A. V. ROE CANADA LIMITED MALTON · ONTARIO TECHNICAL DEPARTMENT (Aircraft)		REPORT No P/EQUIPMENT/67 SHEET No	
AIRCRAFT: C-105	AIR CONDITIONING	PREPARED BY: G.E. Shaw	DATE: November/55
		CHECKED BY	DATE

ANALYZED

TITLE: C-105 AIR CONDITIONING COCKPIT LEAK RATE

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A. V. ROE CANADA LIMITED MALTON - ONTARIO **TECHNICAL DEPARTMENT (Aircraft)**		REPORT NO. P/EQUIPMENT/67 SHEET NO. 1	
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1. PURPOSE OF REPORT

The purpose of this report is to establish permissible leak rates for the C-105 cockpit.

2. SUMMARY

Since the cockpit exhaust is used to cool the armament bay, it is necessary to select a cockpit leak rate as low as possible as this leakage is lost for cooling purposes. The value chosen is a compromise between what is achievable from a production standpoint and system weight. A value of 5% of the cockpit flow for the maximum design case (60,000' altitude, maximum aircraft speed, maximum ambient temperature) was selected. The cabin differential is 4.75 p.s.i. and temperature is 60°F. Converted to S/L conditions at the same differential, this works out to a leakage of 45.7 CFM., for the fuselage structure only.

Present CF-100 experience is to allow a leakage of 30 CFM at Avro with an increase in service to 40 CFM, i.e. a production figure of 75% of the maximum allowable.

Since in the C-105 system the armament bay cooling is dependent on cockpit exhaust, this value has been decreased to 60% the maximum permissible leakage for production would then be 27.5 CFM at 4.75 psi differential for the structure only. This is comparable with the present CF-100 practice of 30 CFM.

Three valves are involved in cockpit leak tests, the safety valve, the inlet non-return valve and the cabin pressure regulator. Maximum permissible leakage is given for the structure with and without the valves installed and for each valve. As an alternative method of testing a

FORM 1318A

curve is given of leak rate in CFM plotted against time for the pressure to drop. This curve is theoretical only and would have to be verified by experience.

3. METHOD

The method used to establish test leakage is to find the equivalent effective orifice areas for known conditions.

This area is then used to find the flow under test conditions. Where leak rates are given in CFM, this is cubic feet of free air at 14.7 psia and 60°F.

4. AIR FLOW EQUATIONS

4.1 Flow Equations (Thermodynamics P301 Emswiles & Schwartz)

4.1.1 Choked $W = 0.53 \dfrac{a P_1}{\sqrt{T_1}}$ #/sec. air flow

4.1.2 Unchoked $W = 1.06\, a \sqrt{\dfrac{P_o (P_1 - P_o)}{T_1}}$ #/sec. air flow

Where W = flow #/sec.

P_1 = cockpit pressure psia

P_o = back pressure psia

T_1 = Cockpit temperature °R

a = Effective nozzle throat area

4.2 Time of Pressure to drop (subsonic flow)

AiResearch Report AE1014 R P. 21

$$t = \frac{1.85\,V}{R a \sqrt{P_o T_1}} \left(\sqrt{P_1' - P_o} - \sqrt{P_1'' - P_o} \right)$$

Where V = Cockpit volume cu. ft.

R = Gas constant 53.3 dry air

a = Effective area

P_o = Atmospheric pressures

T_1 = Cabin Temperature °R

P_1' = Initial Cabin pressure psia

P_1'' = Final Cabin Pressure psia

5. KNOWN LEAKAGE DATA

5.1 Permissible Valve Leakage

5.1.1 Safety Valve 0.2#/min. at 5.15 psig and 520°R

From AiResearch drawing.

5.1.2 Cabin Pressure Regulator 0.75#/min. at 4.75 psia and 520°R

From Avro Specification

5.1.3 Non Return Valve 0.2#/min. at 8.5 psig and 810°R

AiResearch drawing 107192

5.2 Maximum Permissible Cockpit Leak Rate

For the 60,000' maximum speed, maximum ambient temperature flight case - cockpit flow 25#/min.

Leakage 1.25#/min. at 4.75 psig and 520°R

(P/Equipment/20 issue 5)

5.3 Cockpit Volume

127 cubic feet P/Equipment/62

6. EQUIVALENT AREAS

6.1 Cockpit At Altitude

$$m = \frac{1.25}{60} = \frac{0.53 \times 5.8 \times a}{\sqrt{520}}$$

$$a = .155 \ \square''$$

Note: This includes safety valve.

6.2 Safety Valve

$$W = \frac{.2}{60} = 1.06\, a \sqrt{\frac{14.7}{520}}\,(5.15)$$

$$a = .00825 \;\square''$$

6.3 Non Return Valve

$$W = \frac{.2}{60} = 1.06\, a \sqrt{\frac{14.7}{810}}\,(8.5)$$

$$a = .00795 \;\square''$$

6.4 Cabin Pressure Regulator

$$W = \frac{.75}{60} = 1.06\, a \sqrt{\frac{14.7}{520}}\,(4.75$$

$$a = .03230 \;\square''$$

7. TEST LEAKAGE RATES AT SEA LEVEL

These are measured at 4.75 psia and 60°F

7.1 Cockpit Structures

7.1.1 Maximum Leakage

Area = .155 - .00825 = .14675 sq. ins.

$$W = 60 \times 1.06 \times .14675 \sqrt{\frac{14.7}{520}}\,(4.75)$$

= 3.5 #/min.

