AIRCRAFT - LIGHTNING T MK 5 XS 422

TEST EXERCISE - RATES OF ROLL

DATE OF TEST - SEPTEMBER 1978.

COMMENTS ON RESULTS

1 INTRODUCTION Six sorties were flown to assess the operational suitability of the Lightning T Mk 5's rolling performance for the role of supersonic interceptor. The ac's rolling performance was also compared with the requirements of AvP 970. Finally, the tests established how closely the ac's sideslip limitations were approached.

2 CONDITIONS RELEVANT TO THE TESTS

a AC CONFIGURATION Empty missile pylons were fitted and all tests were flown with the artificial feel and the autostabilizers switched on ✓

b CG AND AUW The average AUW for the tests was 32,700 lbf. The CG varied by only ± 0.25% SMC from the take-off CG of 33.5% SMC. This variation should not affect the rolling performance significantly. ✓

c TEST INSTRUMENTATION An A13 paper trace recorder presented altitude, roll rate, sideslip, all control angles, IAS, AOA, normal g and angle of bank for post-flight examination. A sideslip gauge was fitted in the cockpit and a Philips voice recorder was used to record qualitative comments. ✓

d WEATHER All tests were carried out clear of cloud and turbulence. ✓

e LIMITATIONS The manufacturers limitations as laid down in the Aircrew Manual and the sideslip limitations in the ETPS data file were all observed. ✓

3 TESTS CARRIED OUT Table 1 shows the speeds, heights, normal load factors and configurations used in the tests. All rolls were carried out in both directions using full aileron deflexion. In the clean configuration the rolls were timed through 90° while in the approach configuration, the rolls were timed through 30°. Each test was flown by 2 pilots.

TABLE 1 - TESTS CARRIED OUT

Serial (a)	IAS/TMN (b)	Height (c)	Normal g (d)	Configuration (e)
1	190K	10000ft	1	Clean
2	250K	"	"	"
3	300K	"	"	"
4	400K	"	"	"
5	450K	"	"	"
6	500K	"	"	"
7	0.95M	"	"	"
8	165K	10,000ft	1	Gear + full flap
9	190K	"	"	"
10	1.25M	20,000ft	1	Clean
11	"	"	2	"
12	"	"	4	"
13	0.7M	36,000ft	1	Clean
14	0.8M	"	"	"
15	0.9M	"	"	"
16	1.2M	"	"	"
17	1.4M	"	"	"

4 QUANTITATIVE RESULTS

a AILERON CONTROL CHARACTERISTICS Since the aileron system was a simple irreversible one, control forces were measured on the ground. Annex A is a graph of lateral stick displacement against force. The graph shows that breakout forces were light (1lbf) but that the control force for maximum deflexion was high (28lbf). Full
(1) aileron travel (± 16 cm) was only available when the landing gear was down. When the gear was raised, aileron travel was restricted to ± 7cm stick travel. Full stick deflexion with the gear up thus required a force of only 8lbf. The aileron control characteristics were satisfactory with the gear raised even though the rather high stick force per g, when the ac was supersonic, produced poor control harmony. The characteristics were unsatisfactory when the gear was down. However, since the maximum deflexion was never used in the circuit (⅓ to ½ deflexion was the norm) the forces with the gear lowered were ~~satisfactory~~ acceptable. The forces met the level 1 AvP970 requirement when the gear was up but only the level 3 requirement when it was down. ✓

b ROLLING PERFORMANCE

(1) Annex B contains all the quantitative data derived from the A13 traces. These results are, where possible, presented graphically in later annexes. The possible errors affecting these results stem partly from flying inaccuracies and partly from use of the traces. It was difficult to ensure a constant g reading while rolling the ac and, as will be seen, normal g affects the rate of roll. It was not possible to maintain a given height and IAS especially while rolling under g. This will also affect the results slightly. Where any irregularities appeared in the traces, the lines have been smoothed for easier reading. Again this particularly applies to the normal g trace. ✓

(2) Annex C contains a representative selection of A13 traces for the tests flown. ✓

(3) Annexes D and E are plots of time to roll through 90° against IAS and TMN respectively. The points were all at 10,000ft and the ac was clean. Although the times were all longer than that required in level 1 of AvP970, and thus unsatisfactory, the rates of roll were acceptable for a missile-firing interceptor. In such an ac most tracking would be done at long range relative to a gun-armed ac and so the required rates of roll should be quite modest. The best times to roll were in the optimum cruise speed range of the ac (0.7M to 0.9M, 380K to 520K) but increased markedly below 0.55M (300K). All times to roll to the left were longer than those to the right. A deeper investigation of the traces showed that for straight flight the port aileron was, on average, 1.5° up. In consequence, only 5° port-up aileron travel was available to produce a rolling moment while 8° port-down aileron was available. The traces gave no indication of the starboard aileron rigging and so this should be investigated. If the ac was representative of the production model then it was unacceptable. ✓

