558-79	
C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	SHEET No. 5	
		PREPARED BY	DATE
		G. ISAACS	3-22-56
		CHECKED BY	DATE

LOADS DUE TO CURVED VANES DEFLECTING 34.5 p.s.i. PRESSURE

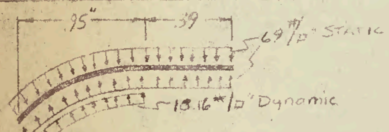
NOTE: Vanes experience Dynamic loading only and will be loaded as shown below)



VANES DEFLECT PRESS. AFTWARD

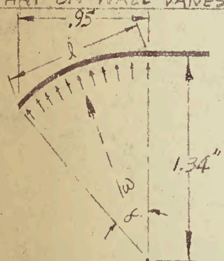


APPLIED LOADING ON CENTER VANES 2 & 3



VIEW LOOKING DOWN

RESULTANT LOADING ON CTR. VANES IS TWICE (2x) THAT ON WALL VANES



$\alpha = \sin^{-1}\frac{.95}{1.34} = 45.15°$

$l = 2R\sin\frac{\alpha}{2} = 2(1.34)\sin 22.575°$

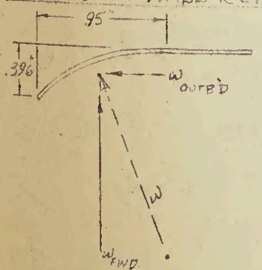
$= 2(1.34).3839$

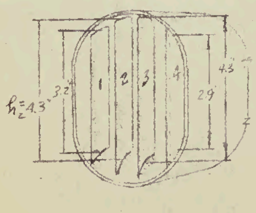
$= 1.029"$

Load/inch on Vanes 2 & 3: $w_{2,3} = p_{2,3} \cdot l = 18.16(1.029) = 18.7$ #/in.

Load/inch on Vanes 1 & 4: $w_{1,4} = p_{1,4}\, l = 9.08(1.029 = 9.35$ #/in.

INNER DUCT WALL REACTIONS DUE TO DYN. LOADS ON VANES





Total Outboard Thrust

$P_{OUTB'D} = w_{1,4\,OUTB'D}(h_1+h_4) + w_{2,3\,OUTB'D}(h_2+h_3)$

$= 3.71(3.2"+2.9") + 7.42(4.3+4.3)$

$= 3.71(6.1) + 7.42(8.6)$

$= 22.6 + 63.8 = 86.4$ # Applied

Total Forward Thrust

$P_{FWD} = w_{1,4\,FWD}(h_1+h_4) + w_{2,3\,FWD}(h_2+h_3)$

$= 8.89(3.2+2.9) + 17.78(4.3+4.3)$

$= 8.89(6.1) + 17.78(8.6)$

$= 54.2 + 153 = 207.2$ # Applied

LOADING ON CTR VANES

$w_{2,3\,OUTB'D} = w_{2,3}(.396) = 18.7(.396) = 7.42$ #/in

$w_{2,3\,FWD} = w_{2,3}(.95) = 18.7(.95) = 17.78$ #/in

LOADING ON WALL VANES

$w_{1,4\,OUTB'D} = 7.42/2 = 3.71$ #/in; $w_{1,4\,FWD} = 17.78/2 = 8.89$ #/in

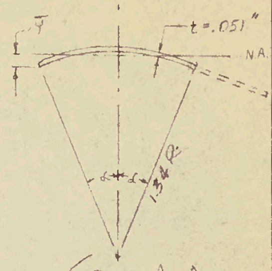
FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	6
AIRCRAFT	C-105
	OVERB'D. AIR BLEED SUPPORT STRUCTURE
PREPARED BY	G. ISAACS
DATE	3-23-56
CHECKED BY	
DATE	

BENDING IN CURVED PORTION OF VANE

Loading on ctr. vanes is max: $w = 18.7\ \#/in$



SECT. A-A
$\alpha = 22.575°$

$$M_{max.} = \frac{wL^2}{8} = \frac{18.7\,(4.3)^2}{8} = 43.25''\# \text{ Comp. Lwr.}$$

SECTION PROPERTIES

$$\bar{y} = R\left(\frac{\sin\alpha}{\alpha} - \cos\alpha\right) \quad \text{Ref. "ROARK", p. 72}$$

$$= 1.34\left(\frac{\sin 22.575°}{22.575°/57.3} - \cos 22.575\right)$$

$$= 1.34\left(\frac{.3839}{.393979} - .9234\right) = 1.34(.9744 - .9234) = 1.34(.0510) = .06834''$$

$$I_{N.A.} = R^3 t\left(\alpha + \sin\alpha\cos\alpha - \frac{2\sin^2\alpha}{\alpha}\right) \quad \text{Ref. "ROARK", p. 72}$$

$$= \overline{1.34}^3 \times .051\left(\frac{22.575}{57.3} + \sin 22.575°\cos 22.575° - \frac{2\sin^2 22.575}{22.575/57.3}\right)$$

$$= \overline{1.34}^3 \times .051\left(\frac{22.575}{57.3} + .3839 \times .9234 - \frac{2(.3839)^2 \times 57.3}{22.575}\right)$$

$$= .1227113\,(.39397905 + .35449326 - .74815758)$$

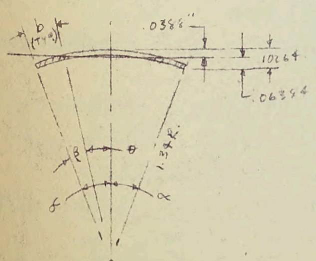
$$= .1227113\,(.00031473) = .00003862093\ in^4$$

STRESS

Max. Stress: $$f_b = \frac{M\bar{y}}{I_{N.A.}} = \frac{43.25\,(.06834)}{.00003862093} = 76{,}531\ \#/\square'' \text{ Comp. Lower}$$

ALLOW. STRESS

Length of Curve in Compression



$.0388 = R - R\cos\theta$

$.0388 = 1.34 - 1.34\cos\theta$

$$\cos\theta = \frac{1.34 - .0388}{1.34} = .971045$$

$\theta = \cos^{-1} .971045 = 13.833°$

$\beta = \alpha - \theta = 22.575 - 13.833 = 8.742°$

Length $b = R\beta = 1.34\left(\frac{8.742}{57.3}\right) = .204''$

Crippling: $b/t = \frac{.204}{.051} = 4$

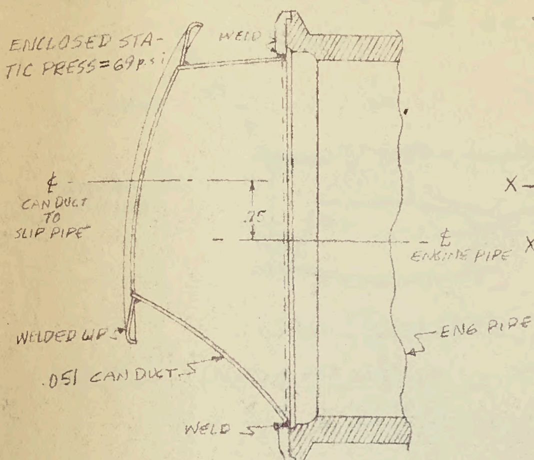
∴ curve will not cripple @ the low b/t

& F_{cy} governs with $179{,}000\ \#/\square''$ for 4130 STEEL (H.T. = 180,000)

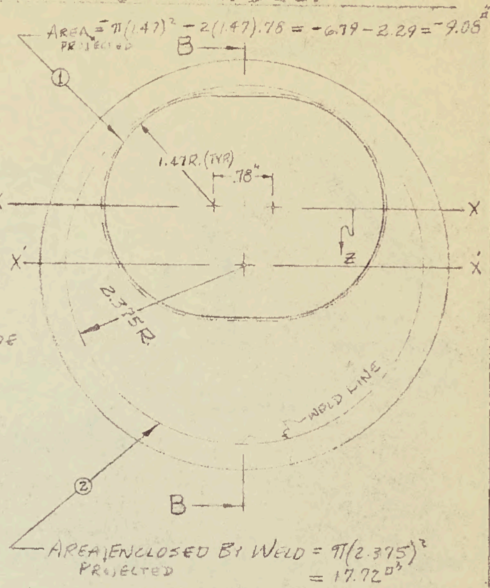
$$M.S. = \frac{179{,}000}{76{,}531} - 1 = +1.34$$

FORM 1319A

LOADS DUE TO CONFIGURATION OF ENGINE PIPE & CAN DUCT



SECT. B-B



LOCATION OF 'CENTER OF PRESSURE'

ITEM	A□"	Z	A·Z
①	−9.08	0	0
②	17.72	.75	13.29
Σ	8.64	—	13.29

$c.p.$ is @ $\bar{Z} = \frac{13.29}{8.64} = 1.54''$ below X-X

AXIAL LOAD ON CAN DUCT @ WELD LINE

AXIAL LOAD: $N = p \cdot A_{NET} = 69.0(8.64) = 596^{\#}$ Tension

BENDING MOMENT ON CAN DUCT AT WELD LINE

Assume no end support at welded lip to slip pipe ℄ is cantilevered at SECT. A-A.

$$M_{x'-x'} = N \cdot (\bar{Z} - .75) = 596(1.54 - .75) = 596(.79) = 471''^{\#}$$ Ten. Lwr.

SECTION PROPERTIES OF CAN DUCT AT WELD LINE

$$A = 2\pi R t = 2\pi(2.375).051 = .761\,\square''$$

$$I_{x'-x'} = \pi R^3 t$$ ~ Ref. "ROARK", p.72

$$= \pi(2.375)^3(.051) = 2.145 \text{ in}^4$$

BENDING & AXIAL STRESS AT WELD (LOWER EXTREME OF CAN DUCT)

$$f_t = \frac{M_{x'-x'}(R)}{I_{x'-x'}} + \frac{N}{A} = \frac{471(2.375)}{2.145} + \frac{596}{.761} = 521 + 784 = 1{,}305^{\#}/\square''$$ Tension

H.S. = High

HOOP TENSION STRESS @ WELD

Average Radius of 1" strip next to weld = 2.10" (scaled)

$P_{Hoop} = p \cdot R = 69(2.1) = 145^{\#}$ Tension. $f_t = \frac{145}{.051 \times 1} = 2{,}840^{\#}/\square''$

H.S. = High

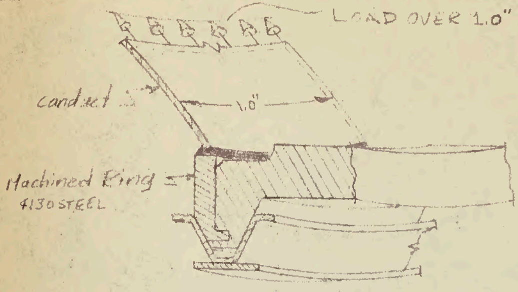
FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

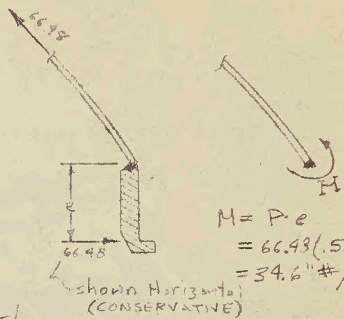
AIRCRAFT:		REPORT No. 7-0558-9	
C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	SHEET No. 8	
		PREPARED BY	DATE
		G. ISAACS	3-26-56
		CHECKED BY	DATE

LOADS DUE TO CONFIGURATION OF ENGINE PIPE & CAN DUCT – Cont'd.
"FLANGE ROLLING EFFECTS" AT WELD LINE BETWEEN MACH. RING & CAN DUCT

LOAD OVER 1.0" STRIP = $f_t A = 1,662(1 \times .04) = 66.48$ #/in



DETAIL @ ENG. PIPE



$M = P \cdot e$
$= 66.48(.52)$
$= 34.6$ "#/in

BENDING STRESS AT WELD

$$f_b = \frac{6M}{bt^2} = \frac{6(34.6)}{1''(.051)^2} = 79{,}800 \text{ \#/}\square''$$

ALLOW. STRESS IN CAN DUCT

The max. applied temperature of 495°F. will not reduce the 180 KSI H.T. 4130 steel after welding; however, no known plating can be put on to withstand this temperature in order to prevent corresion. But, ordinary service repairs will allow inspection of deterioration which may warrent replacing rotted parts or assembly.

$$F_{tu} \text{ (4130 STEEL H.T. 180)} = 180{,}000 \text{ \#/}\square''$$

$$M.S. = \frac{180{,}000}{79{,}800} - 1 = +1.25$$

ALLOW. STRESS IN WELD TO MACHINED RING

Being a fusion type weld (PROCESS SPEC: PC-4) it is suggested that a welding rod of Type MIL-E-8697 (HT180) be utilized rather than the MIL-E-6843 type as specified in PROCESS SPEC: PC-4. See ANC-5, p. 55.

$$F_{bu} \text{ (MIL-S-8697-HT180)} = F_{tu} = 150{,}000 \text{ \#/}\square''$$

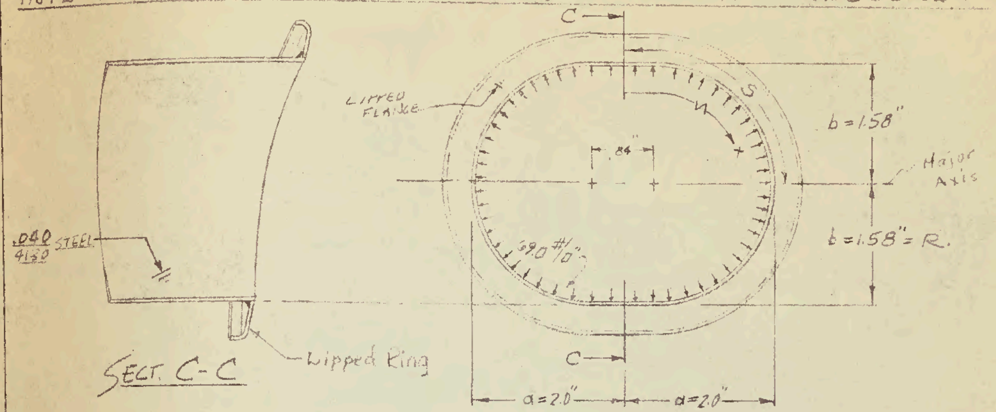
$$M.S. = \frac{150{,}000}{79{,}800} - 1 = +.88$$

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT:		REPORT No. 7-0558-9	
		SHEET No. 9	
		PREPARED BY	DATE
C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	G. ISAACS	3-27-56
		CHECKED BY	DATE

INTERNAL LOADS IN SLIDING DUCT DUE TO STATIC PRESSURE



BENDING MOM. WITHIN DUCT DUE TO ELLIPTICAL SHAPE

For purposes of analysis the figure above will be assumed to be an ellipse for bend. mom. calculations. The max. moments exist in the duct along the major axis (Ref. "ROARK", p. 166). The support offered by the lipped ring will be conservatively neglected.

REF. "ROARK", p. 166

$\frac{1}{4}$ pheriphery $= S = R\theta + \frac{.84}{2} = 1.58\left(\frac{90°}{57.3}\right) + .42 = 2.48 + .42 = 2.90"$

Max. mom. exists when $\frac{x}{S} = 1.00$, or $x = S = 2.90"$

$b/a = \frac{1.58}{2.00} = .79$ $\therefore K = .099$ (Interpolated)

OVER 1" STRIP: $M_{max.} = Kpa^2 = .099(69)\overline{2.0}^2 = 27.3"^{\#}$ Ten. Inner

HOOP TEN. LOAD WITHIN DUCT @ MAJOR AXIS

$P_{H.T.} = p \cdot a = 69(2.0) = 138^{\#}$ over 1" STRIP

TOTAL STRESS DUE TO BENDING & HOOP TENSION

(.040 = t, w = 1.0")

$f_t = \frac{6M}{wt^2} + \frac{P_{H.T.}}{A} = \frac{6(27.3)}{1.0(.040)^2} + \frac{138}{1(.040)}$

$= 102,400 + 3,450 = 105,850$ #/□"

ALLOWABLE STRESS

F_{tu} (4130 STEEL) H.T. 180 KSI AFTER WELDING = 180,000 #/□"

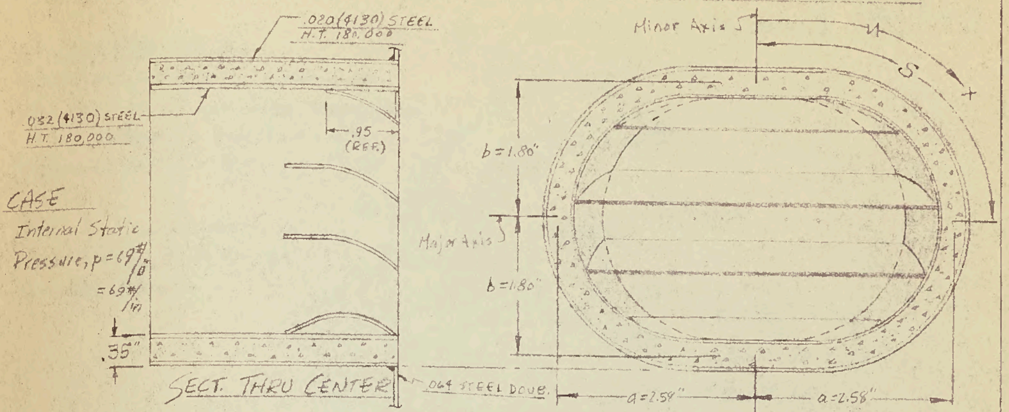
$M.S. = \frac{180,000}{105,850} - 1 = +.70$

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	REPORT No. 7-0558-79	SHEET No. 10
		PREPARED BY: G. ISAACS	DATE: 3-27-56
		CHECKED BY	DATE

LOAD ON INNER & OUTER DUCTS BONDED TO INSULATION



BENDING MOMENTS ON RING ASSEMBLY (PER 1" WIDTH)

Again this ring will be assumed to approach an ellipse; also, the stiffening effects offered by the vanes will be neglected as any tendency to contract along the Major Axis will be assumed by the .064 steel doubler via the continuous weld to the .02 Duct wall.

