AD-A131 457 AIRBORNE LABORATORY MEASUREMENT OF AIRCRAFT PERFORMANCE 1/2
AND STABILITY AND CONTROL FOR LIGHT AIRCRAFT SUPPLEMENT
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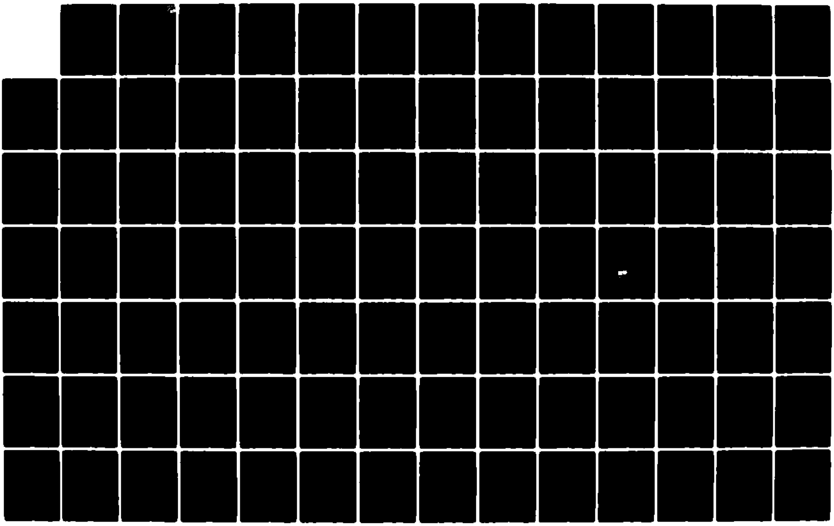

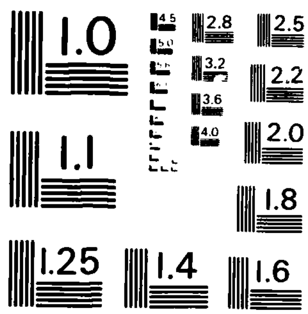

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS - 1963 - A

USAFA-TN-83-3

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Department of Aeronautics
Dean of the Faculty
United States Air Force Academy
Colorado 80840

AIRBORNE LABORATORY MEASUREMENT OF AIRCRAFT PERFORMANCE AND STABILITY AND CONTROL FOR LIGHT AIRCRAFT

TECHNICAL NOTE
USAFA-TN-83-3

Crenshaw, K.R.

24 JUNE 1983

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This Technical Note is approved for publication.

Thomas E. McCann

Thomas E. McCann, Lt Colonel, USAF
Director of Research and Continuing Education

FORWARD

Groundwork on the USAF Academy's Airborne Laboratory, a concept enthusiastically endorsed by Colonel Daniel H. Daley and Lt Colonel Richard C. Oliver, began during the Spring semester of 1982. With the final approval of the Dean of the Faculty and the Superintendent, a new Aero 495 course, "Flight Test Techniques," was taught for the first time during the Fall semester of 1982. Designing the course, planning flight profiles, and handling logistical and other administrative details were accomplished with the help of Captain William C. Roberson. Instrumentation support for measuring important in-flight parameters was provided by Captain Theodore J. Moody of the Department of Electrical Engineering and Mr. Thomas D. Fultz of the Department of Civil Engineering. With the continued support of those mentioned above and the prospective involvement of future members of the Department, the Airborne Laboratory has enormous potential. Aero 495 is expected to become a permanent course in the Aeronautics curriculum by the Fall semester of 1984. What follows is a technical description of the course as it exists today along with sample data and plots.

AIRBORNE LABORATORY MEASUREMENT OF AIRCRAFT PERFORMANCE AND STABILITY AND CONTROL FOR LIGHT AIRCRAFT

Kent R. Crenshaw*

Abstract

This report is a supplement to the article "Integration of an Airborne Laboratory into the United States Air Force Academy Academic Curriculum" in USAFA-TR-83-2. It contains the test plans, flight test planning guides, and aircraft specifications handouts used during the applications phase of the Department of Aeronautics Airborne Laboratory. Sample calculations and plots from actual flight test data taken by cadets are also included. While the test plans, flight test planning guides, and aircraft specifications were designed to be used with the Beechcraft Sierra and Sundowner, the formats are sufficiently general so that they can be applied to any single-engine, general-aviation aircraft. Commonly recognized flight test techniques are used for gathering data, and data reduction is accomplished using accepted procedures.

I. Introduction

The Department of Aeronautics Airborne Laboratory is divided into two phases: "performance" and "flying qualities." Each student receives two flights during each phase, using the Beech Sierra to evaluate performance and the Beech Sundowner to evaluate flying qualities. The geometry, performance charts, and weight and balance data for each aircraft are shown in Appendix A.

II. Performance

The flying portion of the performance phase is conducted according to a test plan with a format similar to that used at the AFFTC (Air Force Flight Test Center). The test plan, shown in Appendix B, defines specific performance objectives that must

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be met if the advertised performance of the test aircraft is to be verified. It also serves as an administrative tool by dividing the students into two separate test teams and by addressing flying and ground safety considerations. Performance parameters that are evaluated include maximum speed, range and rate-of-climb capability, service ceiling, and glide ratio.

Both performance evaluation flights last approximately one hour with Flight 1 dedicated to gathering aircraft cruise and turn performance data and Flight 2 to gathering aircraft climb and descent data. A "Flight Test Planning Guide," shown in Appendix C, is provided to assist the students in their preparation for each flight. Mission events, pilot and student responsibilities, and post-flight data reduction requirements are clearly defined. In addition, data sheets, data reduction sheets, and an "Initial Flight Test Report" form modeled after AFFTC Form 365 are used. After each flight, the cadets submit for grading a flight report that satisfies the requirements laid out in the "Flight Test Planning Guide." See Appendix D for sample performance data records, data reduction, and plots.

III. Flying Qualities

Like the performance phase of the Airborne Laboratory, the flying qualities phase is conducted according to a test plan. The test plan objectives (shown in Appendix E) are to evaluate the Beech Sundowner 180 C23, both qualitatively and quantitatively, as a primary trainer for Class I as defined in

MIL-F-8785C, "Flying Qualities of Piloted Airplanes." The aircraft is evaluated for compliance with selected paragraphs of this document. The test plan also serves the administrative purpose described in the performance section of this paper.

Both of the flights in the flying qualities phase last approximately one hour. Flight 3 is dedicated to evaluating longitudinal and lateral-directional stability and control as well as maneuvering flight. Flight 4 concerns dynamic stability and stalls. A "Flight Test Planning Guide," shown in Appendix F, outlines each flight in detail and helps the student to prepare for flying and to reduce post-flight data. See Appendix G for sample flying qualities data records, data reduction, and plots.

IV. Conclusions

While the test plans, flight test planning guides, and aircraft specifications handouts contained in this report were designed to be used with the Beechcraft Sierra and Sundowner, the formats are sufficiently general so that they can be applied to any single-engine, general-aviation aircraft. The test plan serves primarily as a statement of purpose and objectives, but it is also a useful administrative tool for organizing the flight test effort and addressing safety considerations. The flight test planning guide lays out the specific engineering requirements for each flight. While this might be interpreted as "leading the cadets by the hand," taking data in-flight is very different from gathering data in a ground-based laboratory environment. The flight test planning guide gives the individual without experience in general aviation aircraft all the information he or she needs to fly an effective and efficient flight test mission. It eliminates guesswork about the specific test parameters needed in-flight and makes the flight experience both productive and rewarding.

Symbols

English Symbols

(A)	actual
ALT	altitude
BHP_{iw}	brake horsepower, instrument and weight corrected
BHP_s	standard brake horsepower from engine chart
BHP_t	test brake horsepower from engine chart
C_D	coefficient of drag
C_L	coefficient of lift
C_P	propeller pressure coefficient
c.g. or CG	center of gravity
$(dH/dt)_d$	rate of climb with density correction applied
$(dH/dt)_p$	rate of climb corrected for engine power and propulsive efficiency
DEG	degrees

F_e	elevator stick force
F_R	rudder force
FF	fuel flow
F.M.	flight manual
FPM	feet per minute
FPS	feet per second
FT	feet
FWD	forward
g	acceleration of gravity
"g"	load factor
GPH	gallons per hour
GD	ground
H_c	calibrated altitude
H_i	indicated altitude
h_m	stick-fixed maneuver point
h'_m	stick-free maneuver point
h_n	stick-fixed neutral point
h'_n	stick-free neutral point
H_{Pi}	indicated pressure altitude
H_s or H_{std}	standard altitude
H_t or H_{test}	test altitude
HP	horsepower
HR	hour
IAS (V_i)	indicated airspeed
IN	inches
J	propeller advance ratio

KIAS	knots, indicated airspeed
KTS	knots
$L/D)_{max}$	maximum lift over drag ratio
MAC or $\bar{c}$	mean aerodynamic chord
MAP	manifold pressure
MCP	maximum continuous power
MIN	minutes
MPH	miles per hour
n_t or n_{test}	test load factor
NAM	nautical air miles
OAT	outside air temperature
O/S	overshoots
(P)	predicted from flight manual
p	pressure at altitude
p_o	sea level pressure
PRESS	pressure
q	dynamic pressure
R_t or R_{test}	test turn radius
$R/C)_s$ or $(dH/dt)_{std}$	standard rate of climb
$R/C)_T$ or $(dH/dt)_t$	test rate of climb
RPM	revolutions per minute
R/S	rate of sink
S	planform area of wing
SAR	specific air range
SE	specific endurance
SEC	seconds

T	period of oscillatory dynamic response
t2	time to double amplitude
t1/2	time to 1/2 amplitude
T_a	absolute outside air temperature
T_i	indicated outside air temperature
T_s	standard temperature at altitude
T_t	test temperature at altitude
TACH	tachometer
TED	trailing edge down
TEMP	temperature
TEU	trailing edge up
VCAS (V_c)	calibrated airspeed
V_e	equivalent airspeed
V_{iw}	velocity, instrument and weight corrected
V_t	test indicated airspeed
V_{true}	true airspeed
VVI	vertical velocity indicator
$\dot{W}_f$	fuel flow in pounds (lb) per hour (hr)
W_s or W_{std}	aircraft standard weight
W_t or W_{test}	aircraft test weight

Greek Symbols

ω_t or ω_{test}	test turn rate

η	propeller efficiency
δ	pressure ratio p/p_o
σ	density ratio ρ/ρ_o
ρ	density at altitude
ρ_o	sea level density
ϕ	bank angle
δ_e	elevator stick deflection
δ_R	rudder deflection
δ_a	aileron control wheel deflection
β	sideslip angle
ω_a	actual frequency
ω_n	undamped natural frequency
ξ	damping ratio

References

1. Crenshaw, Kent R., "Integration of an Airborne Laboratory into the United States Air Force Academy Academic Curriculum," Aeronautics Digest, USAFA-TR-83-2, USAF Academy, March 1983.

APPENDIX A

Specifications and Weight and Balance for the Beechcraft Sierra 200 C24R and Sundowner 180 C23

SPECIFICATIONS

AND

WEIGHT AND BALANCE

FOR THE BEECHCRAFT SIERRA 200 C24R

AERO 495

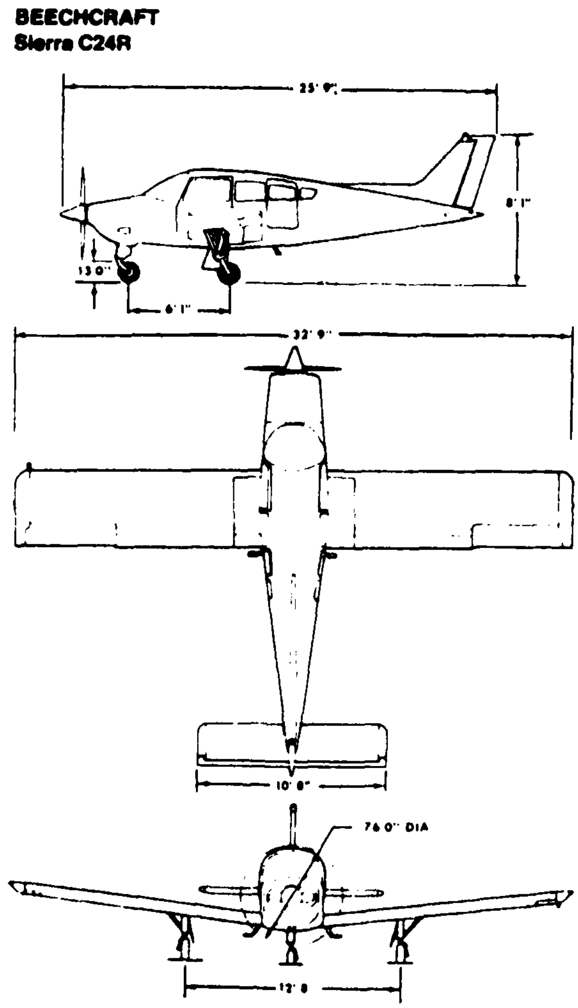
SPRING 1983

CONTENTS

PAGE

I. GEOMETRY

A. Three View



THREE VIEW

B. Wing

Span, b	32'9"
Mean Aerodynamic Chord, MAC	52.7"
Area, S	146 ft^2
Aspect Ratio, Æ	7.5
Taper Ratio	1.0
Dihedral	6.0°

I. GENERAL

A. Engine - Avco Lycoming, 4 cylinder
IO-360-A1
Maximum continuous power (at sea level)
200 HP @ 2,700 rpm
Manifold Pressure Operating Range (15" to 28.7" Hg)

B. Propeller - Two-blade, Hartzell, constant speed
Aluminum alloy
Diameter 76"
Restricted Operation - 2,100 to 2,350 rpm

C. Capacities

Passengers and Pilot	6
Oil	8 quarts
Fuel	59.8 gallons
	57.2 gallons usable

D. Design Load Factor

2,750 pounds, flaps up	+3.8 to -1.9

E. Airspeeds

Takeoff (flaps 15°)	66 KTS/76 MPH
Climb (best rate, V_y)	85 KTS/98 MPH
Climb (best angle, V_x)	71 KTS/82 MPH
Maximum Glide	91 KTS/105 MPH
Emergency Approach	74 KTS/85 MPH
Normal Approach (flaps down)	70 KTS/81 MPH
Cruise Climb	96 KTS/110 MPH
Maximum Permissible Speed, V_{NE}	168 KTS/193 MPH
Maximum Landing Gear Extended Speed	135 KTS/155 MPH
Maximum Flap Extension Speed	96 KTS/110 MPH
Maneuver Speed	125 KTS/144 MPH
1G Stall Speed (gear and flaps up, 2,600 lbs)	65 KTS/75 MPH

III. PERFORMANCE CHARTS

A. Pitot-Static Calibration Data

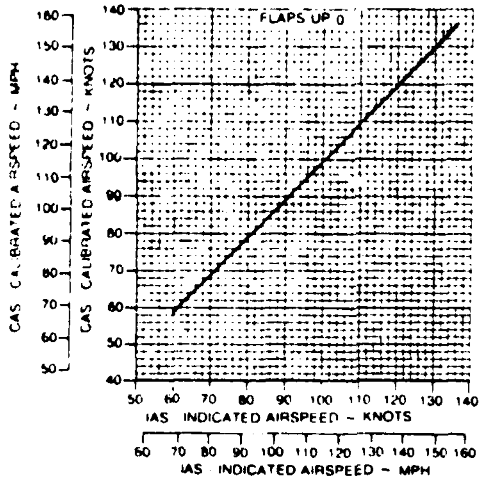
5-10

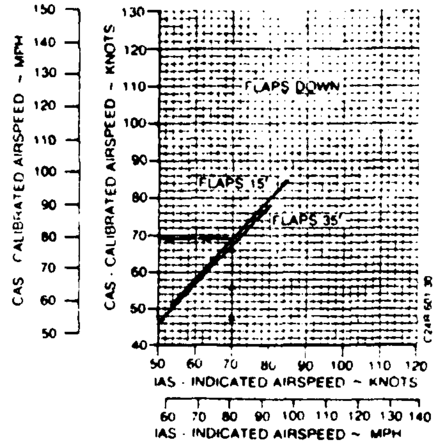
AIRSPEED CALIBRATION - NORMAL SYSTEM

NOTE
INDICATED AIRSPEED ASSUMES ZERO INSTRUMENT ERROR

EXAMPLE

IAS	70 KTS (81MPH)
FLAPS	15°
CAS	69 KNOTS (79MPH)





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Section V Performance

BEECHCRAFT Sierra C24R

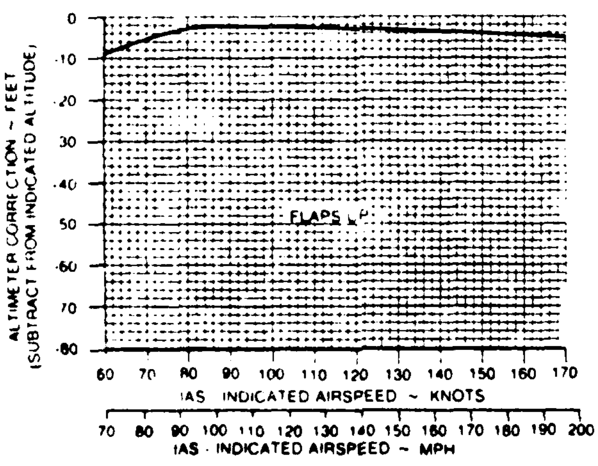
5-12

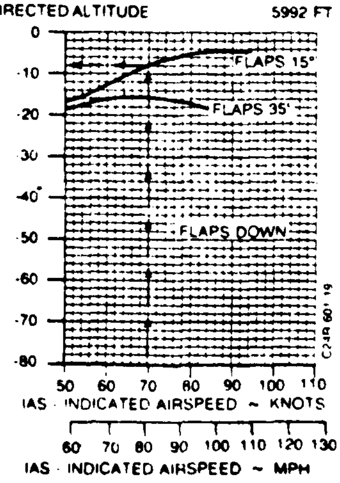
ALTIMETER CORRECTION—NORMAL SYSTEM

NOTE
INDICATED AIRSPEED ASSUMES ZERO INSTRUMENT ERROR

EXAMPLE

IAS	70 KTS (81 MPH)
FLAPS	15°
PRESSURE ALTITUDE	6000 FT
ALTIMETER CORRECTION	-8 FT
CORRECTED ALTITUDE	5992 FT





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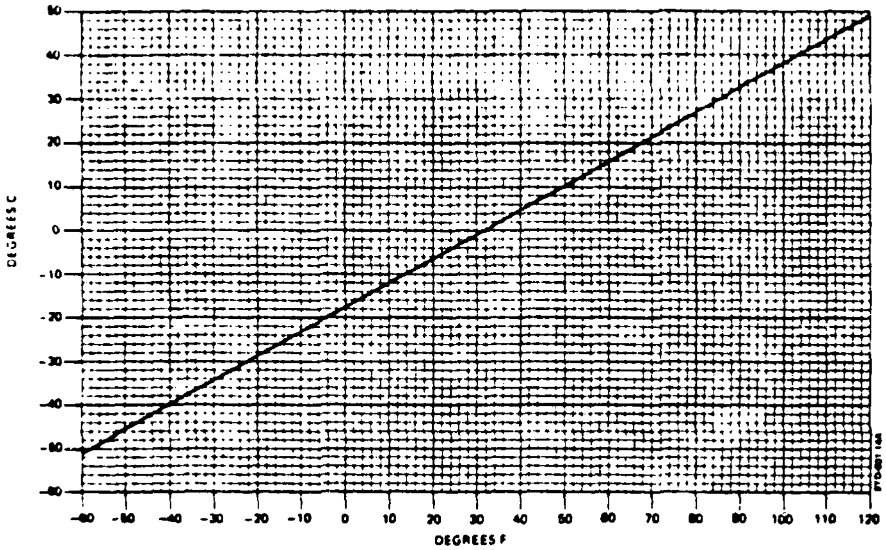
BEECHCRAFT Sierra C24R

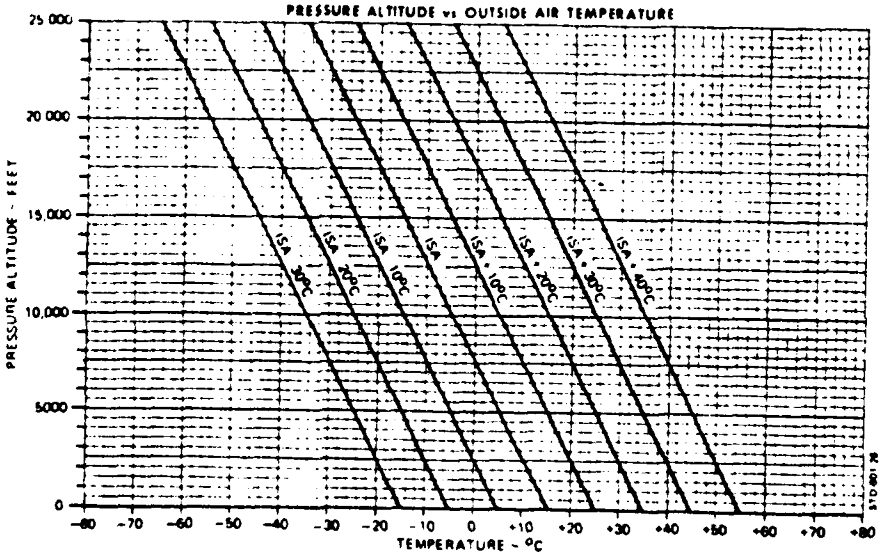
B. Atmospheric Data

FAHRENHEIT TO CELSIUS TEMPERATURE CONVERSION

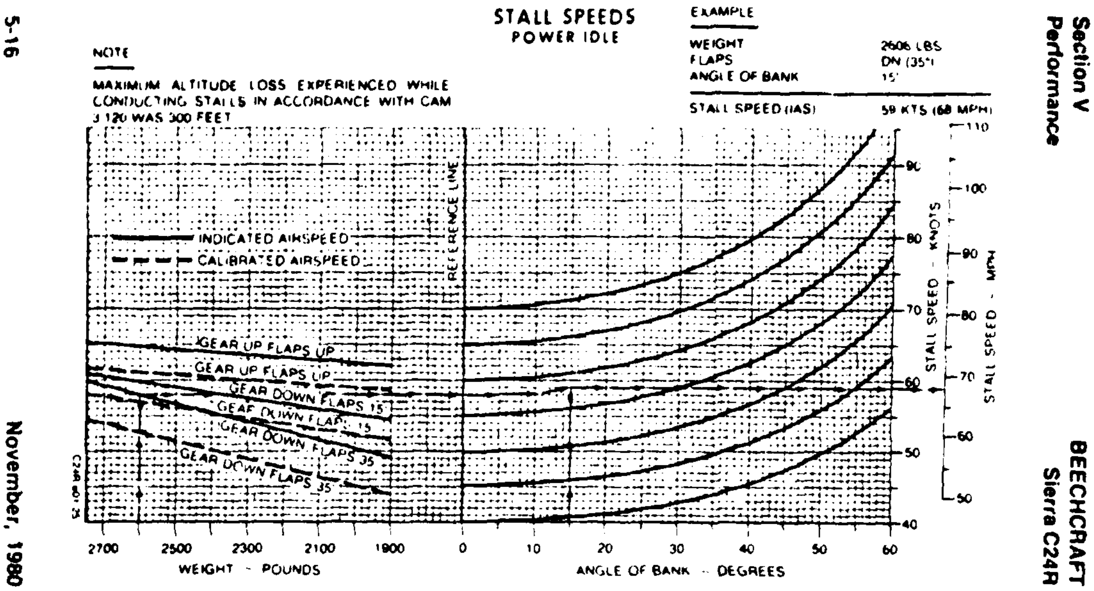


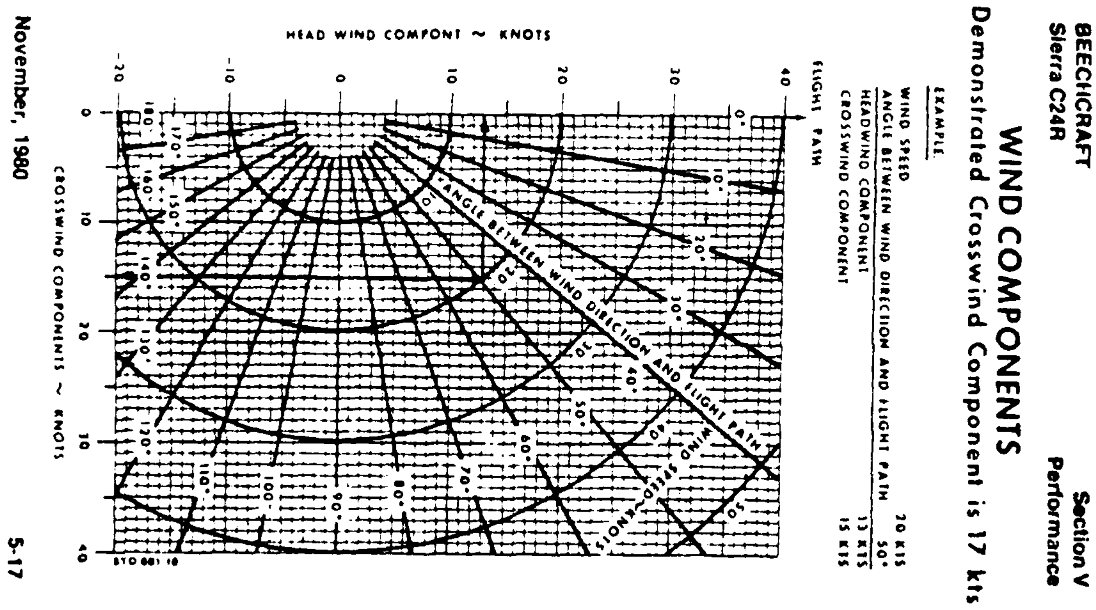
ISA CONVERSION

PRESSURE ALTITUDE vs OUTSIDE AIR TEMPERATURE

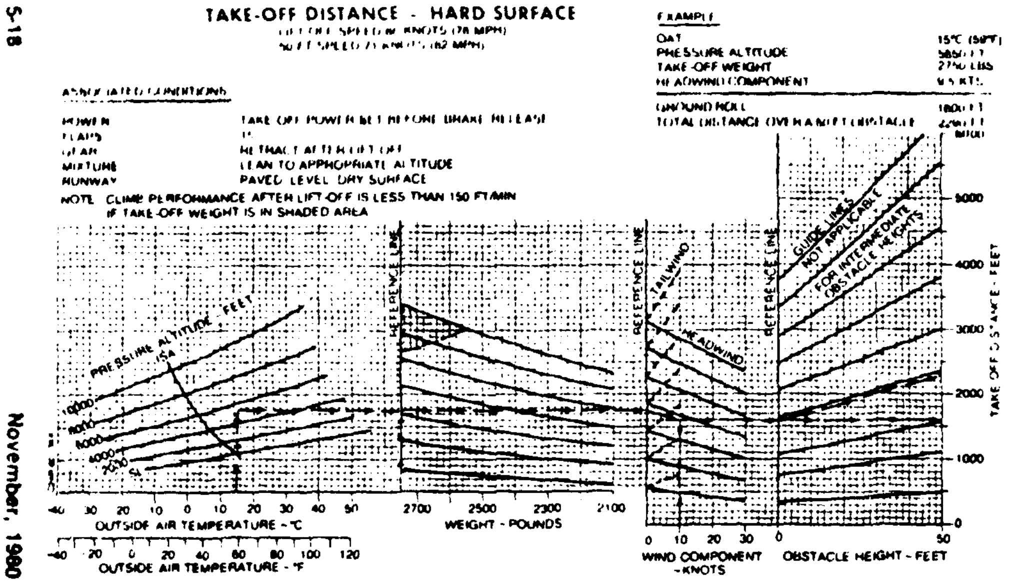


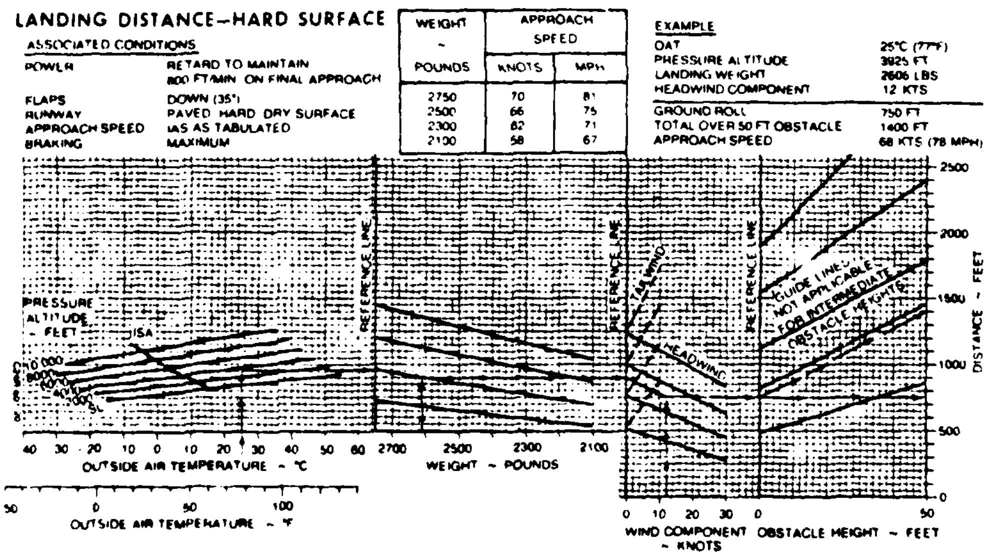
C. Stall Speeds and Crosswinds





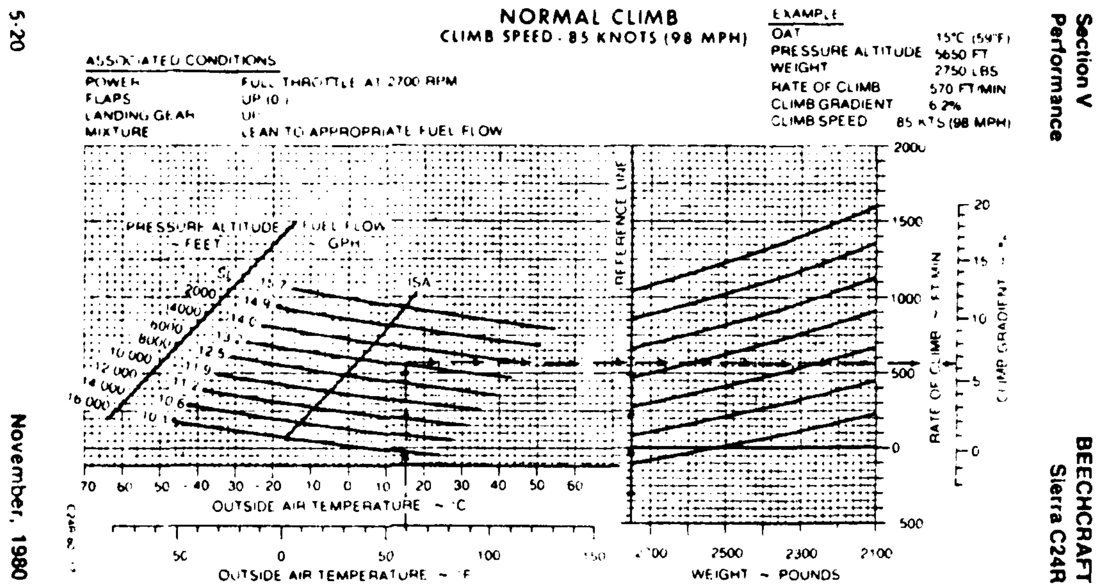
D. Takeoff and Landing Data





WEIGHT ~ POUNDS	APPROACH SPEED KNOTS	APPROACH SPEED MPH
2750	70	81
2500	66	75
2300	62	71
2100	58	67

E. Climb Data


NORMAL CLIMB
CLIMB SPEED - 85 KNOTS (98 MPH)
ASSOCIATED CONDITIONS
POWER FULL THROTTLE AT 2700 RPM
FLAPS UP (0)
LANDING GEAR UP
MIXTURE LEAN TO APPROPRIATE FUEL FLOW
EXAMPLE
OAT 15°C (59°F)
PRESSURE ALTITUDE 5650 FT
WEIGHT 2750 LBS
RATE OF CLIMB 570 FT/MIN
CLIMB GRADIENT 6.2%
CLIMB SPEED 85 KTS (98 MPH)
PRESSURE ALTITUDE ~ FEET
FUEL FLOW ~ GPH
ISA
REFERENCE LINE
RATE OF CLIMB ~ FT/MIN
CLIMB GRADIENT ~ %
OUTSIDE AIR TEMPERATURE ~ °C
OUTSIDE AIR TEMPERATURE ~ °F
WEIGHT ~ POUNDS
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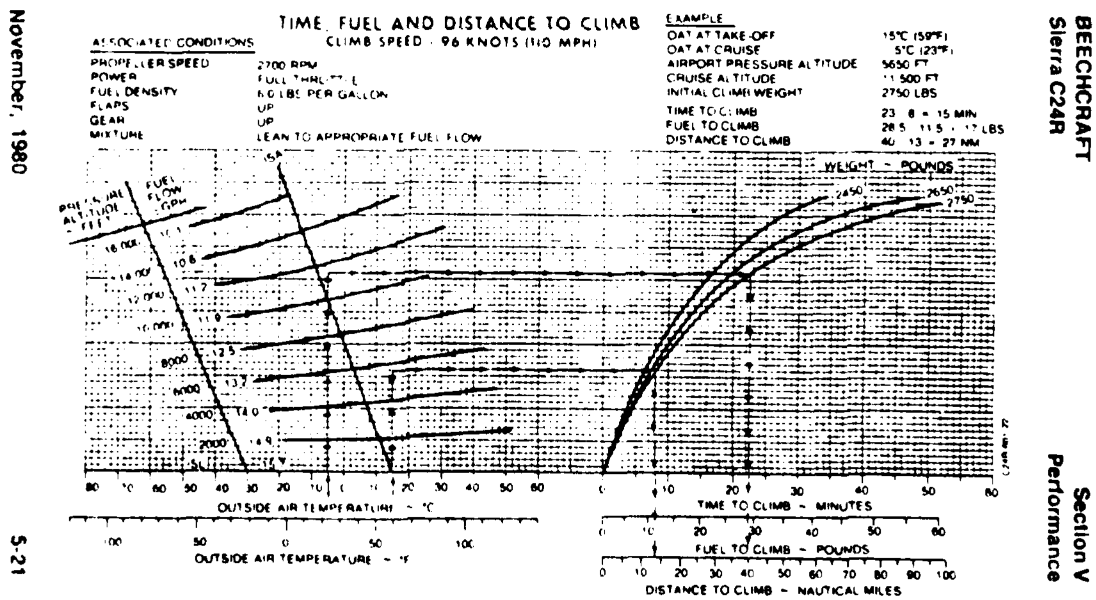
BEECHCRAFT Sierra C24R