(4) Annex F shows the time to roll the ac through 30° in the approach configuration against IAS at 10,000ft. The 25K difference between the 2 test IAS, produced little variation in roll times. The difference between rolls left and right was less pronounced than in the clean cases. In addition all times were inside the AvP970 level 2 requirements for the flight phase category and were thus satisfactory. acceptable

(5) Annex G is a plot of time to roll through 90° against normal g at 1.25M at 20,000ft. 1g points were flown in addition to the 2g and 4g points for comparative purposes. The graph shows that the roll times were long in the supersonic regime, even at 1g and that the time doubles when the normal

acceleration is increased to 4g. Again the times to roll left were longer than those to roll right. As the load factor was increased, the difference became more marked. This was unacceptable as, even for some long range tracking within the missile launch bracket, the ac would have to be unloaded to achieve the desired roll rate. The roll rate, supersonic, under g should be improved to make the ac an acceptable supersonic interceptor. ✓

(6) Annexes H and I are plots of time to roll through 90° against IAS and TMN respectively at 36,000 ft. The best rates of roll were again achieved in the high subsonic speed band and once again the roll times to the left were longer than those to the right. The difference became much more marked when the ac was supersonic. Although theory predicts lower roll damping at higher levels, the roll times at subsonic IASs were closely comparable with those at the same IASs at 10,000 ft (see Annex D) However, the highest rates obtainable at 10,000 ft (400 to 450K) were not achieved at 36,000 ft because of Mach effects. Only the best times met even the level 3 requirements of AvP 970, but even so, as in the 10,000 ft case, the times should be acceptable for a missile-armed interceptor. ✓

(7) Annex J is a plot of modal time constant (T_R) against TMN for the 10,000 ft points while annex K is a similar plot for the 20,000 ft and 36,000 ft points. Despite the roll rates' being generally low, the roll accelerations experienced in achieving the rates were satisfactory and the values of T_R achieved were all below the AvP 970 level 1 limit. In addition, there was little change in T_R with increasing TMN or with configuration changes. Increased normal g reduced the time constant by increasing the time while an increase in altitude increased the time constant at any given mach number. The modal time constants were satisfactory. ✓

(8) Annex L is a plot of the ac's oscillatory roll response against TMN. On some tests, the roll rate did not progress beyond the first peak and so these points have been plotted at 100% along with the points showing no oscillatory response. With the exception of 2 of the 4g rolls, all the points were well above the AvP 970 level 1 limit. The ac rate of roll showed little tendency toward oscillation and those oscillations which did occur were not noticeable at pilot level. The oscillatory roll response was, therefore, satisfactory. ✓

(9) Annexes M and N are plots of sideslip achieved during the manoeuvres against TMN. Annex M covers the 10,000ft points while annex N covers those at 20,000ft and 36,000ft. The ETPS limits shown on the plots are 70% of the design limit and, therefore, represent a sensible dynamic limit. None of the manoeuvres performed brought the ac close to the design limit but the rolls under g produced sideslip readings close to the dynamic limit. There was still a margin of error but this might not exist if the normal g were further increased or the ac were rolled through more than 120°. Further tests should be carried out to find out the rolling under g limits. These tests should also include the carriage of missiles on the pylons. Since the roll rate under g is so poor, operational pilots are unlikely to use less than full aileron when manoeuvring vigorously. Clear limits for full aileron rolling under g should, therefore, be laid down. The sideslip achieved when rolling at 1g was, however, satisfactory. ✓

5 QUALITATIVE RESULTS

a APPROACH CONFIGURATION Although the aileron forces for full deflexion, with the gear down, were high enough to warrant the use of both hands when applying a step input during the tests, no such difficulty was found in the airfield pattern. The use of ⅓ to ½ lateral stick deflexion produced a satisfactory rate of roll down to the lowest approach speed (160K). The control characteristics and rates of roll available in the approach configuration were, therefore, satisfactory. ✓

b ROLE FLYING The rate of roll required of a missile-armed interceptor at any particular speed and height depends on the ac's radar performance and on the missile's launch parameters and performance. However, regardless of these factors, the rates of roll achieved by the Lightning T Mk 5 were always poor. In addition, the rates of roll to the left were always noticeably lower, even at pilot level, than those to the right. It was felt that this was probably a feature of the individual ac and not of the type in general. However, if it were a characteristic of the type, the ac's tactics would be affected by the discrepancy in performance. When the ac was under g and supersonic, roll rates were further reduced. Rates of roll available were therefore unsatisfactory. However, given a long range radar and a high performance missile (20 nm minimum head-on range) the modest rates of roll exhibited by the ac should be acceptable for the type of tracking required. The ac was thus acceptable as a supersonic interceptor. However, with its poor manoeuvrability and limited fuel capacity, the ac could not afford to be drawn into close combat especially in the supersonic regime and consequently the fitting of guns or dogfight missiles would not be worthwhile. All other aspects of the ac's rolling characteristics, oscillatory response, roll acceleration and ease of bank control were satisfactory. ✓

6 SUMMARY OF RECOMMENDATIONS

a The roll performance of the Lightning T Mk 5 was acceptable for a supersonic interceptor but the ac should not be considered for use as an air combat fighter. ✓

b Clear, unambiguous limitations for rolling under g should be laid down to prevent pilots' exceeding the design sideslip limits. ✓

c The discrepancy in roll performance between left and right rolls should be rectified in production models. ✓

d The roll rate under g, supersonic should be improved. ✓

Sq. Ldr BROWN
18 OCT 78

CAPT BAUDRY

CAPT RIDZAN

10,000 FT SCHEDULE. All 1g.