REF. "ROARK", p.166

$b/a = \frac{1.80}{2.58} = .7$

AT $x = 0$: $K = -0.115$

$M_{x=0} = Kpa^2$

$= -.115(69)\overline{2.58}^2$

$= -52.8$ "#

(comp. inner)

AT $x = S$: $K = 0.140$

$M_{x=S} = Kpa^2$

$= .14(69)\overline{2.58}^2$

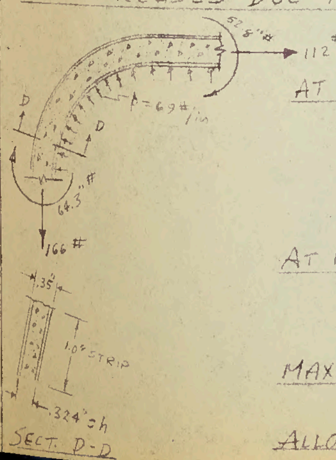
$= 64.3$ "#

(Ten. Inner)

HOOP TENSION LOAD ON DUCTS @ MAJOR AXIS (PER 1" STRIP)

$P_{H.T.} = p(a - \frac{.35}{2}) = p(2.58 - .175) = 69(2.405) = 166^{\#}$ Ten. (Conservative as R fades lesser).

DUCT STRESSES DUE TO BENDING + HOOP TENSION



AT MAJOR AXIS

$P_{inner} = \frac{M}{h} + P_{H.T.}\frac{(t_i)}{(t_i + t_o)} = \frac{64.3}{.324} + 166\left(\frac{.032}{.032 + .02}\right)$

$= 198.3 + 102.2 = 300.5^{\#}$ Ten.

$P_{OUTER} = 198.3 - 166\left(\frac{.020}{.052}\right) = 198.3 - 63.8 = 134.5^{\#}$ Ten.

AT MINOR AXIS

$P_{inner} = \frac{M}{h} - P_{H.T.}\left(\frac{.032}{.052}\right) = \frac{-52.8}{.324} + 112\left(\frac{.032}{.052}\right) = 94^{\#}$ Comp.

$P_{OUTER} = \frac{52.8}{.324} + 112\left(\frac{.02}{.052}\right) = 206^{\#}$ Ten.

MAX. STRESS IS AT MINOR AXIS ON OUTER DUCT

$f_t = \frac{P_{OUTER}}{A} = \frac{206}{1'' \times (.020)} = 10,300\ ^{\#}/\square''$ Ten.

ALLOW. STRESS

F_{tu} (4130 STEEL) H.T. AFTER WELD = 180,000

$M.S. = \frac{180,000}{10,300} - 1 = +16.47$

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	11

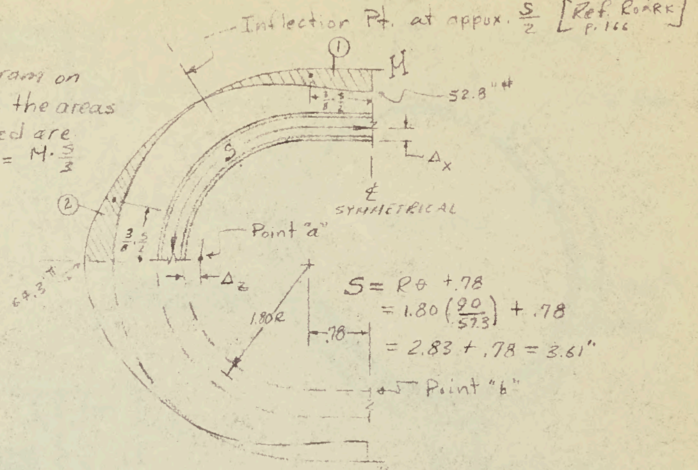
AIRCRAFT:		PREPARED BY	DATE
C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	G. ISAACS	3-28-56
		CHECKED BY	DATE

END SHEAR ON .064 STEEL DOUB. PRODUCED BY DUCT CONTRACTION

CALCULATION OF Δ_z

Since the moment diagram on the ring is a parabola the areas of the ordinates enclosed are equal to $\frac{2}{3} M \cdot l = \frac{2}{3} M \cdot \frac{S}{2} = M \cdot \frac{S}{3}$

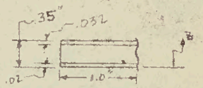
The c.g. of a parabola is located at $\frac{3}{8}$ of its length from max. ordinate



$S = R\theta + .78$
$= 1.80\left(\frac{90}{57.3}\right) + .78$
$= 2.83 + .78 = 3.61"$

ITEM	$A_{M.D.}$	Arm	A · Arm
①	-63.5 in#	2.934"	-186.2 #in³
②	77.4 in#	0.676"	52.4 #in³
Σ	—	—	-133.8 #in³

$E = 29{,}000{,}000 \ \#/\square"$



SECT. THRU RING

SECTION PROPERTIES

$\bar{z} = \frac{.032(1).334}{.032 + .020} = .2055"$

$I_{n.a.} = .020(.2055)^2 + .032(.1445)^2$
$= .000845 + .000669 = .001514 \ in^4$

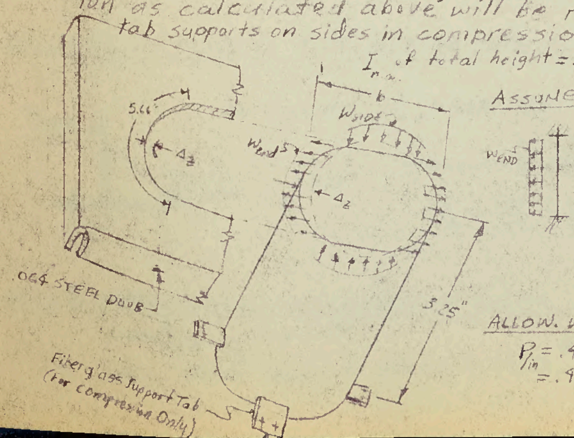
DEFLECTION

$\Delta_z = \frac{M_{M.DIAG}}{EI} = \frac{-133.8}{29{,}000{,}000\,(.001514)} = .003045"$ (This is high as the defl. on sides is restricted by brg. on sides, say point "b")

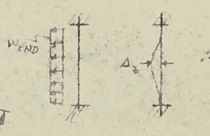
LOAD ON STEEL DOUBLER THRU WELD

An equivalent uniform loading on DUCT that produces same deflection as calculated above will be reacted by weld & by fiberglas tab supports on sides in compression:

$I_{n.a.}$ of total height $= 3.25"(.001514 \ in^4/in) = .00492 \ in^4$



ASSUME FIXED END BEAM ENDS



$\Delta_z = \frac{wL^4}{384EI}$

$\therefore w_{END} = \frac{384(EI)\Delta_z}{L^4}$
$= \frac{384(29 \times 10^6).00492(.003045)}{(5.66)^4}$
$= 163 \ \#/in$ *

* Conservative as all of the defl. would not be restrained by DOUBLER & Side Defl. = 0 due to brg.

ALLOW. WELD STRENGTH ON .02 OUTER DUCT

$P/in = .48 \, L t_s$ (Ref. BRUHNS C5.4)
$= .48(1.0).02(90{,}000) = 864 \ \#/in$

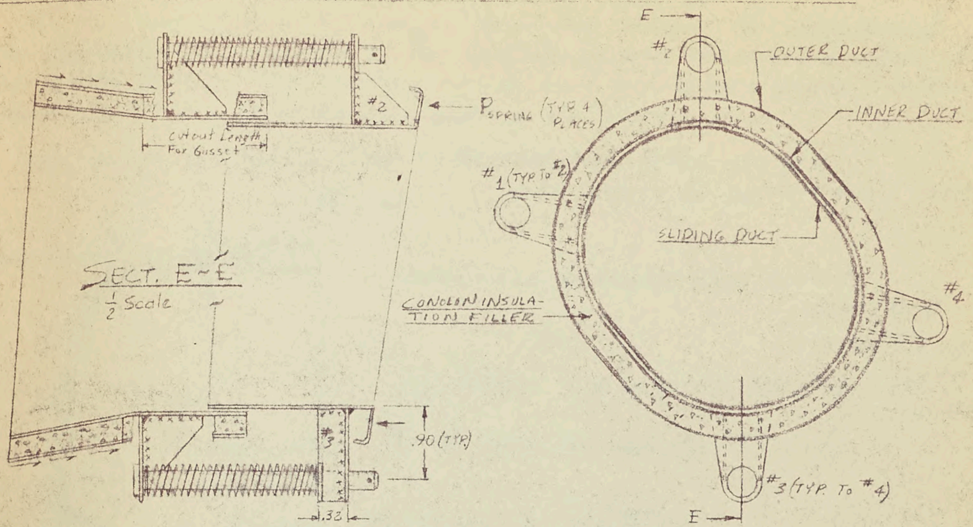
$M.S. (WELD) = \frac{864}{163} - 1 = +4.30$

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	REPORT NO. 7-0558-79	SHEET NO. 12
		PREPARED BY: G. ISAACS	DATE: 3-29-56
		CHECKED BY	DATE

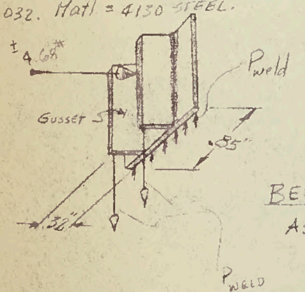
CHECK OF SLIDING DUCT DUE TO SPRING LOADS



LOAD PER SPRING FOR MAX. ENGINE DEFL. = $3.43^{\#}$ LIMIT
= $3.43(1.364) = 4.68^{\#}$ ULT. } Ref. Dwg. 7-0158-333

CRITICAL SUPPORT #3 & #4

Thicknesses of all support pieces are .032. Matl = 4130 STEEL.



MOM. ON SUPPORT @ WALL = $4.68(.90) = 4.21''^{\#}$

$$P_{weld} = \frac{M}{.32''} = \frac{4.21}{.32} = 13.16^{\#}$$

M.S. (weld) = High

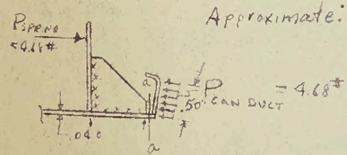
BENDING IN GUSSETS

Assume GUSSETS TAKE TOTAL MOMENT

$$f_b = \frac{6M}{2t \times b^2} = \frac{6(13.16)}{2(.032).32^2} = 12{,}040^{\#}/\square''$$

M.S. (GUSSETS) = $\frac{180{,}000}{12{,}040} - 1 =$ 13.95

BENDING IN SLIDING PIPE DUE TO SPRING COMPRESSION



Approximate: $M_{a-a} = 4.68(.25) = 1.17''^{\#}$

Assuming $\frac{1}{2}''$ effective width (CONSERVATIVE)

$$f_b = \frac{6M}{w t^2} = \frac{6(1.17)}{.5(.04)^2} = 8{,}780^{\#}/\square''$$

M.S. (CAN DUCT) = High

OUTB'D. SHEAR THRU' INSULATION TO OUTER DUCT TO SKIN DOUBLER

Load/spring = $4.68^{\#}$

Total Outb'd. Shear = $4(4.68) = 18.72^{\#}$

Neglect this small load on the insulation check

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

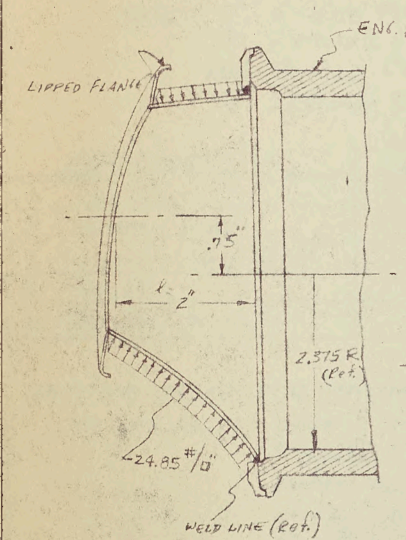
REPORT No. 7-0558-79	SHEET No 13	
AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	PREPARED BY: G. ISAACS — DATE: 4-3-56
		CHECKED BY: — DATE:

LOAD ON DUCTS DUE TO SHROUD PRESSURE

The pressure within the shroud geometry affects the CAN DUCT & the SLIDING DUCT only due to the sealing around the inboard edge of the OUTER DUCT. The loading on the two mentioned ducts, & external reactions if any will be calculated below ~

CAN DUCT LOADING DUE TO EXTERNAL PRESSURE

(Note: see p.7 for pressure area & c.p.)



AXIAL LOAD ON ENGINE PIPE: $N = p \cdot A$
$= 24.35(8.64)$
$= 214.5$ # Comp.

Mom. @ WELD c.g. $= N \cdot e = 214.5(.79) = 170$ "# Comp. Lwr.

I of WELD $= 2.145$ in⁴ (see p.7)

MAX. REACT. AT BOTTOM

$$f_c = \frac{MR}{I} + \frac{N}{A} = \frac{170(2.375)}{2.145} + \frac{214.5}{.761}$$
$$= 189 + 282 = 471 \ \#/□"$$

COLLAPSING STRENGTH OF CAN DUCT

Ref. "ROARK", p.318, CASE #31: The Engine Pipe & Lipped Flange constrain the Duct Ends against instability

Allow. Buckling Pressure: $p' = .807 \frac{Et^2}{\ell R} \sqrt[4]{\left(\frac{1}{1-\nu^2}\right)^3 \frac{t^2}{R^2}}$

$$= .807 \frac{(29\times10^6).051^2}{2"\times2.375} \sqrt[4]{\left(\frac{1}{1-.3^2}\right)^3 \frac{(.051)^2}{(2.375)^2}}$$
$$= 2{,}020 \text{ p.s.i.}$$

$$M.S. = \frac{1100}{24.85} - 1 = +43.25$$

SLIDING DUCT LOADING ANALYSIS DUE TO EXTERNAL PRESS.

NOTE: Since the X-Section does not taper in or out there is no external reaction; rather, there is tendency for collapsing as a ring ~ [Neglect lipped flange]

Ref. "ROARK", p.307, CASE #12

Allow. Buckling Pressure: $p' = \frac{3EI}{R^3}$
$= \frac{3(29\times10^6).00000533}{(1.5)^3}$
$= 137 \ \#/□"$

$I_{Thickness} = \frac{1"(.040)^3}{12} = .00000533$

$$M.S. = \frac{137}{24.85} - 1 = +4.51$$

FORM 1319A

AVRO AIRCRAFT LIMITED MALTON - ONTARIO TECHNICAL DEPARTMENT		REPORT No. 7-0558-79 SHEET No. 14	
		PREPARED BY	DATE
AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	G. ISAACS	4-4-56
		CHECKED BY	DATE

-SUMMARY-

LOAD OCCURANCE CRITERIA FOR MAX. COMPONENT STRESS

One, any pair, combination, or grouping of the following cases may occur concurrently in order to obtain maximum stress; however, due to the geometry of assembly of the component parts each may have different critical cases. Engine pressure is opposite to shroud pressure & for maximum loading do not occur together ~

CASE I: Engine Pressure (STATIC) = 69 p.s.i. OUTB'D.
II: Dynamic Pressure On Vanes
III: Shroud Pressure = 24.85 p.s.i. INB'D.
IV: SPRING LOADS

	COMPONENT	CASE AFFECTING	ADDITIVE CASES (CRIT.)	
a	Can Duct	I, III, IV	I	III + IV
b	Sliding Duct	I, III, IV	I	III + IV
c	Inner & Outer Duct	I, II, IV	I + II + IV	
d	Vanes	II	II	
e	Doubler to skin	I, II, IV	I + II + IV	

ADDITIVE CASES FOR MAXIMUM STRESS OF PARTS

(a) CAN DUCT: CASE I rather than CASES III + IV is more critical. Effects of CASE IV additive to CASE III as computed on p. 13 prove negligible. As a check the stress on this duct due to spring loads: $f_c = \frac{P}{A} = \frac{4(4.68)}{.761} = 24.6 \#/\square$ Therefore CASE I is critical & margin on p. 8 holds.