TIME, FUEL AND DISTANCE TO CLIMB
CLIMB SPEED - 96 KNOTS (110 MPH)
ASSOCIATED CONDITIONS
PROPELLER SPEED 2700 RPM
POWER FULL THROTTLE
FUEL DENSITY 6.0 LBS PER GALLON
FLAPS UP
GEAR UP
MIXTURE LEAN TO APPROPRIATE FUEL FLOW
EXAMPLE
OAT AT TAKE-OFF 15°C (59°F)
OAT AT CRUISE 5°C (23°F)
AIRPORT PRESSURE ALTITUDE 5650 FT
CRUISE ALTITUDE 11 500 FT
INITIAL CLIMB WEIGHT 2750 LBS
TIME TO CLIMB 23 - 8 = 15 MIN
FUEL TO CLIMB 28.5 - 11.5 = 17 LBS
DISTANCE TO CLIMB 40 - 13 = 27 NM
PRESSURE ALTITUDE ~ FEET
FUEL FLOW ~ GPH
ISA
WEIGHT ~ POUNDS
OUTSIDE AIR TEMPERATURE ~ °C
OUTSIDE AIR TEMPERATURE ~ °F
TIME TO CLIMB ~ MINUTES
FUEL TO CLIMB ~ POUNDS
DISTANCE TO CLIMB ~ NAUTICAL MILES
November, 1980
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BEECHCRAFT Sierra C24R
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F. Cruise Data

CRUISE POWER SETTINGS - 2700 RPM
75% MCP (or FULL THROTTLE) - 2600 POUNDS

	ISA -36°F (-20°C)							STANDARD DAY (ISA)							ISA +36°F (+20°C)						
PRESS ALT.	OAT		MAN. PRESS	FUEL FLOW		TAS		OAT		MAN. PRESS	FUEL FLOW		TAS		OAT		MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH
SL	25	4	22.4	61	10.2	123	142	61	16	23.0	61	10.2	125	144	99	37	23.6	61	10.2	128	147
1000	21	6	22.1	61	10.2	124	143	57	14	22.7	61	10.2	126	145	95	35	23.3	61	10.2	129	148
2000	18	-8	21.6	61	10.2	125	144	55	13	22.4	61	10.2	128	147	91	33	23.0	61	10.2	130	150
3000	14	-10	21.6	61	10.2	126	145	52	11	22.2	61	10.2	129	148	88	31	22.8	61	10.2	131	151
4000	12	-11	21.3	61	10.2	127	146	48	9	22.0	61	10.2	130	150	84	29	22.5	61	10.2	133	153
5000	9	-13	21.1	61	10.2	128	147	45	7	21.7	61	10.2	131	151	81	27	22.3	61	10.2	134	154
6000	5	-15	20.9	61	10.2	129	148	41	5	21.5	61	10.2	132	152	77	25	22.1	61	10.2	135	155
7000	1	-17	20.7	61	10.2	131	151	37	3	21.3	61	10.2	133	153	73	23	21.9	61	10.2	136	157
8000	-2	-19	20.5	61	10.2	132	152	34	1	21.1	61	10.2	135	155	70	21	21.8	61	10.2	137	158
9000	-6	21	20.3	61	10.2	133	153	30	-1	20.9	61	10.2	136	157	86	19	21.5	60	10.2	137	158
10000	-9	-23	20.2	61	10.2	134	154	27	-3	20.7	61	10.2	137	158	63	17	20.7	59	9.8	137	158
11000	-13	-25	20.0	60	10.2	134	154	23	-5	20.0	59	9.8	136	157	59	15	20.0	57	9.5	136	157
12000	-17	-27	19.2	59	9.8	134	154	19	-7	19.2	58	9.7	134	154	55	13	19.2	56	9.3	134	154
13000	-20	-29	18.5	58	9.7	133	153	16	-9	18.5	56	9.3	133	153	52	11	18.5	54	9.0	132	152
14000	-24	-31	17.9	56	9.3	131	151	12	-11	17.9	54	9.0	131	151	48	9	17.9	53	8.8	130	150

NOTES 1 Shaded area represents operation with full throttle
2 Full throttle manifold settings are approximate

CRUISE POWER SETTINGS - 2500 RPM
75% MCP (or FULL THROTTLE) - 2600 POUNDS

	ISA -36°F (-20°C)							STANDARD DAY (ISA)							ISA +36°F (+20°C)						
PRESS ALT	OAT		MAN PRESS	FUEL FLOW		TAS		OAT		MAN. PRESS	FUEL FLOW		TAS		OAT		MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH
SL	25	-4	23.6	61	10.2	123	142	61	16	24.4	61	10.2	126	145	99	37	25.1	61	10.2	129	148
1000	21	-6	23.5	61	10.2	124	143	59	15	24.1	61	10.2	127	146	95	35	24.8	61	10.2	130	150
2000	18	-8	23.3	61	10.2	125	144	55	13	23.9	61	10.2	128	147	91	33	24.5	61	10.2	131	151
3000	16	9	23.0	61	10.2	127	146	52	11	23.6	61	10.2	129	148	83	31	24.2	[illegible]	10.2	132	152
4000	12	-11	22.7	61	10.2	128	147	48	9	23.4	61	10.2	130	150	84	29	24.0	[illegible]	10.2	133	153
5000	9	-13	22.5	61	10.2	129	148	45	7	23.1	61	10.2	131	151	81	27	23.7	61	10.2	134	154
6000	5	15	22.3	61	10.2	130	150	41	5	22.9	61	10.2	132	152	77	25	23.5	61	10.2	135	155
7000	1	-17	22.1	61	10.2	131	151	37	3	22.7	61	10.2	134	154	73	23	23.2	60	10.0	135	155
8000	2	-19	21.8	61	10.2	132	152	34	1	22.4	60	10.0	134	154	70	21	22.4	59	9.8	134	154
9000	-6	-21	21.6	60	10.0	132	152	30	-1	21.6	59	9.8	133	153	86	19	21.6	57	9.5	133	153
10000	-9	23	20.8	59	9.8	131	151	27	-3	20.8	57	9.5	132	152	63	17	20.8	56	9.3	131	151
11000	-13	-25	20.1	57	9.5	130	150	23	-5	20.1	56	9.3	130	150	59	15	20.1	54	9.0	130	150
12000	17	-27	19.3	55	9.2	129	148	19	-7	19.3	54	9.0	128	147	55	13	19.3	53	8.8	127	146
13000	-20	-29	18.6	54	9.0	127	146	16	-9	18.8	53	8.8	127	146	52	11	18.6	51	8.5	125	144
14000	24	-31	17.9	53	8.8	126	145	12	-11	17.9	52	8.7	125	144	48	9	17.9	50	8.3	123	142

NOTES 1 Shaded area represents operation with full throttle
2 Full throttle manifold settings are approximate

CRUISE POWER SETTINGS - 2400 RPM
65% MCP (or FULL THROTTLE) - 2600 POUNDS

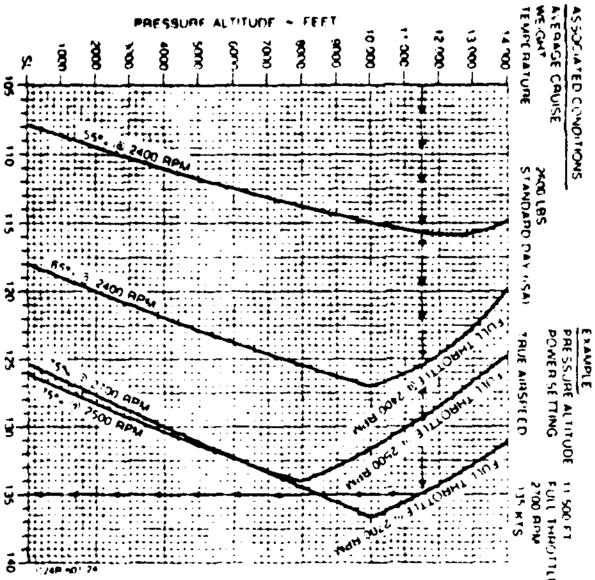
PRESS ALT.	ISA -36°F (-20°C)							STANDARD DAY (ISA)							ISA +36°F (+20°C)						
	OAT		MAN. PRESS	FUEL FLOW		TAS		OAT		MAN PRESS	FUEL FLOW		TAS		OAT		MAN. PRESS	FUEL FLOW		TAS	
FEET	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH
SL	25	-4	22.3	54	9.0	116	134	61	16	22.9	54	9.0	118	136	97	36	23.5	54	9.0	120	138
1000	21	-6	22.0	54	9.0	117	135	57	14	22.6	54	9.0	119	137	93	34	23.2	54	9.0	121	139
2000	18	-8	21.7	54	9.0	118	136	54	12	22.3	54	9.0	120	138	90	32	23.0	54	9.0	122	140
3000	14	-10	21.5	54	9.0	118	136	50	10	22.1	54	9.0	121	139	86	30	22.7	54	9.0	123	142
4000	10	-12	21.2	54	9.0	119	137	46	8	21.8	54	9.0	122	140	84	29	22.4	54	9.0	124	143
5000	7	-14	20.9	54	9.0	120	138	43	6	21.5	54	9.0	123	142	81	27	22.2	54	9.0	125	144
6000	3	-16	20.7	54	9.0	121	139	41	5	21.3	54	9.0	124	143	77	25	22.0	54	9.0	126	145
7000	1	-17	20.5	54	9.0	122	140	37	3	21.1	54	9.0	125	144	73	23	21.7	54	9.0	126	145
8000	-2	-19	20.3	54	9.0	123	142	34	1	20.9	54	9.0	125	144	70	21	21.5	54	9.0	127	146
9000	-6	21	20.1	54	9.0	124	143	30	-1	20.7	54	9.0	126	145	66	19	21.3	54	9.0	127	146
10000	-9	-23	19.9	54	9.0	125	144	27	-3	20.5	54	9.0	127	146	63	17	20.8	53	8.8	127	146
11000	-13	-25	19.8	54	9.0	125	144	23	-5	20.1	53	8.8	126	145	59	15	20.1	52	8.7	126	145
12000	-17	-27	19.3	54	9.0	125	144	19	-7	19.3	52	8.7	125	144	55	13	18.3	51	8.5	123	142
13000	-20	-29	18.6	52	8.7	124	143	16	-9	18.6	51	8.5	123	142	52	11	18.6	49	8.2	120	138
14000	-24	-31	17.9	51	8.5	121	139	12	-11	17.9	49	8.2	120	138	48	9	17.9	48	8.0	117	135

NOTES: 1. Shaded area represents operation with full throttle
2. Full throttle manifold settings are approximate

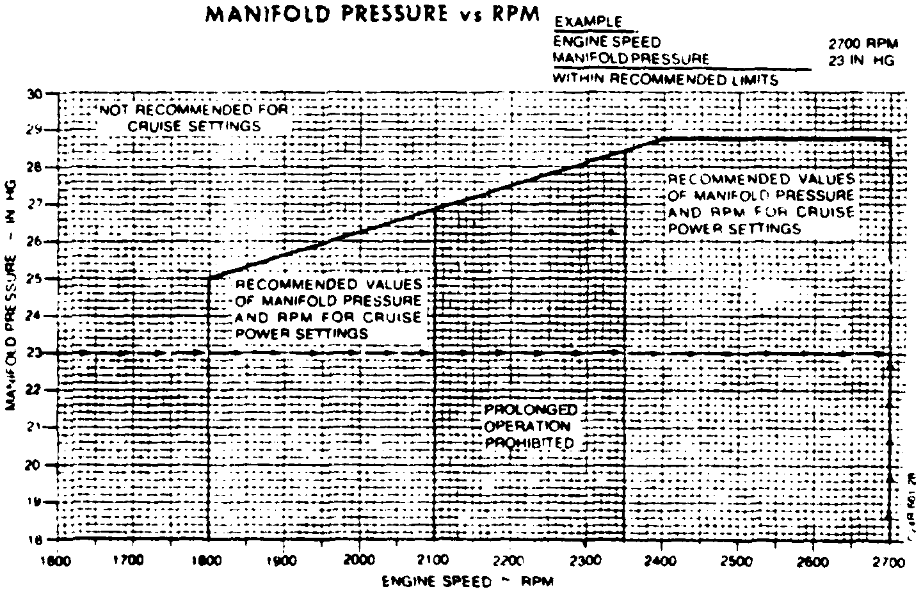
CRUISE POWER SETTINGS - 2400 RPM
55% MCP - 2600 POUNDS

PRESS ALT.	ISA -36°F (-20°C)							STANDARD DAY (ISA)							ISA +36°F (+20°C)						
	OAT		MAN PRESS	FUEL FLOW		TAS		OAT		MAN PRESS	FUEL FLOW		TAS		OAT		MAN PRESS	FUEL FLOW		TAS	
FEET	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH	°F	°C	IN HG	PPH	GPH	KTS	MPH
SL	25	-4	19.7	48	8.0	106	122	61	16	20.3	48	8.0	106	124	97	36	20.8	48	8.0	110	127
1000	21	-6	19.6	48	8.0	107	123	57	14	20.1	48	8.0	108	124	93	34	20.6	48	8.0	110	127
2000	18	-8	19.3	48	8.0	107	123	54	12	19.8	48	8.0	109	125	90	32	20.3	48	8.0	111	128
3000	14	-10	19.1	48	8.0	108	124	50	10	19.6	48	8.0	110	127	86	30	20.1	48	8.0	112	129
4000	10	-12	18.9	48	8.0	109	125	46	8	19.4	48	8.0	111	126	82	28	19.9	48	8.0	113	130
5000	7	-14	18.6	48	8.0	110	127	43	6	19.1	48	8.0	112	129	79	26	19.7	48	8.0	113	130
6000	3	-16	18.4	48	8.0	111	128	39	4	18.9	48	8.0	113	130	75	24	19.4	48	8.0	114	131
7000	0	-18	18.2	48	8.0	111	128	36	2	18.7	48	8.0	113	130	72	22	19.2	48	8.0	115	132
8000	-4	-20	18.0	48	8.0	112	129	32	0	18.5	48	8.0	114	131	68	20	19.1	48	8.0	115	132
9000	-8	-22	17.8	48	8.0	113	130	28	-2	18.3	48	8.0	114	131	64	16	18.9	48	8.0	116	134
10000	-11	-24	17.6	48	8.0	114	131	25	-4	18.1	48	8.0	115	132	61	16	18.7	48	8.0	116	134
11000	-15	-26	17.5	48	8.0	114	131	21	-6	18.0	48	8.0	116	134	57	14	18.5	48	8.0	117	135
12000	-18	-28	17.3	48	8.0	115	132	18	-8	17.8	48	8.0	116	134	55	13	18.3	48	8.0	117	135
13000	-22	-30	17.1	48	8.0	115	132	14	-10	17.6	48	8.0	116	134	50	10	18.1	48	8.0	117	135
14000	-26	-32	16.8	48	8.0	116	134	10	-12	17.4	48	8.0	117	135	46	8	18.0	48	8.0	117	135

CRUISE SPEEDS

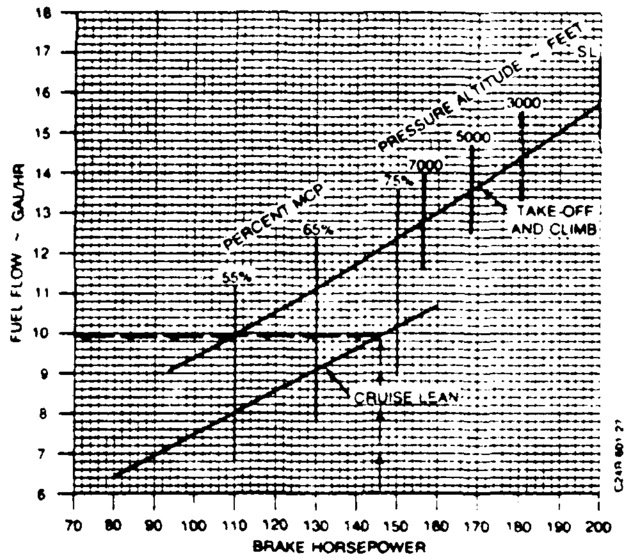


MANIFOLD PRESSURE vs RPM



FUEL FLOW vs BRAKE HORSEPOWER

EXAMPLE	
BRAKE HORSEPOWER	146 HP
CONDITION	LEVEL FLIGHT CRUISE LEAN
FUEL FLOW	9.95 GAL/HR

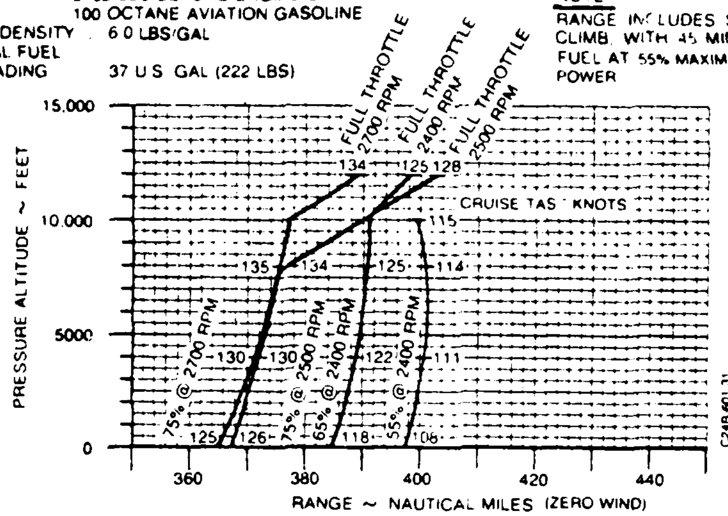


RANGE PROFILE - 37 GALLONS

ASSOCIATED CONDITIONS — STANDARD DAY

WEIGHT: 2758 LBS BEFORE ENGINE START
FUEL: 100 OCTANE AVIATION GASOLINE
FUEL DENSITY: 6.0 LBS/GAL
INITIAL FUEL LOADING: 37 U.S. GAL (222 LBS)

NOTE
RANGE INCLUDES START, TAXI, CLIMB, WITH 45 MINUTES RESERVE FUEL AT 55% MAXIMUM CONTINUOUS POWER

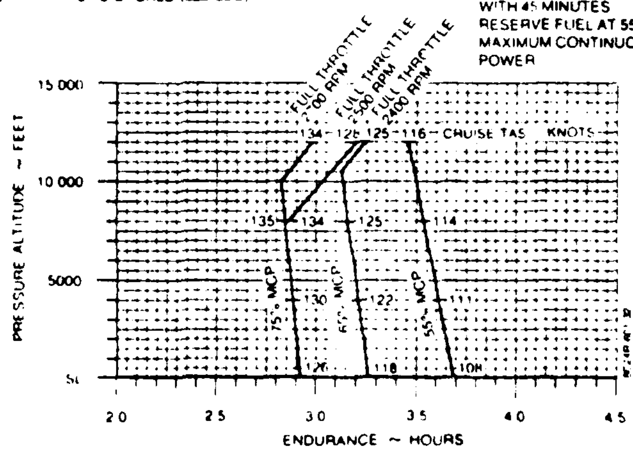


ENDURANCE PROFILE—37 GALLONS

ASSOCIATED CONDITIONS — STANDARD DAY

WEIGHT: 27__ LBS BEFORE ENGINE START
FUEL: 100 OCTANE AVIATION GASOLINE
FUEL DENSITY: 6.0 LBS/GAL
INITIAL FUEL LOADING: 37 U.S. GALS (222 LBS)

NOTE
ENDURANCE INCLUDES START, TAXI, AND CLIMB, WITH 45 MINUTES RESERVE FUEL AT 55% MAXIMUM CONTINUOUS POWER



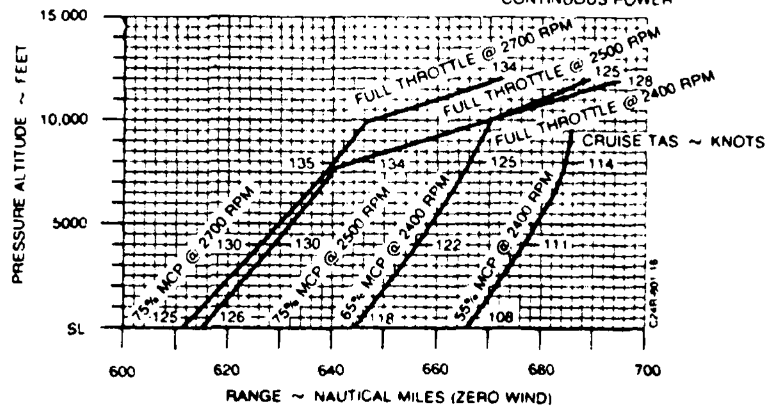
RANGE PROFILE—57 GALLONS

STANDARD DAY

ASSOCIATED CONDITIONS	
WEIGHT	2758 LBS BEFORE ENGINE START
FUEL	100 OCTANE AVIATION GASOLINE
FUEL DENSITY	6.0 LBS/GAL
INITIAL FUEL LOADING	57 U.S. GAL (342 LBS)

NOTE

RANGE INCLUDES START, TAXI AND CLIMB WITH 45 MINUTES RESERVE FUEL AT 55% MAXIMUM CONTINUOUS POWER



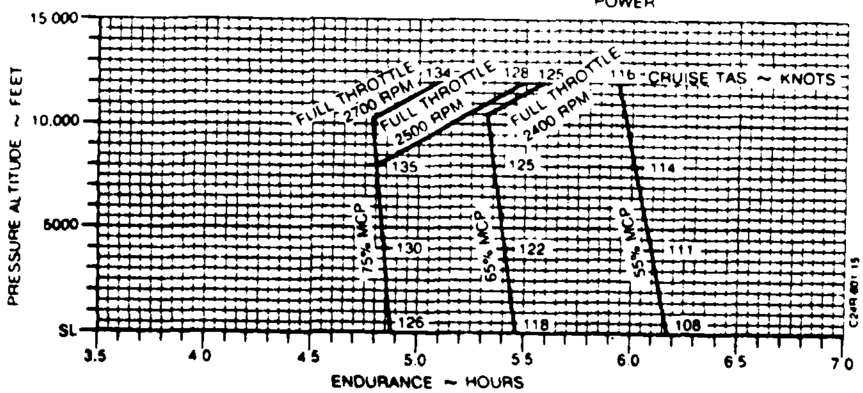
ENDURANCE PROFILE—57 GALLONS

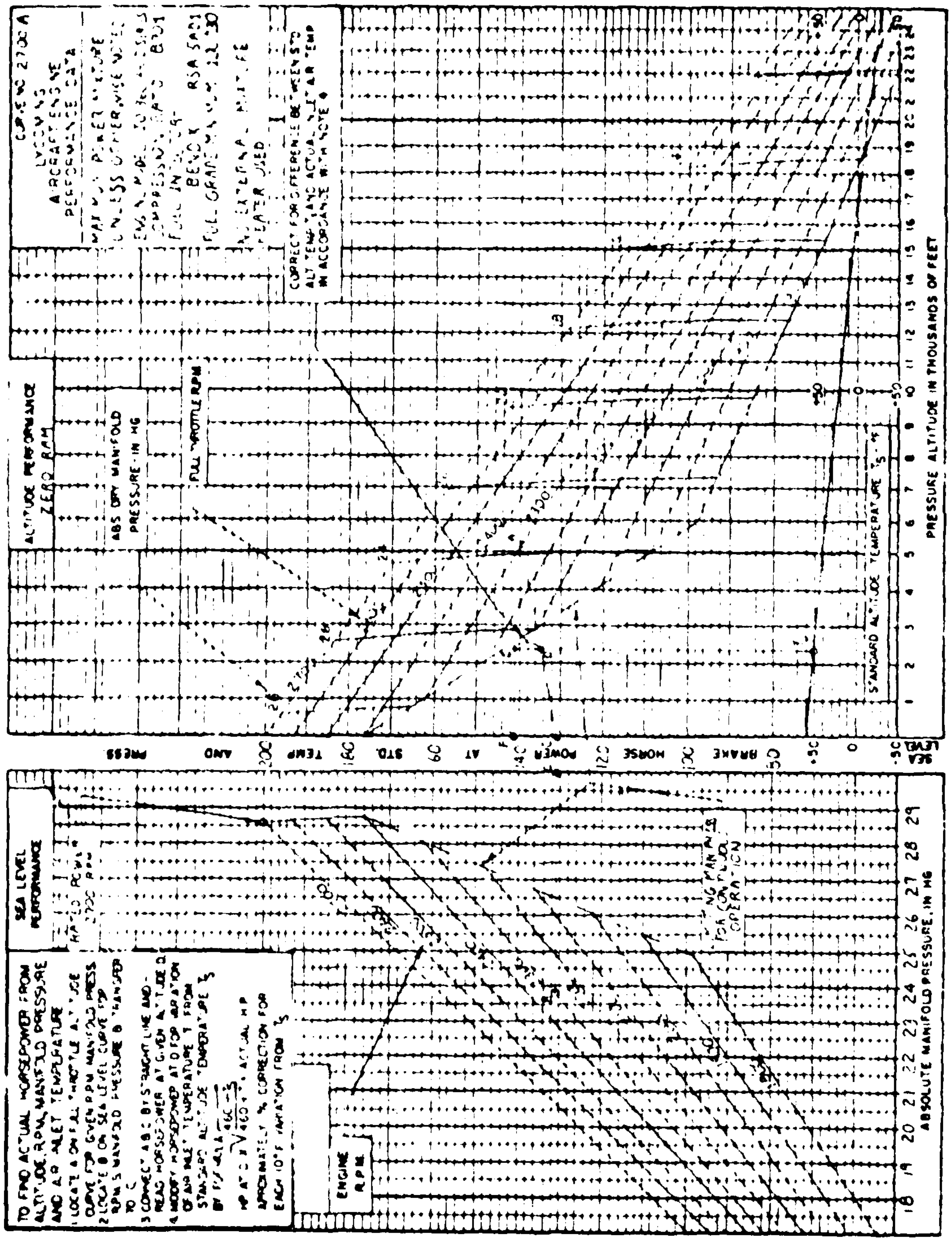
STANDARD DAY (ISA)

ASSOCIATED CONDITIONS	
WEIGHT	2758 LBS BEFORE ENGINE START
FUEL	100 OCTANE AVIATION GASOLINE
FUEL DENSITY	6.0 LBS/GAL
INITIAL FUEL LOADING	57 U.S. GAL (342 LBS)