• — • — • — • —

A. Clean configuration.

RUN	IDENT	[redacted] SPEED	MANOEUVRE	SIDESLI
1	— •	500K	60/60	2.4°
2	• —	550K (≤95)	60/60	2.3°
3	— —	450K	60/60	2.6°
4	• •	400K	60/60	3.5°
5	• • •	300K	60/60	6.7°
6	• — •	250K	60/60	9.7°
7	— • —	190K	60/60.	11.0°

B Gear + Flap

8	— — —	190K	30/~~60~~30	11.0°
9	— • — •	165K	30/~~60~~30	11.0°

36,000 FT SCHEDULE All 1g All clean.

• • • — — — • • •

RUN #	IDENT	SPEED	MANOEUVRE	SIDESL
1	— —	0.9IMN	60/60	[redacted]°
2	— • •	1.2 IMN	60/60	[redacted]°
3	• • —	1.4 IMN	60/60	[redacted]°
	17/17 - 130 ‖ 15/15 - 80 ‖ 13/13 - 30 ‖ 1650/1650			
4	— • —	0.8 IMN	60/60	[redacted]°
5	— — —	0.7 IMN	60/60	[redacted]°

20,000 FT SCHEDULE. All Clean.

~~• — • — • —~~ — • • • — • • •

RUN	IDENT	SPEED	MANOEUVRE	SIDESLI
1	• — •	1.25	1g 60/60	2.3°
2	— —	1.25	2g 60/60	2.3°
	(1 each) 1650/1650 75 ‖ 1500/1500 80 NM M			
3	• • •			
		2 x 2g	L/R	L/
4	— — • •	1 x 1g		L/R
5	— — •			
6	• — —			

10,000 FEET

a) CLEAN → 60° TO 60° RECOVER: 16/16

b) U/C + FLAPS ↓ → 30° TO 30° IDENT: :=.

G 24/001.

WX:

RECORDER: FAST

RUN NO.	IAS	FUEL	SIDESLIP	REMARKS AIL. FORCE / TIME PER TURN ETC.
1	510 550 (.95)	26/26/10	2°	Left / Right
2	~~500~~	~~26/26/8~~	2.5°	L R
3	.8/450	26/26/8	3°	β 1° L — R ½g
4	.73/~~400~~	26/26/6	4°	β 2° L R
5	~~450~~ 300 ~~.54M~~	~~26/26/3~~ 26/26/3 −2	7°	Rt → 2g's 15lb. 3° L β (Lt) Rt β=4° R
6	250 ~~.45M~~	26/26/0	11°	Very slow Lt. 4° L β Rt β 5° R
7	190 .34M	24/25/0	11°	Lt. β 6° L Rt β=7° Rt

GEARS + FLAPS DOWN 30°/30°

8	..	.34 190	23/22/0 22/21/0	11°	Lt β 8° L	Rt β 8° Rt
9	.-.	.29 165	22/20/0 21/20/0	11°	Lt β 8°	Rt β 8°

Sideslip: 1° right at 2

PAR: 350'

EMPIRE TEST PILOTS' SCHOOL
TEST CARD

Aircraft-	No.	Pilot	Date

ROLLING G (MIN. REHEAT)

HEIGHT: 25000 TO 20,000 FT.

RUN NO	IMN	ACT. IMN	ACT. IAS.	FUEL	SIDESLIP LIMIT	SIDESLIP ACTUAL	REMARKS
1.	1.25 2g LEFT	1.25 640K		22/22/4	2°	1 1/4	2.2 6 4
2.	1.25 2g RIGHT				2°	1 1/4	
3.	1.25 4g LEFT			19/19	2°	1 3/4	
4.	1.25 4g RIGHT			18/18	2°	1 1/2°	

FUEL: (20,000 FT.)