(b) SLIDING DUCT: Here again CASE I is more critical than III + IV due to the small stress offered by CASE IV. See p. 9 for margin.

(c) INNER & OUTER DUCT: shroud pressure does not exist in this area and CASES I + II + IV are critical as shown above. Since II & IV stresses are small, see p. 10 for margin.

(d) VANES: These experience CASE II (Dyn. Pressure) loads only. See p. 6

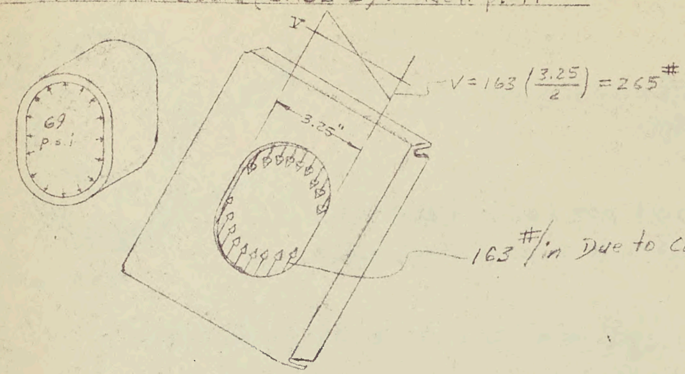
(e) DOUBLER: Since CASE III (Shroud Pressure) produces a compression reaction which is received by the Engine Pipe & does not transmit any load outb'd. it is omitted from the summation of CASES. Loading from the AIR BLEED SUPPORT (under the skin), however, produce negligible stresses on the DOUBLER (See pp 15, 6) & shear flow in the skin governs its design ~

FORM 1319A

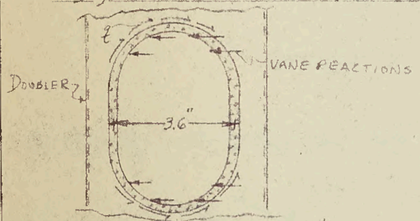
AIRCRAFT:		PREPARED BY	DATE
C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	G. ISAACS	4-4-56
		CHECKED BY	DATE

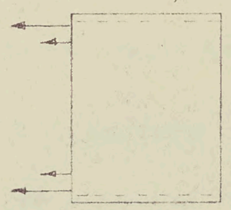
SUMMARY OF LOADS TO DOUB. FROM DUCT

Engine Static Pressure (CASE I): Ref. p. 11



Dynamic Pressure From Vanes (CASE II): Ref. p. 5



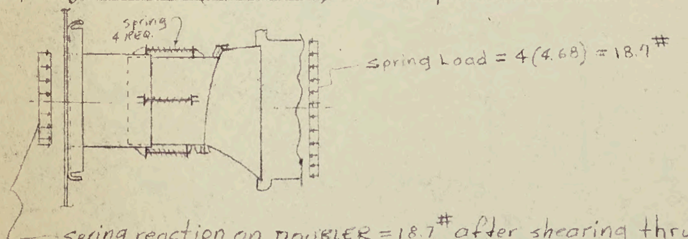


Total Fwd. Thrust = 207.2#

$shear/side = \frac{207.2}{2} = 103.6^{\#}$

Total Outb'd. Thrust = 86.4#

Spring Loads (CASE IV): Ref. p. 12



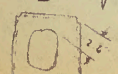
Spring reaction on DOUBLER = 18.7# after shearing thru' conolon filler from Inner to Outer Ducts

RESULTANT OUTB'D. LOAD ON DOUBLER

$$\Sigma P_{OUTB'D.} = P_{VANE} + P_{SPRING} = 86.4 + 18.7 = 105.1^{\#}$$

RESULTANT SHEAR AT CORNER OF DOUBLER

$$\Sigma V = \sqrt{V_{CASE\ I}^2 + V_{CASE\ II}^2} = \sqrt{(265^{\#})^2 + (103.6^{\#})^2} = 285^{\#}$$



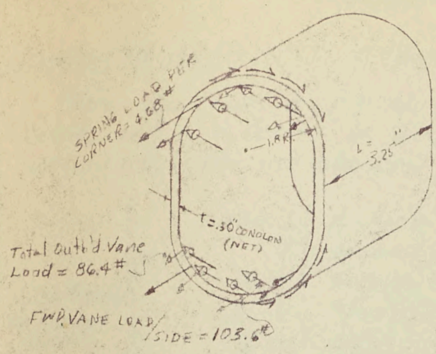
$$STRESS:\ f_s = \frac{V}{wt} = \frac{285}{2.6(.064)} = 1710^{\#}/\square''$$

M.S. (SHEAR) = High

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT No. 7-0558-79			
SHEET No. 16			
AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	PREPARED BY: G. ISAACS	DATE: 4-5-56
		CHECKED BY:	DATE:

SHEAR TRANSFER FROM INNER DUCT THRU' CONOLON TO OUTER DUCT



Assume Spring Loads remain in curved portion of Duct.

CONOLON AREA (CURVED) $= \pi(R_o^2 - R_i^2)$
$= \pi[(1.95)^2 - (1.65)^2]$
$= \pi(3.80 - 2.72) = 3.39\ \square''$

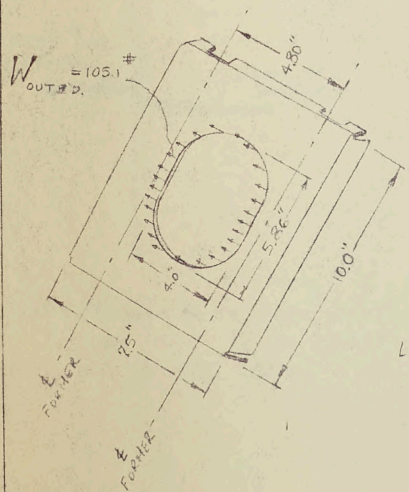
Total Outb'd. Load $= 86.4 + 4(4.68) = 105.1\#$
Total Fwd. Load $= 2(103.6) = 207.2\#$

Shear Stress due to Fwd. Load $= \frac{207.2}{3.39} = 61.1\ \#/\square''$
Shear Stress due to Outb'd. Load $= \frac{105.1}{L \cdot t} = \frac{105.1}{3.25(.30)} = 108\ \#/\square''$

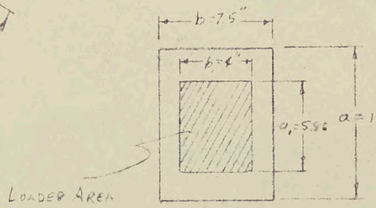
RESULTANT SHEAR STRESS = 61.1 ⟶ 108 = 124 #/□"

M.S. (CONOLON) = High

OUTBOARD BENDING OF .064 STEEL DOUBLER



For a practical bending check a referance from "ROARK", CASE 38, p.204 will be used. Neglect former relief and assume plate is 7.5" wide.



$\frac{a}{b} = \frac{10}{7.5} = 1.333$
$\therefore a = 1.333\,b$

$\frac{a_1}{b} = \frac{5.86}{7.5} = .78$

$\frac{b_1}{b} = \frac{4}{7.5} = .533$

From Table: $\beta = .62$

Max. stress: $f_b = \beta \frac{W}{t^2} = .62 \frac{105.1}{(.064)^2}$
$= 17{,}200\ \#/\square''$

$M.S. = \frac{180{,}000}{17{,}200} - 1 = +9.46$

RIVETS THRU' DOUBLER IN SHEAR & TEN. RESISTING FWD. & OUTB'D. LOADS

With more than 50 AD5's attached to the formers the load per attachment is practically nil. M.S. (RIVETS) = High

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

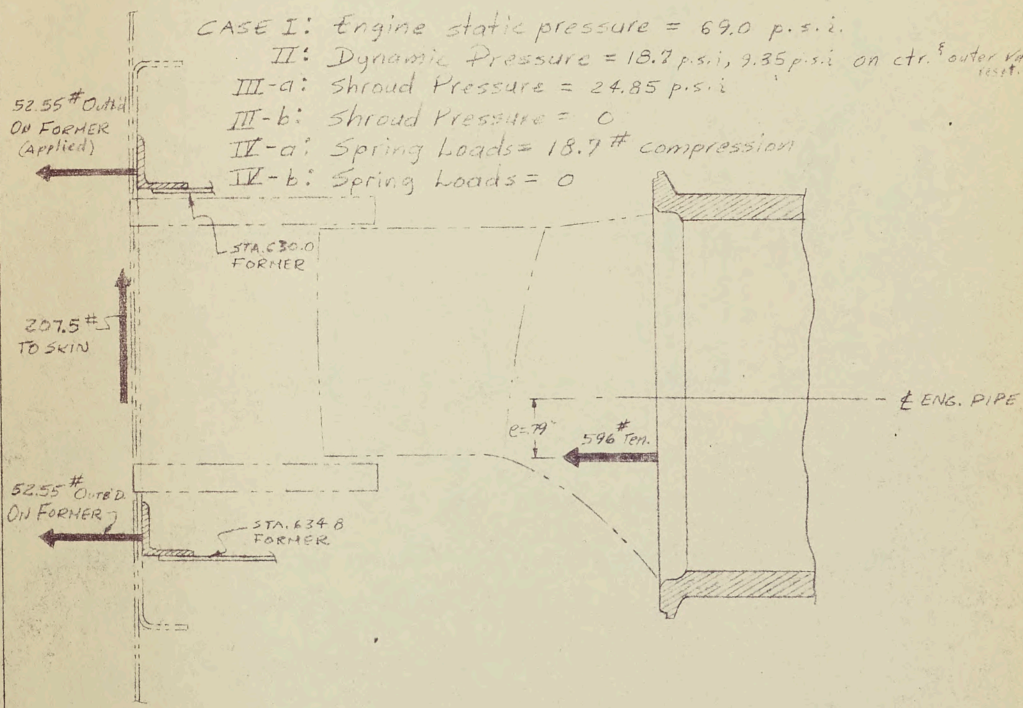
REPORT No. 7-0558-79			
SHEET No. 17			
AIRCRAFT: C-105	OVERB'D. AIR BLEED SUPPORT STRUCTURE	PREPARED BY: G. ISAACS	DATE: 4-5-56
		CHECKED BY:	DATE:

SUMMARY

LOADS TO ADJACENT STRUCTURE

The structure tying on to the Duct outlet installation receive loads and are shown in diagram for the following cases. Maximum (ULT.) loads are shown.

CASE I: Engine static pressure = 69.0 p.s.i.
II: Dynamic Pressure = 18.7 p.s.i, 9.35 p.s.i on ctr. & outer vanes resp.
III-a: Shroud Pressure = 24.85 p.s.i
III-b: Shroud Pressure = 0
IV-a: Spring Loads = 18.7# compression
IV-b: Spring Loads = 0



NOTE: (1) Loads to formers & skin are taken from CASES' I + II ± III + IV-a

NOTE: (1) Load on Engine Pipe is per CASES' I + II + III-b + IV-b
(2) Load on Engine Pipe = 233.2# compression for the following CASES: III-a + IV-a.

FORM 1319A

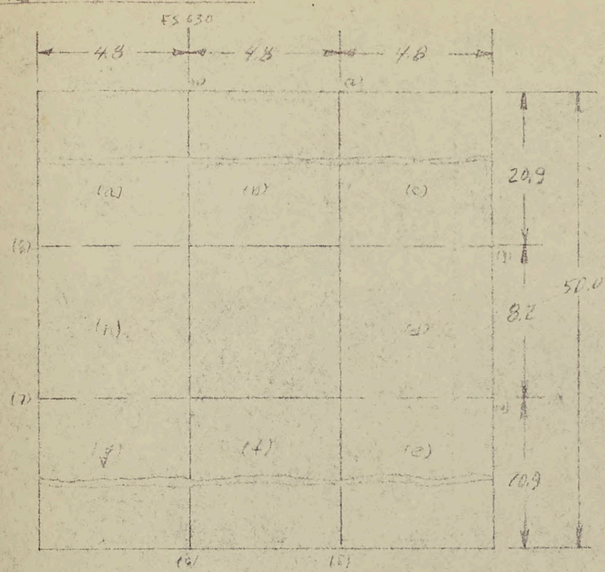
AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	18
PREPARED BY	J. NECORMI
DATE	JAN '56
CHECKED BY	
DATE	

AIRCRAFT: C-105

SKIN CUTOUT FOR OVER-BOARD AIR BLEED

SKIN DOUBLER — F.S. 630
GEOMETRY & LOADS:



OBSOLETE

SHEAR STRESS WITH NO HOLE = 16,000 psi

$q_1 = 16000 \times .051 = 1020\ ^{\#}/in.$

INCREASE OF SHEAR FLOW IN PANEL (b) & (f) DUE TO HOLE

$q_{b,f} \cong 1020 \left(\frac{50}{41.8}\right) = 1220\ ^{\#}/in$

$q_{a,c,e,g} = 1020 - 100 = 920\ ^{\#}/in.$

$q_{h,d} = [(1220 \times 50) - 920 \times 41.8]/8.2 = 12550/8.2 = 1530\ ^{\#}/in.$

LOAD IN MEMBER

$P_{(1\text{-}2),(2,5)} = 1530 \times 8.2 = 12,520^{\#}$

$P_{(1,3),(4,7)} = 1220 \times 4.8 = 5,850^{\#}$

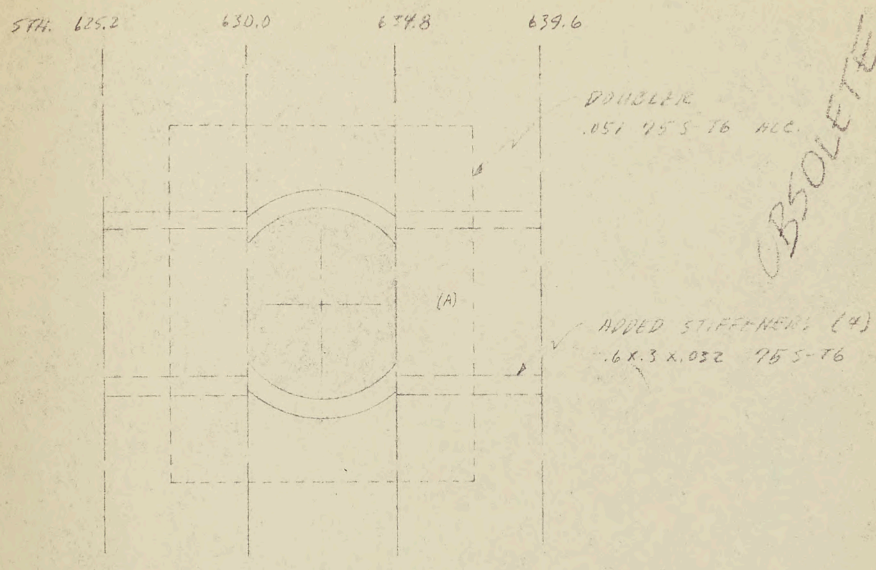
FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No.	7-0558-79
SHEET No.	19
PREPARED BY	DATE
J. NEEDHAM	3-11-55
CHECKED BY	DATE

AIRCRAFT: C 105

SKIN DOUBLER STA. 630



OBSOLETE

THE PRIMARY SKIN LOAD IS SHEAR.
MAX SHEAR STRESS = f_s = 20 000 PSI
q_s = 1020 #/IN.

THE SHEAR MAY BE TRANSFERED AROUND THE CUT-OUT IN TWO WAYS. THE DOUBLER CAN TRANSFER THE SHEAR IN DIFFERENTIAL BENDING AND THE SHEAR PANELS FORMED BY THE ADDED STIFFENERS CAN CARRY A HIGHER SHEAR THAN THE BASIC STRUCTURE.