NOTE

ENDURANCE INCLUDES START, TAXI AND CLIMB, WITH 45 MINUTES RESERVE FUEL AT 55% MAXIMUM CONTINUOUS POWER





Data Source: Courtesy of AVCO Lycoming Williamsport Division

2 BLADES 91 ACTIVITY FACTOR
PROPELLER EFFICIENCY

J	Cp: 0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21
0.1000	[illegible]	[illegible]	[illegible]	[illegible]	0.1050	0.0972	0.0867	[illegible]	[illegible]	0.0659
0.2000	0.4511	[illegible]	[illegible]	0.2616	0.2138	0.1834	0.1682	0.1545	0.1438	0.1334
.3000	0.5917	0.5246	[illegible]	0.3875	0.3168	0.2726	0.2461	0.2259	0.2101	0.1960
0.4000	0.6924	0.6431	[illegible]	.5027	0.4135	0.3597	0.3249	0.2955	0.2759	0.2569
0.5000	0.7596	0.7173	[illegible]	0.6012	0.5056	0.4423	0.3995	0.3662	0.3433	0.3168
0.6000	0.7993	0.7756	0.7347	[illegible]	0.5894	0.5201	0.4718	0.4349	0.4072	0.3739
0.7000	0.8245	0.8175	0.7431	[illegible]	0.6657	0.5932	0.5410	0.5010	0.4695	0.4322
0.8000	0.8390	0.8406	[illegible]	[illegible]	0.7336	0.6616	0.6053	0.5628	0.5256	0.4961
0.9000	0.8449	0.8537	[illegible]	[illegible]	0.7830	0.7248	0.6641	0.6234	0.5846	0.5410
1.0000	0.8470	0.8651	[illegible]	0.8273	0.8137	0.7695	0.7213	0.6736	0.6385	0.5927
1.1000	0.8437	0.8692	[illegible]	0.8448	0.8310	0.7939	0.7631	0.7237	0.6876	0.6383
1.2000	0.8383	0.8721	0.8670	0.8552	0.8441	0.8211	0.7915	0.7677	0.7318	0.6838
1.3000	0.8293	0.8705	[illegible]	0.8625	0.8548	0.8374	0.8173	0.7992	0.7721	0.7237
1.4000	0.8200	[illegible]	0.8722	0.8666	0.8617	0.8514	0.8345	0.8233	0.8007	0.7551
1.5000	0.8063	[illegible]	0.8719	0.8693	0.8685	0.8600	0.8470	0.8369	0.8203	0.7827
1.6000	0.7926	0.8543	[illegible]	0.8705	0.8708	0.8659	0.8573	0.8485	0.8347	0.8084
1.7000	0.7785	0.8465	0.8665	0.8693	0.8715	0.8700	0.8632	0.8573	0.8455	0.8297
1.8000	0.7618	0.8371	0.8619	0.8663	0.8711	0.8715	0.8675	0.8624	0.8541	0.8437
1.9000	0.7453	0.8256	0.8569	0.8567	0.8693	0.8705	0.8698	0.8673	0.8611	0.8540
2.0000	0.7273	0.8102	[illegible]	0.8516	0.8685	0.8695	0.9694	0.8697	0.8635	0.8508

BLADE ANGLE AT 0.75R

J	Cp: 0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21
0.1000	10.39	16.09	[illegible]	[illegible]	26.46	23.63	30.19	31.71	33.15	34.74
0.2000	11.00	16.40	[illegible]	[illegible]	26.68	28.75	30.39	31.90	[illegible]	[illegible]
0.3000	11.80	16.59	[illegible]	[illegible]	26.92	28.96	30.71	32.24	[illegible]	[illegible]
0.4000	12.79	17.32	[illegible]	[illegible]	27.18	29.31	31.09	[illegible]	[illegible]	[illegible]
.5000	13.87	18.52	[illegible]	[illegible]	27.57	29.67	31.52	[illegible]	[illegible]	[illegible]
0.6000	15.25	[illegible]	22.73	25.59	28.01	30.11	32.05	33.56	35.34	37.05
0.7000	16.92	20.70	23.64	26.20	28.61	30.63	32.59	34.11	35.96	37.59
0.8000	18.85	21.97	24.53	26.89	29.21	31.22	33.20	34.79	36.54	38.16
0.9000	20.68	23.28	25.64	27.63	30.01	31.90	33.90	35.43	37.19	38.79
1.0000	22.40	24.69	[illegible]	28.81	30.83	32.76	34.59	36.11	[illegible]	39.38
1.1000	24.02	26.13	[illegible]	[illegible]	31.76	33.66	35.38	[illegible]	[illegible]	[illegible]
1.2000	25.76	27.64	[illegible]	[illegible]	32.87	34.59	36.16	37.53	[illegible]	[illegible]
1.3000	27.41	29.05	[illegible]	32.26	33.89	35.49	36.97	38.34	[illegible]	[illegible]
1.4000	[illegible]	[illegible]	[illegible]	[illegible]	34.98	36.50	37.63	39.17	[illegible]	[illegible]
1.5000	30.63	[illegible]	[illegible]	[illegible]	36.04	37.52	38.77	39.36	[illegible]	42.75
1.6000	[illegible]	[illegible]	[illegible]	[illegible]	37.12	38.55	39.70	[illegible]	42.27	43.46
1.7000	33.56	34.74	[illegible]	[illegible]	38.25	39.50	40.70	41.77	[illegible]	44.16
1.8000	35.13	[illegible]	[illegible]	38.27	39.43	40.59	41.69	42.65	[illegible]	44.91
1.9000	36.52	37.50	[illegible]	39.52	40.53	41.64	42.63	43.63	44.66	45.63
2.0000	37.95	38.85	39.91	40.73	41.69	42.70	43.72	44.60	45.51	46.47

$J = \dfrac{\text{VTAS (fps) } 60}{N\ D_p}$

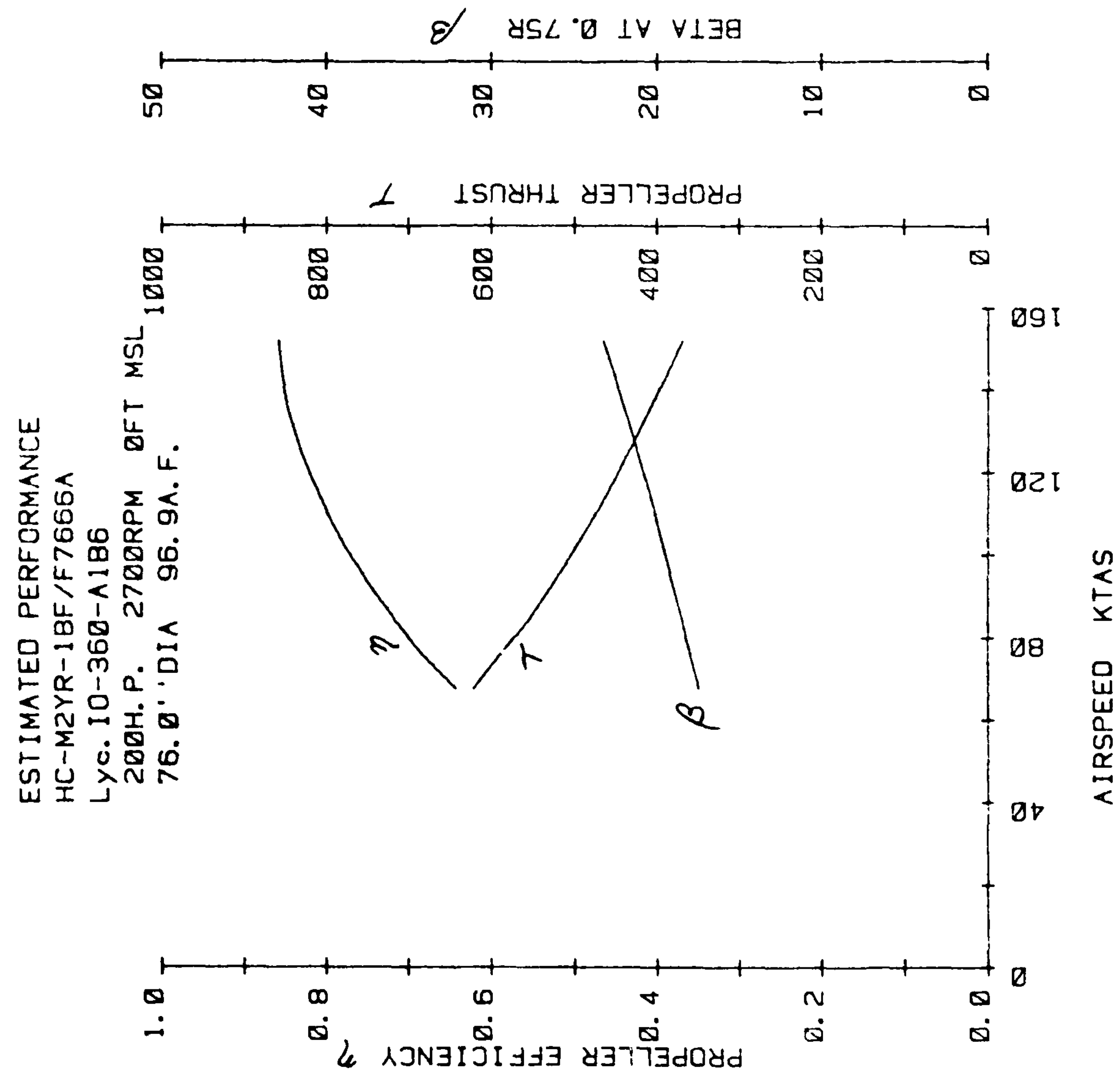
$C_p = \dfrac{550\ BHP_t\ (60)^3}{.002377\ \sigma\ N^3\ D_p^5}$

N = RPM

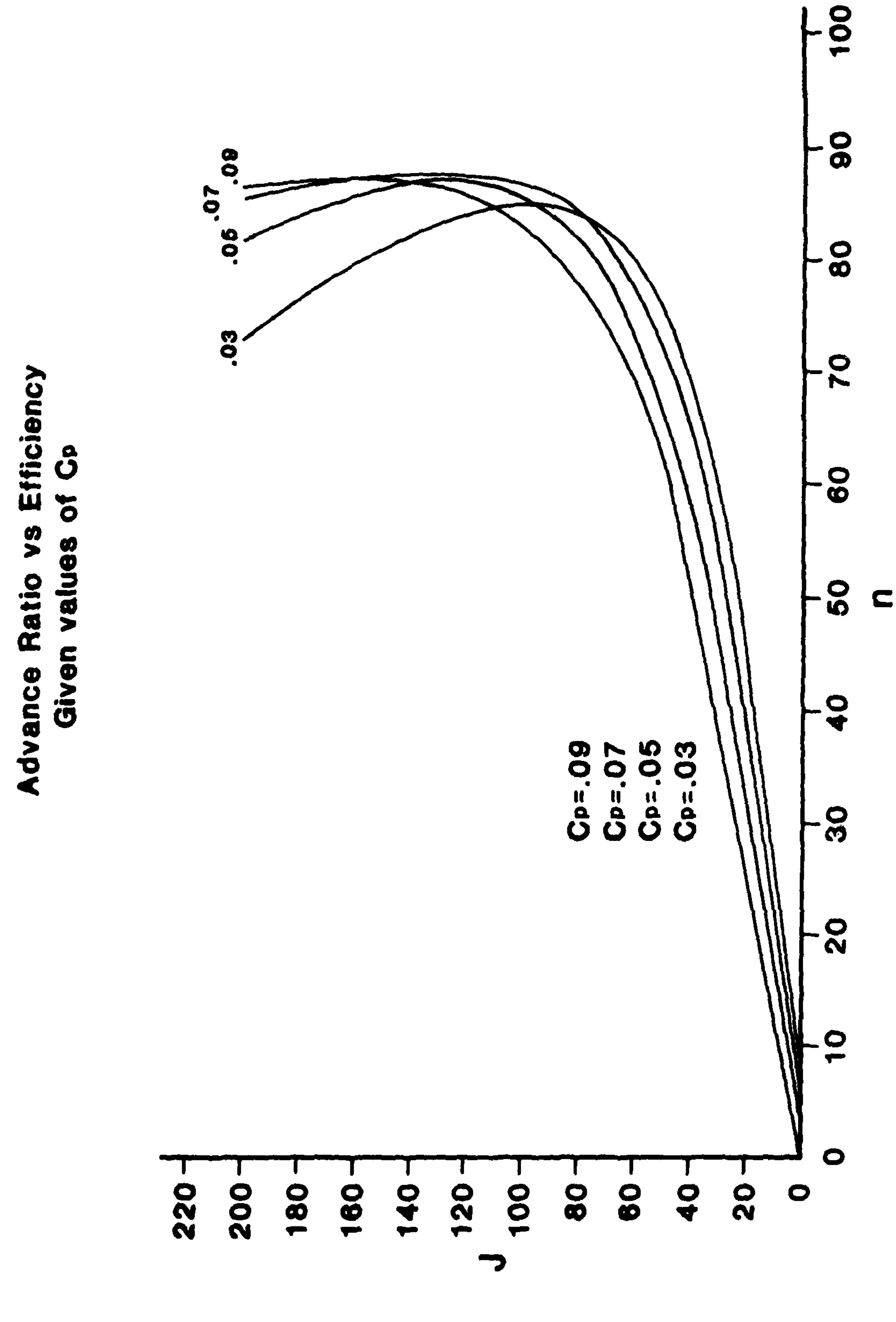
D_p = propeller diameter (ft)

NOTE: Reduce efficiency by 5% for installation blockage effect.

Data Source: Courtesy of TRW Hartzell Propeller



Data Source: Courtesy of TRW Hartzell Propeller


Advance Ratio vs Efficiency
Given values of Cp
Cp=.09
Cp=.07
Cp=.05
Cp=.03
.03
.05
.07
.09
J
n
0
20
40
60
80
100
120
140
160
180
200
220
0
10
20
30
40
50
60
70
80
90
100

BASIC EMPTY WEIGHT AND BALANCE

SIERRA 200 C24R. SER. NO. MC-513 REG. NO. N18892 DATE 10-9-80

JACK POINT LOCATION		PREPARED BY
FORWARD	129 2	Company
AFT	285 9	Signature

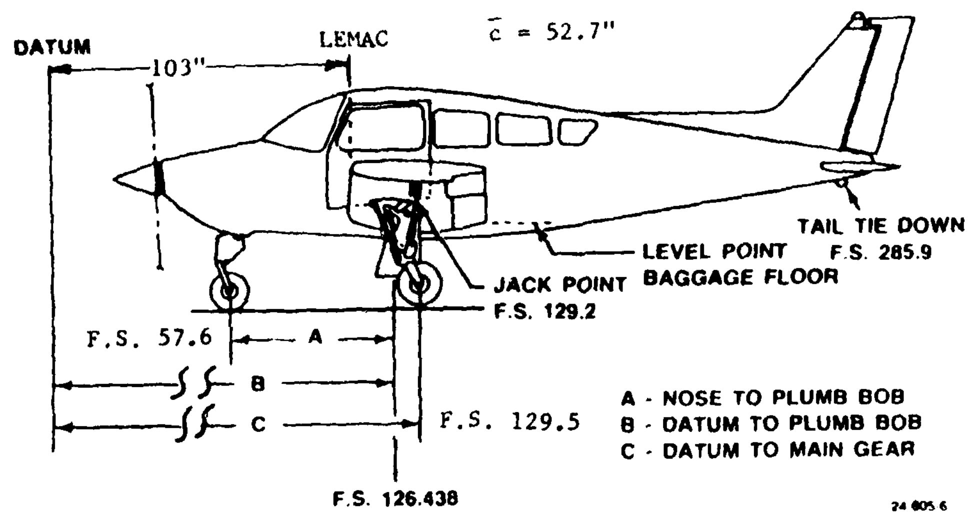
REACTION WHEEL - JACK POINTS	SCALE READING	TARE	NET WEIGHT	ARM	MOMENT
LEFT MAIN	674.5				
RIGHT MAIN	662.0			129.251	172744
NOSE OR TAIL	442.5			57.313	25361
TOTAL (AS WEIGHED)	1779.0		1779.0		198105
Space below provided for additions and subtractions to as - weighed condition					
LESS 8 QT OIL			- 15 0	50	- 750
Plus: Fire Extinguisher			+2.7	107.0	288.9
ELT			+ .6	259.0	155.4
EMPTY WEIGHT			1767.3	111.92	197799
ENGINE OIL			15 0	50 0	750
UNUSABLE FUEL			15 6	125 0	1950
BASIC EMPTY WEIGHT			1797.9	111.52	200499

BASIC EMPTY WEIGHT AND BALANCE

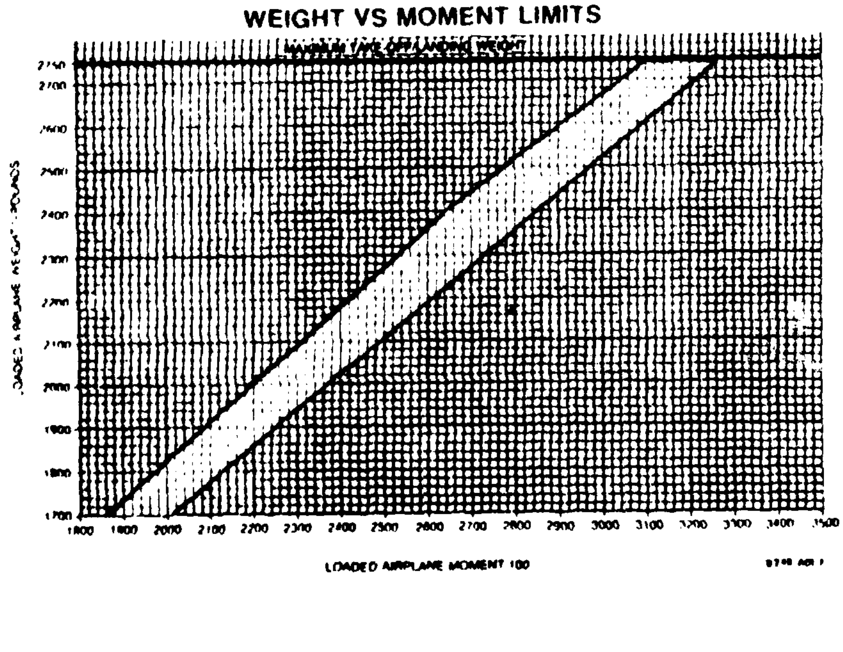
SIERRA 200 C24R SER. NO. MC-690 REG. NO. N6636D DATE 10-9-80

JACK POINT LOCATION		PREPARED BY
FORWARD	129 2	Company
AFT	285 9	Signature

REACTION WHEEL - JACK POINTS	SCALE READING	TARE	NET WEIGHT	ARM	MOMENT
LEFT MAIN	719.0				
RIGHT MAIN	717.5			129.188	185579
NOSE OR TAIL	396.0			56.563	22399
TOTAL (AS WEIGHED)	1832.5		1832.5		207978
Space below provided for additions and subtractions to as - weighed condition					
LESS 8 QT OIL			- 15.0	50	- 750
Less Aft Ballast Weight			-10.1	288.42	-2913
Plus: ELT			+ 2.7	259.0	+ 699
ELT (correction)			+ 1.0	259.0	+ 259
Fire Extinguisher			+ 5.0	126.0	+ 630
EMPTY WEIGHT			1816.1	113.38	205903
ENGINE OIL			15 0	50 0	750
UNUSABLE FUEL			15 6	125 0	1950
BASIC EMPTY WEIGHT			1846.7	112.96	208603



WEIGHT VS MOMENT LIMITS



MOMENT LIMITS vs WEIGHT

Weight	Minimum Moment/100	Maximum Moment/100	Weight	Minimum Moment/100	Maximum Moment/100	Weight	Minimum Moment/100	Maximum Moment/100
1700	1870	2011	2100	2310	2484	2500	2775	2958
1710	1881	2023	2110	2321	2496	2510	2788	2969
1720	1892	2035	2120	2332	2508	2520	2801	2981
1730	1903	2047	2130	2343	2520	2530	2814	2993
1740	1914	2056	2140	2354	2532	2540	2826	3005
1750	1925	2070	2150	2365	2543	2550	2841	3017
1760	1936	2082	2160	2376	2555	2560	2854	3028
1770	1947	2094	2170	2387	2567	2570	2867	3040
1780	1958	2106	2180	2398	2579	2580	2880	3052
1790	1969	2118	2190	2409	2591	2590	2894	3064
1800	1980	2129	2200	2420	2603	2600	2907	3076
1810	[illegible]	2141	2210	2431	2614	2610	2920	3088
1820	2002	2153	2220	2442	2626	2620	2933	3099
1830	[illegible]	2165	2230	2453	2638	2630	2947	3111
1840	2024	2177	2240	2464	2650	2640	2960	3123
1850	2035	2189	2250	2475	2662	2650	2973	3135
1860	2046	2200	2260	2486	2674	2660	2987	3147
1870	2057	2212	2270	2497	2685	2670	3000	3159
1880	2068	2224	2280	2508	2697	2680	3013	3170
1890	2079	2236	2290	2519	2709	2690	3027	3182
1900	2090	2248	2300	2530	2721	2700	3040	3194
1910	2101	2260	2310	2541	2733	2710	3054	3206
1920	2112	2271	2320	2552	2745	2720	3067	3218
1930	2123	2283	2330	2563	2756	2730	3081	3230
1940	2134	2295	2340	2574	2768	2740	3094	3241
1950	2145	2307	2350	2585	2780	2750	3108	3253
1960	2156	2319	2360	2596	2792			
1970	2167	2331	2370	2607	2804			
1980	2178	2342	2380	2619	2815			
1990	2189	2354	2390	2632	2827			
2000	2200	2366	2400	2645	2839			
2010	2211	2378	2410	2658	2851			
2020	2222	2390	2420	2671	2863			
2030	2233	2401	2430	2684	2875			
2040	2244	2413	2440	2697	2887			
2050	2255	2425	2450	2710	2898			
2060	2266	2437	2460	2723	2910			
2070	2277	2449	2470	2736	2922			
2080	2288	2461	2480	2749	2934			
2090	2299	2472	2490	2762	2946			

The above weight and moment limits are based on the following weight and center of gravity limit data

NORMAL CATEGORY

WEIGHT CONDITION	FWD CG LIMIT	AFT CG LIMIT
2750 lb (Max. Take-Off or Landing)	113.0	118.3
2375 lb or less	110.0	118.3

COMPUTING PROCEDURE

1 Record the Basic Empty Weight and Moment from the Basic Empty Weight and Balance form (or from the latest superseding form) under the Basic Empty Condition block The moment must be divided by 100 to correspond to Useful Load Weights and Moments tables

2 Record the weight and corresponding moment from the appropriate table of each of the useful load items (except fuel) to be carried in the airplane

3 Total the weight column and moment column. The SUB-TOTALS are the ZERO FUEL CONDITION

4 Determine the weight and corresponding moment for the fuel loading to be used This fuel loading includes fuel for the flight, plus that required for start, taxi, and takeoff. Add the Fuel Loading Condition to Zero Fuel Condition to obtain the SUB-TOTAL Ramp Condition.

5 Subtract the fuel to be used for start, taxi, and takeoff to arrive at the SUB-TOTAL Take-off Condition.

6 Subtract the weight and moment of fuel to be used from the take-off weight and moment The SUB-TOTAL Condition of No 3 and No 5, as well as the landing condition moment, must be within the minimum and maximum moments shown on the Moment Limits vs Weight graph for that weight If the total moment is less than the minimum moment allowed, useful load items must be shifted aft, or forward load items reduced If the total moment is greater than the maximum moment allowed, useful load items must be shifted forward, or aft load items reduced If the quantity or location of load items is changed, the calculations must be revised and the moments rechecked

WEIGHT AND BALANCE LOADING FORM

MODEL *SIERRA C24R* DATE *X-X-XX*

SERIAL NO. *XXX* REG. NO. *NXXXXX*

ITEM	WEIGHT	MOM/100
1 BASIC EMPTY CONDITION	*1720*	*1912*
2 FRONT SEAT OCCUPANTS	*340*	*374*
3 3rd & 4th SEAT OCCUPANTS	*340*	*482*
4 5th & 6th SEAT OCCUPANTS	*130*	*222*
5 BAGGAGE	—	—
6 CARGO	—	—
7 SUB TOTAL	*2530*	*2990*
8 FUEL LOADING *(32 gal)*	*192*	*225*
9. SUB TOTAL RAMP CONDITION	*2722*	*3215*
10. *LESS FUEL FOR START, TAXI, and TAKE-OFF	*-8*	*-9*
11 SUB TOTAL TAKE-OFF CONDITION	*2714*	*3206*
12 LESS FUEL TO DESTINATION *(25 gal)*	*-150*	*-176*
13 LANDING CONDITION	*2564*	*3030*

SAMPLE

*Fuel for start, taxi and take-off is normally 8 lbs at an average mom/100 of 9.

WEIGHT AND BALANCE LOADING FORM

MODEL *SIERRA C24R* ______ DATE ______

SERIAL NO. ______ REG. NO. ______

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION		
2. FRONT SEAT OCCUPANTS		
3. 3rd & 4th SEAT OCCUPANTS		
4. 5th & 6th SEAT OCCUPANTS		
5. BAGGAGE		
6. CARGO		
7. SUB TOTAL		
8. FUEL LOADING		
9. SUB TOTAL RAMP CONDITION		
10. *LESS FUEL FOR START, TAXI, AND TAKE-OFF		
11. SUB TOTAL TAKE-OFF CONDITION		
12. LESS FUEL TO DESTINATION		
13. LANDING CONDITION		

*Fuel for start, taxi and take-off is normally 8 lbs at an average mom/100 of 9.

Section VI
Wt & Bal/Equip List

BEECHCRAFT
Sierra C24R

WEIGHT AND BALANCE LOADING FORM

MODEL *SIERRA C24R* ______ DATE ______

SERIAL NO. ______ REG. NO. ______

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION		
2. FRONT SEAT OCCUPANTS		
3. 3rd & 4th SEAT OCCUPANTS		
4. 5th & 6th SEAT OCCUPANTS		
5. BAGGAGE		
6. CARGO		
7. SUB TOTAL		
8. FUEL LOADING		
9. SUB TOTAL RAMP CONDITION		
10. *LESS FUEL FOR START, TAXI, AND TAKE-OFF		
11. SUB TOTAL TAKE-OFF CONDITION		
12. LESS FUEL TO DESTINATION		
13. LANDING CONDITION		

*Fuel for start, taxi and take-off is normally 8 lbs at an average mom/100 of 9.

6-16

November, 1980

USEFUL LOAD WEIGHTS AND MOMENTS

OCCUPANTS

	FRONT SEATS			3RD AND 4TH SEATS	
	*FWD POS.		*AFT POS.	BENCH SEAT	SPLIT SEAT
	††ARM **104	†ARM **105	ARM **112	ARM **142	ARM **144
WEIGHT	MOM/100	MOM/100	MOM/100	MOM/100	MOM/100
120	125	126	134	170	173
130	135	137	146	185	187
140	146	147	157	199	202
150	156	158	168	213	216
160	166	168	179	227	230
170	177	179	190	241	245
180	187	189	202	256	259
190	198	200	213	270	274
200	208	210	224	284	288

†Effective MC 449, MC 452 thru MC 555
††Effective MC 556 and after
*Reclining seat with back in full up position
**Values computed from a C.G. criterion based on a 170 pound male. Differences in physical characteristics can cause variation in center of gravity location.