115 nm – 1600/1600

90 nm – 1650/1650

65 nm – 1500/1500

15 nm – 1200/1200

RP 250

EMPIRE TEST PILOTS' SCHOOL
TEST CARD

Aircraft-	No.	Pilot	Date
LIGHTNING	XS 422	BAUDRY/ ORME	

10000 ft

60/60 BANK. 1G. CLEAN

TGT SPEED	RECORD.	ACT. SPEED MACH No.		S.S.	REM.
550/0.95	•	510/.95	RIGHT	1.8/2.1	5 1° RT
550/0.95	••	510/.95	LEFT	"	6 1° L 24/26/5
500	—	500/.91	RIGHT	2.1	3 26/26/8 1° R
500	— —	500/.915	LEFT	"	4 1° L
450	• ✓	450/.8	RIGHT	2.5	1 26/26/10 1° Rt
450	• • ✓	440/.79	LEFT	"	2 1° L
400	—	400/.72	RIGHT	3.5	7 26/26/3 2° R
400 X2	— —	400/.72 400/.72	LEFT	"	8 2° L 1.5g
300	•	300/.54	RIGHT	6.5	9 26/26/0 5° R
300	••	300/.53	LEFT	"	10 3° L
250	—	250/.45	RIGHT	9.5	11 6° R
250	— —	256/.45	LEFT	"	12 5° L
190	•	200/.35	RIGHT	10.7	24/24/0
190	••	—	LEFT	"	

RP 250

EMPIRE TEST PILOTS' SCHOOL
TEST CARD

Aircraft-	No.	Pilot	Date
LIGHTNING	XS 422	BAUDRY/	

10000 ft

30/60 BANK. 1G. GEAR + FLAPS DOWN.

TGT SPEED		RECORD	ACT. SPEED	S.S.	REM
190	RIGHT	•	195/.34	10.7	22/20/0
	LEFT	••	190/.33	"	5° L
165	RIGHT	—	165/.29	"	8° R
	LEFT	— —	165/.29	"	20/20/0.

RP 250

EMPIRE TEST PILOTS' SCHOOL
TEST CARD

Aircraft-	No.	Pilot	Date
LIGHTNING	XS 422	BAUDRY /	

20000 ft 1.25 MN (MIN REH) CLEAN.

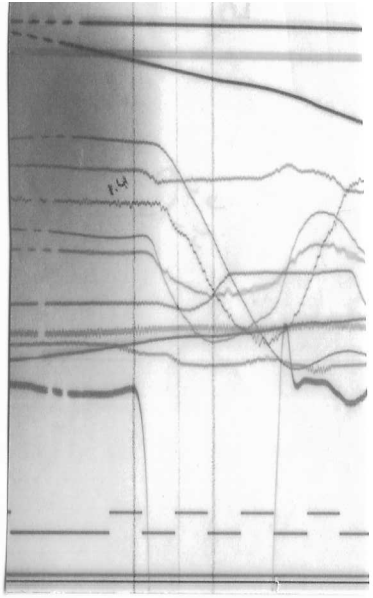
ACCEL.		RECORD.	ACT. MN/G	S.S.	REM SPEED. FUEL. SS
1 G	RIGHT	•	1.2/590	2°	All Inside Limits
	LEFT	• •	1.2/590		
4 G	RIGHT	—	1.25/600	2°	
	LEFT	— —	1.25/580?		