FORM 1319A

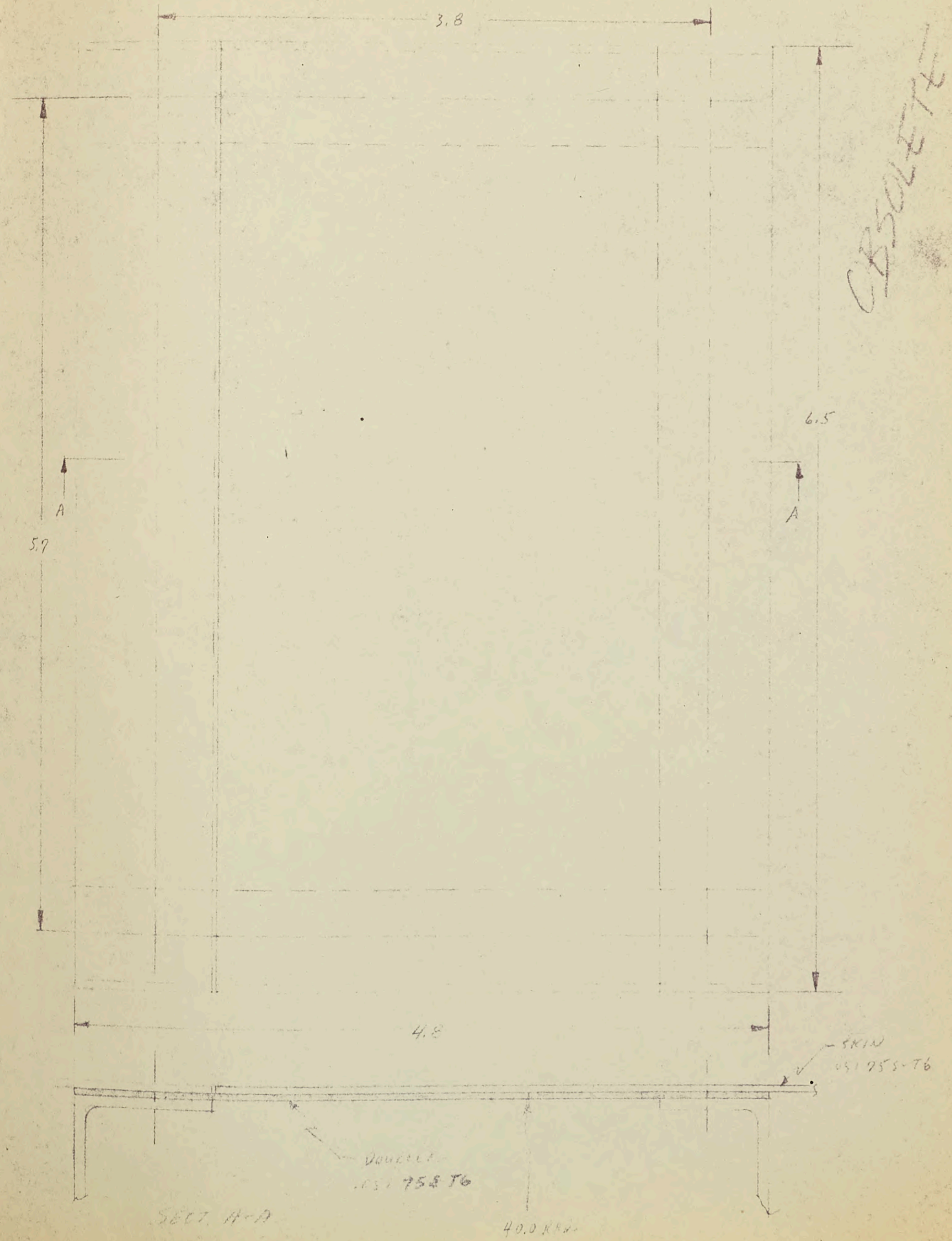
AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	20

AIRCRAFT:		PREPARED BY	DATE
C-105		J. NEEDHAM	5 JAN 55
		CHECKED BY	DATE

SKIN DOUBLER STA. 630

SHEAR PANEL (A) (SEE SHT. ...)



FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No. 7-0558-79	SHEET No. 21
PREPARED BY: J. [illegible]	DATE: 5 JAN '55
CHECKED BY:	DATE:

AIRCRAFT: C-105

SKIN DOUBLER STA 630

SHEAR PANEL [illegible] [illegible]

ANALYSIS OF CURVED WEB IN TENSION FIELD

NO.	ITEM	VALUE	
1	q	1725	
2	t_s (EDGE) t_s (CENTER)	.051 .102	
2a	* $t_{s\,eff}$	.068	
3	f_s	25400	
4	r	40	
5	d	3.8	
6	h	5.7	
7	t_{ST}	.064	
8	t_{RG}	.100	
9	R_{ST}	.139	
10	R_{RG}	.141	
11	d^2/rt	7.2	
12	K_s	8.0	
13	* τ_{cr}	26000	
14	φ τ/τ_{cr}	.976	
15			
16			
17			
18a			
18b			
18c			
19			
19a			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			

$$q = .051 \times 20000 + \frac{1020}{2}\left(\frac{[illegible]}{4.8}\right)$$

$$= 1020 + 705 = 1725\ ^{\#}/_{IN}$$

$$* \; t_{s\,eff} = \tfrac{2}{3}(.051 + .051) = .068''$$

$$* \; \tau_{cr} = 8.0 \times 10.14 \times 10^6 \left(\frac{.068}{5.7}\right)^2 = 26000$$

φ WEB DOES NOT BUCKLE

∴ SATISFACTORY

OBSOLETE

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	22
AIRCRAFT:	C-105
PREPARED BY	J. NEEDHAM
DATE	5 JAN. 55
CHECKED BY	
DATE	

TRIM DOUBLER [illegible]

SHEAR PANEL CONT'D

ALLOWABLE SHEAR IN PANEL

SHEAR BUCKLING STRESS FOR $t = .051$

$F_{s_{cr}} = K_s E \left(\frac{t}{b}\right)^2$ $E = 10.14 \times 10^6$ @ TEMP. OF 265°F

$\frac{b^2}{rt} = \frac{(3.8)^2}{4 \times .051} = 71.2$ $\frac{a}{b} = \frac{5.7}{3.8} = 1.54$

$K_s = 8.0$ (REF. "AIRCRAFT STRUCTURES" BY PEERY PG. 396)

$F_{s_{cr}} = 8 \times 10.14 \times 10^6 \left(\frac{.051}{3.8}\right)^2 = 14{,}620$ psi

SHEAR BUCKLING STRESS FOR $t = .051$ EDGES CLAMPED

$K_s = 8.0 \left(\frac{11.1}{5.84}\right) = 15.2$

$F_{s_{cr}} = 15.2 \times 10.14 \times 10^6 \left(\frac{.051}{3.8}\right)^2 = 27{,}800$ psi

ALLOWABLE SHEAR BUCKLING STRESS FOR $t = .051$ EDGES CLAMPED CONSIDERED AS A FLAT PANEL.

$F_{s_{cr}} = K_s E \left(\frac{t}{b}\right)^2$ $K_s = 11.1$ (REF. 'PEERY' PG. 361)

$F_{s_{cr}} = 11.1 \times 10.14 \times 10^6 \left(\frac{.051}{3.8}\right)^2 = 20{,}300$ psi

OBSOLETE

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	23
PREPARED BY	DATE
J. NEEDHAM	5 JAN. '55
CHECKED BY	DATE

AIRCRAFT: C-105.

SKIN DOUBLER STA. 630

ATTACHMENT OF SKIN TO DOUBLER ALONG TOP & BOTTOM

SHEAR = 1020 #/IN.

ATTACHMENT CONSISTS OF [illegible]

$P_{br} = 340 \times .75 = 255$ #/IN. @ 265°F.

3 ROWS OF RIVETS SPACED AT .60"

$Q_s = \frac{3 \times 255}{.6} = 1275$ #/IN.

$M.S. = \frac{1275}{1020} - 1 = \underline{.25}$

OBSOLETE

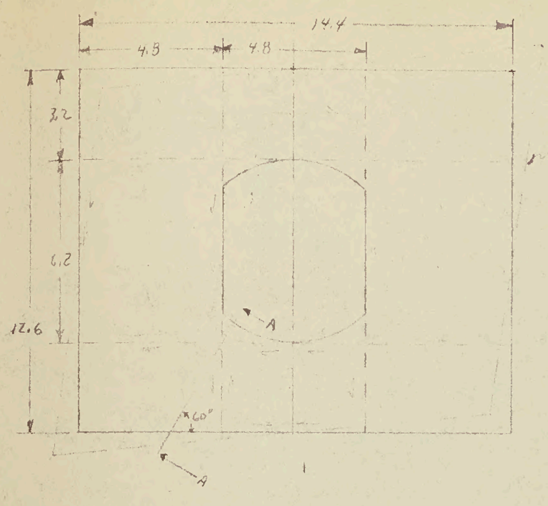
FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT No. 7-0558-79		
SHEET No 24		
PREPARED BY	J NEEDHAM	DATE 6 JAN 55
CHECKED BY		DATE

AIRCRAFT: C 105

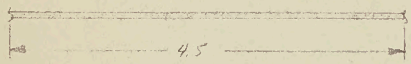
SKIN DOUBLER STA 650



$q_s = 20{,}000 \times .051 = 1020^{\#}/\text{IN.}$

DEFLECTED POSITION OF DOUBLER UNDER LOAD.

SECTION A-A (ROTATED)



LOADS

SHEAR = 1020 × 4.8 cos 60° = 2450#

AXIAL LOAD = 4900 sin 60° = 4240# (COMP)

MOM = 4900 (6.2 − 4.5 sin 60°) = 11280 "#

$f_b = \dfrac{11280 \times 6}{.051 (4.5)^2} = 65{,}500 \text{ psi}$

$f_c = \dfrac{4240}{.051 \times 4.5} = 18{,}500 \text{ psi}$

DOUBLER ALONE WILL NOT TRANSFER SHEAR AROUND CUT-OUT.

OBSOLETE

FORM 1319A

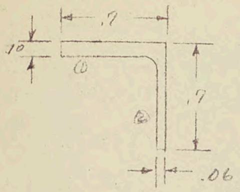
AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No. 7-0558-79
SHEET No. 25

AIRCRAFT: C 105		PREPARED BY	DATE
		J. NEEDHAM	
		CHECKED BY	DATE

OUTER CAP SPLICE OF FRAME STN. 654.85

BASIC SECTION



$A = .10 \times .7 + .06 \times .6 = .106 \text{ in}^2$

$\bar{X} = [.070 \times .35 + .036 \times .03] / .106 = \frac{.0256}{.106} = .241$

MAT'L - 75 S-T6 EXTRU. @ 265° F.

$E = 10.1 \times 10^6$ $\quad F_{cy} = 72000 \times .76 = 54700$ psi

$[E F_{cy}]^{\frac{1}{2}} = 744000$ $\quad F_{co} = 54700 \times 1.075 = 58800$ psi

$F_{cc_①} = \frac{.342 \times 744000}{(.64/.10)^{.75}} = 63200$ psi $\quad (F_{co} = 58800$ psi$)$

4.26

$F_{cc_②} = \frac{.342 \times 744000}{(.64/.06)^{.75}} = 45,200$ psi

5.62

TOTAL LOAD CAP CAN CARRY IN COMP.

$P_c = 45200(.6 \times .06) + 58800(.106 - .036) = 5740^{\#}$

MAX. TENSION LOAD

NET AREA $= .106 - .159(.10 + .06) = .0806 \text{ in}^2$

$F_{tu} = 80000 \times .76 = 60,800$ psi

$P_T = .0806 \times 60800 = 4900^{\#}$

OBSOLETE

FORM 1319 A

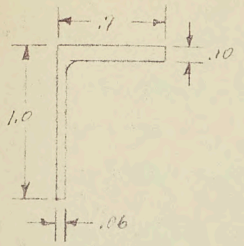
AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	26

AIRCRAFT:		PREPARED BY	DATE
C-105		J. NEEDHAM	JAN '56
		CHECKED BY	DATE

OUTER CAP SPLICE CONT'D

SPLICE SECTION AT ATTACH TO FRAME CAP



$$A = .7 \times .10 + .9 \times .06 = .124 \text{ in.}^2$$

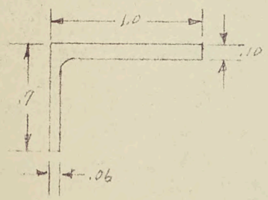
$$\bar{X} = [.07 \times .35 + .054 \times .03] / .124 = \frac{.02612}{.124} = .229''$$

$$I_{11} = .07(.121)^2 + .054(.199)^2 + \frac{.10(.7)^3}{12}$$

$$= .00103 + .00214 + .00286 = .00603 \text{ in.}^4$$

@ ATTACH BASIC SECTION SAME AS SPLICE SECTION

SPLICE SECTION @ CENTER OF SPLICE



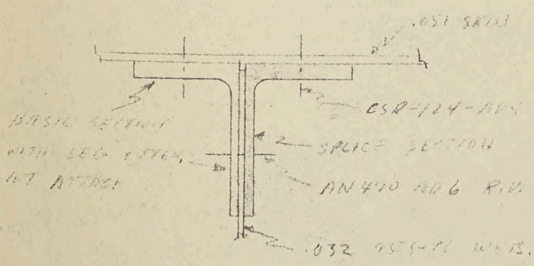
$$A = 1.0 \times .10 + .6 \times .06 = .136 \text{ in.}^2$$

$$\bar{X} = [.100 \times .5 + .036 \times .03] / .136 = .0511 / .136 = .376$$

$$I = .10(.124)^2 + .036(.346)^2 + \frac{.10(1.0)^3}{12}$$

$$= .00154 + .00431 + .00833 = .01418 \text{ in.}^4$$

CROSS-SECTION @ SPLICE ATTACHMENT



OBSOLETE

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No. 7-0558-79	SHEET No. 27	
AIRCRAFT: C.105	PREPARED BY: J. HEADMAN	DATE
	CHECKED BY	DATE

OUTER CAP SPLICE CONT'D

(b) ATTACH. TO FRAME BAR

ALLOW. TENSION LOAD

NET AREA = .124 - .159 x .10 - .191 x .06 = .0966 IN.^{2}

P_T = 60800 x .0966 = 5870 #

ALLOW. COMP. LOAD.

$F_{cc} - F_{cy}$ = 58800 psi

$F_{cc(b)} = \frac{.342 \times 744000}{(.90/...)^{.75}}$ = 33,400 psi

P_c = 33400 (.054) + 58800 (.124 - .054) = 5915 #

ALLOW. B. MOM

$Q_{..}$ = .10 (.471)^2 / 2 = .01088 IN^3 $K = \frac{2 \times .01088 \times .471}{.00603}$ = 1.70

F_b = 122000 (60800 / 74000) = 100,000 psi

ALLOW. B. MOM = 100000 x .00603 / .471 = 1280 "#

LOADS ON SECTION

P_c = 5740 # P_T = 4900 #

UNBALANCED MOMENT (MAX.) = 5740 (2 x .229 + .031) = 2810 "#

THE MOMENT IS RESISTED BY THE SHEAR LOAD IN RIVETS ATTACHING SPLICE TO CAP & SPLICE

$P_n = \frac{2810}{.75}$ = 3750 #

ATTACHED BY (9) CSK. 3/16 ... AT ... MECH. CSK. ... .050 ... S-76

P_{br} = 321 x 1.364 x .83 = 363 #/RIV.

ALLOWABLE = 363 x 9 = 3267 #   N.D.

3267 x .75 = 2450 "#   M.S. = 3993 / 3750 - 1 = .065

MOM. TO BE CARRIED BY BENDING IN SPLICE = 2810 - 2450 = 360 "#

$K_c = \frac{5740}{5915}$ = .970

$M.S. = \frac{1}{.970 + .281}$ - 1 = -.20

$R_M = \frac{360}{1280}$ = .281   1.251   -.038

OBSOLETE

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	28

AIRCRAFT:		PREPARED BY	DATE
C-105		J. Newman	
		CHECKED BY	DATE

OUTER CAP SPLICE CONT'D

ATTACHMENT OF SPLICE TO CAP ALONG LEG.

ATTACH. CONSISTS OF (8) AN470 AD6 RIV. BRG. IN .06 75S-T6 EXTRU.