USEFUL LOAD WEIGHTS AND MOMENTS

5th & 6th SEATS ARM 171			
Weight	Moment/100	Weight	Moment/100
80	137	140	239
90	154	150	257
100	171	160	274
110	188	170	291
120	205	180	308
130	222	190	325
		200	342

USABLE FUEL
ARM 117

GALLONS	WEIGHT	MOMENT/100
5	30	35
10	60	70
15	90	105
20	120	140
22	132	154
25	150	176
27	162	189
30	180	211
32	192	225
35	210	246
37	222	259
40	240	281
45	270	316
50	300	351
52	312	365
57	342	400

USEFUL LOAD WEIGHTS AND MOMENTS

BAGGAGE

ARM 167

Weight	Moment/100	Weight	Moment/100
10	17	140	234
20	33	150	251
30	50	160	267
40	67	170	284
50	84	180	301
60	100	190	317
70	117	200	334
80	134	210	351
90	150	220	367
100	167	230	384
110	184	240	401
120	200	250	418
130	217	260	434
		270	451

SPECIFICATIONS

AND

WEIGHT AND BALANCE

FOR THE BEECHCRAFT SUNDOWNER 180 C23

AERO 495

FALL 1982

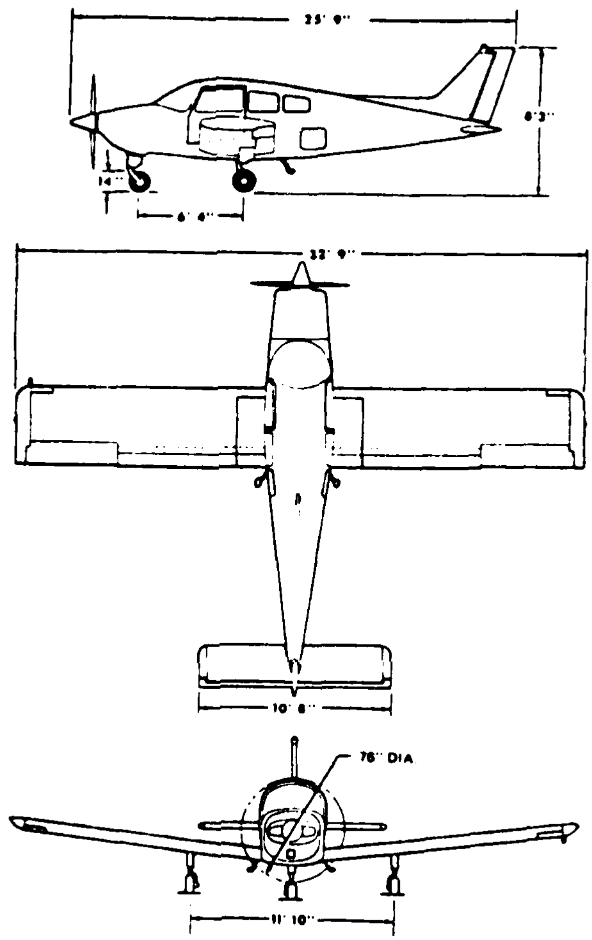
CONTENTS

I. GEOMETRY

A. Three View

BEECHCRAFT Sundowner 180
C23 (M-1285 and After)

Section I
General



THREE VIEW

C23-607-10

B. Wing

Span, b	32'9"
Mean Aerodynamic Chord, MAC	52.7"
Area, S	146 ft^2
Aspect Ratio, AR	7.5
Taper Ratio,	1.0
Dihedral	6.0°

II. GENERAL

A. Engine, Avco Lycoming, 4 cylinder 0-360-A

Maximum continuous power (at sea level)	180 HP @ 2,700 rpm

B. Propeller, two bladed, fixed pitch Sensenich, diameter 76"

Restricted Operation	2,150-2,350 rpm

C. Capacities

Crew and Pilot	4
Oil	8 quarts
Fuel	59.8 gallons
	52 gallons usable

D. Design Load Factor

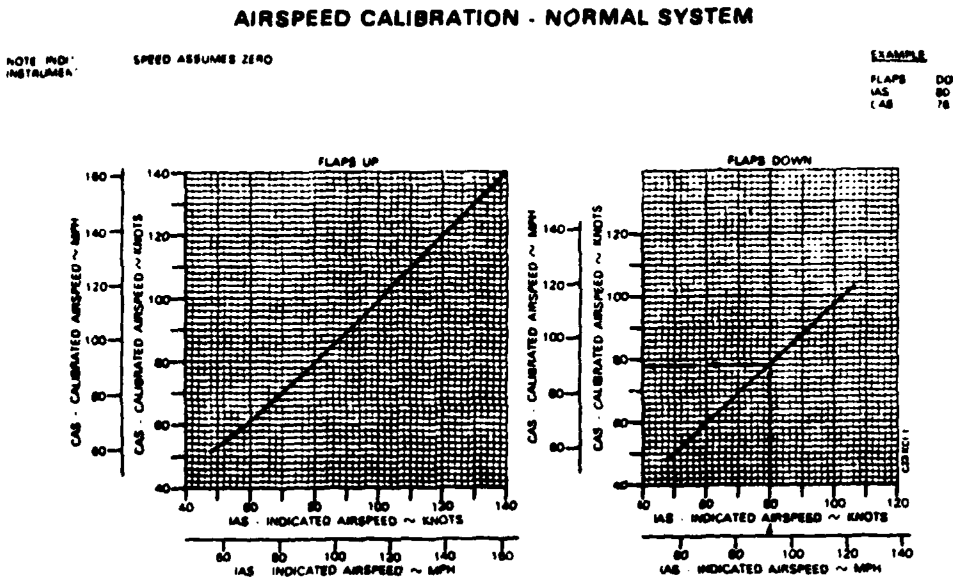
(2,450 pounds, flaps up)	+3.8 to -1.9

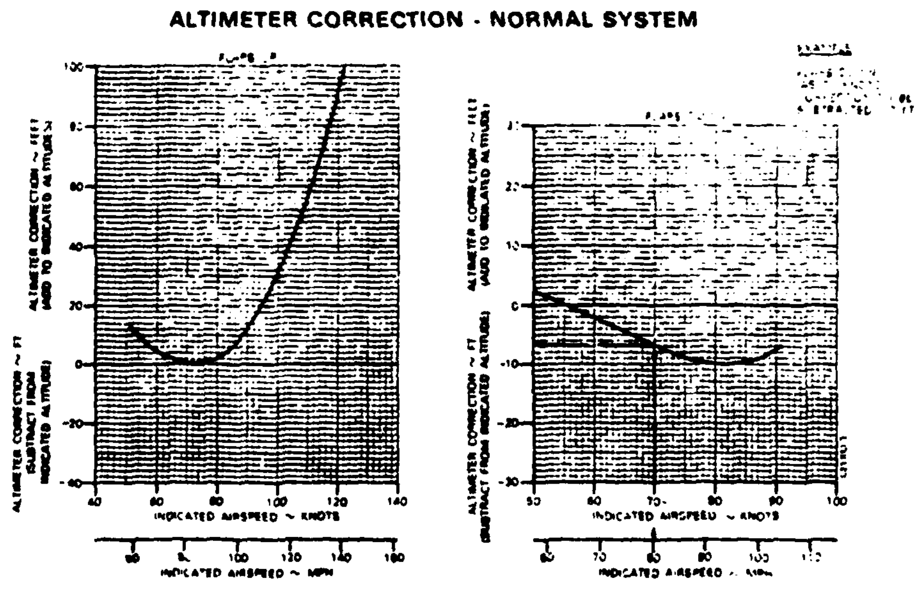
E. Airspeeds

Takeoff (flaps up)	65 KTS/75 MPH
Climb (best rate)	75 KTS/86 MPH
Climb (best angle)	69 KTS/79 MPH
Max Glide	78 KTS/90 MPH
Emergency App.	68 KTS/78 MPH
Normal App. (flaps down)	68 KTS/78 MPH
Normal App. (flaps up)	80 KTS/92 MPH
1G Stall Speed (flaps up, 2,450 lbs)	63 KTS/72 MPH
Maximum permissible speed, V_{NE}	152 KTS/175 MPH

III. Performance Charts

A. Pitot-Static Calibration Data





B. Power-Off Stall Speeds

POWER OFF STALL SPEEDS

(WEIGHT 2450 LBS)

Maximum altitude loss during a normal stall recovery is approximately 300 ft.

ANGLE OF BANK			
LEVEL	30°	45°	60°
FLAPS-UP			
72 mph 63 kts	77 mph 67 kts	85 mph 74 kts	101 mph 88 kts
FLAPS - DOWN (35°)			
59 mph 51 kts	63 mph 55 kts	70 mph 61 kts	83 mph 72 kts

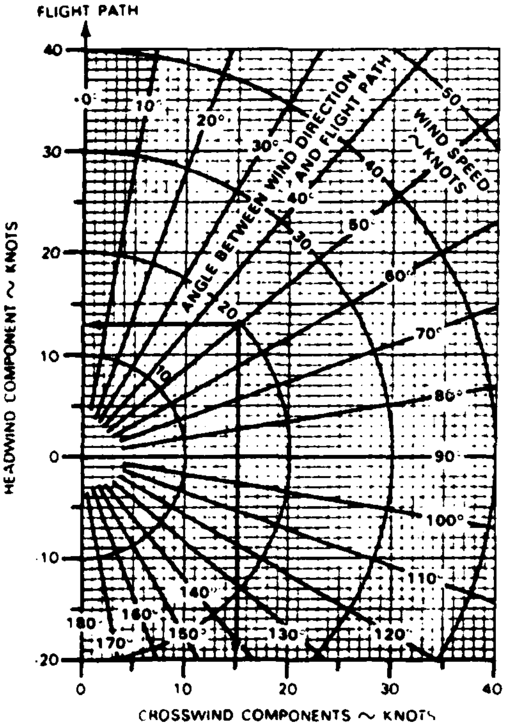
C. Crosswind Chart

WIND COMPONENTS

Demonstrated Crosswind Component Is 17kts/20mph

EXAMPLE

WIND SPEED	20 KTS
ANGLE BETWEEN WIND DIRECTION AND FLIGHT PATH	50°
HEADWIND COMPONENT	13 KTS
CROSSWIND COMPONENT	15 KTS



D. Takeoff and Landing Data

TAKE-OFF DISTANCE – HARD SURFACE

ASSOCIATED CONDITIONS

POWER FULL THROTTLE
MIXTURE LEAN TO MAXIMUM RPM, THEN ENRICH SLIGHTLY
FLAPS UP
RUNWAY LEVEL, DRY, HARD SURFACE
WEIGHT 2450 LBS

TAKE-OFF SPEEDS

LIFT OFF 65 KTS 75 MPH
AT 50 FT 74 KTS 85 MPH

WIND COMPONENT DOWN RUNWAY KNOTS	SEA LEVEL				2000 FT				4000 FT				6000 FT				8000 FT			
	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET
0	23	-5	917	1592	16	-9	1048	1805	9	-13	1196	2051	2	-17	1368	2334	-6	-21	1580	2862
	41	5	1020	1767	34	1	1165	2007	27	-3	1333	2284	20	-7	1518	2604	13	-11	1756	2976
	59	15	1130	1955	52	11	1293	2224	45	7	1481	2535	38	3	1701	2894	31	-1	1967	3311
	77	25	1248	2155	70	21	1429	2465	63	17	1640	2802	56	13	1866	3204	49	9	2173	3671
	95	35	1373	2369	88	31	1575	2701	81	27	1809	3087	74	23	2083	3635	67	19	2404	4086
15	23	-5	720	1404	16	-9	836	1683	9	-13	981	1883	2	-17	1108	2149	-6	-21	1279	2456
	41	5	813	1618	34	1	936	1842	27	-3	1077	2102	20	-7	1243	2402	13	-11	1438	2750
	59	15	904	1783	52	11	1042	2046	45	7	1202	2338	38	3	1380	2674	31	-1	1608	3067
	77	25	1003	1980	70	21	1196	2261	63	17	1336	2587	56	13	1540	2985	49	9	1793	3408
	95	35	1107	2180	88	31	1279	2402	81	27	1479	2856	74	23	1714	3277	67	19	1980	3768
30	23	-5	560	1337	16	-9	647	1523	9	-13	751	1730	2	-17	873	1988	-6	-21	1017	2278
	41	5	628	1490	34	1	720	1700	27	-3	847	1944	20	-7	986	2227	13	-11	1149	2566
	59	15	702	1664	52	11	816	1880	45	7	949	2164	38	3	1107	2483	31	-1	1292	2864
	77	25	782	1829	70	21	910	2084	63	17	1060	2401	56	13	1237	2758	49	9	1446	3174
	95	35	868	2017	88	31	1011	2311	81	27	1180	2653	74	23	1378	3052	67	19	1613	3518

LANDING DISTANCE – HARD SURFACE

ASSOCIATED CONDITIONS

POWER IDLE
MIXTURE RICH
FLAPS 35°
RUNWAY LEVEL, DRY, HARD SURFACE
WEIGHT 2450 LBS

LANDING SPEEDS

AT 50 FT 66 KTS 76 MPH
TOUCHDOWN 61 KTS 70 MPH

WIND COMPONENT DOWN RUNWAY KNOTS	SEA LEVEL				2000 FT				4000 FT				6000 FT				8000 FT			
	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET	OAT °F	OAT °C	GROUND ROLL FEET	TOTAL OVER 50 FT OBSTACLE FEET
0	23	-5	654	1408	16	-9	693	1467	9	-13	736	1532	2	-17	780	1600	-6	-21	828	1672
	41	5	678	1446	34	1	719	1508	27	-3	763	1575	20	-7	810	1644	13	-11	861	1724
	59	15	703	1484	52	11	745	1548	45	7	791	1617	38	3	840	1691	31	-1	894	1776
	77	25	727	1521	70	21	771	1587	63	17	819	1658	56	13	871	1740	49	9	926	1827
	95	35	751	1560	88	31	798	1626	81	27	847	1703	74	23	901	1788	67	19	958	1882
15	23	-5	498	1190	16	-9	530	1243	9	-13	557	1302	2	-17	607	1366	-6	-21	650	1431
	41	5	518	1222	34	1	553	1280	27	-3	582	1342	20	-7	634	1407	13	-11	679	1478
	59	15	538	1257	52	11	576	1317	45	7	617	1381	38	3	661	1448	31	-1	708	1520
	77	25	560	1291	70	21	600	1354	63	17	642	1420	56	13	688	1489	49	9	737	1565
	95	35	582	1326	88	31	623	1390	81	27	667	1458	74	23	715	1530	67	19	766	1614
30	23	-5	361	1005	16	-9	390	1049	9	-13	421	1095	2	-17	456	1149	-6	-21	493	1211
	41	5	379	1032	34	1	409	1078	27	-3	443	1127	20	-7	479	1188	13	-11	518	1252
	59	15	397	1060	52	11	429	1107	45	7	464	1163	38	3	502	1226	31	-1	544	1293
	77	25	416	1088	70	21	449	1138	63	17	486	1200	56	13	526	1264	49	9	569	1334
	95	35	434	1114	88	31	469	1172	81	27	508	1235	74	23	550	1303	67	19	595	1375

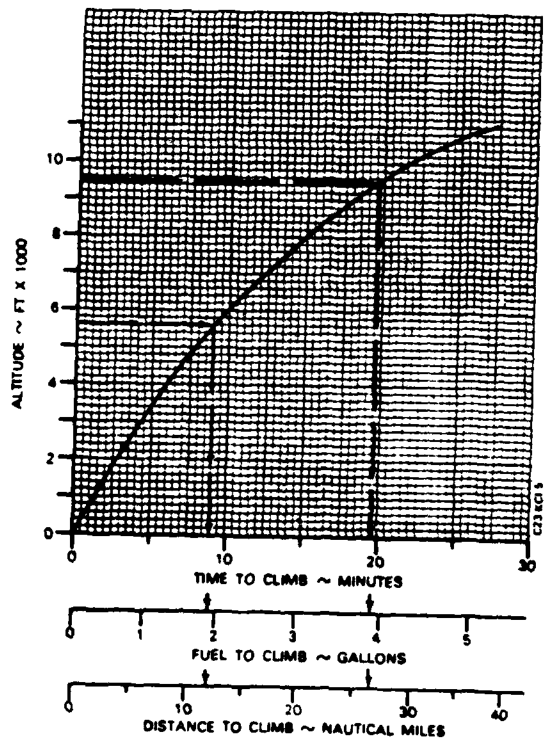
E. Climb Data

TIME, FUEL, AND DISTANCE TO CLIMB

ASSOCIATED CONDITIONS	
POWER	FULL THROTTLE
MIXTURE	LEAN TO MAXIMUM RPM THEN ENRICH SLIGHTLY
FLAPS	UP
WEIGHT	2450 LBS
STANDARD DAY	

EXAMPLE	
AIRPORT PRESSURE ALTITUDE	5650 FT
CRUISE ALTITUDE	9500 FT
TIME TO CLIMB 20-9 =	11 MIN
FUEL TO CLIMB 3.9-1.9 =	2 GAL
DIST TO CLIMB 27-12 =	15 NM

78 KTS/90 MPH



F. Cruise Data

CRUISE PERFORMANCE

STANDARD DAY

ALTITUDE	POWER SETTINGS			TAS	RANGE - N.M. INITIAL FUEL ONBOARD (USABLE)	
FEET	THROTTLE SETTINGS RPM	BHP	FUEL FLOW GAL/HR	KTS/MPH	37 GAL	57 GAL
2500	2700 2500 2300	88 73 60	13.2 10.4 8.2	124/143 113/130 100/115	278 318 365	465 536 595
3500	2700 2500 2300	86 71 59	12.8 10.1 8.1	123/142 112/129 99/113	272 319 364	471 561 612
4500	2700 2500 2300	84 70 59	12.6 9.8 8.0	123/141 111/127 98/113	288 328 354	484 553 597
5500	2695 2500 2300	82 68 58	12.0 9.6 7.9	122/140 110/127 97/112	295 333 356	498 562 600
6500	2688 2500 2300	79 67 58	11.6 9.4 7.9	121/139 109/125 96/110	308 337 349	512 572 592
7500	2680 2500 2300	77 66 57	11.2 9.2 7.9	120/138 109/125 95/109	308 340 348	521 576 587
8500	2670 2500 2300	75 65 57	10.8 9.0 7.8	119/136 108/124 94/108	316 341 341	533 582 579
9500	2662 2500 2300	73 64 57	10.5 8.8 7.8	117/135 107/123 93/106	318 296 334	542 585 571
10,500	2654 2500 2300	71 63 57	10.2 8.7 7.9	116/133 106/122 91/104	320 340 325	546 582 556

NOTES:
1. Range includes start, taxi, climb, and a 45 minute reserve at 2300 RPM.
2. Cruise performance is based on best power mixture. Lean to maximum RPM for a given throttle setting.
3. It is recommended that use of tanks be alternated and that a fuel log be maintained showing time remaining in tanks.
4. For a particular RPM the fuel flow and true airspeed will vary with temperature. To determine in flight fuel flow, enter the table at the nearest altitude corresponding to the density altitude, and the actual true airspeed.

ASSOCIATED CONDITIONS:

Pressure Altitude	4500 feet
OAT	53°F
Indicated Airspeed	111 kts

EXAMPLE:

Density Altitude	5200 feet
Actual True Airspeed	121 kts
Corresponding Altitude on Table	5500 feet
Interpolating Factor (121 kts is 92% of the difference between 110 and 122 kts)	92%
Fuel Flow (12.0-9.6 = 2.4 x .92 = 2.2 + 9.6 = 11.8)	11.8 gal/hr

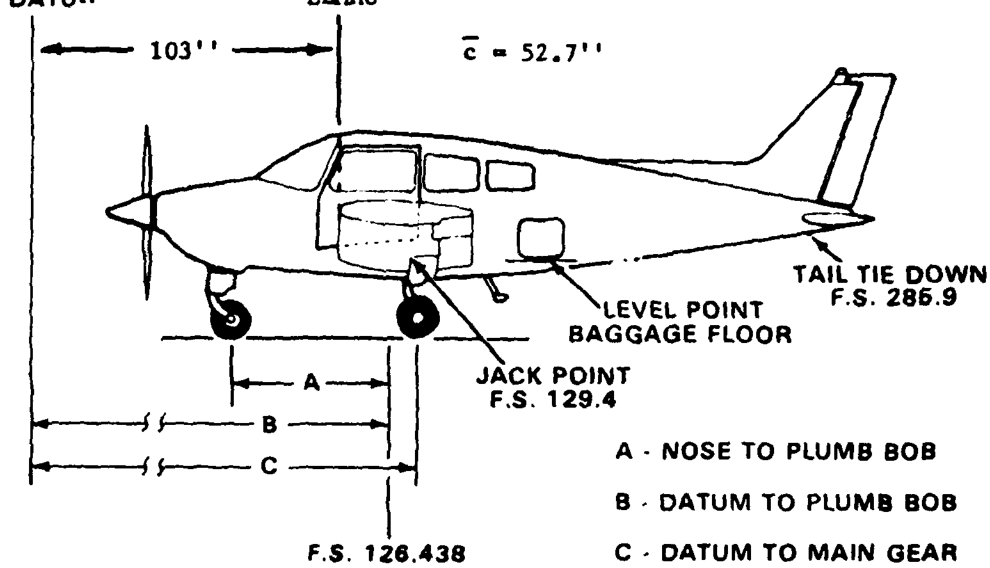
IV. Weight and Balance

Maximum Ramp Weight = 2455 lbs
Maximum Take-off and Landing Weight = 2450 lbs
Maximum Baggage Compartment Load = 270 lbs

6-6

Section VI
Wt and Bal/Equip List

BEECHCRAFT Sundowner 180
C23 (M-1285 and After)



February 1979

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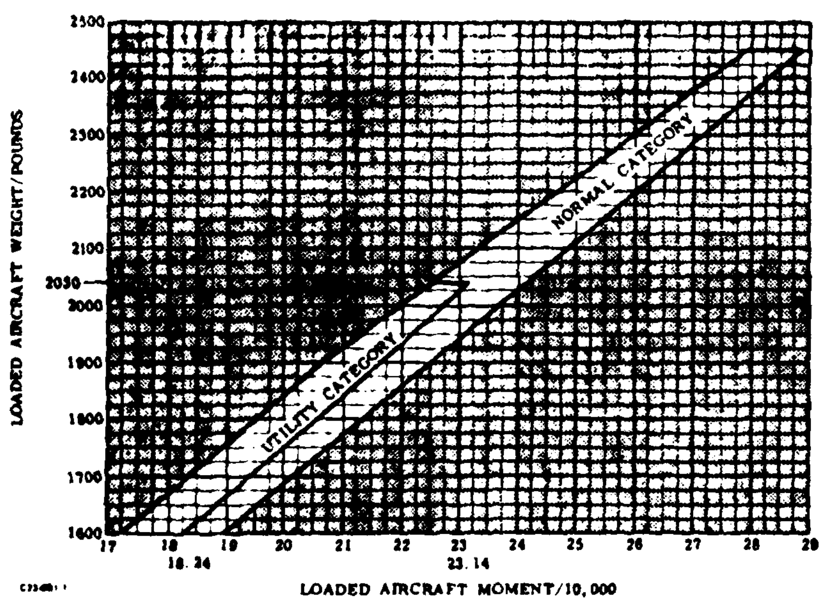
Section VI
Wt and Bal/Equip List

BEECHCRAFT Sundowner 180
C23 (M-1285 and After)

GROSS WEIGHT MOMENT LIMITS GRAPH



February 1979

COMPUTING PROCEDURE

1. *Record the Basic Empty Weight and Moment from the* Basic Empty Weight and Balance form (or from the latest superseding form) under the Basic Empty Condition block. *The moment must be divided by* 100 to correspond to Useful Load Weights and Moments tables.
2. Record the weight and corresponding moment from *the appropriate table of each of the useful load items* (except fuel) to be carried in the airplane.
3. Total the weight column and moment column. The SUB-TOTAL is the Zero Fuel Condition.
4. Determine the weight and corresponding moment for the fuel loading to be used. This fuel loading includes fuel for the flight, plus that required for start, taxi, and take-off. Add the Fuel to Zero Fuel Condition to obtain the SUB-TOTAL Ramp Condition.
5. Subtract the fuel to be used for start, taxi, and take-off to arrive at the SUB-TOTAL Take-off Condition.
6. Subtract the weight and moment of the fuel in the incremental sequence in which it is to be used from the take-off weight and moment. The Zero Fuel Condition, the Take-Off Condition, and the Landing Condition moment must be within the minimum and maximum moments shown on the Moment Limit vs Weight graph for that weight. If the total moment is less than the minimum moment allowed, useful load items must be shifted aft or forward load items reduced. If the total moment is greater than the maximum moment allowed, useful load items must be shifted forward or aft load items reduced. If the quantity or location of load items is changed, the calculations must be revised and the moments rechecked.

GROSS WEIGHT MOMENT LIMITS

(NORMAL CATEGORY)

Gross Weight	Minimum Moment/100	Maximum Moment/100	Gross Weight	Minimum Moment/100	Maximum Moment/100	Gross Weight	Minimum Moment/100	Maximum Moment/100
1500	1617	1775	1900	2068	2248	2300	2599	2721
1510	1628	1786	1910	2081	2260	2310	2613	2733
1520	1638	1798	1920	2094	2271	2320	2626	2745
1530	1649	1810	1930	2107	2283	2330	2640	2756
1540	1660	1822	1940	2120	2295	2340	2654	2768
1550	1671	1834	1950	2133	2307	2350	2668	2780
1560	1682	1845	1960	2146	2319	2360	2681	2792
1570	1692	1857	1970	2158	2331	2370	2695	2804
1580	1703	1869	1980	2172	2342	2380	2708	2816
1590	1714	1881	1990	2186	2354	2390	2722	2827
1600	1725	1893	2000	2198	2366	2400	2736	2839
1610	1736	1905	2010	2211	2378	2410	2750	2851
1620	1746	1916	2020	2224	2390	2420	2764	2863
1630	1757	1928	2030	2237	2401	2430	2777	2875
1640	1768	1940	2040	2250	2413	2440	2791	2887
1650	1779	1952	2050	2263	2425	2450	2805	2898
1660	1789	1964	2060	2276	2437			
1670	1800	1976	2070	2290	2449			
1680	1811	1987	2080	2303	2461			
1690	1822	1999	2090	2316	2472			
1700	1833	2011	2100	2329	2484			
1710	1843	2023	2110	2343	2496			
1720	1854	2035	2120	2356	2508			
1730	1865	2047	2130	2369	2520			
1740	1876	2058	2140	2383	2532			
1750	1887	2070	2150	2396	2543			
1760	1897	2082	2160	2409	2555			
1770	1908	2094	2170	2423	2567			
1780	1919	2106	2180	2436	2579			
1790	1930	2118	2190	2450	2591			
1800	1940	2129	2200	2463	2603			
1810	1953	2141	2210	2477	2614			
1820	1966	2153	2220	2490	2626			
1830	1978	2165	2230	2504	2638			
1840	1991	2177	2240	2517	2650			
1850	2004	2189	2250	2531	2662			
1860	2017	2200	2260	2544	2674			
1870	2029	2212	2270	2558	2686			
1880	2042	2224	2280	2572	2697			
1890	2055	2236	2290	2585	2709			

The above weight and moment limits are based on the following weight and center of gravity limit data.

NORMAL CATEGORY

WEIGHT CONDITION	FWD CG LIMIT	AFT CG LIMIT
2450 lbs (max. take-off or landing)	114.5	118.3
1950 lbs or less	107.8	118.3

WEIGHT AND BALANCE LOADING FORM

MODEL __________ DATE __________

SERIAL NO. __________ REG NO. NXXX

ITEM	WEIGHT	MOM/100
1. BASIC EMPTY CONDITION		
2. FRONT SEAT OCCUPANTS		
3. 3rd & 4th SEAT OCCUPANTS		
4. BAGGAGE OR CARGO		
5. SUB TOTAL ZERO FUEL CONDITION		
6. FUEL LOADING (GAL)		
7. SUB TOTAL RAMP CONDITION		
8. *LESS FUEL FOR START, TAXI, AND TAKE-OFF		
9. SUB TOTAL TAKE-OFF CONDITION		
10. LESS FUEL TO DESTINATION (GAL)		
11. LANDING CONDITION		

*Fuel for start, taxi and take-off is normally 5 lbs at an average mom/100 of 6.

REG NO.	BASIC EMPTY CONDITION	MOM/100
N6014M	1590.0 lbs	1778
N60171	1525.0 lbs	1688
N18325	1580.5 lbs	1792

The following Sample Loading chart is presented to depict the sample method of computing a load. Weights used DO NOT reflect an actual airplane loading.

WEIGHT AND BALANCE LOADING FORM

MODEL C23 DATE __________

SERIAL NO. M-XXXX REG NO. NXXX

ITEM	WEIGHT	MOM/100
1 BASIC EMPTY CONDITION	1600	1650
2 FRONT SEAT OCCUPANTS	340	374
3 3rd & 4th SEAT OCCUPANTS	340	482
4. BAGGAGE OR CARGO	40	67
5. SUB TOTAL ZERO FUEL CONDITION	2220	2573
6. FUEL LOADING (37 GAL)	222	259
7. SUB TOTAL RAMP CONDITION	2442	2832
8. *LESS FUEL FOR START, TAXI, AND TAKE-OFF	-5	-6
9. SUB TOTAL TAKE-OFF CONDITION	2437	2826
10 LESS FUEL TO DESTINATION (25 GAL)	-150	-176
11 LANDING CONDITION	2287	2650

SAMPLE

*Fuel for start, taxi and take-off is normally 5 lbs at an average mom/100 of 6

USEFUL LOAD WEIGHTS AND MOMENTS

OCCUPANTS

WEIGHT	FRONT SEATS			3RD AND 4TH SEATS	
	*FWD POS.		*AFT POS.	BENCH SEAT	SPLIT SEAT
	††ARM **104	†ARM **105	ARM **112	ARM **142	ARM **144
	MOM/100	MOM/100	MOM/100	MOM/100	MOM/100
120	125	126	134	170	173
130	135	137	146	185	187
140	146	147	157	199	202
150	156	158	168	213	216
160	166	168	179	227	230
170	177	179	190	241	245
180	187	189	202	256	259
190	198	200	213	270	274
200	208	210	224	284	288

†Effective M-1285 thru M-2006
††Effective M-2007 and after
*Reclining seat with back in full-up position
**Values computed from a C.G. criterion based on a 170 pound male. Differences in physical characteristics can cause variation in center of gravity location.

USEFUL LOAD WEIGHTS AND MOMENTS

OIL
(Included in Basic Empty Weight)

ARM 48		
QTS	WT	MOMENT/100
8	15	7

USABLE FUEL

ARM 117		
GALLONS	WEIGHT	MOMENT/100
5	30	35
10	60	70
15	90	105
20	120	140
22	132	154
25	150	176
27	162	189
30	180	211
32	192	225
35	210	246
37	222	259
40	240	281
45	270	316
50	300	351
52	312	365
55	330	386
57	342	400
58	348	407

USEFUL LOAD WEIGHTS AND MOMENTS

BAGGAGE

ARM 167	
WEIGHT	MOMENT 100
10	17
20	33
30	50
40	67
50	84
60	100
70	117
80	134
90	150
100	167
110	184
120	200
130	217
140	234

APPENDIX B

Test Plan
Sierra C24R Limited Performance Evaluation

UNITED STATES AIR FORCE ACADEMY

COLORADO 80840

DEPARTMENT OF AERONAUTICS

AERO 495

TEST PLAN

SIERRA C24R LIMITED PERFORMANCE EVALUATION

JUNE 1982

TEST PLAN

DEPARTMENT OF AERONAUTICS

SIERRA C24R LIMITED PERFORMANCE EVALUATION

JUNE 1982

This test plan has been prepared by:

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Hedrick Beechcraft Inc.

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TEST PLAN

DEPARTMENT OF AERONAUTICS

SIERRA C24R LIMITED PERFORMANCE EVALUATION

INTRODUCTION

A limited performance evaluation of the Beech Sierra C24R will be conducted at the U. S. Air Force Academy by Department of Aeronautics (DFAN) faculty pilots and the students enrolled in Aero 495. Flight testing will be conducted during the spring semester from the fifth to tenth week of classes. Results of the evaluation will be presented in a formal oral report given by each of two flight test teams.

OBJECTIVES

The objectives of this evaluation are to determine the Sierra C24R's general performance characteristics and to compare them to the contractor's Flight Manual. In addition, certain contractual guarantees are verified. Specific objectives follow.

A. <u>Takeoff Performance</u>

- determine takeoff power ground roll using the Flight Manual takeoff procedure
- verify the takeoff performance predicted in the contractor's Flight Manual

B. <u>Climb Performance</u>

- determine the full throttle maximum rate of climb
- determine the full throttle best angle of climb
- verify the climb performance predicted in the contractor's Flight Manual

C. <u>Level Turn Performance</u>

- determine the level sustained turn performance in cruise power at 2,700 rpm
- determine the speed for optimum sustained turn performance at the test altitude

D. <u>Cruise Performance</u>

- determine the airspeeds and rpm for maximum range and maximum endurance as derived from test data
- determine the aircraft drag polar
- compare test results with the contractor's Flight Manual

E. Descent Performance

- determine the propeller windmilling best no wind glide ratio

- determine the best glide speed and minimum sink speed with propeller windmilling

- compare test results with the contractor's Flight Manual maximum glide configuration of 91 knots

F. Contractual Guarantees

- maximum speed at sea level-142 knots

- cruise speed at 75% power, 10,000 feet-137 knots

- range with 45 minute reserve at 75% power at 10,000 feet-640 nautical miles

- rate of climb at sea level-927 fpm

- service ceiling-15,385 feet

AUTHORITY

This test program will be conducted by Department of Aeronautics faculty and students as an integral part of the curriculum for Aero 495, a course in flight test techniques. The program has the approval of the Superintendent, the Dean of the Faculty, the Head of the Department of Aeronautics, and the Director of Flight Operation of Hedrick Beechcraft Inc.

TEST TEAM ORGANIZATION

Test team organization shown in Figure 1 will consist of two DFAN faculty pilots and two student flight test engineer teams. Each test team will be assigned to it, with one faculty pilot. A Test Director for each team will be appointed to coordinate the entire evaluation effort. He will in turn appoint individuals to be in charge of each test area (i.e., data monitors). It will be the data monitor's responsibility to specify the tests to be flown in support of his test area. Test areas to be assigned are takeoff, climb, turn, cruise and descent performance.