= 45.7 CFM at 14.7 psia and 60°F

This is with all valves blanked.

7.1.2 Maximum for Production 60% of 7.1.1

.6 X 3.5 = 2.1#/min.
= 27.5 CFM

Area = .14675 X.6 = .088 sq. ins.

7.2 Valve Leakage

	a	M.	CFM
Safety Valve	.00825	.196	- 2.55
Non Return Valve	.00795	.189	- 2.47
Pressure Regulator	.03230	.765	10.00
		1.150#/min.	15.02 CFM

7.3 Maximum Production Leakage - Valves Installed

Structures	27.50
Valves	15.02
Total	42.5 CFM

8. TIME FOR PRESSURE TO DROP

As a test the time for pressure to drop from 4.75 to 2 psig is suggested

From equation 4.2

$$t = \frac{5.58}{a} \text{ sec.}$$

And from equation 4.12

$$a = \frac{W}{23.8}$$

Then selecting a range of flows the times may be found

Flow CFM	Flow M #/min.	a □"	t Sec.
15	1.15	.0482	116
20	1.53	.064	87
25	1.91	.08	70
30	2.3	.0965	58
35	2.67	.1125	49.5

Flow CFM	Flow M #/min.	a □"	t Sec.
40	3.06	.1285	43.5
45	3.45	.1450	38.5
50	3.83	.1605	35

These are plotted on figure 1.

COCKPIT LEAK RATE

TIME REQUIRED FOR PRESSURE TO DROP FROM 4·75 TO 2·0 PSIG.
VS.
LEAK RATE MEASURED IN CFM @ 4·75 PSIG.

COCKPIT VOL 127 CU. FT.

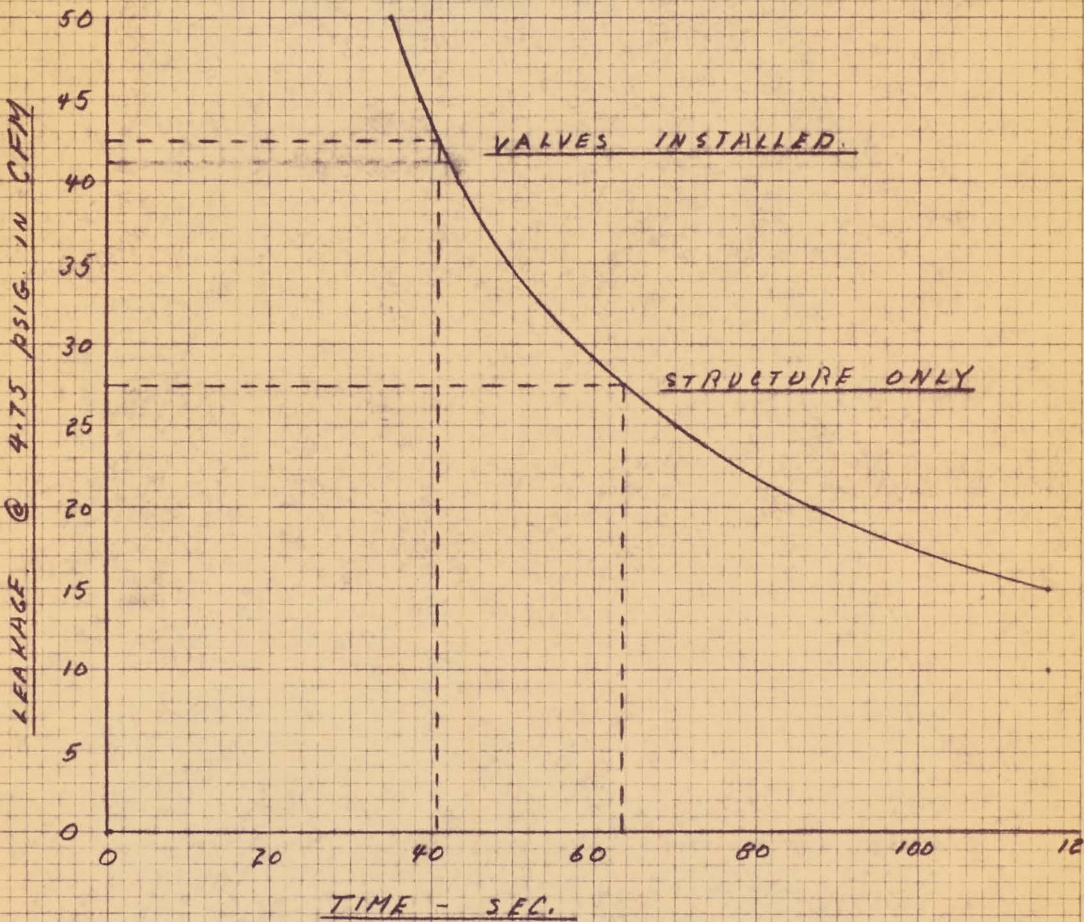

FIG. 1

A. Hew · Nov 17/55

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