$P_s = 862 \times .95 = 819^{\#}$

$P_{br} = 1144 \times 1.46 \times .83 = 1388^{\#}$ } @ TEMP. 265°F

ALLOW. = $8 \times 819 = 6552^{\#}$

LOAD = $5740^{\#}$

$M.S. = \frac{6550}{5740} - 1 = \underline{.14}$

SPLICE SECTION @ CENTER OF SPLICE

ALLOW. TENSION LOAD

NET AREA $= .136 - .4 \times .1 - .1255 \times .06 = .0883 \text{ in}^2$

$P_T = 60800 \times .0883 = 5360^{\#}$

ALLOW. COMP. LOAD

$F_{cc①} = \frac{.342 \times 744000}{(.94/.10)^{.75}} = 48,600 \text{ psi}$

$F_{cc②} = 45,200 \text{ psi}$

$P_c = 48600 \times .094 + 45200 \times .036 + 58800 (.136 - .094 - .036)$

$= 4570 + 1630 + 350 = 6550^{\#}$

ALLOW. B. MOMENT

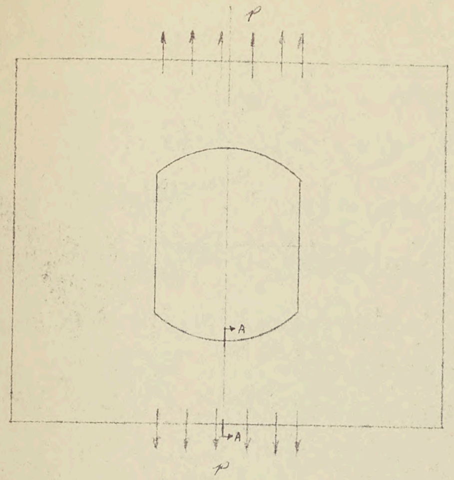
$Q_{NA} = \frac{.10(.624)^2}{2} = .01942$ $\qquad K = \frac{2 \times .01942 \times .624}{.01418} = 1.71$

$F_b = 122000 \left(\frac{60800}{74000}\right) = 100,000$

ALLOW MOM. $= \frac{100000 \times .01418}{.624} = 2270^{"\#}$

FORM 1319A

SHROUD [illegible] DOUBLER [illegible] 650



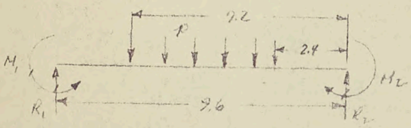
RADIUS OF SHROUD = 29"

INTERNAL PRESSURE = 24.85 PSI ULT.

$P = 29 \times 24.85 = 721\ \#/\text{IN.}$

OBSOLETE

STRESS ANALYSIS OF DOUBLER

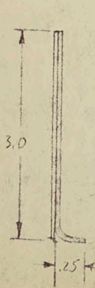


$R_1 = R_2 = .5 \times 721 \times 4.8 = 1730\ \#$

$M_1 = M_2 = \frac{11}{96} w l = \frac{11}{96}(4.8 \times 721)(9.6) = 3800\ ''\#$

SECTION A-A

MAT'L - .025 75S-T6



$A = 3 \times .025 + .225 \times .025 + 3 \times .025 = .1556$

$\bar{y} = [.150 \times 1.5 + .0056 \times 2.988] / .1556 = \frac{.2418}{.1556} = 1.554''$

$I = .150(.054)^2 + .0056(1.434)^2 + \frac{2 \times .025(3)^3}{12}$

$= .00044 + .01152 + .11240 = .12436\ \text{in}^4$

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79	
SHEET No.	30	
AIRCRAFT: C-105	PREPARED BY: J. NEEDHAM	DATE: 6 JAN. 55
	CHECKED BY:	DATE:

SHROUD SKIN DOUBLER STA. 630

SECT. B-B CONT'D

LOADING:

SHEAR = 0.

$MOM. = 1730 \times 4.8 - 3800 - 721(2.4)(1.2)$

$= 8300 - 3800 - 2080 = 2420$ "#

$f_{bc} = \frac{2420\,(1.554)}{.1244} = 30200$ psi

$f_{bt} = \frac{2420\,(1.446)}{.1244} = 28100$ psi

$F_{tu} = 70000 \times .75 = 52500$ psi

$F_{cc} = \frac{.342\sqrt{F_{cy}E}}{(b'/t)^{.75}}$

$F_{cy} = 62000 \times .75 = 46500$ psi } @ TEMP

$E = 10.5 \times 10^6 \times .96 = 10.1 \times 10^6$ } OF 265°F

$b' = 1.554/2 = .777 \qquad t = .050$

$F_{cc} = \frac{.342\sqrt{.465 \times 1.01 \times 10^{12}}}{(.777/.05)^{.75}} = \frac{.342 \times 686000}{7.82} = 30,000$ psi

$M.S. = \frac{30000}{30200} - 1 = -.006$ OK

IF DOUBLER MADE OF .032 75S-T6 ALC.

$I = .0119 + .1124\left(\frac{.057}{.050}\right) = .1401$ in.⁴

$f_{bc} = \frac{2420\,(1.554)}{.1401} = 26,800$ psi

$F_{cc} = \frac{.342 \times 770000}{(.777/.057)^{.75}} = 27400$ psi

$M.S. = \frac{27400}{26800} - 1 = .02$

ATTACHMENT OF SHROUD SKIN TO DOUBLER

ATTACHMENT CONSISTS OF AN470AD4 RIVETS SPACED @ .60 IN. (4) ROWS.

ALLOW. AN470AD4 RIV. IN .025 75S-T6 ALC.

$P_s = 388 \times .948 \times .85 = 312$ #/riv

$P_{br} = 321 \times 1.33 \times .75 = 317$ #/riv

$ALLOW = \frac{4 \times 312}{.6} = 2080$ #/in.

LOAD = 721 #/in.

M.S. > 1

FORM 1319A

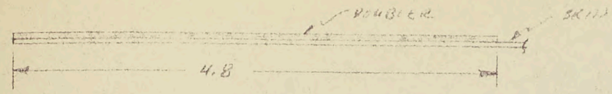
AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	31
PREPARED BY	DATE
J. MEEGHAN	6 JAN. '55
CHECKED BY	DATE

AIRCRAFT: C-105

SHROUD SKIN DOUBLER STA. 630

SECTION B-B (SEE PG. ___)



MAT'L BOTH SKIN & DOUBLER – .05 75 S-T6 ALC.

TENSION LOAD = 1780 + 4.8 × 721 = 5190#

MOM = 3800 "#

$f_t = \frac{5190}{.05 \times 4.8} = 21600$ psi

$f_b = \frac{6 \times 3800}{.05 (4.8)^2} = 19800$ psi

$f_t = 21,600 + 19800 = 41,400$ psi

$F_{tu} = 52500$ psi

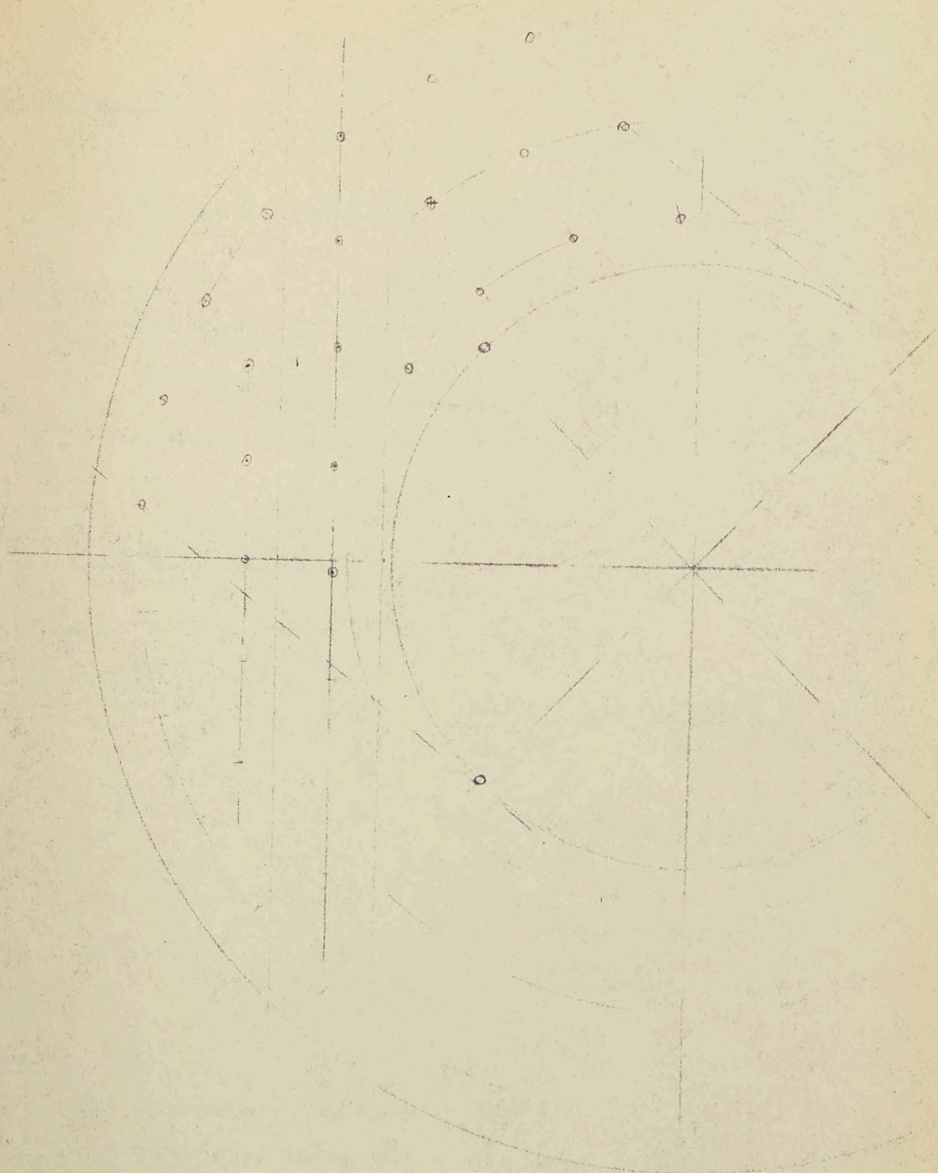
$M.S. = \frac{52500}{41400} - 1 = \underline{.27}$

OBSOLETE

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7-0558-79		SHEET No. 32	
AIRCRAFT: C105	OVER BOARD AIR BLEED	PREPARED BY: G.A. COLLETT	DATE: 17-1-52.
		CHECKED BY	DATE



SUPERCEDED

FORM 1319 A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7-0558-79		SHEET No. 33	
AIRCRAFT: C105.	OVERBOARD A/R BLEED	PREPARED BY: G.M. COILEY	DATE: 17-1-56
		CHECKED BY	DATE

USEING CONVAIR DATA

FIG 2 SAY $\frac{W}{D} = .5$, 1000 lb/in, UTS = 72,000 lb/□"

REINFORCING THICKNESS = .091"

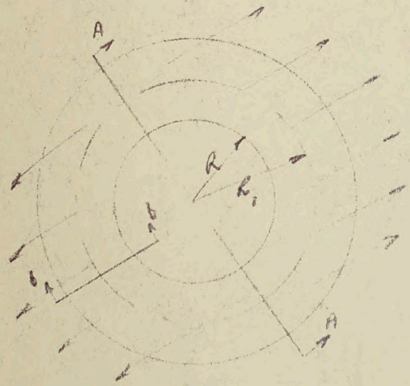
FLANGE DESIGN

WEB + D·091 = ·051 + ·091
= ·142 "

$\frac{D}{t} = \frac{4}{.091} = 44$ D = 4"

∴ NO FLANGE REQUIRED.
(ONLY JUST IN THIS RANGE BUT FRAMES WILL STABILISE)

HOLE REINFORCEMENT STRESSES.



SUMMATION OF STRESSES AT SECT AA.

$$f_B + f_t = f_u$$

$$\frac{.75\,\tau D\,(D+W)}{t_r W^2} + \frac{\tau D}{W t_r} = f_u$$

$$\frac{.75 \times 1{,}000 \times 4 \times 6}{.091 \times 4} + \frac{1{,}000 \times 4}{2 \times .091} = f_u$$

$$f_u = 49{,}400 + 22{,}000$$
$$= 71{,}400 \text{ lb/□"}$$

RIVETING

2D × WEBSHEAR = 2 × 4 × 1000 = 8000 lb

5/32 DIA A17S-T3 RIVET 100° M/C CSK in ·051 GIVE = 479 lb.

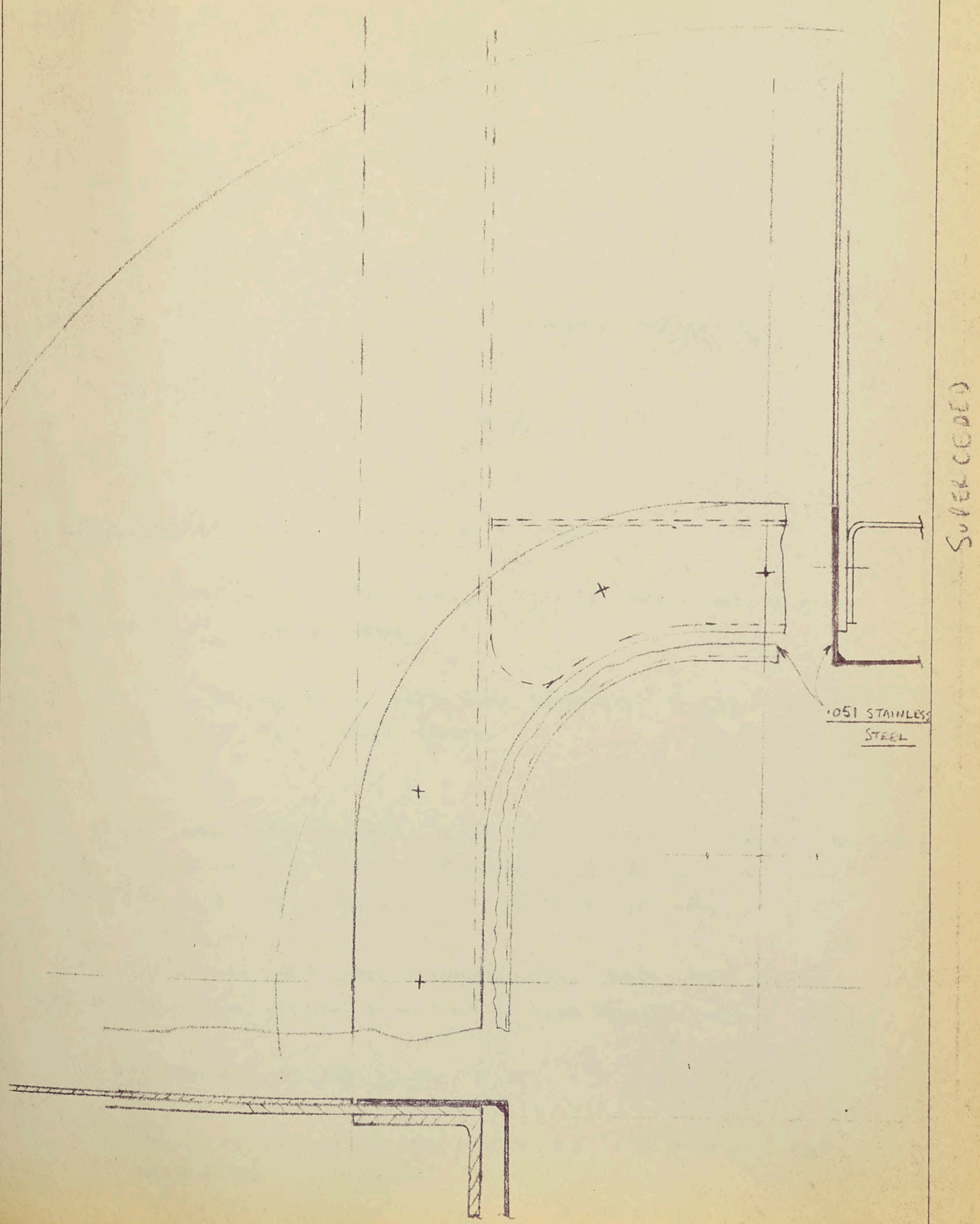
$\frac{8{,}000}{479}$ = 17 RIVETS REQD BETWEEN TANGENTS.