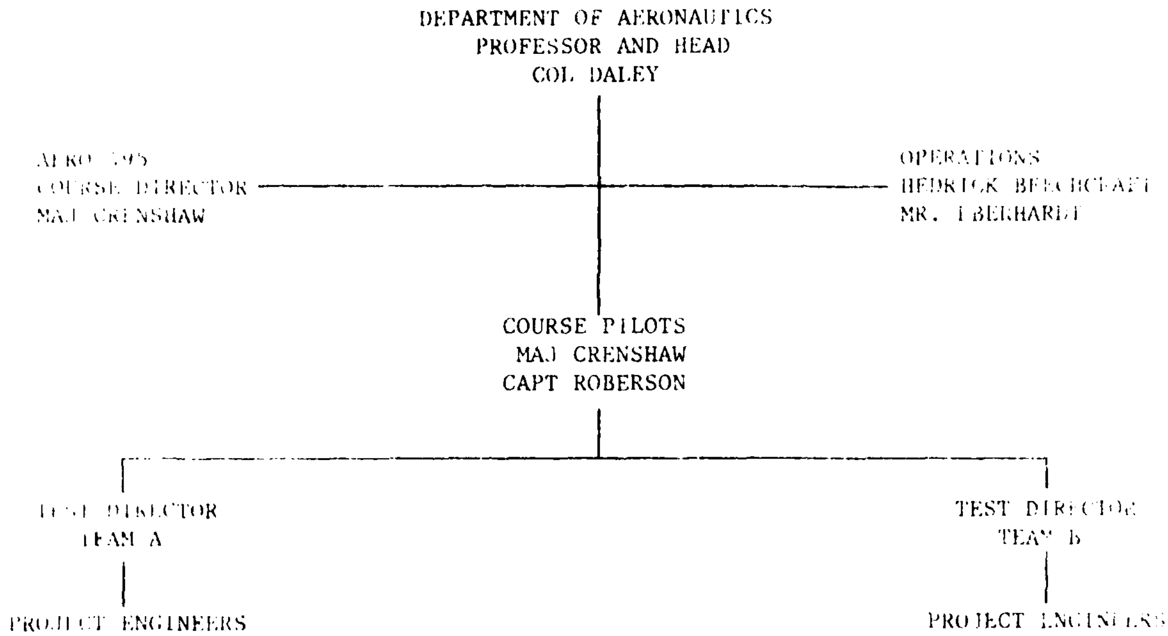

Figure 1. Organization Chart

SCOPE/SCHEDULE

The evaluation will consist of sorties as specified in Table 1.

Table 1. Data Sorties

Test	Sorties Per Test Team	Flight Time Per Sortie
• Flight #1 Takeoff Performance Cruise Performance Turn Performance	2.5	1.0
• Flight #2 Takeoff Performance Climbs and Descents	2.5	1.0
*Total	5	

*One sortie will be shared by both test teams.

Flight #1 and #2 are scheduled as shown on the Integrated Academics and Flying Schedule for Aero 495. Mission time will not exceed 1.0 hour.

LIMITATIONS

The following limitations will be observed during this evaluation.

A. The aircraft will be operated in accordance with the Airplane Flight Manual, FAR Part 91 and all Beech Aero Club Operating Instructions.

B. All data sorties will be flown with one DFAN faculty pilot and two cadets.

C. Testing will only be accomplished under VFR daytime conditions at 10,000 ft MSL and below.

D. All testing will be accomplished within the local flying area of Colorado Springs.

TEST AIRCRAFT DESCRIPTION

The Beechcraft Sierra C24R, manufactured by Beech Aircraft Corporation, is a six-place, retractable, general aviation aircraft powered by one fuel-injected, 4-cylinder, 200 HP Avco Lycoming engine. The propeller is a Hartzell constant-speed, two-blade, aluminum-alloy prop with spinner. See Figure 2 for general dimensions and Table 2 for Aircraft Limitations.

$S = 146\ ft^2$

$AR = 7.5$

$c = 52.7$ in

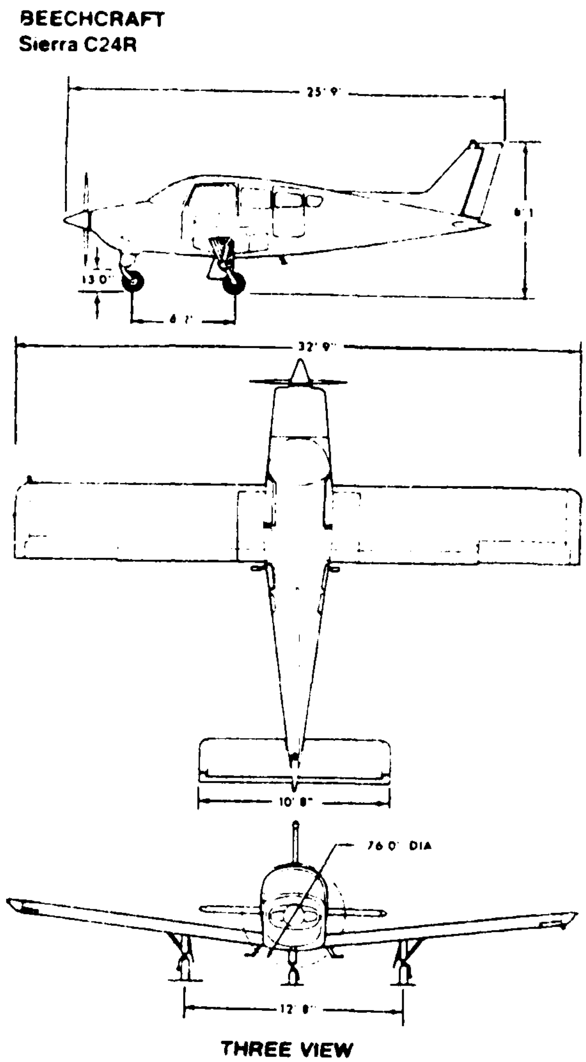

Figure 2. Three View of Sierra C24R
(Reference 1)

Table 2. Aircraft Limitations

	IAS Knots/mph
Never Exceed Speed (V_{NE})	168/193
Maximum Maneuvering Speed (V_A)	125/144
Maximum Cruising Speed in Turbulent Air (V_c)	143/165
1G Stall Speed Gear and Flaps Up (2,600 lbs) (power idle)	65/75
Maximum Ramp Weight	2,785 lbs
Maximum Takeoff Weight	2,750 lbs
Maximum Landing Weight	2,750 lbs
Flight Maneuvering Load Factor Flaps Up	+3.8 to -1.9G
Flight Maneuvering Load Factor Flaps Down	+1.9G
Maneuver, Bank Angles No More Than 60°	

Service Ceiling	15,385 feet
Test Plan Ceiling	10,000 feet

FLIGHT TEST INSTRUMENTATION

All test data will be hand recorded using standard cockpit instrumentation. The only exceptions are the use of an accelerometer, a stopwatch and a cassette tape recorder.

WEIGHT AND BALANCE

Detailed weight and balance records for each aircraft are available at Hedrick Beechcraft. Prior to every data mission, student test engineers will calculate aircraft weight and balance data for both takeoff and landing.

TEST DESCRIPTION/PROCEDURES

Unless otherwise noted, all performance tests will be performed with engine operating, landing gear and wing flaps retracted. All data will be hand and voice recorded, and manually reduced to standard aircraft weight and atmospheric conditions. Specific test techniques for each area will be covered in classroom lectures and handouts from references 2, 3, and 4.

A. Takeoff Performance

The takeoff ground roll will be determined and hand recorded for each sortie.

All takeoffs will be made with 15° of flaps in accordance with the Sierra C24R Airplane Flight Manual.

B. Climb Performance

Climb data at different airspeeds will be obtained using sawtooth climbs. Data will be obtained at 2,700 rpm with mixture adjusted for best power at test altitudes of 8,000, 8,500, 9,000 and 9,500 feet. Engine operating limitations as specified in the Flight Manual will be followed.

C. Level Turn Performance

Turn performance for the Sierra will be determined from stabilized turns at various altitudes and airspeeds. Data will be obtained at 2,700 rpm, or full throttle, between 7,000 and 10,000 feet. Engine operating limitations as described in the Flight Manual will be followed.

D. Cruise Performance

Cruise performance will be evaluated using the P_{iw} versus V_{iw} test technique covered in references 2 and 4. Using the backside trim shot technique, the aircraft will be stabilized at several altitude and airspeed combinations. Data will be obtained at altitudes between 7,000 and 10,000 feet.

E. Descent Performance

Descent performance will be determined at various airspeeds at test altitudes of 8,000, 8,500, 9,000 and 9,500 feet. The aircraft will be operated with the throttle at idle and propeller at high pitch for gathering descent data. The Flight Manual restriction concerning prolonged idle settings will be observed.

TRAINING

Both DFAN faculty pilots will have at least an FAA commercial pilot rating and be current in the Beech Sierra C24R in accordance with FAA and Hedrick Beechcraft Aero Club standards.

All cadets enrolled in Aero 495 will participate in the flying portion of the course as passengers only and will receive appropriate aircraft orientation and safety instruction. All the performance flight test techniques required to gather test data will be covered during classroom lectures prior to the flights for which they will be used.

CREW DUTIES

A. Pilot

1. Check local flying weather.

2. Brief students on mission profile, and ground and in-flight safety.

3. Check maintenance status of aircraft and perform preflight.

4. Provide a stopwatch.

5. Provide the tachometer reading at which the aircraft was refueled and the quantity of fuel and oil on board.

6. Act as pilot in command of the aircraft and occupy the left front seat at all times.

B. Students

1. Bring data cards and a clipboard.

2. Complete aircraft weight and balance form.

3. Compute takeoff data using temperature and pressure altitude provided by the pilot.

4. Provide cassette tape player for each flight. (optional)

5. Record tachometer reading at which the aircraft was refueled and the quantity of fuel and oil on board.

6. Cadets will be assigned to two man teams for purposes of taking flight test data. Flight crew duties will be rotated each flight. Along with the pilot who will be primarily concerned with precisely flying the aircraft, both cadets will act as lookouts and notify the pilot immediately of any aircraft sighted. The cadet in the right front seat will act as data observer and timekeeper and the cadet in the rear seat will act as data recorder.

SAFETY

Flight personnel will adhere to the following while on the flightline and in and around the aircraft:

a. Smoking is prohibited in or near the aircraft.

b. Seat belts will be worn at all times.

c. Flight personnel will be seated in the aircraft prior to engine start and will remain seated until the engine is stopped.

d. Remain clear of the propeller area at all times.

e. Do not stand, walk, or lean on the aircraft except in designated areas.

f. Do not open aircraft windows or doors in flight.

g. Advise the pilot immediately upon observing another aircraft.

h. Do not manipulate the aircraft flight controls or engine controls unless told to do so by the pilot.

i. Advise the pilot of impending airsickness. Use the bag provided, your hat, your shoe, anything except the floor of the aircraft.

j. Stay clear of taxiing aircraft and other flightline vehicles.

COMMAND AND CONTROL

All testing to be accomplished will be for academic purposes only and will be performed within the restrictions of the Flight Manual, Part 91 of the FAR's, Fredrick Beechcraft Aero Club Rules and the limitations imposed by this test plan.

All information with respect to this test plan is unclassified.

TEST PLAN AMENDMENTS

An amendment to this test plan is required if the flight test envelope is expanded or if any limitations in the test plan are made less restrictive. An amendment to the test plan must be reviewed and approved by the same authority who approved the basic plan.

REFERENCES

1. Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for the Beechcraft Sierra C24R, Beech Aircraft Corporation, Wichita, Kansas, November 1980.

2. Kimberlin, Ralph D., Performance Flight Testing Lecture Notes, The University of Tennessee Space Institute, Tullahoma, Tennessee, 1982.

3. Performance Theory and Flight Test Techniques, USAF Test Pilot School, Edwards AFB, California, FTC-TIH-79-1, 1 August 1979.

4. Roberts, Sean C., Light Aircraft Performance for Test Pilots and Flight Test Engineers, Flight Research, Inc., Mojave, California, 1980.

APPENDIX C

Flight Test Planning Guide
Sierra C24R Limited Performance
Evaluation

AERO 495 FLIGHT TEST TECHNIQUES

FLIGHT TEST PLANNING GUIDE

SIERRA C24R LIMITED PERFORMANCE EVALUATION

MAJ CRENSHAW

JUNE 1982

CONTENTS PAGE

FLIGHT 1

Cruise and Turn Performance

I. OBJECTIVES

A. Determine power required as a function of flight speed in order to estimate various aircraft performance parameters.

B. Determine the sustained level turn performance as a function of flight speed and estimate optimum sustained maneuvering speed at test altitude.

II. AIRCRAFT

Beechcraft Sierra C24R

III. LIMITATIONS

As specified in the test plan.

IV. MISSION EVENTS

A. Pilot

1. Lineup abeam a runway light prior to brake release for takeoff. Make Flight Manual 15° flap takeoff.

2. Stabilize the aircraft in level flight at a selected test altitude between 7,000 and 10,000 feet.

3. Trim at V_{max} airspeed at 2,700 rpm/75% MCP, 2,500 rpm/75% MCP, 2,400 rpm/65% MCP and 2,400 rpm/55% MCP. Use the Flight Manual leaning procedure for fuel flow and cruise table for manifold pressure.

4. Trim at different flight velocities at a selected rpm of 2,700, 2,600, 2,500 or 2,400. Do this by varying manifold pressure in 1 inch Hg increments. Do not go below 15" Hg or above 28.7" Hg for any rpm setting. Again, use the Flight Manual leaning procedure for fuel flow.

5. Perform stabilized turns starting from the wings level V_{max} airspeed at 2,700 rpm/75% MCP. Stabilize at bank angles up to and including 60° in 10° increments.

6. Make normal full stop landing.

B. Students

1. Record takeoff ground roll.

2. For each stabilized wings level and turn point, record IAS, pressure altitude, OAT, RPM, MAP, fuel flow and tach time. Also record for turns the time through 360 degrees.

3. Record post flight aircraft tach time.

V. STUDENT POST-FLIGHT DATA REDUCTION

A. Reduce data using the attached data reduction sheets. Use a standard weight of 2,750 lbs where indicated.

B. Plot

1. $BHP_{iw}\, V_{iw}$ versus V_{iw}^4 (knots)

2. BHP_{iw} versus V_{iw} (knots)

3. SAR versus V_{iw} (knots)

4. SE versus V_{iw} (knots)

5. C_L^2 versus C_D

6. C_L versus C_D

7. n_t versus VCAS (knots)

8. R_t versus VCAS (knots)

9. ω_t versus VCAS (knots)

C. Determine

1. Sea level maximum range airspeed (knots).

2. Estimated maximum range with 57 gallons of fuel at the test altitude with a 45 minute reserve.

3. Sea level maximum endurance airspeed (knots).

4. Airspeed for maximum range glide, power off (knots).

5. Maximum power-off glide ratio

6. Aircraft efficiency factor.

7. Aircraft drag polar.

8. Airspeed for optimum sustained turn performance at the test altitude (knots).

D. Tabulate the actual true airspeeds versus the Flight Manual predicted true airspeeds from the "Cruise Power Settings" table for 2,700 rpm/75% MCP, 2,500 rpm/75% MCP, 2,400 rpm/65% MCP and 2,400 rpm/55% MCP. Use a standard weight of 2,600 pounds.

E. Complete the "Initial Flight Test Report".

F. Complete a set of sample calculations.

G. Turn in "Initial Flight Test Report" with results, recorded data, data reduction sheets, sample calculations, and plots.

FLIGHT 1 DATA RECORD

DATE____________________

INSTRUCTOR____________________

STUDENTS____________________

____

AIRCRAFT NU.____________________

PRE-FLIGHT TACH TIME__________

POST-FLIGHT TACH TIME__________

REMARKS:

TAKEOFF DATA: FIELD ELEVATION-6,172 FEET

ALTIMETER________________

WINDS________________

PRESS. ALT.________________

TEMP________________

GD ROLL (P)________________

GD ROLL (A)________________

TAKEOFF V_i________________

CRUISE DATA								
RUN NU.	IAS KTS	TACH TIME	OAT °C	ALT FT	MAP IN.	RPM	FF GPH	REMARKS

FLIGHT 1 DATA RECORD

TURN DATA									
RUN NO.	IAS KTS	TACH TIME	OAT °C	ALT FT	MAP IN.	RPM	FF GPH	TIME TO TURN 360°	REMARKS

CRUISE PERFORMANCE DATA REDUCTION

AIRCRAFT, SIERRA C24R　　　　WING AREA, S = 146 .FT^2　　　　STANDARD WEIGHT, W_S = 2,750 .LB

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Vi (Kts)	Ve (Kts)	Hi (ft.)	Hc (ft.)	Wt (lb.)	BHPt (H.P.)	Ti °C	Ta °K	$\dot{W}f$ lb/hr.	δ p/p_o	σ ρ/ρ_o	Viw (Kts)	BHPiw (HP)	Vtrue (Kts)	SAR	Propeller C_p	J	η	C_L	C_D	SE	BHPiw X Viw	V^4_{iw}

1. Vi (Kts.) indicated airspeed
2. V_c (Kts.) $\approx V_e$ (Kts.) p. 5-10 F.M.
3. Hi (ft.) indicated pressure altitude
4. H_c (ft.) calibrated pressure altitude, p. 5-12 F.M.
5. Test Weight, Wt. = Basic Empty Weight + crew + fuel
6. BHP_t Test brake H.P. obtained from engine charts
7. Ti Indicated outside air temperature
8. Ta Outside air temperature, °Kelvin
9. $\dot{W}_f$ fuel flow $= \frac{6 \text{ lb}}{\text{gal}} \times \frac{\text{gal}}{\text{hr}}$ = lb./hr.
10. δ, pressure ratio, obtained directly from altitude charts & H_c
11. σ, density ratio $= \dfrac{\delta}{\text{Ta } {}^\circ\text{K}/288.15} = \dfrac{(10) \times 288.15}{(8)}$
12. $\text{Viw} = \text{Ve}\left(\dfrac{W_s}{W_t}\right)^{1/2} = (2) \times \left(\dfrac{W_s}{(5)}\right)^{1/2}$
13. $\text{BHPiw} = \text{BHP}_t\left(\dfrac{W_s}{W_t}\right)^{3/2} (\sigma)^{1/2} = (6) \times \left(\dfrac{W_s}{(5)}\right)^{3/2} \times (11)^{1/2}$
14. $\text{Vtrue Kts} = \dfrac{V_e}{\sqrt{\sigma}} = (2) \div (11)^{1/2}$
15. SAR, Specific Air Range $= \dfrac{\text{Vtrue}}{\dot{W}f}\,\dfrac{W_t}{W_s} = ((14) \div (9)\ \text{NAM/lb})\ \dfrac{(5)}{W_s}$
16. C_p, Propeller Power Coefficient from charts knowing BHP_t, RPM & σ.
17. J, Propeller Advance Ratio $\frac{V}{ND}$ from charts knowing V_e, RPM & $\sqrt{\sigma}$

CRUISE PERFORMANCE DATA REDUCTION

(CONTINUED)

18. η, Propeller Efficiency, from charts knowing C_p & J.

19. C_L, Aircraft lift coefficient $= \dfrac{W_t}{\frac{1}{2}\,\rho_o (V_e \times 1.689)^2\, S}$

20. C_D, Aircraft drag coefficient $= \left(\dfrac{550\ \eta\ BHP_t}{V_{true} \times 1.689}\right) \left(\dfrac{1}{[\frac{1}{2}\rho_o (V_e \times 1.689)^2\ S]}\right)$

21. SE, Specific Endurance $= \dfrac{1}{\dot{W}_f} \left(\dfrac{W_t}{W_s}\right)^{3/2} = \dfrac{1}{9} \left(\dfrac{5}{W_s}\right)^{3/2}$ hr/lb

TURN PERFORMANCE DATA REDUCTION

AIRCRAFT, SIERRA C24R | WING AREA, $S = 146\ FT^2$ | STANDARD WEIGHT, $W_s = 2{,}750$ LB

1	2	3	4	5	6	7	8	9	10	11	12	13
V_i (KTS)	V_e (KTS)	H_i (FT)	H_c (FT)	T_i °C	T_a °K	δ p/p_o	σ ρ/ρ_o	V_{true} FPS	TIME SEC'S	ω_t DEG/SEC	n_t	R_t (FT)

1. V_i (Kts) indicated airspeed
2. V_c (Kts) = V_e (Kts) equivalent airspeed, p. 5-10 F.M.
3. H_i (ft) indicated pressure altitude
4. H_c (ft) calibrated pressure altitude, p. 5-12 F.M.
5. T_i Indicated outside air temperature
6. T_a Outside air temperature, °Kelvin
7. δ, pressure ratio, obtained from altitude charts and H_c
8. σ, density ratio $= \dfrac{\delta}{T_a\ °K/288.15} = \dfrac{⑦ \times 288.15}{⑥}$
9. $V_{true}\ fps = \dfrac{V_e}{\sqrt{\sigma}}\, 1.689 = \left(② \div (⑧)^{1/2}\right) 1.689$
10. Time to turn through 360°
11. $\omega_t = \dfrac{360°}{TIME} = \dfrac{360°}{⑩}$ deg/sec
12. $n_t = \sqrt{\left(\dfrac{\omega_t\ V_{true}}{57.296 \times g}\right)^2 + 1} = \sqrt{\left(\dfrac{⑪ \times ⑨}{57.296 \times g}\right)^2 + 1}$
13. $R_t = \dfrac{V_{true}}{\omega_t}\, 57.296 = (⑨ \div ⑪) \times 57.296$

FLIGHT 2

Climb and Descent Performance

I. OBJECTIVES

A. Determine maximum rate of climb and maximum angle of climb and respective airspeeds at which they occur.

B. Determine best glide speed, best no wind glide ratio and minimum sink rate and speed with propeller windmilling. Produce a propeller windmilling drag polar for the aircraft.

II. AIRCRAFT

Beechcraft Sierra C24R

III. LIMITATIONS

As specified in the Test Plan.

IV. MISSION EVENTS

A. Pilot

1. Lineup abeam a runway light prior to brake release for takeoff. Make normal 15° flap takeoff.

2. For climbs, set RPM at 2,700 and adjust mixture for best power. Stabilize the aircraft in a steady climb at airspeeds of 70, 80, 90, 100 and 110 knots on a heading perpendicular to the wind direction. At 500 feet below the test altitude, set full throttle and climb to 500 feet above the test altitude. Also establish level flight speed at the test altitude using climb power. Test altitudes are 8,000, 8,500, 9,000 and 9,500 feet.

3. For descents, fly power-off glides (throttle idle, propeller high pitch) in 10 knot increments from 120 knots to 80 knots from 500 feet above to 500 feet below the test altitude. Test altitudes are 8,000, 8,500, 9,000 and 9,500 feet.

4. Make normal full stop landing.

B. Students

1. Record takeoff ground roll.

2. During climbs, record the time to climb through 1,000 feet with a stopwatch. Also record tach time and OAT at 500 feet below the test altitude, at the test altitude, and 500 feet above the test altitude. Record RPM and MAP at the test altitude. Record the climb rate indicated on the Vertical Velocity Indicator (VVI) and elapsed time at each 100 feet. Note the maximum velocity at climb power in level flight at the test altitude.

3. During glides, time the glide through 1,000 feet of descent with a stopwatch. Record tach time and OAT at 500 feet above the test altitude, at the test altitude and at 500 feet below the test altitude. Also record VVI and elapsed time every 100 feet.

4. Record post flight aircraft tachometer time.

V. STUDENT POST-FLIGHT DATA REDUCTION

A. Reduce data using the attached data reduction sheets. Use a standard weight of 2,750 lbs where indicated.

B. Plot

1. $(R/C)_T$ versus IAS (knots)

2. $(R/C)_S$ versus V_{iw} (knots)

3. L/D versus V_{iw} (knots) } for descents

4. C_D versus C_L^2 (drag polar) } for descents

5. Sink rate (ft/min) versus V_{iw} (knots)

C. Determine

1. Airspeed for best rate of climb and for best angle of climb on both plots of $(R/C)_T$ and $(R/C)_S$.

2. Airspeed for max glide range and minimum sink.

D. Complete the "Initial Flight Test Report".

E. Complete a set of sample calculations.

F. Turn in "Initial Flight Test Report" with results, recorded data, data reduction sheets, sample calculations and plots.

AIR FRAME NO.

PRE-FLIGHT TACH TIME

POST-FLIGHT TACH TIME

REMARKS:

PRESS. ALT.

TEMP

GD ROLL (P)

GD ROLL (A)

TAKEOFF V_1

CLIMB DATA

RUN NO.	[illegible]	TACH TIME	OAT -500	OAT ALT	OAT +500	TOTAL TIME SECS	RPM MAP FF	VVI (FPM) ELAPSED TIME -400	-300	-200	-100	ALT	+100	+200	[illegible]	+400	[illegible]
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

TIME (FROM) ELAPSED TIME

1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

[illegible]

( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
[illegible]	[illegible]	H_i (ft.)	[illegible]	[illegible]	[illegible]	$\frac{dH}{dt}_t$ [illegible]	[illegible]	[illegible]	[illegible]	$\left(\frac{dH}{dt}\right)_d$ [illegible]	BHP_t [illegible]	BHP_s (HP)	ΔBHP (HP)	[illegible]	[illegible]	Propeller [illegible]	$\Delta\frac{dH}{dt}$ (fpm)	$\left(\frac{dH}{dt}\right)_p$ [illegible]	$\left(\frac{dH}{dt}\right)_{STD}$ (fpm)

1. V_i (Kts.) indicated airspeed
2. V_e (Kts.) = V_e (Kts.), p. 5-10 F.M.
3. H_i (ft.) indicated pressure altitude
4. H_c (ft.) calibrated pressure altitude, p. 5-12 F.M.
5. Test Weight, W_t = Basic Empty Weight + crew + fuel
6. $V_{iw} = V_e \left(\frac{W_s}{W_t}\right)^{\frac{1}{2}}$ = ( ) $\times \left(\frac{W_s}{5}\right)^{\frac{1}{2}}$
7. $\left(\frac{dH}{dt}\right)_t$ Plot H_c versus time. Draw a tangent to the curve at test altitude. Slope = $\left(\frac{dH}{dt}\right)_t$
8. $\frac{T_t}{T_s}$ = $\frac{\text{Absolute Test Temperature}}{\text{Absolute Std. Temperature}}$ at test altitude
9. Density Correction to Rate of Climb

$$\left(\frac{dH}{dt}\right)_d = \left(\frac{dH}{dt}\right)_t \sqrt{\frac{T_t}{T_s}} = 7 \times \sqrt{8}$$

10. BHP_t from engine chart for actual test altitude temperature
11. BHP_s from engine chart for standard temperature at test altitude
12. ΔBHP = BHP_s - BHP_t = 11 - ( )
13. [illegible] pressure ratio from altitude charts for H_c
14. [illegible] density ratio [illegible]
15. [illegible] Propeller Power Coefficient knowing BHP_t, RPM and [illegible]
16. [illegible] Propeller Advance Ratio knowing V_e, $\sqrt{\sigma}$ and RPM

17. η, Propeller Efficiency [illegible] $_p$ and

18. Change in Power and Propulsive Efficiency Correction to Rate of Climb

$$\Delta\left(\frac{dH}{dt}\right) = \frac{\eta}{W_s}\left[\Delta BHP + BHP_s\left(1 - \frac{\eta_s}{\eta_t}\right)\right] 550$$

$$\Delta\left(\frac{dH}{dt}\right) = \frac{(17)}{W_s}\left[([illegible]) - (11)\left(1 - \frac{1}{(8)}\right)\right] 550$$

19. $\left(\frac{dH}{dt}\right)_p = \left(\frac{dH}{dt}\right)_d + \Delta\left(\frac{dH}{dt}\right) = (9) + (18)$

20. <u>Weight Correction to Rate of Climb</u>

$$\left(\frac{dH}{dt}\right)_{STD} = \left(\frac{dH}{dt}\right)_p \sqrt{\frac{W_s}{W_t}}\ 60 = (19) \times \sqrt{\frac{W_s}{(5)}} \times 60 \text{ (FPM)}$$

1 V_i (Kts)	2 V_e (Kts)	3 H_i (ft.)	4 H_c (ft.)	5 W_t (lb)	6 V_{iw} (Kts)	7 $\left(\frac{dH}{dt}\right)_t$ (fps)	T_t (°K)	T_s (°K)	8 T_t/T_s	9 $\left(\frac{dH}{dt}\right)_d$ (fps)	10 $\left(\frac{dH}{dt}\right)_{STD}$ (fpm)	11 δ (P/P_0)	12 σ (ρ/ρ_0)	13 V_{true} (Kts)	14 C_L		C_L^2	C_L

1. V_i (Kts.) indicated airspeed
2. V_e (Kts.) = V_e (Kts), p. 5-10 F.M.
3. H_i (ft.) indicated pressure altitude
4. H_c (ft.) calibrated pressure altitude, p. 5-12 F.M.
5. Test Weight, W_t = Basic Empty Weight + crew + fuel
6. $V_{iw} = V_e \left(\frac{W_s}{W_t}\right)^{\frac{1}{2}} = ② \times \left(\frac{W_s}{⑤}\right)^{\frac{1}{2}}$
7. $\left(\frac{dH}{dt}\right)_t$ Plot H_c versus time. Draw a tangent to the curve at test altitude. Slope is $\left(\frac{dH}{dt}\right)_t$
8. $\frac{T_t}{T_s} = \frac{\text{Absolute Test Temperature}}{\text{Absolute Std. Temperature}}$ at test altitude
9. Density Correction to Rate of Descent

$$\left(\frac{dH}{dt}\right)_d = \left(\frac{dH}{dt}\right)_t \sqrt{\frac{T_s}{T_t}} = ⑦ \times \sqrt{⑧}$$

10. Weight Correction to Rate of Descent

$$\left(\frac{dH}{dt}\right)_{STD} = \left(\frac{dH}{dt}\right)_d \sqrt{\frac{W_s}{W_t}} \times 60 = ⑨ \times \sqrt{\frac{W_s}{⑤}} \times 60 \text{ (FPM)}$$

11. δ, pressure ratio from altitude charts for H_c
12. σ, density ratio = $\frac{\delta}{T_t / 288.15} = \frac{⑪ \times 288.15}{T_t}$
13. $V_{true}(\text{Kts}) = \frac{V_e}{\sqrt{\sigma}} = ② \div \sqrt{⑫}$
14. $C_L = \frac{W_t}{\frac{1}{2}\rho_0 (V_e \times 1.689)^2 S} = \frac{⑤}{\frac{1}{2}\rho_0 (② \times 1.689)^2 S}$

[illegible]

15. [illegible] = $\dfrac{(dH\ dt)\ W_t\ V_{true}}{[illegible]\ (V_e \times 1.6897)}$ = $\dfrac{9 \times 5\ /\ [illegible]}{[illegible]\ (2 \times 1.6897)}$

REFERENCES

1. Flight Test Engineering Handbook, Air Force Flight Test Center, Edwards AFB, California, TR 6273, January 1965.

2. Roberts, Sean C., Light Aircraft Performance for Test Pilots and Flight Test Engineers, Flight Research, Inc., Mojave, California, 1980.