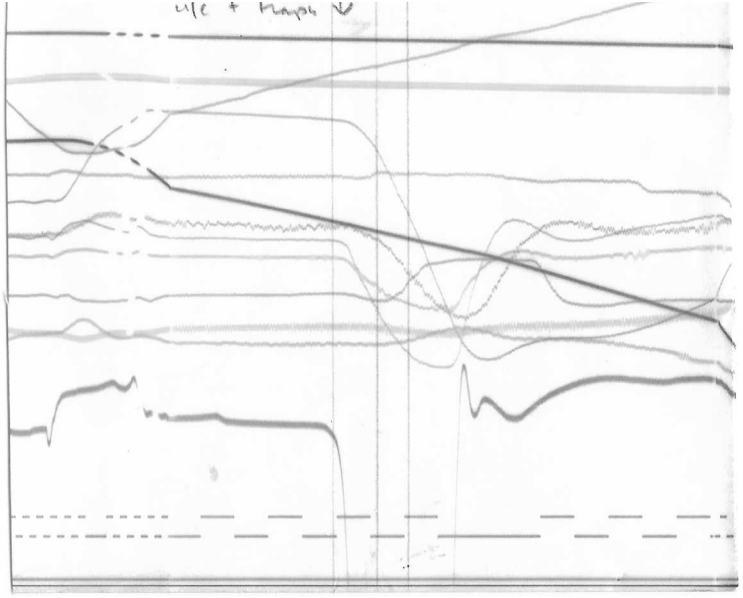
1900 x2

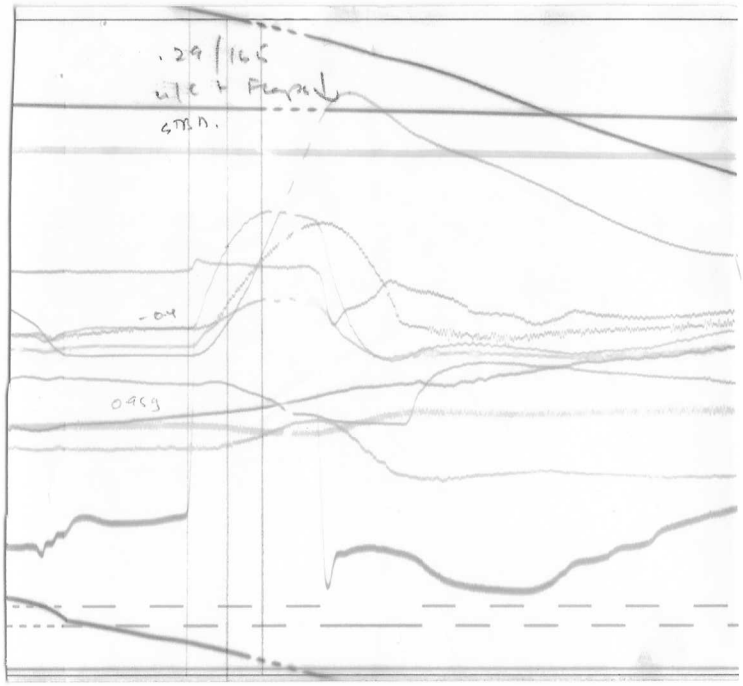
Gnor quite as good on run 3.