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7-0558-79			
SHEET No. 34			
AIRCRAFT: C105	OVERBOARD AIR BLEED	PREPARED BY: G.M. COLBEY	DATE: 24-1-56
		CHECKED BY:	DATE:



FORM 1319A

A. V. ROE CANADA LIMITED MALTON - ONTARIO **TECHNICAL DEPARTMENT (Aircraft)**		REPORT No. 7-0558-79 SHEET No. 35	
AIRCRAFT: C105	OVERBOARD AIR BLEED	PREPARED BY G. M. COLEY	DATE 24-1-56
		CHECKED BY	DATE

USEING RAeS 55 02 04 03.

$$q = 1000/.051 = 19,600 \ lb/in^2$$

SKIN $t = .051$
SAY REINF $t = .064$
$\therefore \frac{.064}{.051} = 1.256$

FOR $D/d = 2.0$ $\quad f_{max}/q = 2.68$

$$f_{max} = 2.68 \times 19,600 = 52,500 \ lb/in^2$$

75S-T6 @ 265°F 50 HRS

$$F_{cy} = 64,000 \times .87 = 55,700 \ lb/in^2$$

LOCAL INSTABILITY OF INSIDE EDGE OF HOLE.

1. REINFORCING (.064) EXTENDS .95" INSIDE HOLE AND PROBABLY REDUCES f_{max} SHOWN ABOVE.

2. FOR THE D/d RATIO USED MAX COMPRESSIVE STRESS WILL BE LOCATED AT 45° TO AXES SHOWN

3. THE .064 REINFORCING CANNOT BE FLANGED ALL ROUND BECAUSE OF CLEARANCES AT SIDES. FLANGING TOP AND BOTTOM ONLY WOULD PRODUCE STRESS RAISERS AT CRITICAL SECTIONS.

4. STABILISERS ARE .051 STAINLESS STEEL DUCT AND FORMER SEALING BETWEEN OUTSIDE SKIN AND SHROUD SKIN (SAY .051)

5. AN ESTIMATE OF L.I. STRESS IS :-

SAY $f_{cc} = 53,000 \ lb/in^2$ THEN $E_T = 8.3 \times 10^6 \times .91 = 7.55 \times 10^6$

SAY $D = .75"$ $\quad K = 1.0$

$$f_{cc} = 1.0 \times 7.55 \times 10^6 \times \left(\frac{.064}{.75}\right)^2 = 56,600 \ lb/in^2$$

SUPERSEDED

A. V. ROE CANADA LIMITED MALTON - ONTARIO **TECHNICAL DEPARTMENT (Aircraft)**		REPORT No. 7-0558-79 SHEET No. 36	
AIRCRAFT: C105	OVERBOARD AIR BLEED	PREPARED BY G.M. [illegible]	DATE 25-[illegible]
		CHECKED BY	DATE

ESTIMATE OF L.E. STRESS AT INNER EDGE USING R.Ae.S. DS 02.04.04

$$\frac{a}{b} = \frac{2.5}{4.35} = .575 \qquad \frac{f_2}{f_1} = -1.0$$

USE K = 22.0

$$f_{cc} = 22.0 \times 10.5 \times .91 \times 10^{6} \times \left(\frac{.064}{2.5}\right)^2$$

$$= \underline{138,000\ ^{lb}/_{in^2}}$$

AT 60,000 $^{lb}/_{in^2}$ $E_T = 5.5 \times .91 \times 10^{6} = 5.01 \times 10^{6}\ ^{lb}/_{in^2}$

$\therefore f_{cc} = 72,300\ ^{lb}/_{in^2}$

AT 63,000 $^{lb}/_{in^2}$ $E_T = 4.00 \times .91 \times 10^{6} = 3.64 \times 10^{6}\ ^{lb}/_{in^2}$

$\therefore f_{cc} = 52,600$

SAY $f_{cc} = 60,000\ ^{lb}/_{in^2}$

SUPERSEDED

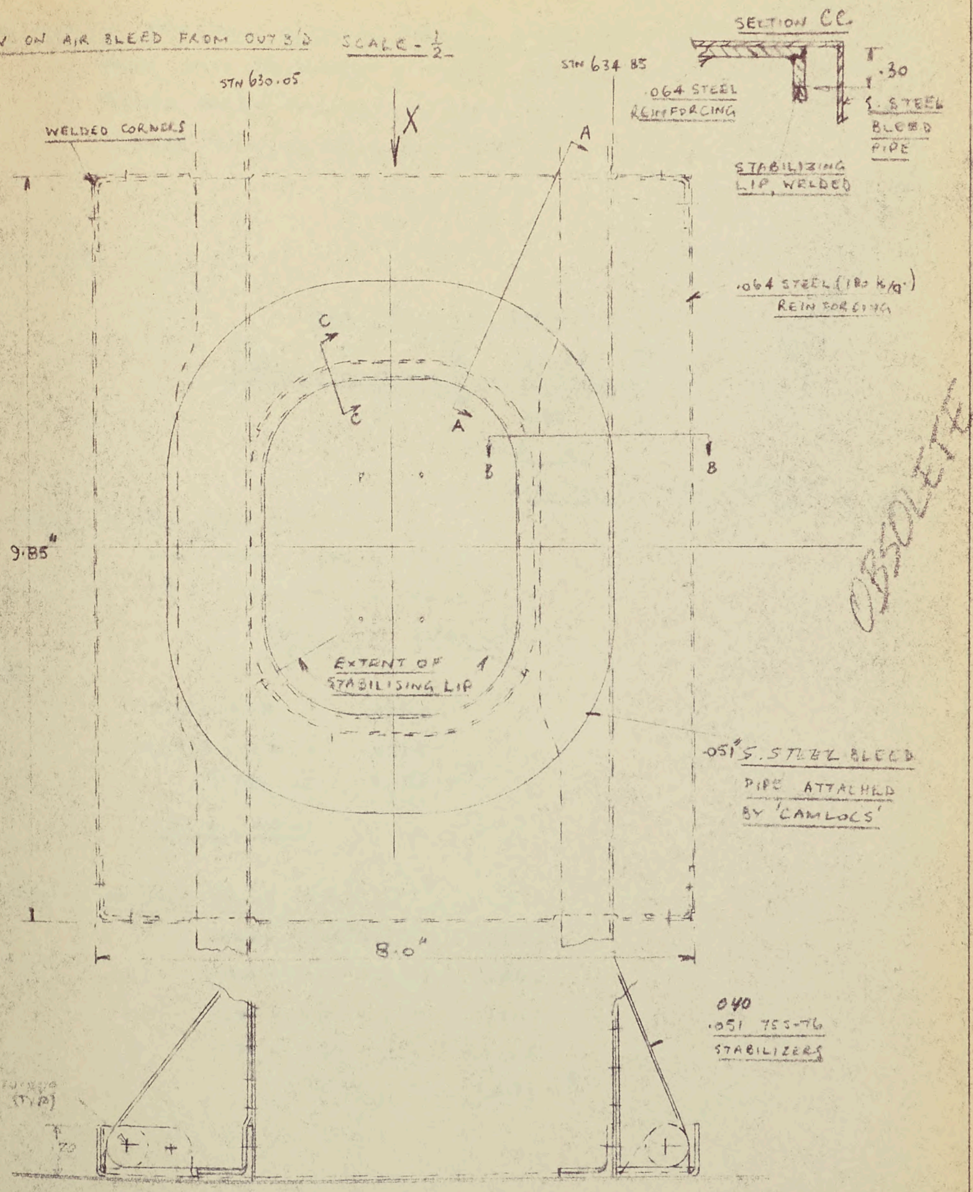
FORM 1319 A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO 7-0558-79
SHEET NO 37

AIRCRAFT:		PREPARED BY	DATE
C105	OVERBOARD AIR BLEED	G M COILEY	7-2-56
		CHECKED BY	DATE

VIEW ON AIR BLEED FROM OUTB'D SCALE - 1/2



VIEW ON ARROW X

7-1058-333

FORM 1310A

AIRCRAFT:		PREPARED BY	DATE
C105	OVERBOARD AIR BLEED	G. M. COILEY	2-2-56
		CHECKED BY	DATE

PROPERTIES OF EFFECTIVE SECTIONS THROUGH DOUBLER

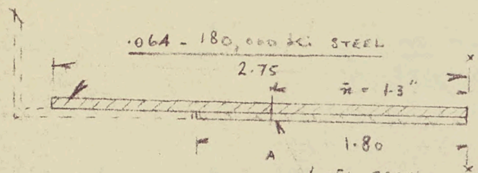
BASIC SKIN THICKNESS = .051" 75S-T6

FRAME ANGLE THICKNESS = .10 75S-T6 (∥ to skin)

DOUBLER THICKNESS ASSUMED = .064"

OBSOLETE

SECTION AA.



.051 75ST6

EFFECTIVE t $= .051 \times \frac{10.5 \times .91}{29} = .0175''$

1st MOMENTS OF AREA ABOUT XX

$2.75 \times .064 \times 1.375 = .2420$

$1.8 \times .0175 \times .9 = .0283$

TOTAL $= .2703\ in^3$

AREA

$2.75 \times .064 = .1760$

$1.80 \times .0175 = .0315$

TOTAL $= .2075\ in^2$

$\therefore \bar{x} = 1.3\ in$

2nd MOMENT OF AREA ABOUT N.A.

$.064 \times 1.45^3 \times \frac{1}{3} = .0650$

$.064 \times 1.30^3 \times \frac{1}{3} = .0468$

$.0175 \times 0.5^3 \times \frac{1}{3} = .0007$

$.0175 \times 1.30^3 \times \frac{1}{3} = .0128$

TOTAL $= .1253\ in^4$

FORM 1319A

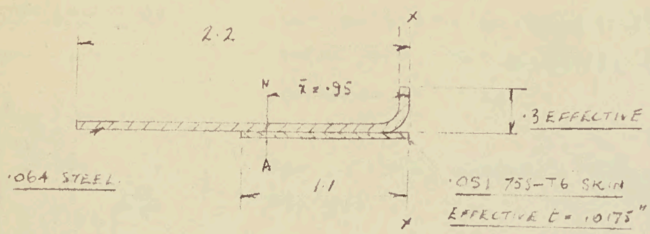
A. V. ROE CANADA LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No. 7-0558-79
SHEET No. 39

AIRCRAFT:		PREPARED BY	DATE
C105	OVERBOARD AIR BLEED	C M COILEY	2-2-56
		CHECKED BY	DATE

SECTION BB

NONE OF THE LIGHT FRAME AREA IS CONSIDERED EFFECTIVE BECAUSE OF DIFFICULTY IN LOADING THIS MEMBER



OBSOLETE

1st MOMENTS ABOUT XX

$2.2 \times .064 \times 1.1 = .155$

$1.1 \times .0175 \times .55 = .011$

TOTAL = .166 in^3

AREA.

$2.2 \times .064 = .141$

$.24 \times .064 = .015$

$1.1 \times .0175 = .019$

TOTAL = .175 in^2

$\bar{x} = 0.95$ in

2nd MOMENT OF AREA ABOUT NA

$.064 \times .95^3 \times \frac{1}{3} = .0193$

$.064 \times 1.25^3 \times \frac{1}{3} = .0416$

$.064 \times .24 \times .92^2 = .0130$

$.0175 \times .95^3 \times \frac{1}{3} = .0053$

TOTAL = .0792 in^4

FORM 1319A

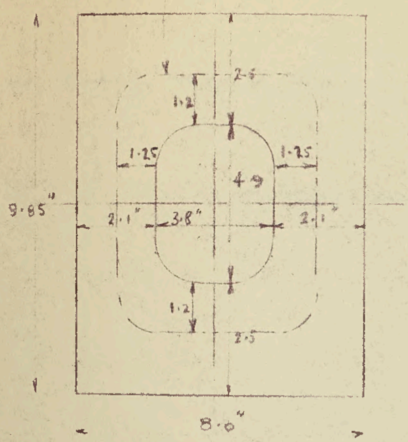
A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7-0558-79
SHEET NO. 40

AIRCRAFT:		PREPARED BY	DATE
C105	OVERBOARD AIR BLEED	G. M. COILEY	2-2-56
		CHECKED BY	DATE

BM'S AROUND CUTOUT

ASSUMED POSITION OF N.A.



APPLIED SHEAR FLOW = 1,000 lb/in.

SAY SHEAR TO BE CARRIED BY DOUBLER IN BENDING AS A PORTAL FRAME IS EQUAL TO THE SHEAR FLOW MULTIPLIED BY THE DISTANCE BETWEEN THE N.A.S.

∴ MAX BM IN THE CORNERS (SECT AA) $= \frac{1000 \times 7.3 \times 6.3}{4}$

$= 11,500$ lb-in

BM AT SECT BB

$BM = \frac{1000 \times 6.3 \times 1.5}{2} = 4,730$ lb-in

OBSOLETE

CONSIDER SECTION A-A

ASSUME MAX BM ACTS ON THIS SECTION.

MAX BENDING STRESS IN REINFORCING AT INSIDE EDGE (TENSION OR COMPRESSION) $= \frac{11,500 \times 1.45}{.1253}$

$= 133,000$ lb/in²

MAX BENDING STRESS IN REINFORCING AT OUTSIDE EDGE $= \frac{11,500 \times 1.3}{.1253}$

$= 119,000$ lb/in²

" " " " 75S-T6 SKIN " " " $= \frac{119,000 \times 10.5 \times .91}{29.0}$

$= 39,200$ lb/in²

F_{cy} MIL.T. 6732 (180 K/in² STEEL) AFTER WELDING AND HEAT TREATMENT = 179,000 lb/in²
F_{ty} " " " " " " " = 163,000 lb/in²
F_{cy} 75S-T6 ALCLAD @ 265°F 500 HRS = 64,000 × .87 = 55,600 lb/in²
F_{ty} " " " " " = 63,000 × .78 = 49,100 lb/in²

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7-0558-79
SHEET NO. 41

AIRCRAFT:		PREPARED BY	DATE
C105	OVER BOARD AIR BLEED	G M COLLEY	2-2-56
		CHECKED BY	DATE

CONSIDER SECT BB

MAX BENDING STRESS IN REINFORCING AT INSIDE EDGE = $\frac{4730 \times 1.25}{.0792}$
(TENSION OR COMPRESSION)

$= 74,700$ lb/□"

MAX BENDING STRESS IN REINFORCING AT OUTSIDE EDGE = $\frac{4,730 \times .95}{.0792}$

$= 56,700$ lb/□"

" " " " 75S-T6 SKIN " " " = $\frac{56,700 \times 10.5 \times .41}{29.0}$

$= 18,700$ lb/□"

OBSOLETE

ORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT No.	7-0558-79
SHEET No.	42

AIRCRAFT:		PREPARED BY	DATE
C105	OVERBOARD AIR BLEED	G.M. COILEY	3-2-56
		CHECKED BY	DATE

STABILITY OF REINFORCING PLATE :-

THE OUTSIDE LIP OF THE REINFORCING PLATE IS CUT AWAY IN FOUR PLACES TO CLEAR THE FRAME ANGLES. THE STABILITY OF THESE FREE EDGES WILL BE CHECKED BY USING RAeS ds 02.01.15

STRESS AT WHICH SHEET BUCKLES BETWEEN RIVETS

$$f = \frac{3\pi^2 E_t t^2}{12 l^2}$$ WHERE l = RIVET PITCH, t = PLATE THICKNESS

FROM ANC5, FIG 2.113 (b) FOR 8630 SHEET 180,000 psi LEVEL
$E_t = 29 \times 10^6$ psi UP TO 136,000 lb/in².

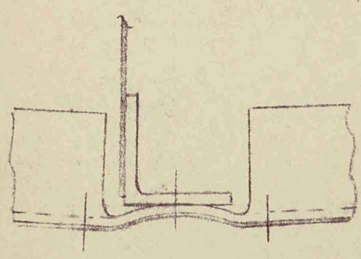
FOR $E = 29 \times 10^6$ psi

$$\therefore f = \frac{3 \times \pi^2 \times 29 \times 10^6 \times .064^2}{12 \times .63^2} = 173,000 \text{ lb/in}^2$$

@ 155,000 lb/in² $E_t = 26 \times 10^6$ lb/in²

THEN $f = 173,000 \times \frac{26}{29} = 155,000$ lb/in²

$$RF = \frac{155\,000}{151,800} = 1.02.$$



TYPE OF LOCAL INSTABILITY FAILURE CONSIDERED ABOVE.

OBSOLETE

FORM 1319A

A. V. ROE CANADA LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT (Aircraft)

REPORT NO. 7-0558-79		SHEET NO. 43	
AIRCRAFT: C105	OVERBOARD AIR BLEED	PREPARED BY: C. H. COILEY	DATE: 6-7-56
		CHECKED BY:	DATE:

FOR 25,000 lb/in² SHEAR STRESS IN ·051 SKIN:-

SHEAR/IN = 25,000 x ·051 = 1,275 lb/in.