3. [illegible], V. V., (EA 41) Elements of Flight Test Engineering, United States Naval Academy, Annapolis, Maryland, 1981.

INITIAL FLIGHT TEST REPORT	1. AIRCRAFT TYPE	2. SERIAL NUMBER

CONDITIONS RELATIVE TO TEST

a. [illegible]:	e. CONFIGURATION:	i. FUEL LOAD:
b. PILOT:	f. INSTRUMENTATION:	j. SURFACE WIND:
c. OBSERVERS:	g. START UP GR WT:	k. WEATHER:
d. [illegible] TIME/T.O. TIME:	h. START UP C.G.:	l. GROUND BLOCK:

3. TESTS PERFORMED

4. RESULTS OF TESTS (Continue on reverse side if needed)

5. REMARKS (Continue on reverse side if needed)

AFFTC Form 364 APR '74

APPENDIX D

Sample Performance Data Records, Data Reduction and Plots

Contents

* Note that the data records for both of these flights show only a sample of the actual data taken on the dates indicated. As the plots derived from both flights indicate, several more data runs were performed.

21 Sept '82

Crenshaw

Webster

Goodwin

N6636 D

TACH TIME 885.88

TACH TIME 886.94

REMARKS: Test Altitude = 10,000 ft pressure altitude

ALTIMETER 30.36

WINDS 010/6 knots

PRESS. ALT. 5700 ft

TEMP 41°F

GD ROLL (P) 1600 ft

GD ROLL (A) 1450 ft

TAKEOFF V_1 66 knots

CRUISE DATA

RUN NO.	IAS KTS	TACH TIME	OAT °C	ALT FT	MAP IN.	RPM	FF GPH	REMARKS
1	107	886.21	10	10,000	20	2600	10.5	
2	100	886.42	10	10,000	18	2600	9.0	
3	79	886.53	10	10,000	15	2600	7.0	

1 Vi (Kts)	2 Ve (Kts)	3 Hi (ft.)	4 Hc (ft.)	5 Wt (lbs.)	6 BHPt (H.P.)	7 Ti	8 Ta	9 Wf lb/hr.	10 δ	11 σ	12 Viw (Kts)	13 BHPiw (HP)	14 Vtrue (Kts)	15 SAR	16 Propeller	17	18	19	20	21	22 BHPiw X Viw	23 V³iw
107.	106.	10K	9998	2712.	134.3	10	283	63	.6878	.7003	106.7	114.8	126.67	1.98	.054	.78	.85	.49	.053	.016	12249	1.3E08
100.	99.	10K	9998	2700	116.8	10	283	54	.6878	.7003	99.9	100.5	118.30	2.15	.047	.73	.82	.56	.055	.018	10040	9.96E07
79.	78.	10K	9997	2695.	88.6	10	283	42	.6878	.7003	78.8	76.4	93.21	2.17	.035	.57	.79	.89	.081	.023	7121	3.86E07

1. Vi (Kts.) indicated airspeed
2. V_c (Kts.) ≈ V_e (Kts.) p. 5-10 F.M.
3. Hi (ft.) indicated pressure altitude
4. H_c (ft.) calibrated pressure altitude, p. 5-12 F.M.
5. Test Weight, Wt. = Basic Empty Weight + crew + fuel
6. BHP_t Test brake H.P. obtained from engine charts
7. Ti Indicated outside air temperature
8. Ta Outside air temperature, °Kelvin
9. $\dot{W}_f$ fuel flow = $\frac{6\ lb}{gal} \times \frac{gal}{hr}$ = lb./hr.
10. δ, pressure ratio, obtained directly from altitude charts & H_c
11. σ, density ratio = $\frac{\delta}{Ta\ °K / 288.15} = \frac{10 \times 288.15}{8}$
12. $Viw = Ve\left(\frac{w_s}{w_t}\right)^{1/2} = 2 \times \left(\frac{w_s}{5}\right)^{1/2}$
13. $BHPiw = BHP_t\left(\frac{w_s}{w_t}\right)^{3/2} (\sigma)^{1/2} = 6 \times \left(\frac{w_s}{5}\right)^{3/2} \times (11)^{1/2}$
14. $Vtrue\ Kts = \frac{V_e}{\sqrt{\sigma}} = 2 \div \sqrt{11}$
15. SAR, Specific Air Range = $\frac{Vtrue}{\dot{W}_f} \frac{Wt}{Ws}$ = (14 ÷ 9) × $\frac{5}{w_s}$
16. C_p, Propeller Power Coefficient from charts knowing BHP_t, RPM & σ.
17. J, Propeller Advance Ratio $\frac{V}{ND}$ from charts knowing V_e, RPM & $\sqrt{\sigma}$

18. η, Propeller Efficiency, from charts knowing C_p & J.

19. C_L, Airplane lift coefficient = $\dfrac{W_t}{\frac{1}{2}\rho_0 (V_e \times 1.689)^2 S}$

20. C_D, Airplane drag coefficient = $\left(\dfrac{550 \eta BHP_t}{V_{true} \times 1.689}\right)\left(\dfrac{1}{\frac{1}{2}\rho_0 (V_e \times 1.689)^2 S}\right)$

21. SE, Specific Endurance = $\dfrac{1}{W_f}\left(\dfrac{W_t}{W_s}\right)^{3/2} = \dfrac{1}{(9)}\left(\dfrac{(5)}{W_s}\right)^{3/2}$ hr/lb

AD-A131 457 AIRBORNE LABORATORY MEASUREMENT OF AIRCRAFT PERFORMANCE AND STABILITY AND CONTROL FOR LIGHT AIRCRAFT SUPPLEMENT (U) AIR FORCE ACADEMY CO K R CRENSHAW 24 JUN 83 2/2

UNCLASSIFIED USAFA-TN-83-3 F/G 14/2 NL

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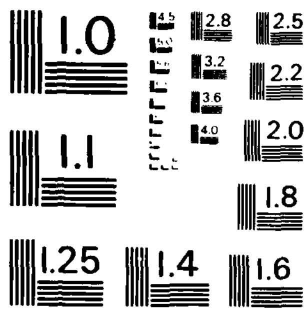
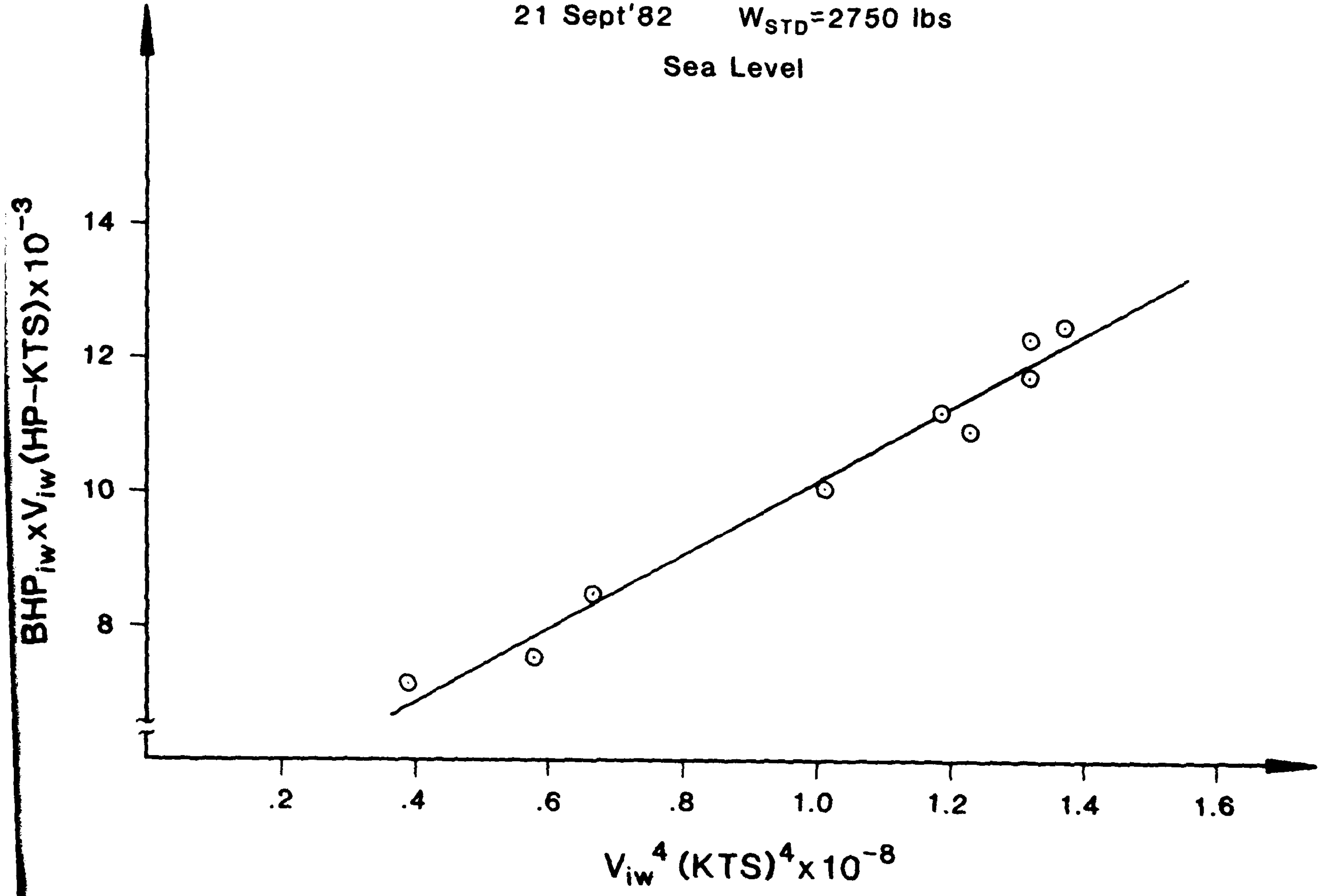
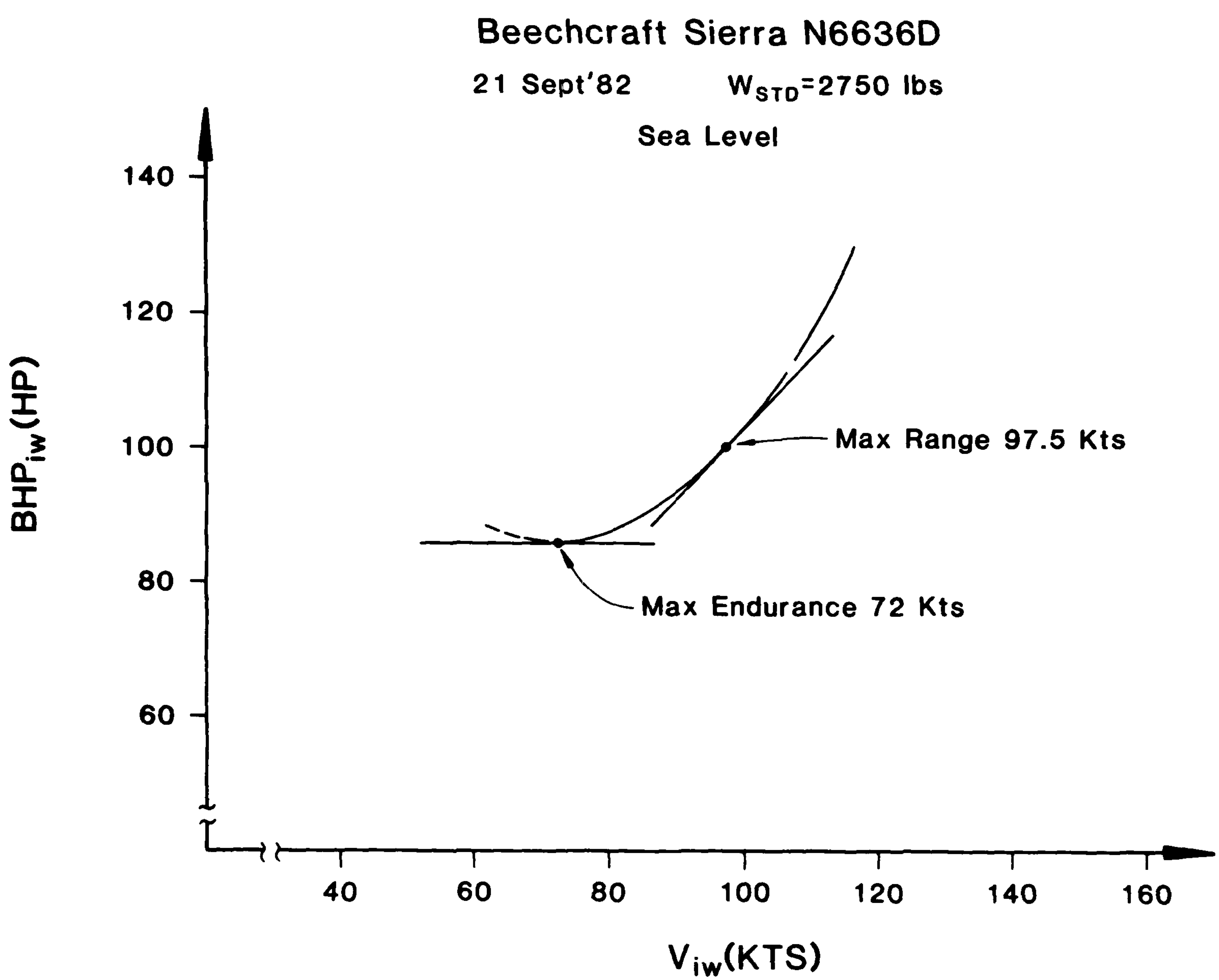

1.0
4.5
5.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

Beechcraft Sierra N6636D

21 Sept'82 W_{STD}=2750 lbs

Sea Level

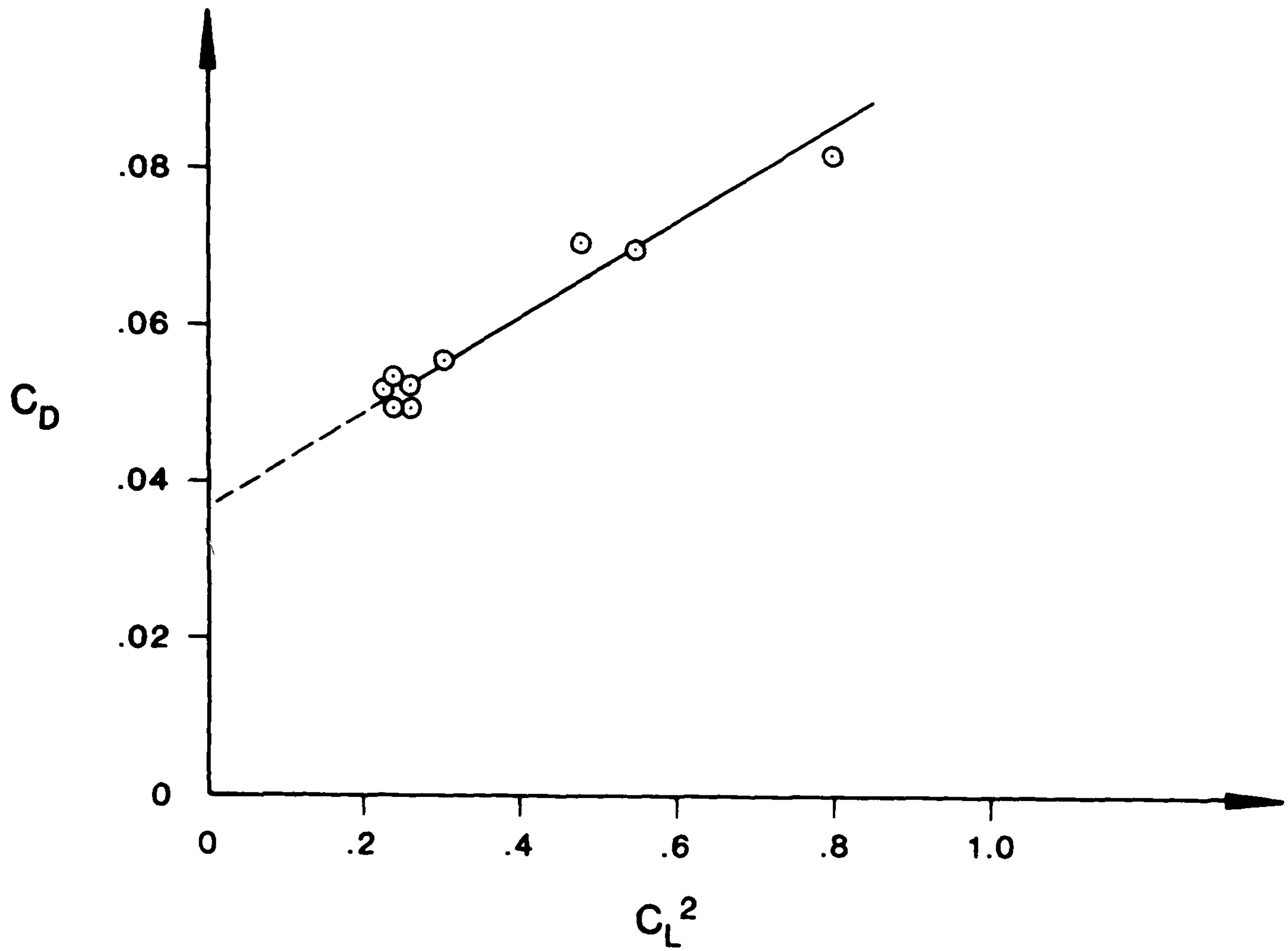




Beechcraft Sierra N6636D
21 Sept'82
W_{STD}=2750 lbs
Sea Level
140
120
100
80
60
BHP_{iw}(HP)
Max Range 97.5 Kts
Max Endurance 72 Kts
40
60
80
100
120
140
160
V_{iw}(KTS)

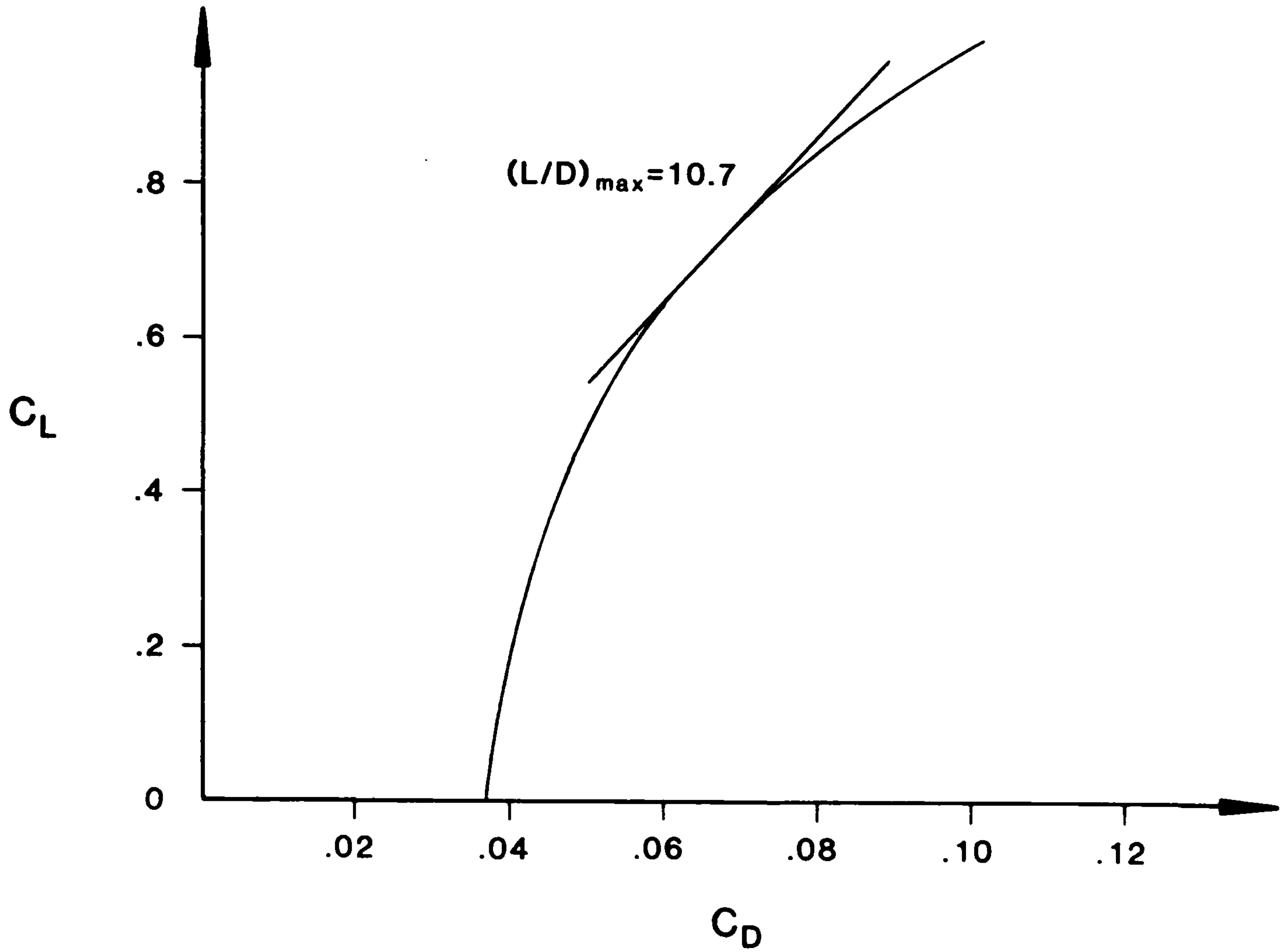
Beechcraft Sierra N6636D

21 Sept'82 $C_D = .037 + .06 C_L^2$



Beechcraft Sierra N6636D

21 Sept'82 $C_D = .037 + .06 C_L^2$



FLIGHT 1 DATA RECORD

RUN NO.	IAS KTS	TACH TIME	OAT °C	ALT FT	MAP IN. (TURN DATA)	RPM (TURN DATA)	FF GPH (TURN DATA)	TIME TO TURN 360° (TURN DATA)	REMARKS
1	108	886.62	10	10,000	20	2650	10.5	208 sec's	$\phi = 10°$
2	104	886.69	10	10,000	20	2650	10.5	70 sec's	$\phi = 30°$
3	96	886.71	10	10,000	20	2600	10.5	42 sec's	$\phi = 45°$

TURN PERFORMANCE DATA REDUCTION

AIRCRAFT: [illegible] WING AREA, S = [illegible] FT² STANDARD WEIGHT, W_s = 2,7[illegible]

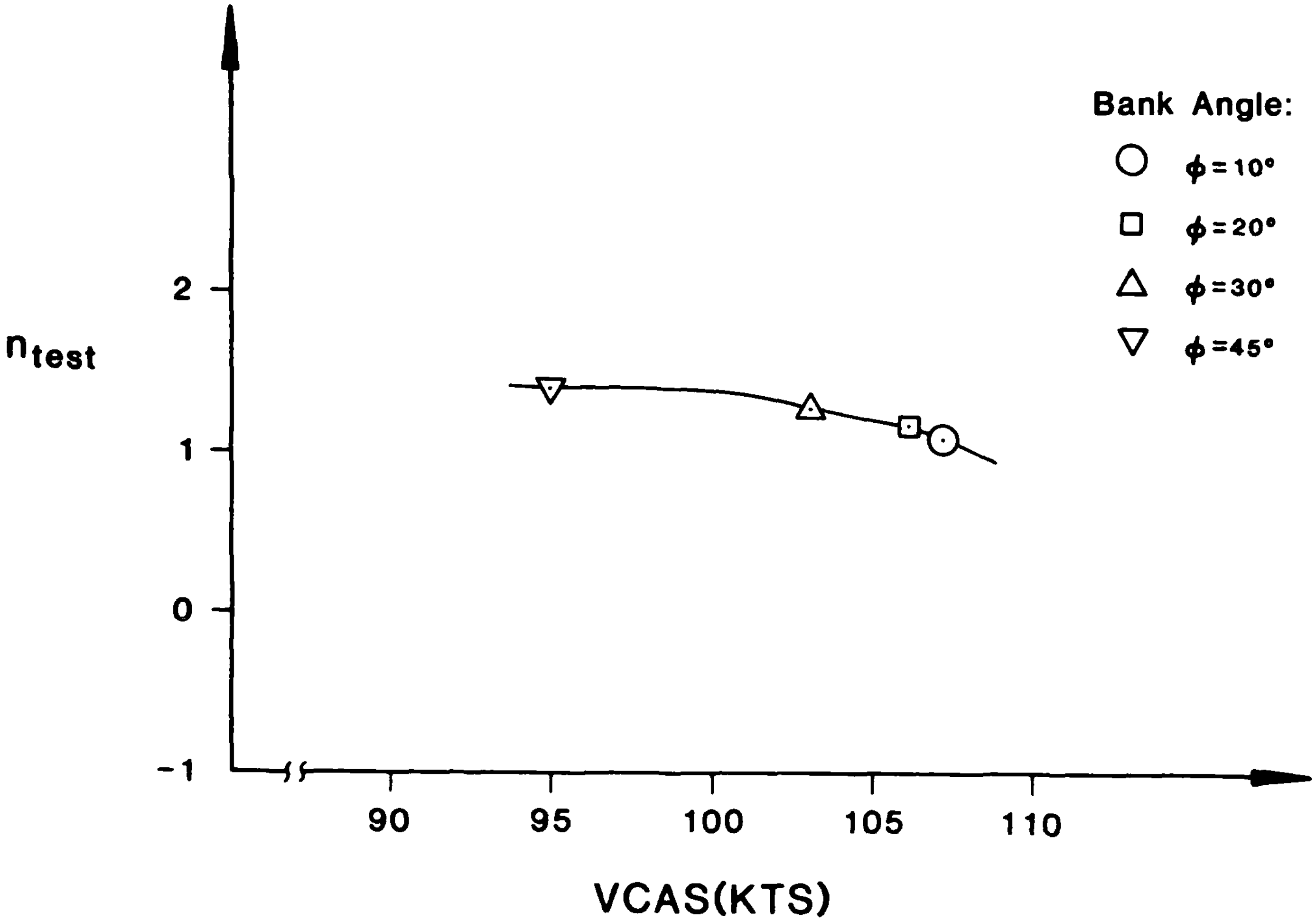
1 V_i (KTS)	2 V_c (KTS)	3 H_i (FT)	4 H_c (FT)	5 T_i °C	6 T_a °K	7 δ P/P_0	8 σ ρ/ρ_0	9 V_{true} FPS	10 TIME SEC'S	11 ω_t DEG/SEC	12 n_t	13 R_t (FT)
108	107	10,000	9998	10	283	.6878	.7003	215.96	208	1.73	1.097	7152
104	103	10,000	9998	10	283	.6878	.7003	207.89	70	5.14	1.257	2317
96	95	10,000	9998	10	283	.6878	.7003	191.74	42	8.57	1.375	1282

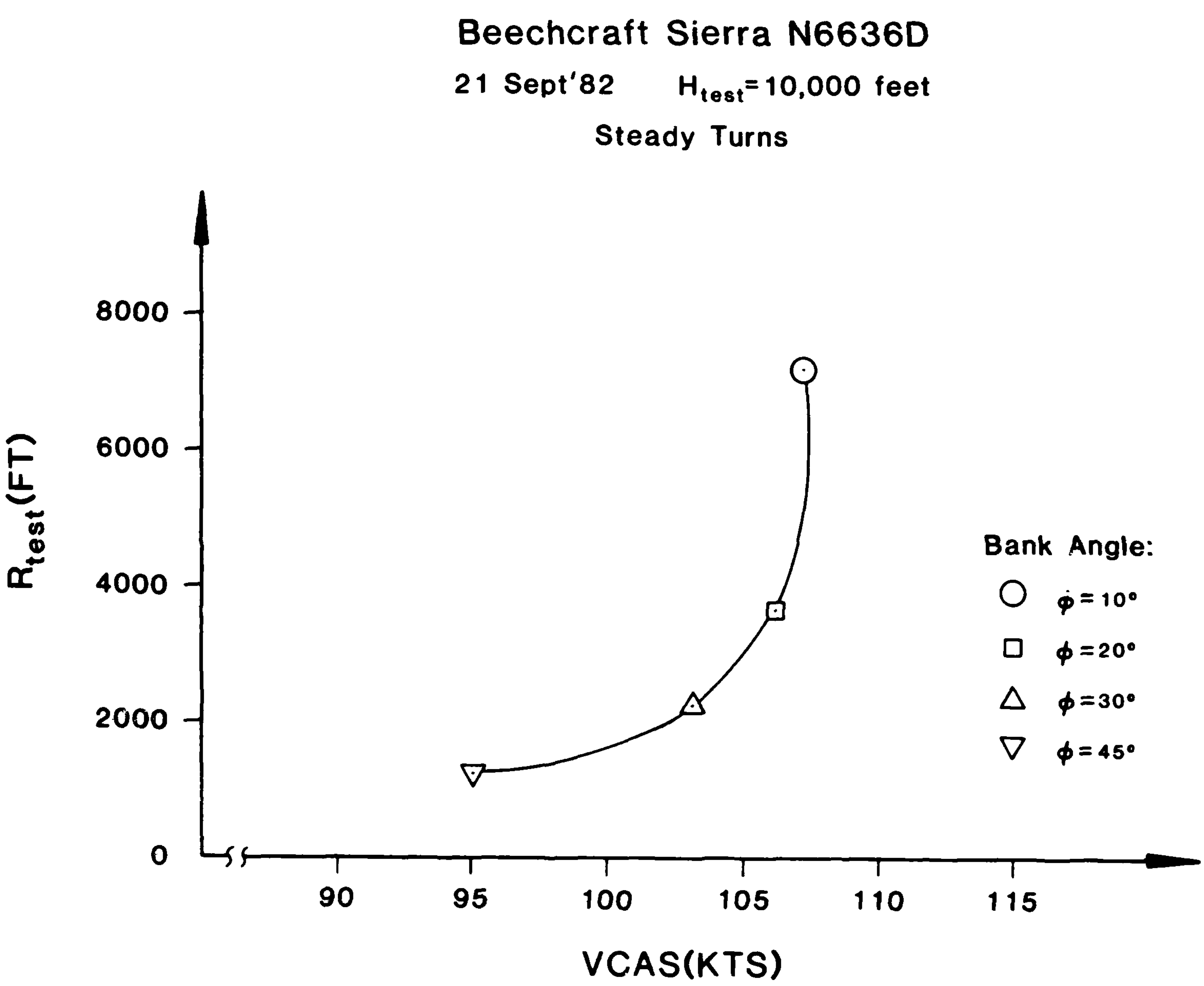
1. V_i (Kts) indicated airspeed
2. V_c (Kts) ≈ V_e (Kts) equivalent airspeed, p. 5-10 F.M.
3. H_i (ft) indicated pressure altitude
4. H_c (ft) calibrated pressure altitude, p. 5-12 F.M.
5. T_i Indicated outside air temperature
6. T_a Outside air temperature, °Kelvin
7. δ, pressure ratio, obtained from altitude charts and H_c
8. σ, density ratio = $\frac{\delta}{T_a\ °K/288.15} = \frac{7 \times 288.15}{6}$
9. V_{true} fps = $\frac{V_e}{\sqrt{\sigma}}$ 1.689 = $(2 \div (8)^{\frac{1}{2}})$ 1.689
10. Time to turn through 360°
11. $\omega_t = \frac{360°}{TIME} = \frac{360°}{10}$ deg/sec
12. $n_t = \sqrt{\left(\frac{\omega_t V_{true}}{57.296 \times g}\right)^2 + 1} = \sqrt{\left(\frac{11 \times 9}{57.296 \times g}\right)^2 + 1}$
13. $R_t = \frac{V_{true}}{\omega_t}$ 57.296 = $(9 \div 11) \times 57.2$[illegible]