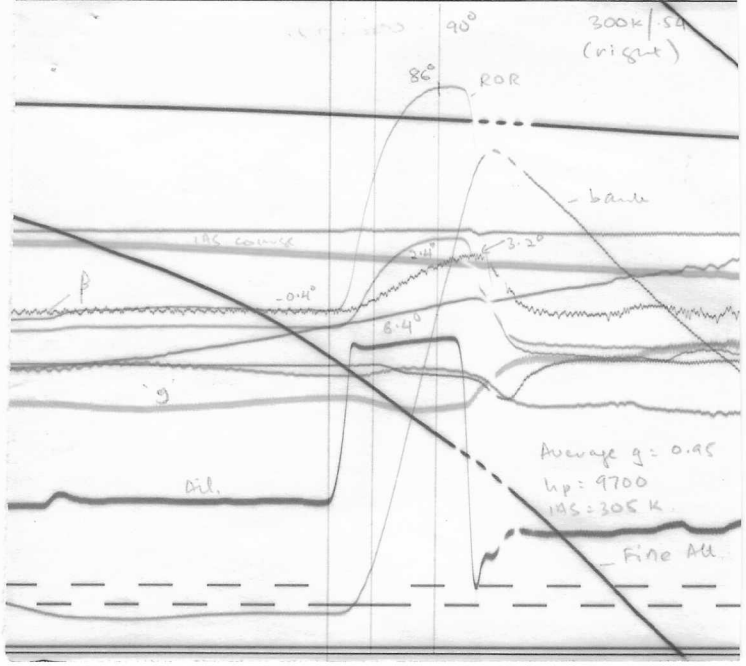
190 K

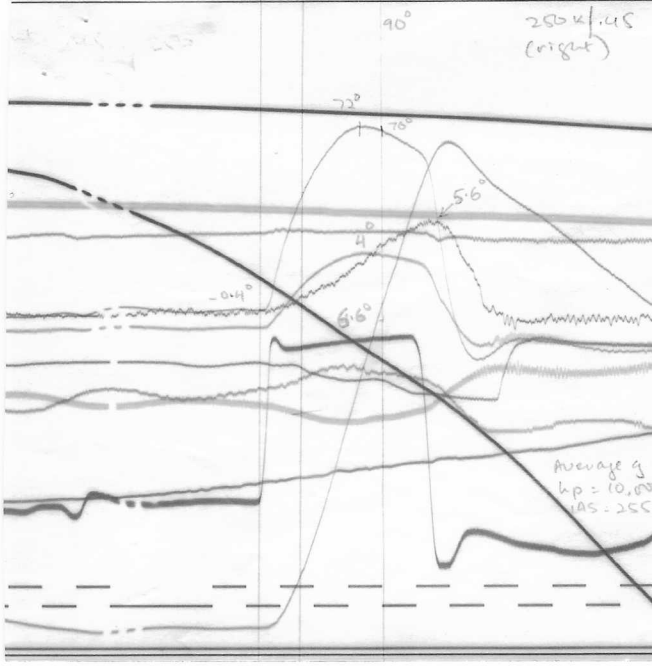
RP 250

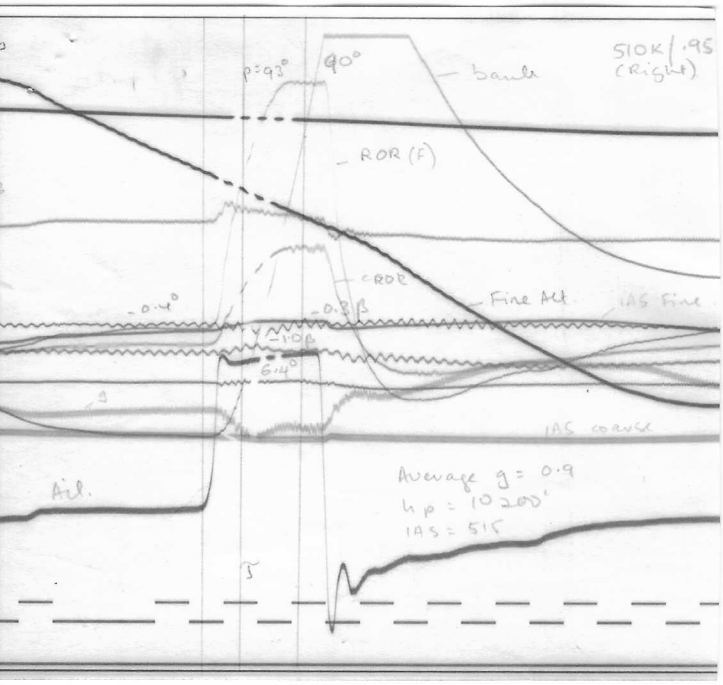


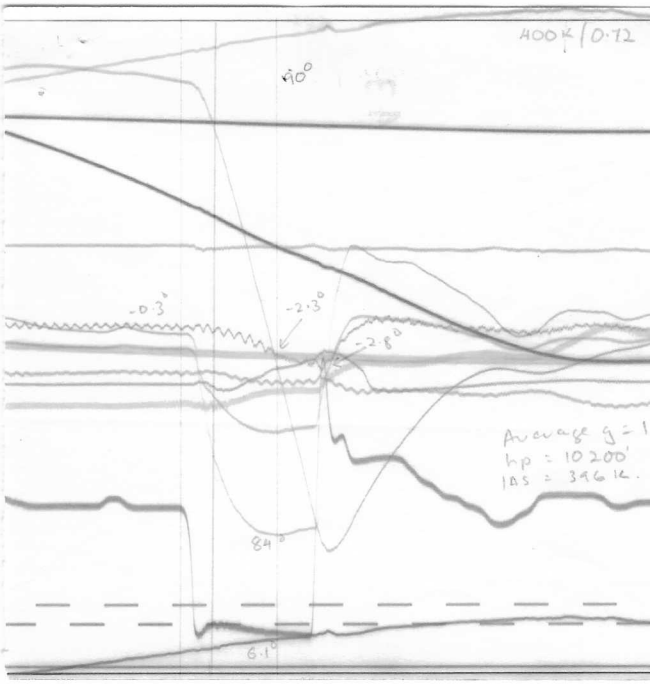


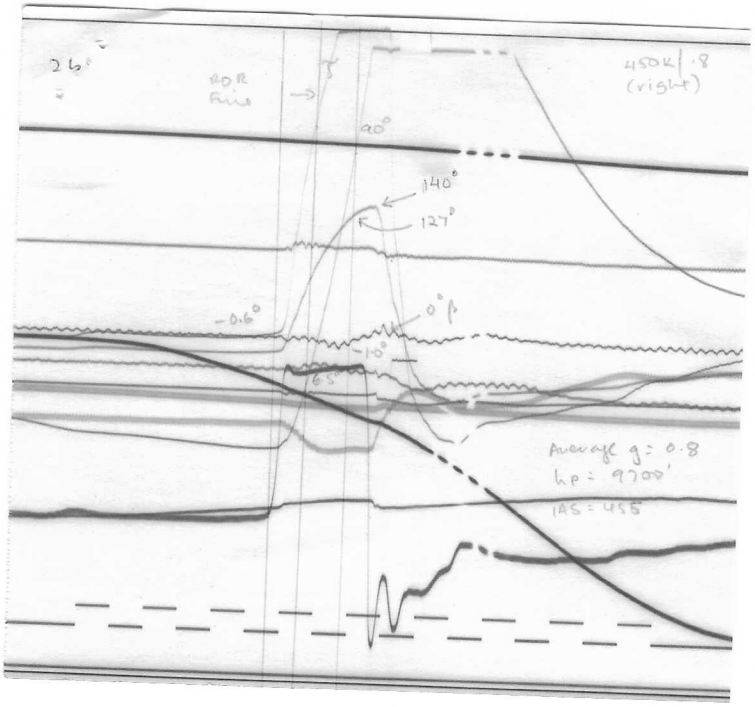


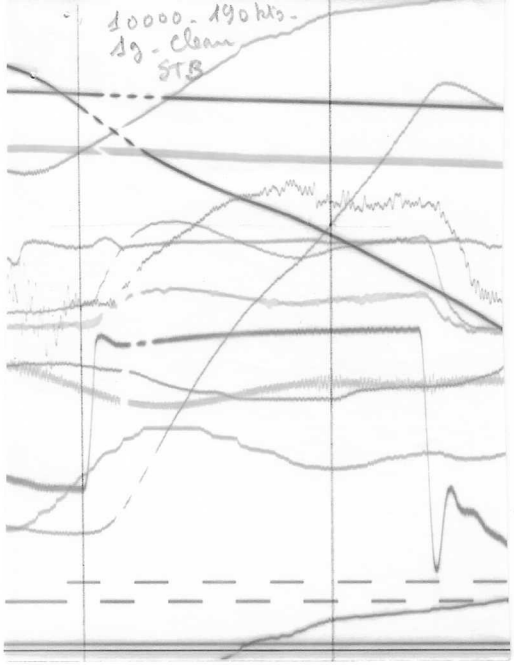

90°
300K/.5
(right)
86°
ROR
bank
IAS coarse
3.2°
-0.4°
6.4°
β
g
Ail.
Average g = 0.95
hp = 9700
IAS = 305 K.
Fine Ail.