SECTION AA

ASSUME MAX BM ACTS ON THIS SECTION

MAX BENDING STRESS IN REINFORCING AT INSIDE EDGE = 133,000 x 1·275
(TENSION OR COMPRESSION) = 169,500 lb/in²

MAX. BENDING STRESS IN REINFORCING AT OUTSIDE EDGE = 119,000 x 1·275
= 151,800 lb/in²

MAX BENDING STRESS IN 75S-T6 SKIN AT OUTSIDE EDGE = 39,200 x 1·275
= 50,000 lb/in²

NOTE:- REDUCTION IN SECANT MODULUS FOR
180,000 lb/in² STEEL @ 151,800 lb/in² AND
75S-T6 ALCLAD @ 50,000 lb/in² IS
NEGLIGIBLE

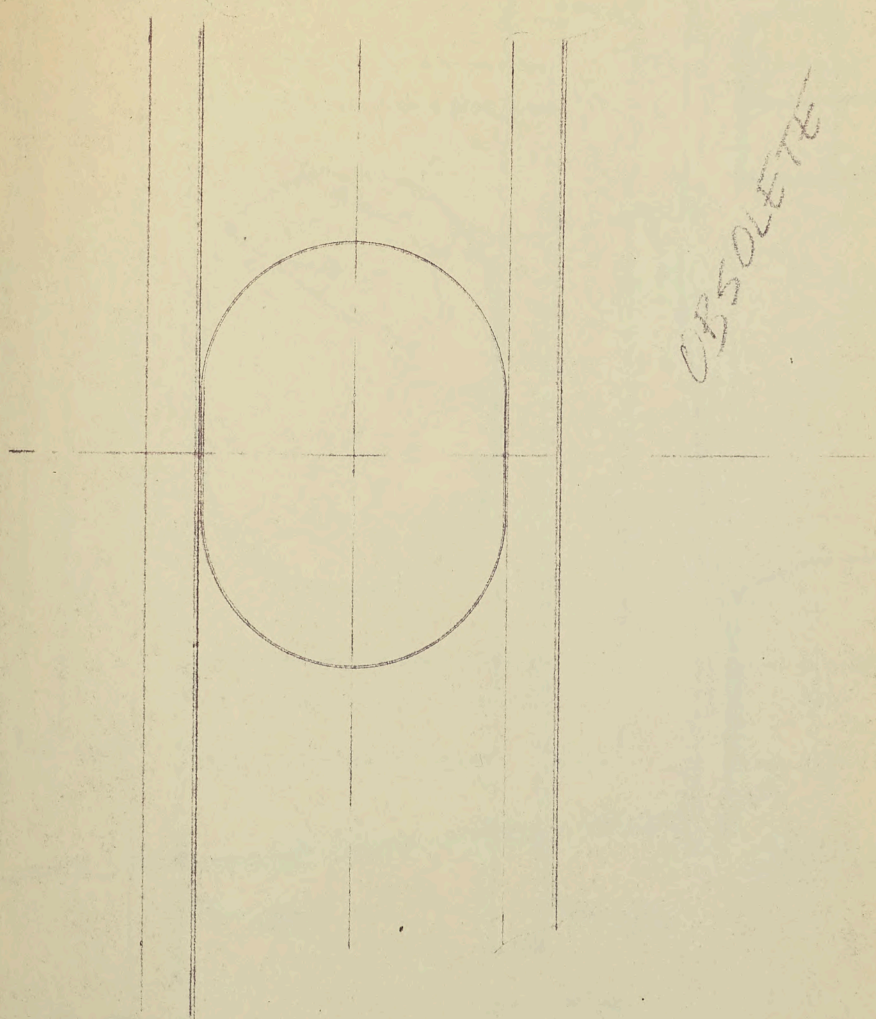
OBSOLETE

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No. 7-0558-79		
SHEET No. 44		
AIRCRAFT: C105	OVERBOARD AIR BLEED	PREPARED BY: G. M. COILEY — DATE: 2-3-56
		CHECKED BY: — DATE:

VIEW OF AIR BLEED REINFORCING FROM INB'D



OBSOLETE

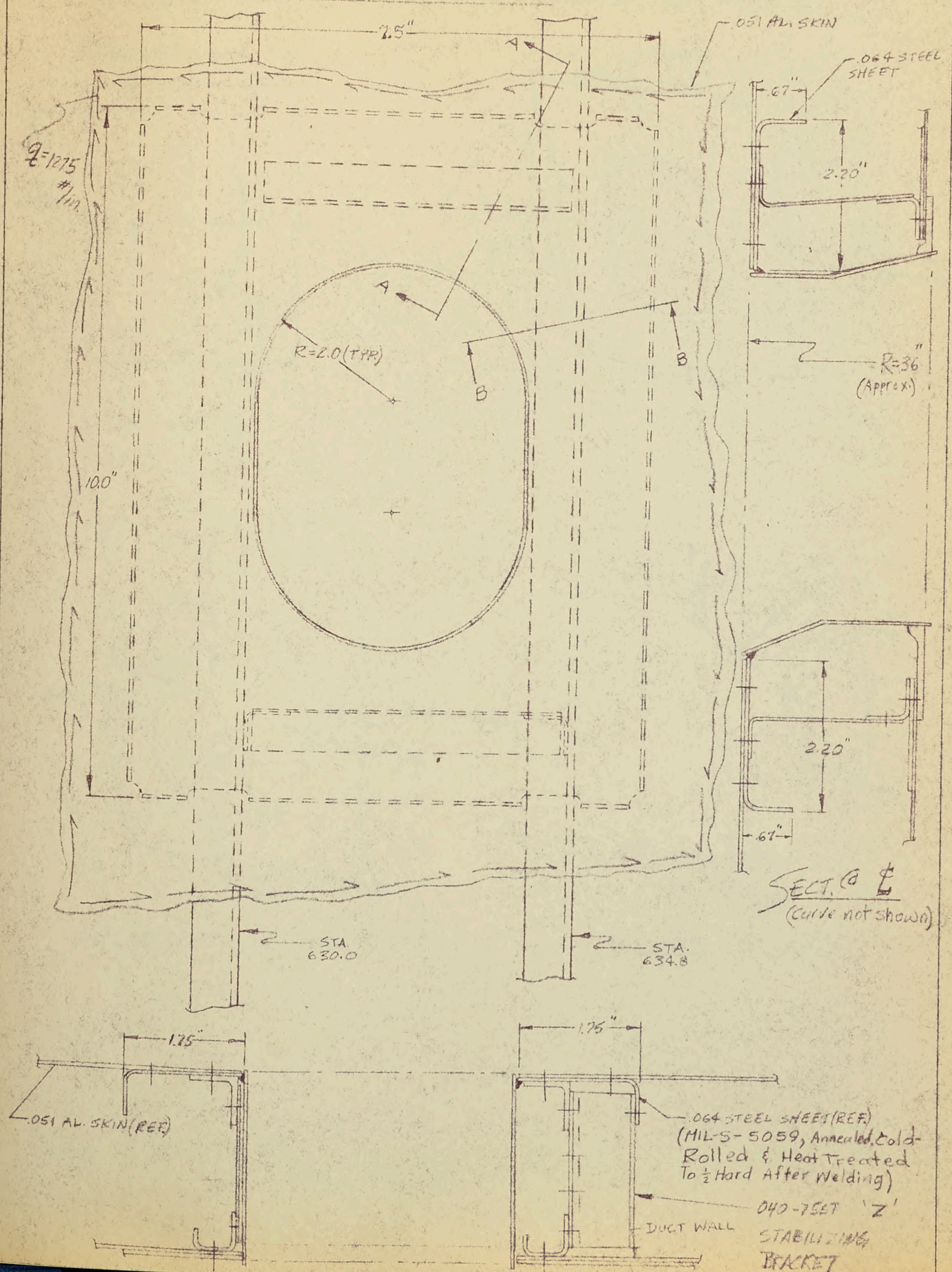
FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-79
SHEET No.	45

AIRCRAFT:		PREPARED BY	DATE
C-105	SKIN CUTOUT FOR OVERBOARD AIR BLEED	G. ISAACS	3-15-56
		CHECKED BY	DATE

GEOMETRY & LOADING

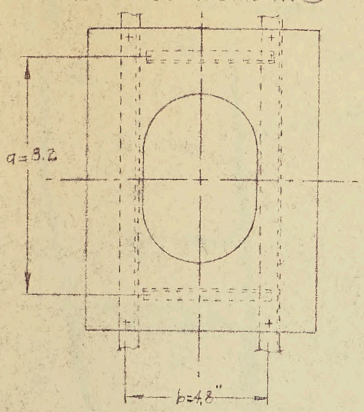


FORM 1319A

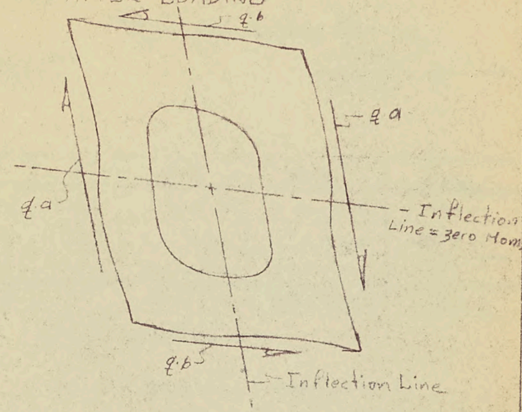
AVRO AIRCRAFT LIMITED MALTON · ONTARIO TECHNICAL DEPARTMENT		REPORT No. 7-0558-79 SHEET No 46	
AIRCRAFT:		PREPARED BY	DATE
C-105	SKIN CUTOUT FOR OVERBOARD AIR BLEED	G. ISAACS	3-16-56
		CHECKED BY	DATE

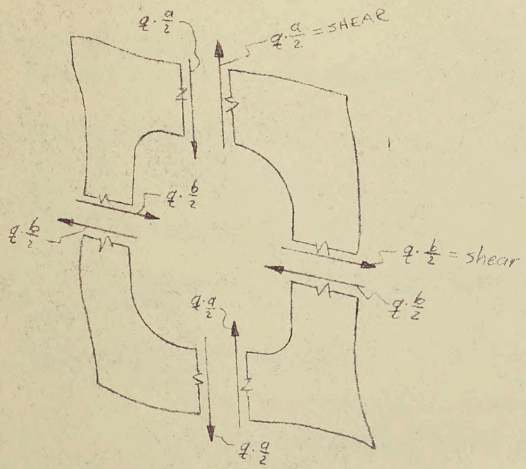
LOAD DISTRIBUTION ON CUTOUT DUE TO INFLECTION POINTS

BEFORE LOADING

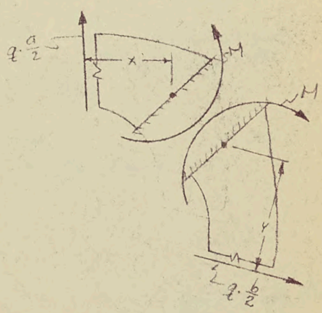


AFTER LOADING





SHEAR DISTRIBUTION (Portal)



$$M_{(max.)} = \pm q \cdot \frac{a}{2}(x)$$

$$\sigma_1 = \pm q \cdot \frac{b}{2}(y)$$

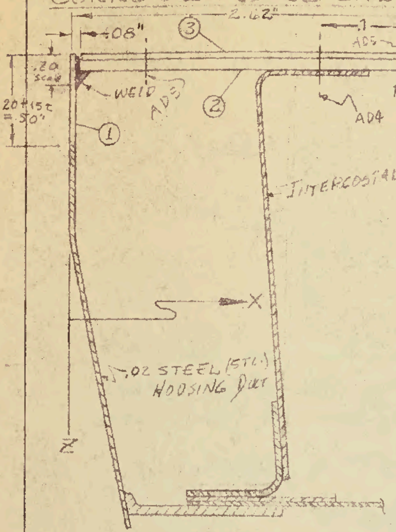
CORNER MOMENTS

FORM 1319 A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT NO. 7-0558-79	SHEET NO 47	
AIRCRAFT: C-105	SKIN CUTOUT FOR OVERBOARD AIR BLEED	
PREPARED BY: G. ISAACS	DATE: 3-16-56	
CHECKED BY	DATE	

CORNER BENDING CHECK AT SECT. A-A



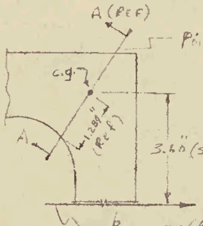
*Equiv. skin thick = $\frac{E_{AL}}{E_{STL}} \times t_{AL}$
$= \frac{29\times10^6}{10.3\times10^6} \times .051 = .018"$

ITEM	$A^{□"}$	X	A·X	$A \cdot X^2$	I_{oz}
①	.0 000	.020	.000200	.000004	———
②	.16256	1.350	.219456	.296266	.087398
③	.04597*	1.350	.062059	.083780	.024717
Σ	.21853	———	.281715	.380050	.112115

$\bar{X} = \frac{.281715}{.21853} = 1.289"$

$I_{Z_{N.A.}} = .112115 + .380050 - 1.289(.281715)$
$= .492165 - .363169 = .128996 \text{ in}^4$

SECT. A-A (ROTATED)
(Shaded portion not effective)



$q' \frac{b}{2} = 1275\left(\frac{4.8}{2}\right) = 3{,}060^{\#}$

$M_{A-A} = 3{,}060(3.60)$
$= \pm 11{,}000 "^{\#}$

STRESS AT POINT "a"

$f_{b_{STEEL}} = \frac{Mc}{I} = \frac{11{,}000(1.331)}{.128996}$
$= 113{,}500 \ ^{\#}/□"$ Ten. or Comp.

$f_{b_{AL.SKIN}} = \frac{10.3(10^6)}{29\times10^6}(113{,}500) = 40{,}300 \ ^{\#}/□"$

ALLOWABLE CRIPPLING @ POINT "a"

(Both ends fixed)

SKIN: Consider fixity at AD4 rivet & at ADS rivet : $b/t = \frac{.70}{.051} = 13.7$

$\therefore F_{cc} = 65{,}000$ @ Room Temp. ; $F_{cc} = 65{,}000(86\%) = 55{,}900 \ ^{\#}/□"$ @ 215° F

$M.S.(SKIN) = \frac{55{,}900}{40{,}300} - 1 =$ +.38

STEEL DOUBLER: $F_{cc} = 3.64 \, E\left(\frac{t}{b}\right)^2$ ~ Ref. "BRUHN", p. B5.4

$= 3.64(29\times10^6)\left(\frac{.064}{.70}\right)^2 = 882{,}000 \ ^{\#}/□"$ [Won't cripple ∴ $F_{cf} = 105{,}000^{\#}$]

Stress @ AD4 Rivet line $= \frac{11{,}000(.401)}{.128996} = 34{,}200 \ ^{\#}/□"$; $f_{ADS} = \frac{11{,}000(1.101)}{.128996} = 94{,}000 \ ^{\#}/□"$

Average stress over "b" width $= \frac{34{,}200 + 94{,}000}{2} = 64{,}100 \ ^{\#}/□"$

$M.S.(DOUB.) = \frac{105{,}000}{64{,}100} - 1 =$ +.64

STRESS @ WELD TO DUCT

Shear/in $= \frac{V}{h} = \frac{3{,}060}{2.62"} = 1{,}167 \ ^{\#}/in$ Approximately

Throat = .064" [thinnest of jointed parts]

F_{su} (MIL-E-8697-HT190) $= 90{,}000 \ ^{\#}/□"$

Allow. SHEAR/in = 1" × Throat × F_{su} = 1"(.02) 90,000 = 1800 #/in

$M.S. = \frac{1{,}800}{1{,}167} - 1 =$ +.54

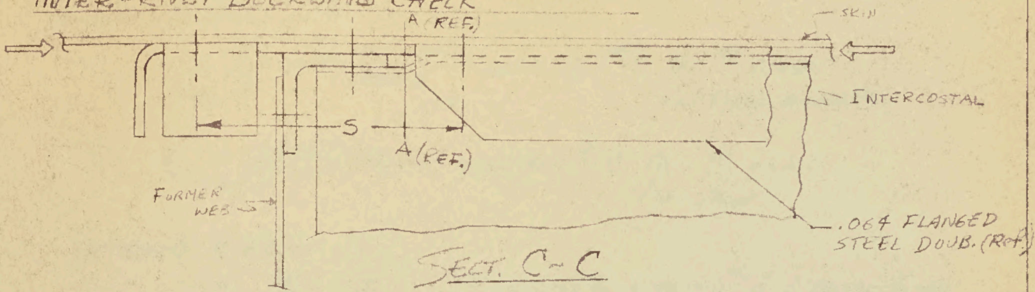
FORM 1319 A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

REPORT NO.	7-0558-79
SHEET NO.	48
AIRCRAFT:	C-105
	SKIN CUTOUT FOR OVERB'D. AIR BLEED
PREPARED BY	S. ISAACS
DATE	3-19-56
CHECKED BY	
DATE	

CORNER BENDING CHECK AT SECT. A-A ~ Cont'd.