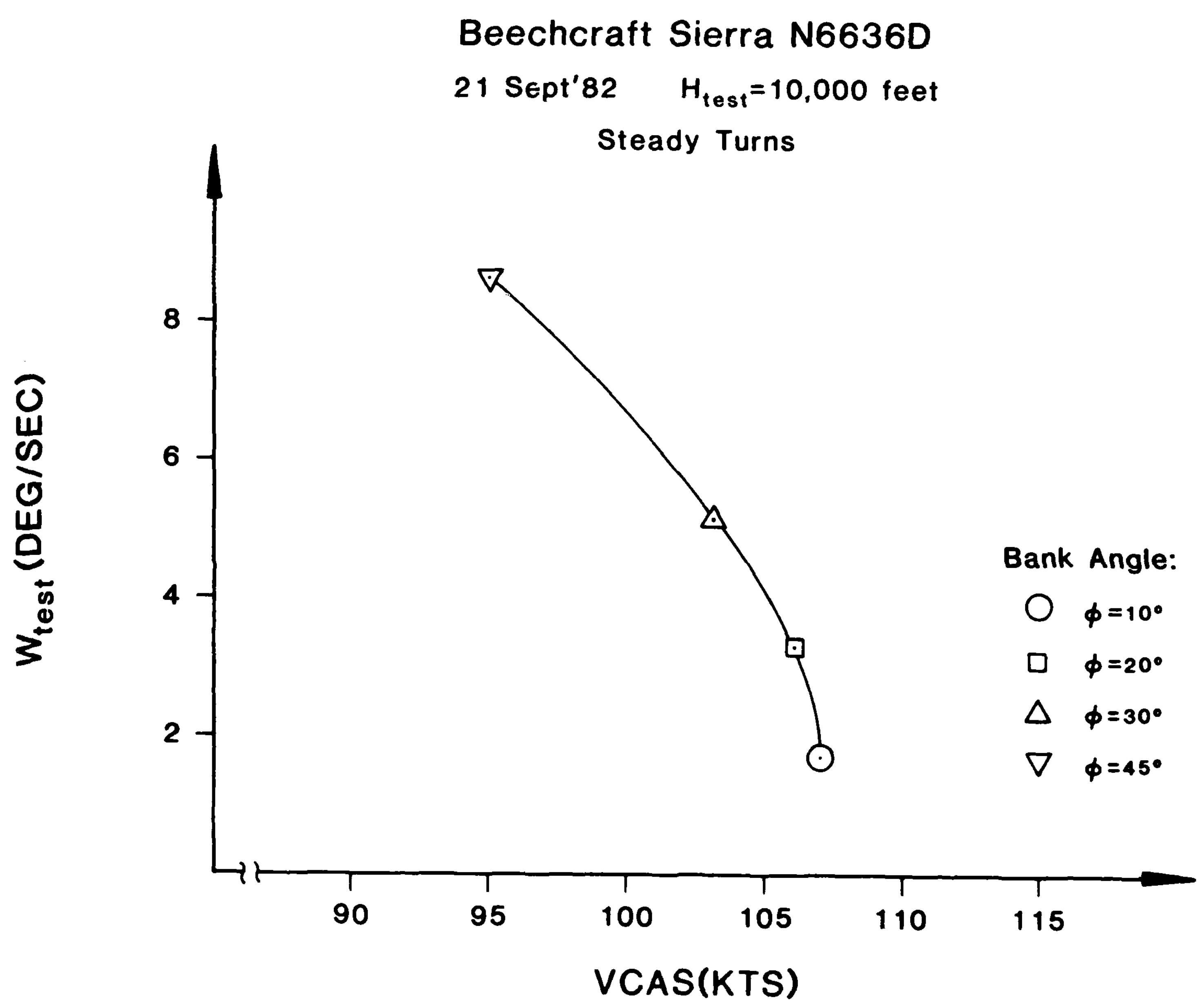
Beechcraft Sierra N6636D

21 Sept'82 H_{test}=10,000 feet

Steady Turns




Beechcraft Sierra N6636D
21 Sept'82 H_{test}=10,000 feet
Steady Turns
R_{test}(FT)
8000
6000
4000
2000
0
90
95
100
105
110
115
VCAS(KTS)
Bank Angle:
$\phi = 10°$
$\phi = 20°$
$\phi = 30°$
$\phi = 45°$


Beechcraft Sierra N6636D
21 Sept'82
H_{test}=10,000 feet
Steady Turns
W_{test} (DEG/SEC)
2
4
6
8
90
95
100
105
110
115
VCAS(KTS)
Bank Angle:
ϕ=10°
ϕ=20°
ϕ=30°
ϕ=45°

FLIGHT DATA RECORD

DATE 18 Feb 83

INSTRUCTOR Crenshaw

STUDENTS Muller

Koehn

AIRCRAFT NO. N18892

PRE-FLIGHT TACH TIME 1644.53

POST-FLIGHT TACH TIME 1645.37

REMARKS:

TAKEOFF DATA: FIELD ELEVATION [illegible]

ALTIMETER 29.99

WINDS 320/5 knots

PRESS. ALT. 6000 ft

TEMP 34°F

GD ROLL (P) 2200 ft

GD ROLL (A) 1900 ft

TAKEOFF V_1 76 mph

CLIMB DATA

RUN NO.	IAS ~~KTS~~ (MPH)	TACH TIME	OAT °C -500	OAT °C ALT	OAT °C +500	TOTAL TIME SECS	RPM MAP FF	VVI (FPM)/ELAPSED TIME (sec's) -400	-300	-200	-100	ALT	+100	+200	+300	+400	+500
1	81	1644.78	+10	+9	+8	116	2600/20/10	600/12	610/21	550/32	510/43	520/55	550/66	510/81	550/92	550/105	520/116
2	100	1644.94	+10	+9	+9	132	2650/19/9	700/7	550/22	510/34	500/47	480/61	500/76	510/87	500/102	450/117	410/132
3	125	1645.16	+11	+10	+8	267	2700/19.5/9	150/40	380/57	180/85	200/113	210/136	220/166	200/192	280/216	280/243	250/267
4																	
5																	
6																	
7																	
8																	
9																	
10																	

CLIMB PERFORMANCE DATA REDUCTION

Aircraft, Sierra [illegible] Wing Area, S = [illegible] ft^2 Standard Weight, W_s = [illegible] lb

1	2	3	4	5	6	7			8	9	10	11	12	13	14	15	16	17	18	19	20
V_i (Kts)	V_c (Kts)	H_i (ft.)	H_c (ft.)	W_t (lb.)	V_{iw} (Kts)	$\left(\frac{dH}{dt}\right)_t$ (fps)	T_t (°K)	T_s (°K)	T_t/T_s	$\left(\frac{dH}{dt}\right)_d$ (fps)	BHP_t (HP)	BHP_s (HP)	ΔBHP (HP)	δ (p/p_o)	σ (ρ/ρ_o)	Propeller C_p	J	η	$\Delta\frac{dH}{dt}$ (fps)	$\left(\frac{dH}{dt}\right)_p$ (fps)	$\left(\frac{dH}{dt}\right)_{STD}$ (fpm)
70.3	69.8	8500	8494	2572	72.2	8.62	282	288	.979	8.44	131	122	9	.7290	.745	.049	.295	.489	2.12	10.56	658
86.8	86.0	8500	8498	2562	89.1	7.58	282	288	.979	7.42	128	127	11	.7287	.745	.045	.356	.585	2.25	9.67	601
108.5	108.0	8500	8498	2550	112.2	3.75	283	288	.983	3.67	133	122	11	.7287	.745	.044	.439	.725	2.29	5.96	371

1. V_i (Kts.) indicated airspeed
2. V_c (Kts.) ≈ V_e (Kts.), p. 5-10 F.M.
3. H_i (ft.) indicated pressure altitude
4. H_c (ft.) calibrated pressure altitude, p. 5-12 F.M.
5. Test Weight, W_t = Basic Empty Weight + crew + fuel
6. $V_{iw} = V_e \left(\frac{W_s}{W_t}\right)^{1/2} = (2) \times \left(\frac{W_s}{(5)}\right)^{1/2}$
7. $\left(\frac{dH}{dt}\right)_t$ Plot H_c versus time. Draw a tangent to the curve at test altitude. Slope is $\left(\frac{dH}{dt}\right)_t$
8. $\frac{T_t}{T_s} = \frac{\text{Absolute Test Temperature}}{\text{Absolute Std. Temperature}}$ at test altitude
9. Density Correction to Rate of Climb

   $$\left(\frac{dH}{dt}\right)_d = \left(\frac{dH}{dt}\right)_t \sqrt{\frac{T_t}{T_s}} = (7) \times \sqrt{(8)}$$
10. BHP_t from engine chart for actual test altitude temperature
11. BHP_s from engine chart for standard temperature at test altitude
12. $\Delta BHP = BHP_s - BHP_t = (11) - (10)$
13. δ, pressure ratio from altitude charts for H_c
14. σ, density ratio $= \frac{\delta}{T_t\ °K/288.15} = \frac{(13) \times 288.15}{T_t\ °K}$
15. C_p, Propeller Power Coefficient knowing BHP_t, RPM and σ
16. J, Propeller Advance Ratio knowing V_e, $\sqrt{\sigma}$ and RPM

17. η, Propeller Efficiency Knowing C_p and J

18. Engine Power and Propulsive Efficiency Correction to Rate of Climb

$$\Delta\left(\frac{dH}{dt}\right) = \frac{\eta}{W_s}\left[\Delta BHP + BHP_s\left(1 - \frac{T_s}{T_t}\right)\right]550$$

$$\Delta\left(\frac{dH}{dt}\right) = \frac{17}{W_s}\left[12 + 11\left(1 - \frac{1}{8}\right)\right]550$$

19. $$\left(\frac{dH}{dt}\right)_p = \left(\frac{dH}{dt}\right)_d + \Delta\left(\frac{dH}{dt}\right) = 9 + 18$$

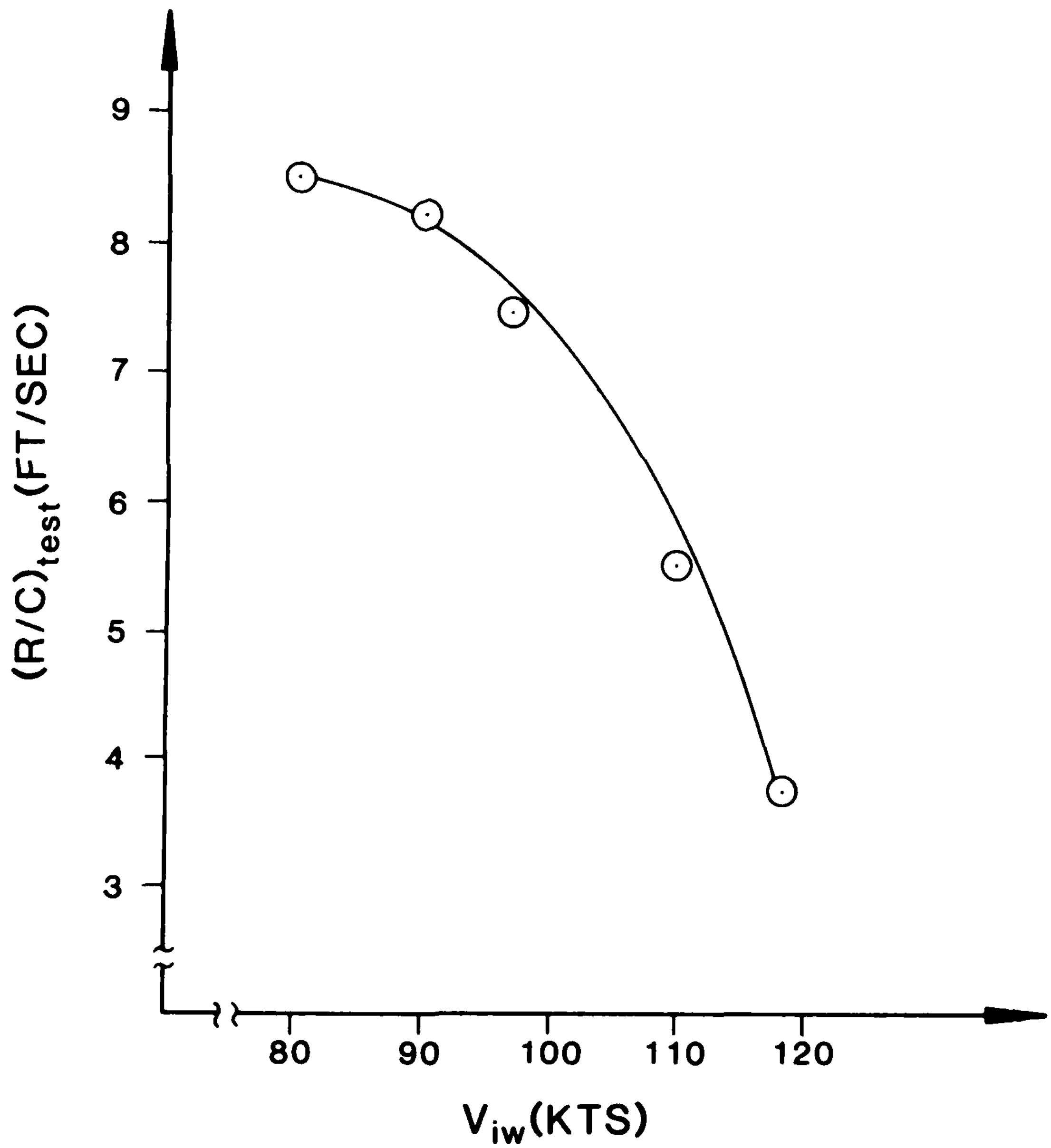
20. Weight Correction to Rate of Climb

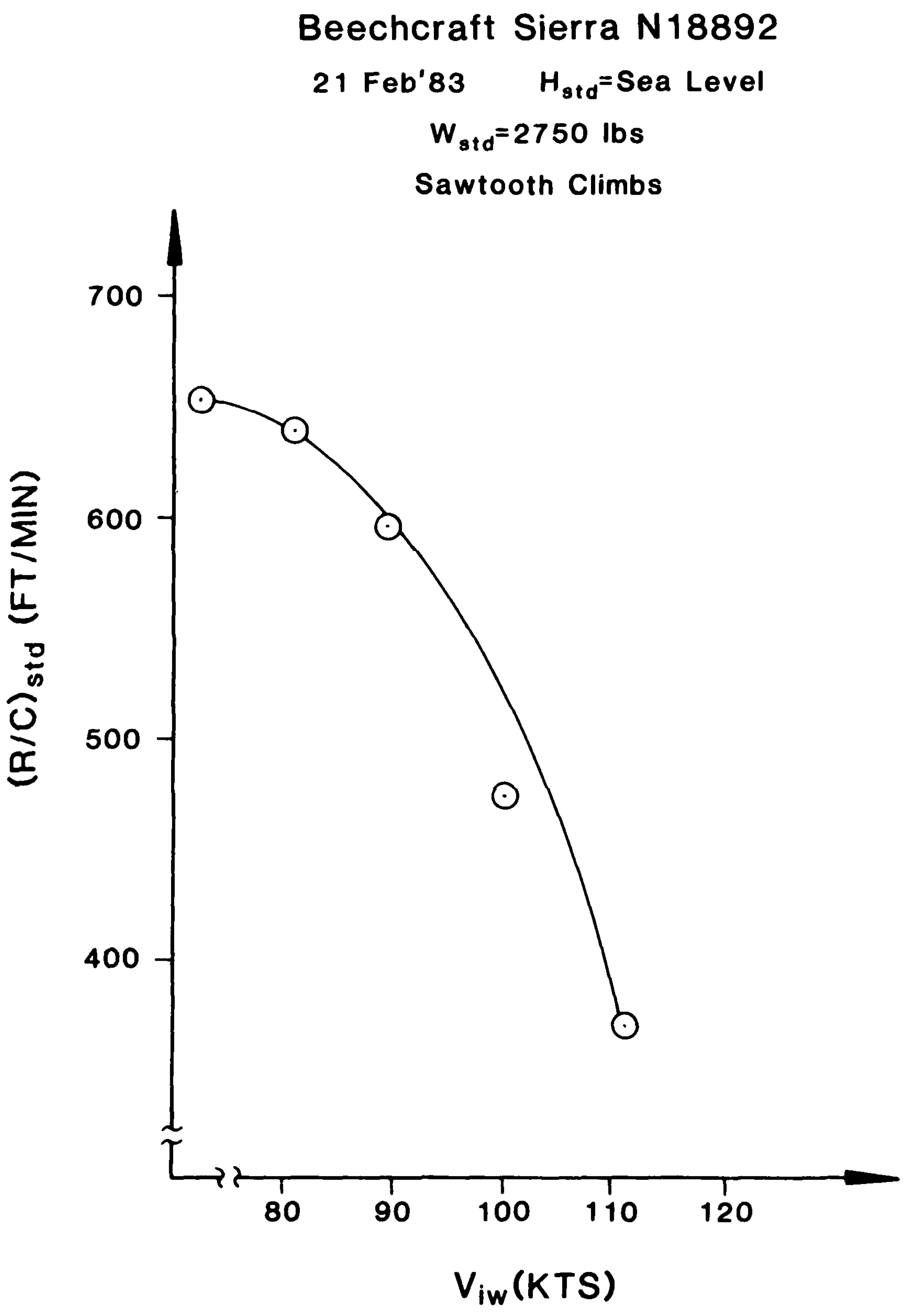
$$\left(\frac{dH}{dt}\right)_{STD} = \left(\frac{dH}{dt}\right)_p\sqrt{\frac{W_s}{W_t}}\,60 = 19 \times \sqrt{\frac{W_s}{5}} \times 60 \text{ (FPM)}$$

Beechcraft Sierra N18892

21 Feb'83 H_{test}=8500 feet

Sawtooth Climbs





Beechcraft Sierra N18892
21 Feb'83 H std=Sea Level
W std=2750 lbs
Sawtooth Climbs
700
600
500
400
(R/C)std (FT/MIN)
80
90
100
110
120
Viw(KTS)

[illegible] DATA

RUN NO.	IAS ~~KTS~~ (MPH)	TACH TIME	[illegible] °C +500	ALT	-500	TOTAL TIME IN SECONDS	VVI (FPM) ELAPSED TIME (sec's) +400	+300	+200	+100	ALT	-100	-200	-300	-400	-500
1	92	1644.76	+7	+8	+9	63	-750/5	-900/13	-950/18	-960/25	-950/30	-990/36	-900/42	-880/48	-900/54	-900/63
2	115	1644.91	+8	+8	+9	53	-920/5	-1000/10	-1150/15	-1100/20	-1000/22	-950/32	-1000/38	-1005/44	-1300/48	-1200/53
3	140	1645.11	+8	+9	+9	34	-1500/4	–	-1700/9	–	-1600/17	–	-1700/25	–	-1800/30	-1800/34
4																
5																
6																
7																
8																
9																
10																

DESCENT PERFORMANCE DATA REDUCTION

AIRCRAFT [illegible] WING AREA, [illegible] SQ. FT. STANDARD WEIGHT, W_s = [illegible]

RUN NO.	V_i (Kts)	V_c (Kts)	H_i (ft.)	H_c (ft.)	W_t (lb)	V_{iw} (Kts)	$\left(\frac{dH}{dt}\right)_t$ (fps)	T_t (°K)	T_s (°K)	T_t/T_s	$\left(\frac{dH}{dt}\right)_d$ (fps)	$\left(\frac{dH}{dt}\right)_{STD}$ (fpm)	δ (p/p_0)	σ (ρ/ρ_0)	V_{true} (Kts)	C_L	C_D	C_L^2	C_L/C_D
1	79.89	79.0	8500	8497	2558	80.4	-16.22	281	271	1.037	-16.82	-1046	.7287	.7472	91.39	1.07	.197	1.145	5.431
2	99.87	98.7	8500	8498	2549	100.6	-18.18	281	271	1.037	-18.85	-1175	.7287	.7472	114.18	.683	.113	.466	6.044
3	121.58	121.1	8500	8497	2537	123.6	-29.63	282	271	1.041	-30.84	-1927	.7287	.7446	140.34	.451	.099	.203	4.556

1. V_i (Kts.) indicated airspeed
2. V_c (Kts.) ≈ V_e (Kts), p. 5-10 F.M.
3. H_i (ft.) indicated pressure altitude
4. H_c (ft.) calibrated pressure altitude, p. 5-12 F.M.
5. Test Weight, W_t = Basic Empty Weight + crew + fuel
6. $V_{iw} = V_e \left(\frac{W_s}{W_t}\right)^{\frac{1}{2}} = (2) \times \left(\frac{W_s}{(5)}\right)^{\frac{1}{2}}$
7. $\left(\frac{dH}{dt}\right)_t$ Plot H_c versus time. Draw a tangent to the curve at test altitude. Slope is $\left(\frac{dH}{dt}\right)_t$
8. $\frac{T_t}{T_s} = \frac{\text{Absolute Test Temperature}}{\text{Absolute Std. Temperature}}$ at test altitude
9. Density Correction to Rate of Descent

$$\left(\frac{dH}{dt}\right)_d = \left(\frac{dH}{dt}\right)_t \sqrt{\frac{T_t}{T_s}} = (7) \times \sqrt{(8)}$$

10. Weight Correction to Rate of Descent

$$\left(\frac{dH}{dt}\right)_{STD} = \left(\frac{dH}{dt}\right)_d \sqrt{\frac{W_s}{W_t}}\ 60 = (9) \times \sqrt{\frac{W_s}{(5)}} \times 60 \text{ (FPM)}$$

11. δ, pressure ratio from altitude charts for H_c
12. σ, density ratio $= \frac{\delta}{T_t\ °K/288.15} = \frac{(11) \times 288.15}{T_t\ °K}$
13. $V_{true}(\text{Kts}) = \frac{V_e}{\sqrt{\sigma}} = (2) \div (12)^{\frac{1}{2}}$
14. $C_L = \frac{W_t}{\frac{1}{2}\rho_0 (V_e \times 1.689)^2 S} = \frac{(5)}{\frac{1}{2}\rho_0 ((2) \times 1.689)^2 S}$

DESCENT PERFORMANCE DATA REDUCTION (continued)

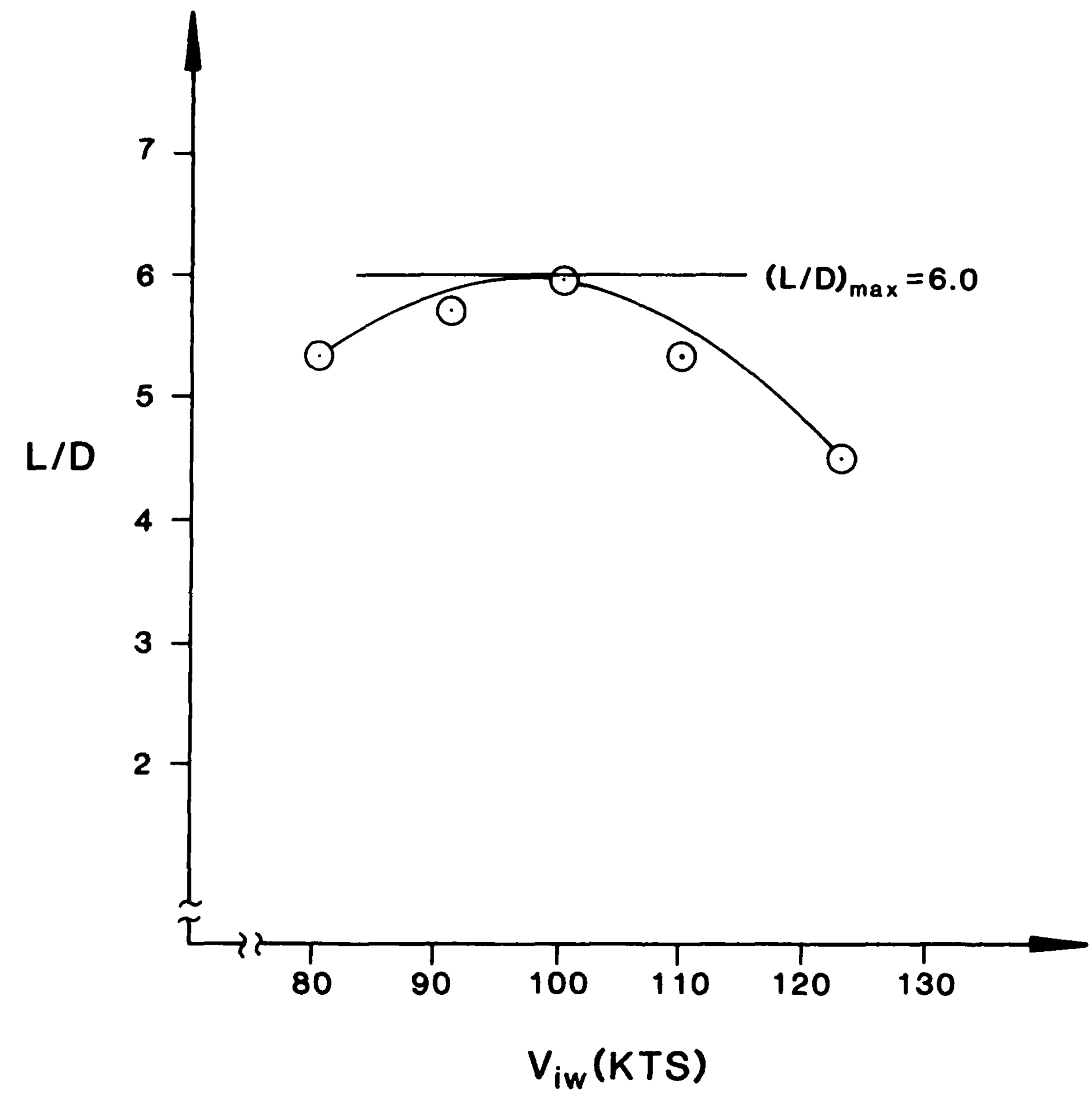
15. $C_D = \dfrac{(dH/dt)_d \, W_t / V_{true}}{\frac{1}{2} \rho_o (V_e \times 1.689)^2 S} = \dfrac{(9) \times (5) \,/\, (13)}{\frac{1}{2} \rho_o ((2) \times 1.689)^2 S}$