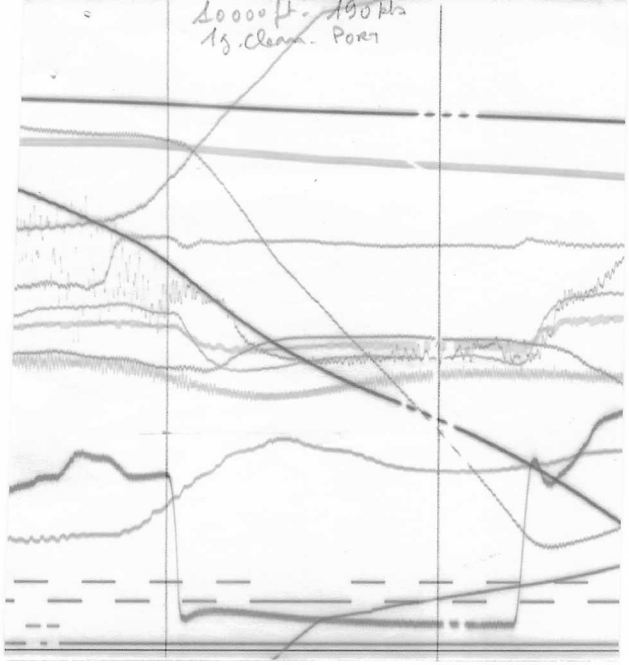

90°
250K/.45
(right)
72°
70°
5.6°
4°
-0.4°
5.6°
Average g
hp = 10,00
IAS = 255

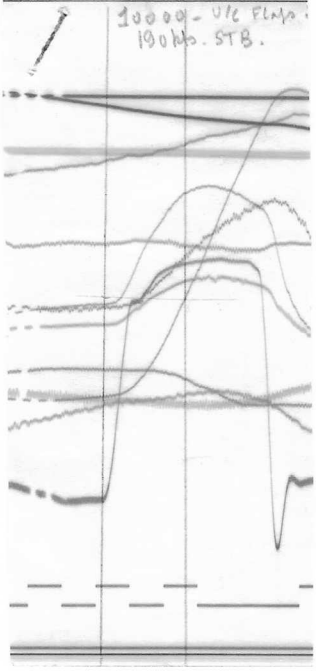

510K/.95
(Right)
p=93°
90°
bank
ROR (F)
ROR
-0.4°
-0.8°β
Fine Ail
IAS Fine
-1.0β
6.4°
g
IAS coarse
Ail.
Average g = 0.9
hp = 10200'
IAS = 515