INTER-RIVET BUCKLING CHECK



SECT. C-C

Since the skin will not buckle untill after the doubler buckles the doubler will be checked. As a conservative column length the distance "S" will be used (neglect stabalizing effects of former).

ALLOW. BUCKLING

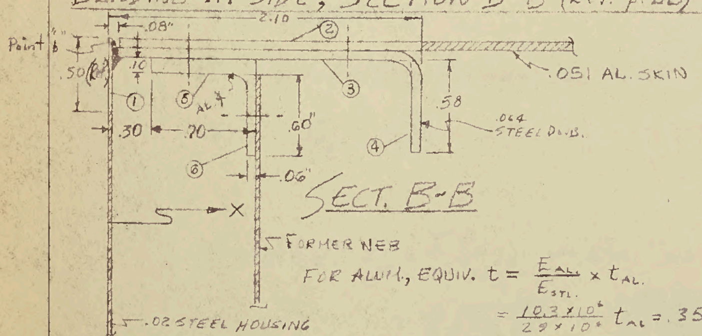
$$F_{ir} = \frac{\pi^2 E_t}{3(S/t)^2} \quad \sim \text{Ref. "GLEN MARTIN A/C" SDM, Fig. 404.3}$$

$$= \frac{\pi^2 (29\times10^6)}{3\left(\frac{1.77}{.064}\right)^2} = \frac{9.88\,(29\times10^6)}{3\left(\frac{3.13}{.0041}\right)} = 125{,}000\ \#/\square''$$

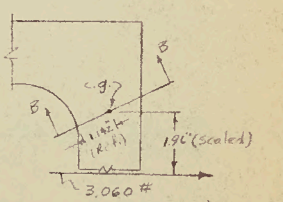
$$M.S. = \frac{125{,}000}{113{,}500} - 1 = +.10^*$$

*conservative

BENDING AT SIDE, SECTION B-B (Ref. p. 28)



SECT. B-B



$$M_{B-B} = 3{,}060(1.96) = \pm 6{,}000\ ''\#$$

FOR ALUM., EQUIV. $t = \frac{E_{AL.}}{E_{STL.}} \times t_{AL.}$

$= \frac{10.3\times10^6}{29\times10^6} t_{AL} = .355\, t_{AL.}$

ITEM	t	EQUIV. t	A	X	A·X	A·X²	I_{o}
①	.020	.020	.01000	.010	.000100	.000001	—
②	.051	.0181	.03656	1.090	.039850	.043437	.012432
③	.064	.064	.12928	1.090	.140915	.153598	.043960
④	.064	.064	.03712	2.068	.076764	.158748	.000013
⑤	.100	.0355	.02485	.650	.016152	.010499	.001015
⑥	.060	.0213	.01278	.970	.012397	.012025	—
Σ	—	—	.25059	—	.286178	.378308	.057420

$$\bar{X} = \frac{.286178}{.25059} = 1.142$$

$$I_{N.A.} = .057420 + .378308 - 1.142(.286178) = .108908\ in^4$$

FORM 1319A

BENDING AT SIDE, SECTION B-B (Ref. p.45) ~ Cont'd.

STRESS @ POINT "b"

$$f_{b_{STEEL}} = \frac{Mc}{I} = \frac{\pm 6{,}000(1.142)}{.108908} = 63{,}000 \,\#/\square'' \text{ Ten. or Comp.}$$

for STEEL DOUBLER

$$f_{b_{AL.SKIN}} = \frac{10.3\times10^6}{29\times10^6}(63{,}000) = 22{,}400\,\#/\square'' \text{ Ten. or Comp.}$$

(E ratio) for SKIN

CRIPPLING @ POINT "b"

SKIN: $b/t = \frac{.50 \text{ from rivet}}{.051} = 9.8$; $F_{cc} = 45{,}000\,\#/\square''$ @ Room Temp.
$= 45{,}000(86\%) = 38{,}700\,\#/\square''$ @ 265°F.

$$M.S.\ (SKIN) = \frac{38{,}700}{22{,}400} - 1 = +.72$$

STEEL DOUBLER: $b/t = 9.8$ (Assume loose weld & one-edge free)

$F_{cc} = .452\,E_t\left(\frac{t}{b}\right)^2$ ~ Ref. "BRUHN", p. B54

$= .452(29\times10^6)\left(\frac{.064}{.50}\right)^2 = 215{,}000\,\#/\square''$

∴ will not buckle & $F_{cy} = 105{,}000\,\#/\square''$

$$M.S.\ (DOUBLER) = \frac{105{,}000}{63{,}000} - 1 = +.66$$

INTER-RIVET BUCKLING

Rivet pitch along former, s, = .75"

SKIN: $s/t = \frac{.75}{.051} = 14.7$; $F_{ir} = 60{,}500\,\#/\square''$

$$M.S.\ (SKIN) = \frac{60{,}500}{22{,}500} - 1 = +1.70$$

DOUBLER: $F_{ir} = \frac{\pi^2 E_t}{3(s/t)^2}$ ~ Ref. "GLEN MARTIN A/c" SDM, Fig. 404.3

$$= \frac{\pi^2(29\times10^6)}{3\left(\frac{.75}{.064}\right)^2} = \frac{9.88(29\times10^6)}{3\left(\frac{.5625}{.0041}\right)} = 696{,}000\,\#/\square''$$

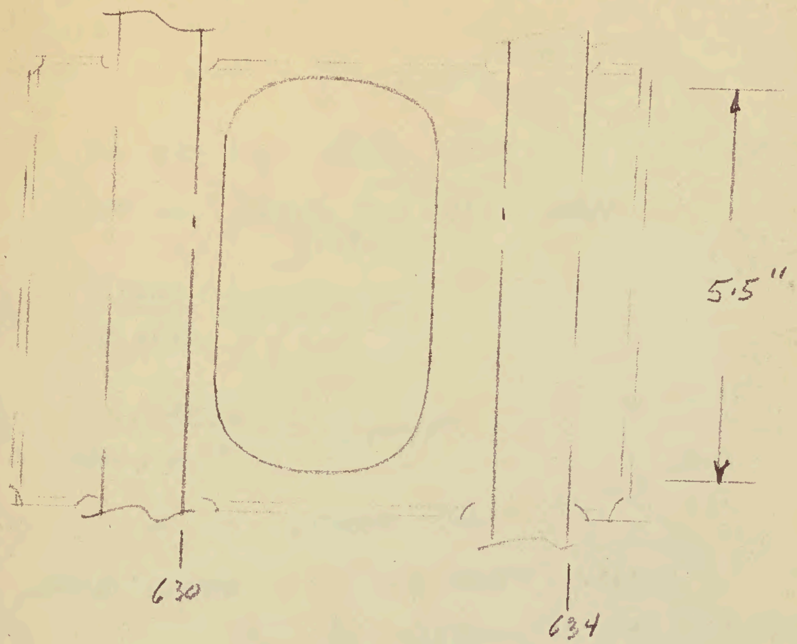
∴ will not buckle

M.S. (DOUBER) = High

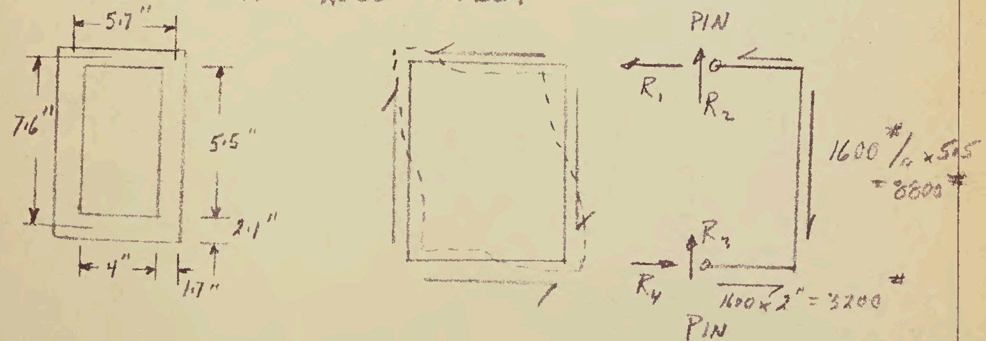
AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.	7-0558-'79
SHEET No.	50
AIRCRAFT:	C105
	SKIN CUTOUT FOR OVERB'D. AIR BLEED
PREPARED BY	S. YOUNG
DATE	APRIL 20/56
CHECKED BY	
DATE	

.1625 STEEL DOUBLER OVER SKIN CUTOUT



CONSIDER SKIN $q = 1600\ ^{\#}/_{in}$ & TREAT CUTOUT AS PORTAL UNDER SIDESWAY ACTION WITH LOADS BASED ON ACTUAL HOLE SIZE.



ASSUME $R_2 = R_3 = \frac{1}{2}(1600 \times 5.5) = 4400^{\#}$

$$\Sigma M_{①} = +8800 \times \frac{5.7}{2} - 3200 \times 7.6'' - 7.6\,R_4 = 0$$

$R_4 = 0$

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT:		REPORT No. 7-0558-79	
C 105	SKIN CUTOUT FOR OVERB'D AIR BLEED	SHEET No. 51	
		PREPARED BY	DATE
		S. YOUNG	APRIL 29/58
		CHECKED BY	DATE

AT CORNER,

END LOAD = 3200#

$$B.M. = 4400 \times \frac{5.7}{2} = 12{,}530 \text{''\#}$$

SECTION 2.6" OF .0625 STEEL PLUS .051 75ST SHEET

$$\text{EFF } t = .0625 + \frac{10 \times 10^6}{29 \times 10^6} .051 = .0801''$$

$$P/A = \frac{3200}{2.6 \times .0801} = 15{,}380 \text{ PSI}$$

$$f_b = \frac{6 \times 12530}{.0801 \times 2.6^2} = 139{,}000 \text{ PSI}$$

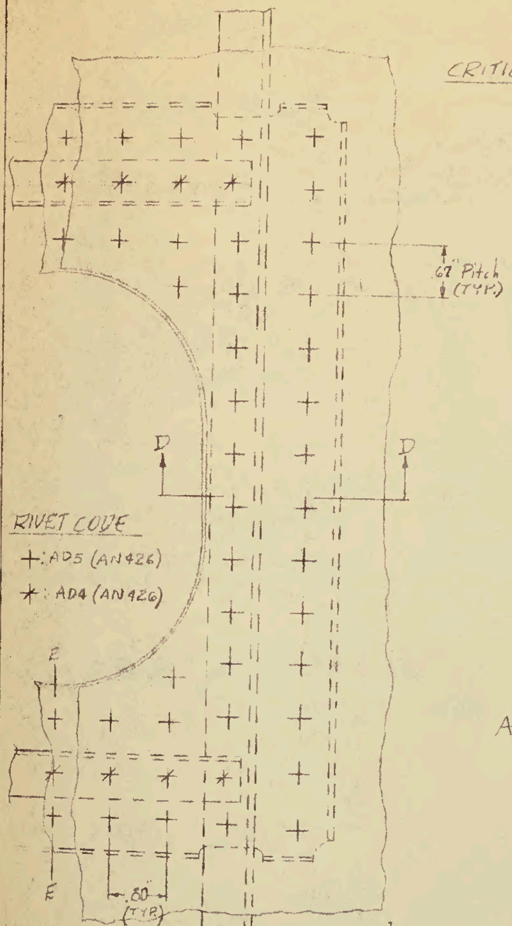
$$f = 154{,}400 \text{ PSI}$$

.0625 AN-QQ-S-685 H.T. AFTER WELDING
TO $F_{TU} = 150\,000$ PSI (AS MIN. REQUIREMENT)

AVRO AIRCRAFT LIMITED
MALTON · ONTARIO
TECHNICAL DEPARTMENT

AIRCRAFT:		REPORT NO. 7-0558-79	SHEET NO. 52
C-105	SKIN CUTOUT FOR OVERB'D. AIR BLEED	PREPARED BY: G. ISAACS	DATE: 3-20-56
		CHECKED BY:	DATE:

CHECK OF SKIN RIVETS TO DOUBLER & FORMERS



CRITICAL RIVETS THRU' SECT. D-D

Applied Loading per inch = q = 1275 #/in
Applied " " pitch = q(.67") = 855 #

FROM ANC-5

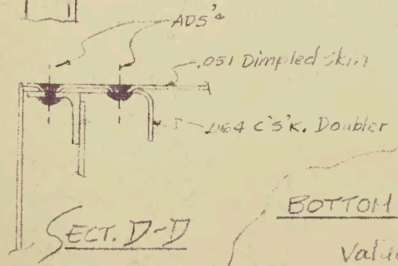
Shear Allow. of AD5 = 596 # @ Room Temp.
Dimpled " of AD5 in .051 AL. = 778 # " "
C'S'K. Value of AD5 in .064 ST. SHT. = 523 # " "

Since the C'S'K. .064 SHT. governs the allow. it will be reduced for temerature effects. The .064 SHT. is steel & is not affected by temp. of 265°F.; however, to obtain a temp. reduction factor for the A17S ALUM. Rivet the curve on p. 93 of the ANC5 will be utilized (Ref. 24S-EXTR.) since the shear allow. of the rivet mat'l. & of the 24S EXTR. closely agree.

∴ Value of AD5 = 523 #(92%) = 481 # @ 265°F.

Allow. Load per .70" = 2(481) = 962 #

$$M.S. = \frac{962}{855} - 1 \qquad +.11$$



SECT. D-D

BOTTOM RIVETS (SECT. E-E)

Value of 2 – AD5's = 2(481) = 962 #
C'S'K. Value of AD4 = 363(92%) = 334
ADD: Value per pitch = 1296 #
Load/pitch = q(.80) = 1275(.80) = 1,020 #

$$M.S. = \frac{1296}{1020} - 1 = \qquad +.27$$

FORM 1319A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No	7-0558-79
SHEET No	53

AIRCRAFT:		PREPARED BY	DATE
C-105	OVERBOARD AIR BLEED CUTOUT & SUPPORT STRUCT.	G. ISAACS	23 MAY 1956
		CHECKED BY	DATE

MINIMUM RESERVE FACTORS FOR EACH PART

COMPONENT	QUOTED ON	PAGE	R.F. *
CAN DUCT	BENDING	8	+2.25
WELD TO MACHINED ENG. PIPE	BENDING TENSION	8	+1.88
SLIDING DUCT	BENDING & HOOP TEN.	9	+1.70
INNER & OUTER DUCTS	BENDING & HOOP TEN.	10	+17.47
SPRING GUSSETS	BENDING	12	+14.95
CONOLON FILLER	SHEAR	16	HIGH
SKIN	CRIPPLING	47	+1.38
DOUBLER	INTER-RIV. BUCKLING	48	+1.10 *
RIVETS (Skin-Doubler)	SHEAR	52	+1.11
WELD (Doubler to Duct)	SHEAR	47	+1.54

NOTE: * R.F. = M.S + 1.00
* conservative check

FORM 1319A

AIRCRAFT:		PREPARED BY	DATE
C-105	OVERBOARD AIR BLEED CUTOUT & SUPPORT STRUCT	G. ISAACS	24 MAY 1956
		CHECKED BY	DATE

SUMMARY

FATIGUE

SPRING SUPPORTS: The fatigue life of this item is infinite due to the low stresses encountered (Ref. p. 12) & derivation of fatigue is not necessary.

DOUBLER (SKIN-CUTOUT): Here, again, it is not necessary to compute fatigue life due to the low stresses arising from normal loading on the DOUBLER (see p.16).

TEMPERATURE & DETERIORATION

DUCTS: The ducts being the only structure affected by the high temperature (495°F.), their allowables are not lowered since their materials are steel. Temperature within shroud area is 265°F & its reducing characteristics has been considered on the aluminium parts.

Since the 4130 STEEL has been called out for the ducts because of its heat-treatable qualities after welding it is subject to deterioration from the exaust gases of the engine. Because no known plating can be put on to withstand this temperature (495°F.) the only other possible solution would be to use thicker gages of STAINLESS STEEL (non-heat treatable after welding) at a weight penalty. However, these 4130 STEEL parts can easily be replaced at engine removal schedules if deterioration shows.