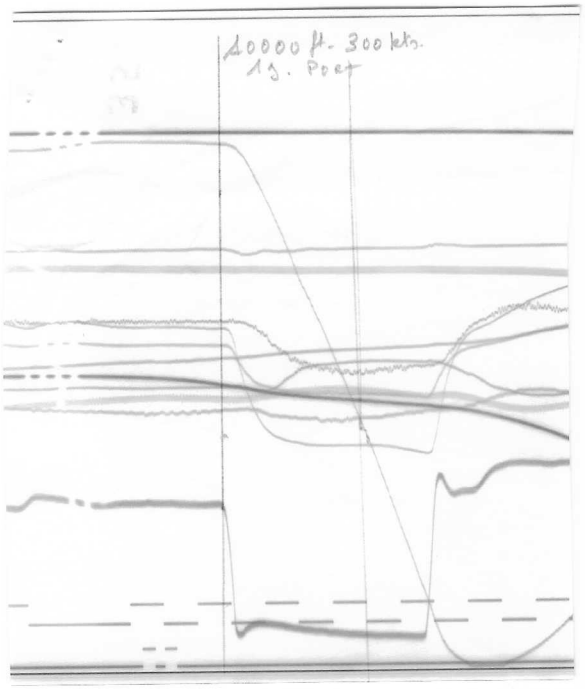

400K/0.72
90°
-0.3°
-2.3°
-2.8°
Average g = 1
hp = 10200'
IAS = 396 K.
84°
6.1°

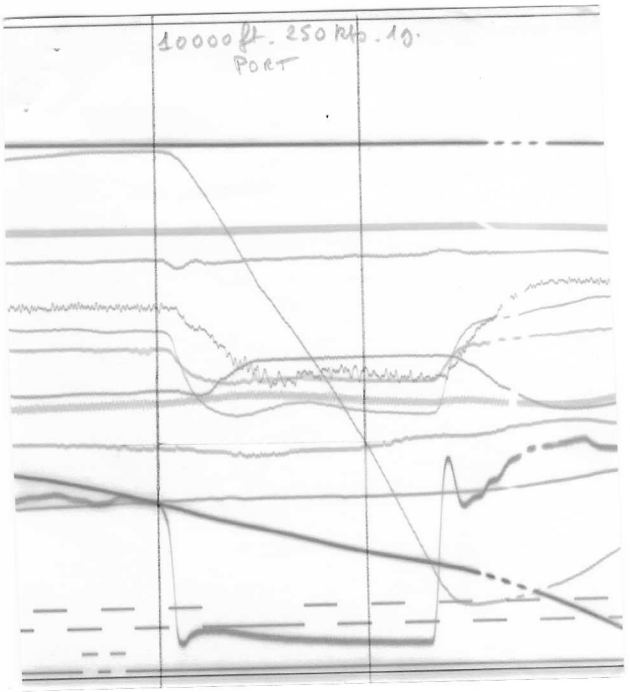

26°
ROR
Fine
450K/.8
(right)
90°
140°
127°
-0.6°
0°β
-1.0°
6.5°
Average g = 0.8
hp = 9700'
IAS = 455

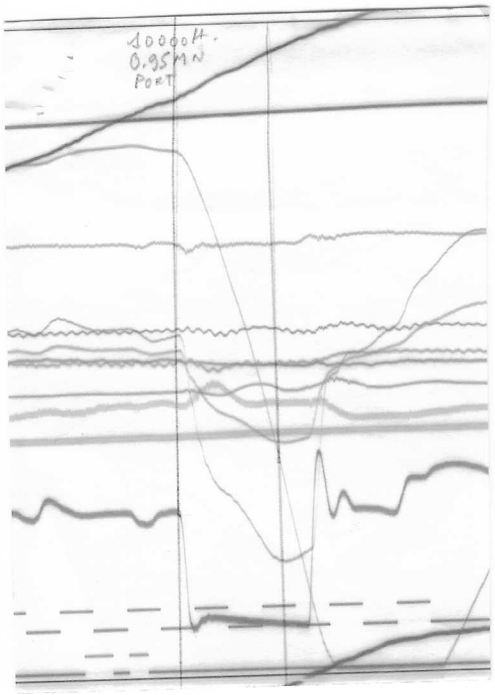

10000 - 190 kts -
1g - Clean
STB

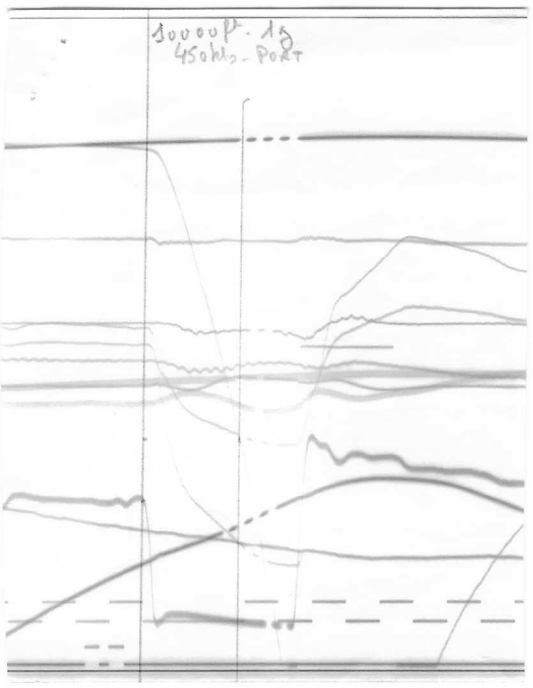

10000 ft - 190 kts
1g. Clean - Port

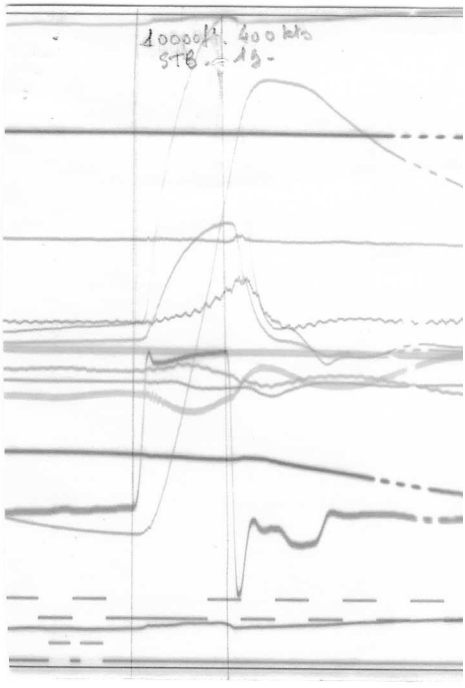

10000 - 0.6 Flaps
190 kts. STB.


10000 ft - 300 kts.
1g. Port


10000 ft - 250 kts - 1g.
PORT


10000 ft.
0.95 MN
PORT


10000 ft. 1g
450 kts - PORT


10000 ft. 400 kts
STB. - 1g -