Beechcraft Sierra N18892

21 Feb'83 Throttle Idle and

Prop at High Pitch

Sawtooth Descents



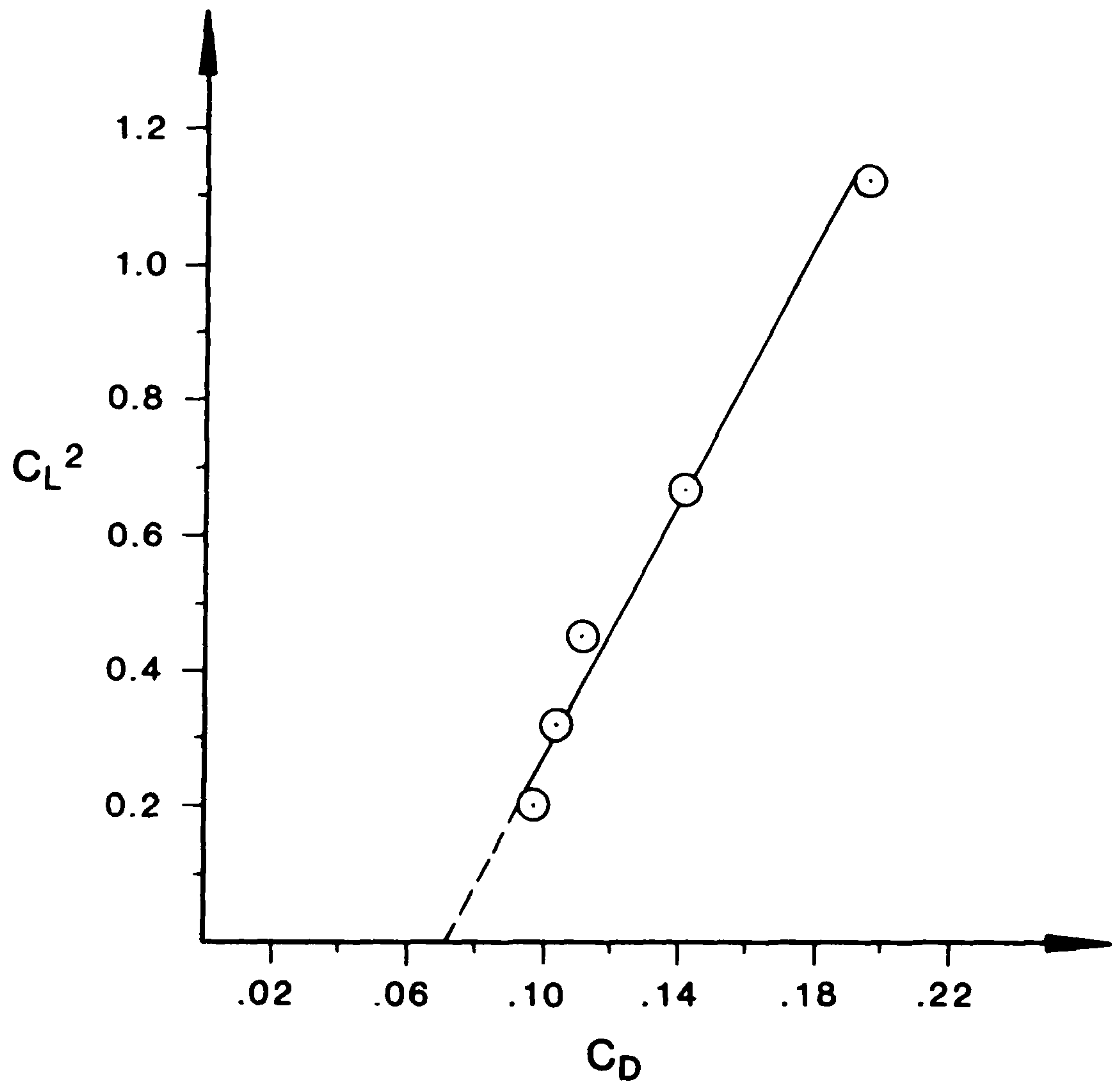
Beechcraft Sierra N18892

21 Feb'83 $C_D = .07 + .10 C_L^2$

Throttle Idle and Prop at

High Pitch

Sawtooth Descents



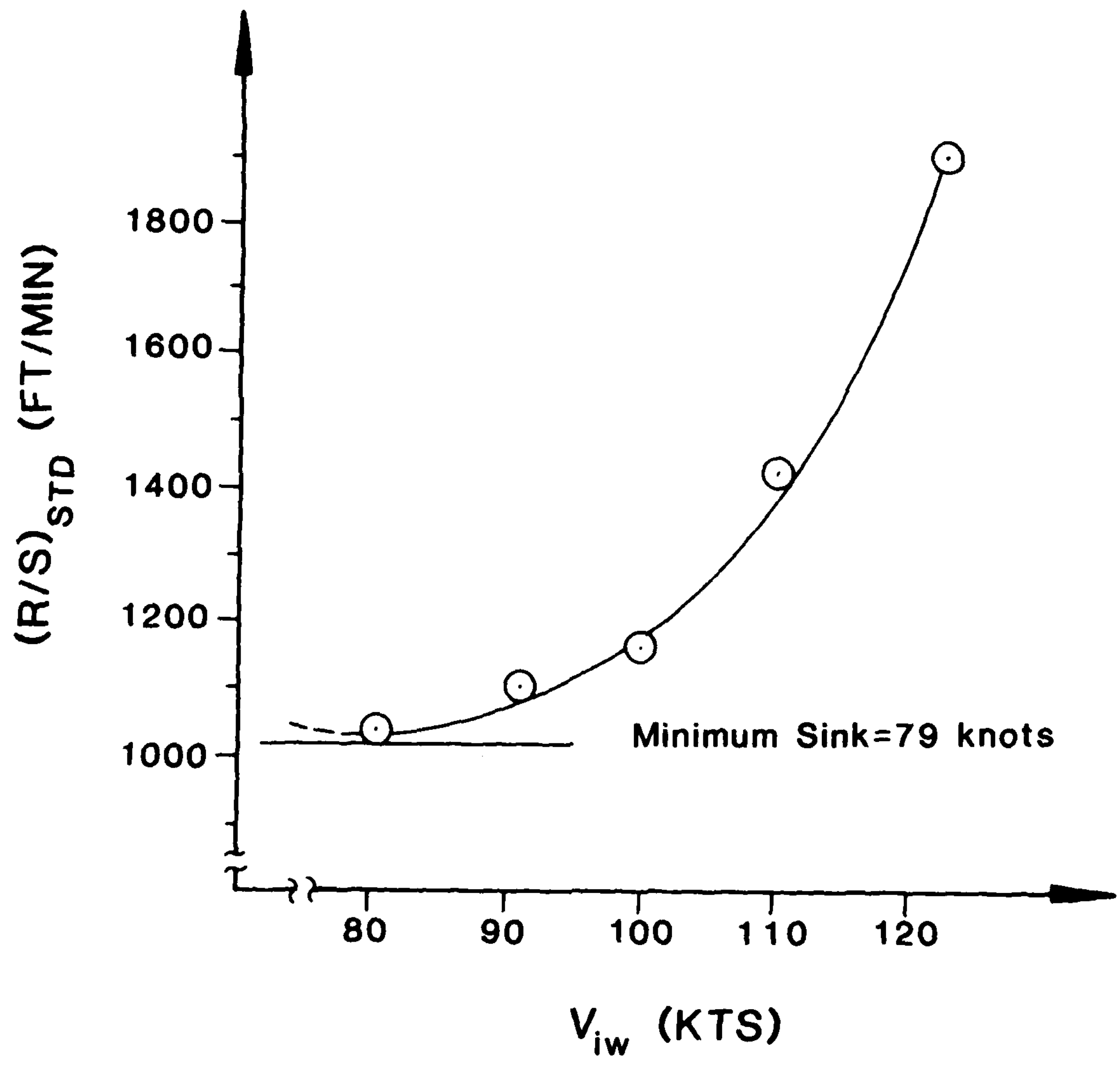
Beechcraft Sierra N18892

21 Feb'83 W_{STD}=2750 pounds

Sea Level

Throttle Idle and Prop at High Pitch

Sawtooth Descents



APPENDIX E

Test Plan
Sundowner 180 C23 Limited Flying Qualities Evaluation

UNITED STATES AIR FORCE ACADEMY

COLORADO 80840

DEPARTMENT OF AERONAUTICS

AERO 495

TEST PLAN

SUNDOWNER 180 C23 LIMITED FLYING QUALITIES EVALUATION

AUGUST 1982

TEST PLAN

DEPARTMENT OF AERONAUTICS

SUNDOWNER 180 C23 LIMITED FLYING QUALITIES EVALUATION

AUGUST 1982

This test plan has been prepared by:

KENT R. CRENSHAW, Major, USAF
Aero 495 Course Director
Department of Aeronautics

Reviewed by:

WILLIAM C. ROBERSON, Captain, USAF
Aero 495 Course Pilot
Department of Aeronautics

Reviewed by:

WAYLAND S. EBERHARDT
Director of Flight Operation
Hedrick Beechcraft Inc.

TABLE OF CONTENTS

TEST PLAN

DEPARTMENT OF AERONAUTICS

SUNDOWNER 180 C23 LIMITED FLYING QUALITIES EVALAUTION

INTRODUCTION

A limited flying qualities evaluation of the Beech Sundowner 180 C23 will be conducted by U. S. Air Force Academy, Department of Aeronautics (DFAN) faculty pilots and students enrolled in Aero 495. Flight testing will be conducted during the Fall 1982 semester from the 13th to 18th week of classes. Results of the evaluation will be presented in a formal oral report given by each of two student test teams.

OBJECTIVES

The primary objective of this test program is to provide the cadets with practical experience in flying qualities testing. They will qualitatively and quantitatively evaluate the Beech Sundowner 180 C23 as a primary trainer for Class I. The aircraft will be tested for compliance with MIL-F-8785C, Flying Qualities of Piloted Airplanes. Only those paragraphs of MIL-F-8785C listed under the Test Description/Procedures section of this test plan will be used in evaluating the Sundowner.

AUTHORITY

This test program will be conducted by Department of Aeronautics faculty and students as a part of the curriculum for Aero 495, a course in flight test techniques. The program has the approval of the Superintendent, the Dean of the Faculty, the Head of the Department of Aeronautics, and the Director of Flight Operation of Hedrick Beechcraft Inc.

TEST TEAM ORGANIZATION

Test team organization shown in Figure 1 will consist of two DFAN faculty pilots and two student flight test engineer teams. Each test team will be assigned to fly with one faculty pilot. A Test Director for each team will be appointed to coordinate the evaluation effort. He will appoint individuals to be in charge of each test area (i.e., data monitors). It will be the data monitor's responsibility to specify the test to be flown in support of his test area. Test areas to be assigned are weight and balance; longitudinal static stability and control; maneuvering flight; lateral-directional stability and control; dynamic stability; and high angle of attack (AOA) flying qualities.

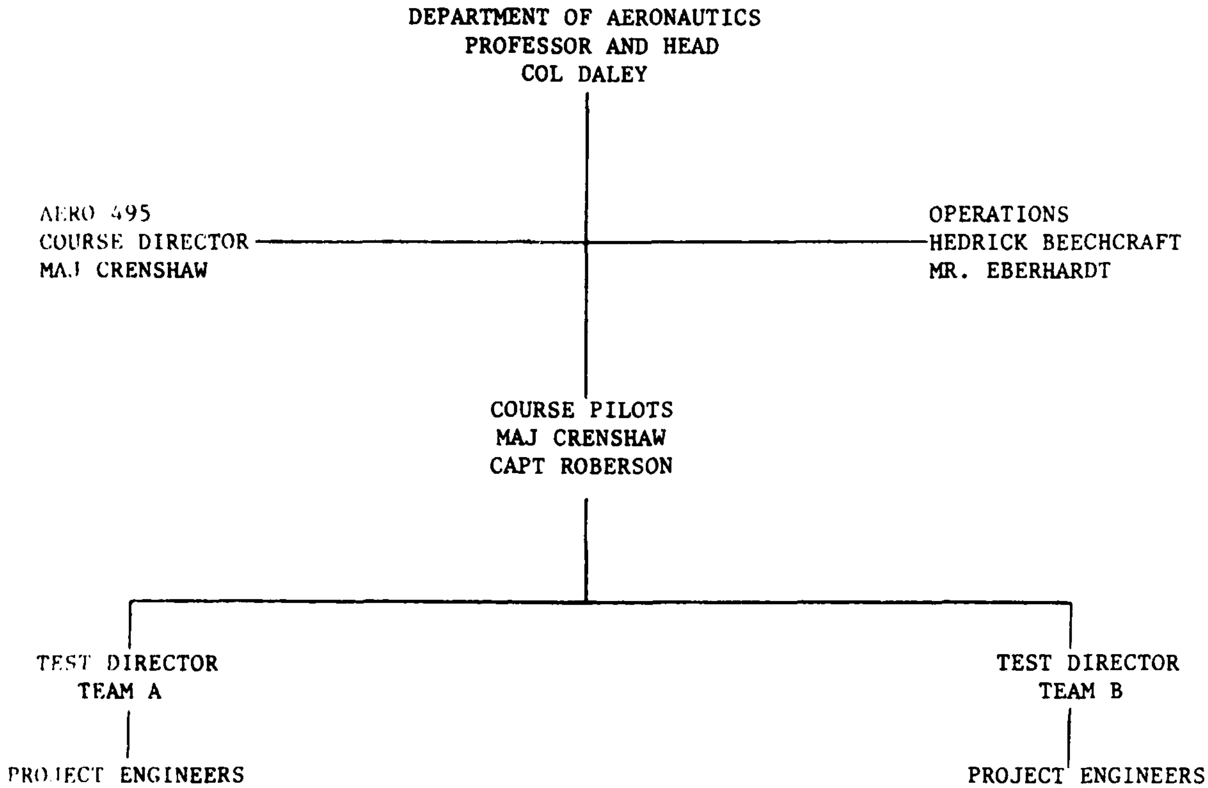


Figure 1. Organization Chart

SCOPE/SCHEDULE

The evaluation will consist of sorties as specified in Table I.

Table I. Data Sorties

Test	Sorties Per Test Team	Flight Time Per Sortie
· Flight #3 Longitudinal and Lateral-Directional Stability and Control; Maneuvering Flight	2.5	1.0
· Flight #4 Dynamic Stability; Stalls	2.5	1.0
*Total	5.0	

*One sortie will be shared by both test teams. Flight #3 and #4 are scheduled as shown on the Integrated Academics and Flying Schedule for Aero 495. Mission time will not exceed 1.0 hour.

LIMITATIONS

The following limitations will be observed during this evaluation.

A. The aircraft will be operated in the normal category in accordance with the Airplane Flight Manual, FAR Part 91 and all Beech Aero Club Operating Instructions.

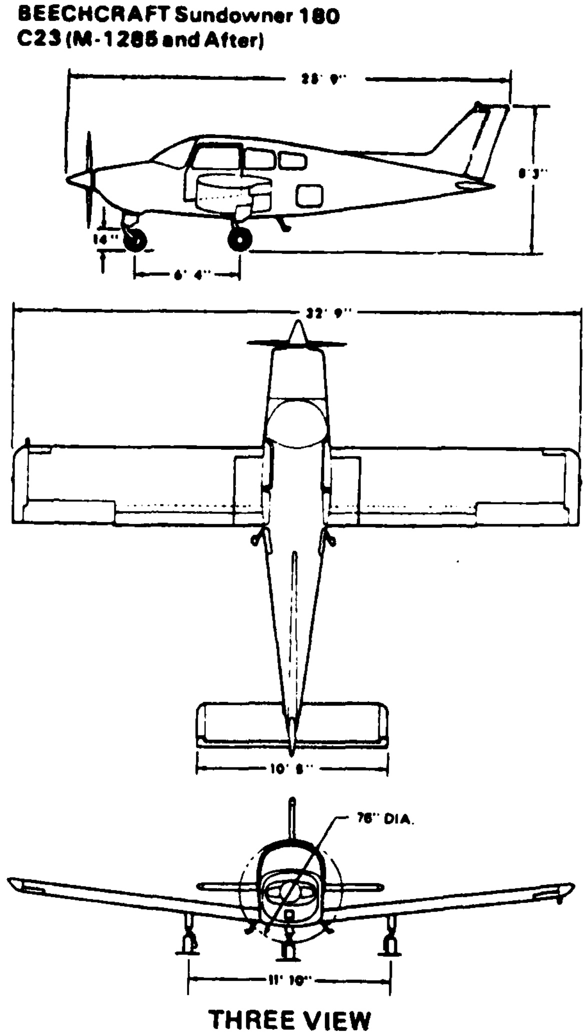
B. All data sorties will be flown with one DFAN faculty pilot and two cadets.

C. Testing will only be accomplished under VFR daytime conditions at 10,000 feet MSL and below.

D. All testing will be accomplished within the local flying area of Colorado Springs.

TEST AIRCRAFT DESCRIPTION

The Beechcraft Sundowner 180 C23, manufactured by Beech Aircraft Corporation, is a four-place, fixed gear, general aviation aircraft powered by one 4-cylinder, 180 HP Avco Lycoming engine. The propeller is a Sensenich fixed pitch, two-blade prop with spinner. See Figure 2 for general dimensions and Table II for Aircraft Limitations.



$S = 146 \text{ ft}^2$

$AR = 7.5$

$\bar{c} = 52.7$ inches

Figure 2. Three View of Sundowner 180 C23
(Reference 1)

Table II. Aircraft Limitations

	IAS Knots/mph
Never Exceed Speed (V_{NE})	152/175
Maximum Maneuvering Speed (V_A)	118/136
Maximum Cruising Speed in Turbulent Air (V_C)	136/156
1G Stall Speed, Flaps Up (2,450 lbs) (power idle)	63/ 72
Maximum Ramp Weight	2,455 lbs
Maximum Takeoff and Landing Weight	2,450 lbs
Flight Maneuvering Load Factor:	
Flaps Up	+3.8 to -1.9G
Flaps Down	+1.9G
Maneuver Bank Angles No More Than 60°	
Sideslips are restricted to 30 seconds duration	
Service Ceiling 12,600 feet	
Test Plan Ceiling 10,000 feet	

FLIGHT TEST INSTRUMENTATION

Test data will be hand recorded using standard cockpit instrumentation, a mechanical force gage for elevator forces, a six volt electric strain gage device for rudder pedal forces, an accelerometer, and a stopwatch. As an option, a cassette tape player may be used to record data.

WEIGHT AND BALANCE

Detailed weight and balance records for each aircraft are available at Hedrick Beechcraft and will be reproduced in a handout for student use. Prior to every data mission, student test engineers will calculate aircraft weight and balance data for both takeoff and landing. Each test team will evaluate the longitudinal and maneuvering flying qualities of the Sundowner in both a forward and aft center of gravity (c.g.) condition. The only approved means of c.g. control will be in passenger seating, i.e., heaviest cadet either in front or back seat. Under no circumstances will the aircraft be operated outside the Flight Manual forward and aft c.g. limits.

TEST DESCRIPTION/PROCEDURES

A. General

All flying qualities tests will be performed with the engine operating and the wing flaps retracted. All data will be hand and/or voice recorded; and, as required, manually reduced to standard conditions.

B. Longitudinal Static Stability and Control

1. The aircraft will be evaluated against the following paragraphs of reference 2 at the test points in Table III.

3.2.1.1 Longitudinal Static Stability
3.2.3.1 Longitudinal Control in Unaccelerated Flight

2. (3.2.1.1) The test will be accomplished using one of the methods described in reference 3. The airspeed will be varied over a range of ± 15 percent of the trim speed. The altitude will be maintained within ± 1,000 feet of the test altitude.

3. Using data from both aft and forward c.g. locations, the stick-free and stick-fixed neutral points will be determined using the procedure in reference 3.

C. Maneuvering Flight

1. The aircraft will be evaluated against the following paragraphs of reference 2 at the test points in Table III.

3.2.2.2 Control Feel and Stability in Maneuvering Flight
3.2.2.2.1 Control Forces in Maneuvering Flight
3.2.2.2.2 Control Motions in Maneuvering Flight
3.2.3.2 Longitudinal Control in Maneuvering Flight

2. (3.2.2.2, 3.2.2.2.1, 3.2.2.2.2) Data for evaluating the aircraft against these paragraphs will be obtained using one of the methods described in reference 3. Altitude will be maintained within ± 1,000 feet of the trim altitude. "G" will be relaxed during rollout to avoid excessive asymmetric "G" loads on the aircraft.

3. Data from both aft and forward c.g. tests will be used to determine the stick-free and stick-fixed maneuver points in accordance with the procedure outlined in reference 3.

Table III. Static and Dynamic Stability and Control Test Points

*Test Point Nu	Pressure Altitude (feet)	Trim Airspeed (KIAS)
1	8,000	80
2	8,000	90
3	9,000	80
4	9,000	90

*Accomplish each test point at both forward and aft c.g. for longitudinal and maneuvering flight tests.

D. Lateral-Directional Stability and Control

1. The aircraft will be evaluated against the following paragraphs of reference 2 at the test points in Table III.

3.3.4	Roll Control Effectiveness
3.3.4.4	Linearity of Roll Response
3.3.4.5	Wheel Control Throw
3.3.2.5	Control of Sideslip in Rolls
3.3.2.6	Turn Coordination
3.2.3.7	Longitudinal Control in Sideslip
3.3.5	Directional Control Characteristics
3.3.6.1	Yawing Moments in Steady Sideslips
3.3.6.2	Side Forces in Steady Sideslips
3.3.6.3	Rolling Moments in Steady Sideslips

2. (3.3.2.6) This test will be accomplished by first trimming the aircraft in wings-level flight at the desired test point. Then a coordinated 45° bank turn will be established at the trim airspeed.

3. (3.2.3.7, 3.3.5, 3.3.6.1, 3.3.6.2, 3.3.6.3) Testing in these areas will be accomplished using the techniques described in reference 3.

4. Altitude for all tests will be maintained within ± 1,000 feet of the trim altitude.

5. Maximum sideslip duration will not exceed 30 seconds.

E. Dynamic Stability

1. The aircraft will be evaluated for compliance with the following paragraphs of reference 2.

3.2.1.2	Phugoid Stability
3.2.2.1	Short-Period Response
3.3.1.1	Lateral-Directional Oscillations (Dutch Roll)
3.3.1.2	Roll Mode
3.3.1.3	Spiral Stability

2. These tests will be accomplished at the points listed in Table III using the test methods specified in reference 3.

3. (3.3.1.1) The Dutch Roll will be excited using ramp rudder inputs applied smoothly to ½ deflection either side of neutral. Sharp or rapid rudder inputs, which impose high loads on the aircraft structure, will not be used to excite the Dutch Roll.

4. (3.3.1.2) The aircraft will be trimmed initially for wings-level flight at the desired test point. From a coordinated 45° bank turn at the trim airspeed, roll performance will be tested by rolling the aircraft with a step aileron input to the same bank angle in the other direction. Roll performance will be measured at ½ and full control wheel deflections.

F. High AOA Tests

1. The aircraft will be tested for compliance with the following paragraphs of reference 2 and at the test points shown on Table IV.

Table IV. High AOA Test Points

Test Point Nu	Pressure Altitude (feet)	*Trim Airspeed (KIAS)
5	9,000	1.2 V_s
6	10,000	1.2 V_s

*For the purpose of determining trim airspeed, V_s will be the wings level, flaps up, power off stall speed of 72 mph/ 63 KIAS.

3.4.2	Flight at High Angle of Attack
3.4.2.1	Stalls
3.4.2.1.1	Stall Approach
3.4.2.1.1.1	Warning Speed for Stalls at 1g Normal to the Flight Path
3.4.2.1.2	Stall Characteristics
3.4.2.1.3	Stall Prevention and Recovery

2. The aircraft will be tested only during Phase A stalls as defined in reference 4. Emphasis during the test program will be placed on determining the adequacy of the aircraft controls during the approach to the stall and during stall recovery; the adequacy and nature of the stall warning characteristics; and the stall recovery techniques. The aircraft will not be flown into a deep stall. Recovery will be initiated when (see Table I, reference 4):

a. a definite g-break occurs.

b. a rapid, uncommanded angular motion develops.

c. the aft stick stop has been reached and pitch attitude cannot be increased.

d. sustained heavy buffet develops.

3. The aircraft will be trimmed for 1g flight at the airspeed and altitudes specified in Table IV. Using the test methods in reference 3, the aircraft will then be maneuvered so that the stall occurs at the test altitude (± 500 feet).

4. Stall recovery will be initiated at the onset of the first stall.

5. Stalls will be accomplished at 8,500 feet MSL minimum.

TRAINING

Both DFAN faculty pilots will have at least an FAA commercial pilot rating and be current in the Beech Sundowner 180 C23 in accordance with FAA and Hedrick Beechcraft Aero Club standards.

All cadets enrolled in Aero 495 will participate in the flying portion of the course as passengers only and will receive appropriate aircraft orientation and safety instruction. All the performance flight test techniques required to gather test data will be covered during classroom lectures prior to the flights for which they will be used.

CREW DUTIES

A. Pilot

1. Check local flying weather.

2. Brief students on mission profile, and ground and in-flight safety.

3. Check maintenance status of aircraft and perform pre-flight.

4. Provide a stopwatch.

5. Provide the tachometer reading at which the aircraft was refueled and the quantity of fuel and oil on board.

6. Act as pilot in command of the aircraft and occupy the left front seat at all times.

B. Students

1. Bring data cards and a clipboard.

2. Complete aircraft weight and balance form.

3. Compute takeoff data using temperature and pressure altitude provided by the pilot.

4. Provide cassette tape player for each flight. (optional)

5. Record tachometer reading at which the aircraft was refueled and the quantity of fuel and oil on board.

6. Cadets will be assigned to two man teams for purposes of taking flight test data. Flight crew duties will be rotated each flight. Along with the pilot who will be primarily concerned with precisely flying the aircraft, both cadets will act as lookouts and notify the pilot immediately of any aircraft sighted. The cadet in the right front seat will act as data observer and timekeeper, and the cadet in the rear seat will act as data recorder.

SAFETY

Flight personnel will adhere to the following while on the flightline and in and around the aircraft:

a. Smoking is prohibited in or near the aircraft.

b. Seat belts will be worn at all times.

c. Flight personnel will be seated in the aircraft prior to engine start and will remain seated until the engine is stopped.

d. Remain clear of the propeller area at all times.

e. Do not stand, walk, or lean on the aircraft except in designated areas.

f. Do not open aircraft windows or doors in flight.

g. Advise the pilot immediately upon observing another aircraft.

h. Do not manipulate the aircraft flight controls or engine controls unless told to do so by the pilot.

i. Advise the pilot of impending airsickness. Use the bag provided, <u>your</u> hat, <u>your</u> shoe, anything except the floor of the aircraft.

j. Stay clear of taxiing aircraft and other flightline vehicles.

COMMAND AND CONTROL

All testing to be accomplished will be for academic purposes only and will be performed within the restrictions of the Flight Manual, Part 91 of the FAR's, Hedrick Beechcraft Aero Club Rules and the limitations imposed by this test plan.

All information with respect to this test plan is unclassified.

TEST PLAN AMENDMENTS

An amendment to this test plan is required if the flight test envelope is expanded or if any limitations in the test plan are made less restrictive. An amendment to the test plan must be reviewed and approved by the same authority who approved the basic plan.

REFERENCES

1. Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for the Beechcraft Sundowner 180 C23, Beech Aircraft Corporation, Wichita, Kansas, August 1980.

2. Military Specification, Flying Qualities of Piloted Airplanes, Department of the Air Force, Washington, D.C., MIL-F-8785C, 5 November 1980.

3. Roberts, Sean C., Flying Qualities Flight Testing of Light Aircraft for Test Pilots and Flight Test Engineers, Flight Research, Inc., Mojave, California, September 1981.

4. Military Specifications, Stall/Post-Stall/Spin Flight Test Demonstration Requirements for Airplanes, Department of the Air Force, Washington, D.C., MIL-S-83691A (USAF), 15 April 1972.

MEMORANDUM FOR THE RECORD 29 October 1982

Subject: Aero 495 Test Plan Revision for Sundowner 180 C23 Limited Flying Qualities Evaluation

To: Captain William C. Roberson William C. Roberson
Aero 495 Course Pilot

Mr. Wayland S. Eberhardt ____________________
Director of Flight Operation
Hedrick Beechcraft, Inc.

1. The Test Plan for the Sundowner 180 C23 Limited Flying Qualities Evaluation dated August 1982 is revised. The second to the last sentence in the paragraph titled Weight and Balance on page 5 should read:

> "The only approved means of aft c.g. control will be with the use of two 50 pound lead weights secured in the baggage area. Ballast will not be carried for forward c.g. control."

2. There may not be sufficient spread in center of gravity location by using passenger seating alone to get adequate forward and aft c.g. flying qualities data. Adding lead ballast to the baggage compartment, however, does enhance the importance of checking the weight and balance prior to flight.

3. The following table is provided to aid you in computing weight and balance with ballast on board:

REG NO.	BASIC EMPTY CONDITION + 100 LBS BALLAST	MOM/100 (in/lb_f)	% c.g. SHIFT AFT
N6014M	1690.0 lbs	1945	2.7%
N60171	1625.0 lbs	1855	2.7%
N18325	1680.5 lbs	1959	2.8%

Kent R. Crenshaw
KENT R. CRENSHAW, Maj, USAF
Aero 495 Course Director

APPENDIX F

Flight Test Planing Guide
Sundowner 180 C23 Limited Flying Qualities
Evaluation

AERO 495 FLIGHT TEST TECHNIQUES

FLIGHT TEST PLANNING GUIDE

SUNDOWNER C23 LIMITED FLYING QUALITIES EVALUATION

MAJ CRENSHAW

FEBRUARY 1983

CONTENTS

PAGE

FLIGHT 3

Longitudinal and Lateral-Directional Stability and Control; Maneuvering Flight

I. OBJECTIVES

A. Measure the slope and linearity of the longitudinal stick force and elevator displacement curves.

B. Determine the stick-fixed and stick-free neutral points.

C. Determine the stick-fixed and stick-free maneuver points.

D. Measure the slope and linearity of the rudder pedal force and displacement versus sideslip.

E. Evaluate the turn coordination of the aircraft.

II. AIRCRAFT

Beechcraft Sundowner 180 C23

III. LIMITATIONS

As specified in the test plan.

IV. MISSION EVENTS

A. Pilot

1. Make a Flight Manual, no flap takeoff.

2. Stabilize the aircraft in level flight at a selected test altitude of either 8,000 or 9,000 feet.

3. Trim the aircraft for either 80 or 90 KIAS. Lean the engine for best cruise.

4. From the trim airspeed, use the stabilized test technique and vary airspeed ± 15%, staying within ± 1,000 feet of the test altitude.

5. From the trim airspeed, use the stabilized test technique and vary load factor up to and including ≈ 2.0 "g's" while descending to maintain constant airspeed. Stay within ± 1,000 feet of the test altitude. Perform the test in both directions.

6. Perform steady sideslips at various sideslip angles up to maximum sideslip in both directions. Maximum sideslip duration will not exceed 30 seconds.

7. Stabilize the aircraft in 45° bank turns in both directions at the trim airspeed and test altitude.

8. Make normal full stop landing.

B. Students

1. Compute take-off weight, center of gravity and predicted take-off roll.

2. Record the data required on the attached data sheets.

3. Record both pre-flight and post-flight aircraft tach time.

V. STUDENT POST-FLIGHT DATA REDUCTION

A. Reduce the data using the attached data reduction sheets.

B. Plot:

1. Stick deflection δ_e and stick force F_e versus indicated airspeed V_i for longitudinal static stability test points.

2. Stick deflection δ_e and F_e/q versus lift coefficient C_L.

3. Stick deflection δ_e and stick force F_e versus load factor n.

4. Rudder deflection δ_R and rudder force F_R versus sideslip angle β.

5. Bank angle $\emptyset$, aileron deflection δ_a and stick force F_e versus β.

C. Using data from other flights (if available) with forward and aft centers of gravity, determine the following:

1. Stick-fixed and stick-free neutral points.

2. Stick-fixed and stick-free maneuver points.

3. Compare these points to the forward and aft center of gravity limits in the flight manual.

D. Evaluate the aircraft against the following paragraphs of MIL-F-8785C:

3.2.1.1	Longitudinal Static Stability
3.2.2.2	Control Feel and Stability in Maneuvering Flight
3.2.2.2.1	Control Forces in Maneuvering Flight
3.2.2.2.2	Control Motions in Maneuvering Flight
3.3.2.6	Turn Coordination
3.2.3.7	Longitudinal Control in Sideslip
3.3.6.1	Yawing Moments in Steady Sideslips
3.3.6.2	Side Forces in Steady Sideslips
3.3.6.3	Rolling Moments in Steady Sideslips

E. Complete the "Initial Flight Test Report".

F. Complete a set of sample calculations.

G. Turn in the "Initial Flight Test Report", MIL-F-8785C evaluation results, recorded data sheeets, data reduction sheets, sample calculations and plots using the format specified in the "Guidelines for Flight Reports" handout.

FLIGHT 3 DATA RECORD

DATE ______________________

INSTRUCTOR ______________________

STUDENTS: OBSERVER - ______________________

RECORDER - ______________________

AIRCRAFT NU. N- ______________________

PRE-FLIGHT TACH TIME ______________________

REMARKS:

TAKEOFF DATA: FIELD ELEVATION - 6,172 FEET

ALTIMETER ______________________

WINDS ______________________

PRESS. ALT. ______________________

TEMP. ______________________

GD ROLL (P) ______________________

FUEL ______________ OIL ______________

POST-FLIGHT TACH TIME ______________________

LONGITUDINAL STATIC STABILITY

Trim Conditions: (RUN 1)

V_i (KTS) ______

H_i (FT) ______

T_i (°C) ______

Tach Time ______

MAP/RPM ______

V_{aim} (KTS)	V_i (KTS)	δ_e (IN)	F_e (lb_f)
V_{trim}			
V_{trim}			

Remarks:

Trim Conditions: (RUN 2)

V_i (KTS) ______

H_i (FT) ______

T_i (°C) ______

Tach Time ______

MAP/RPM ______

V_{aim} (KTS)	V_i (KTS)	δ_e (IN)	F_e (lb_f)
V_{trim}			
V_{trim}			

MANEUVERING STABILITY

Trim Conditions: (Right Turn)

V_i (KTS) ______

H_i (FT) ______

T_i (°C) ______

Tach Time ______

MAP/RPM ______

V_i (KTS)	"g"	δ_e (IN)	F_e (lb_f)

Remarks:

Trim Conditions: (Left Turn)

V_i (KTS) ______

H_i (FT) ______

T_i (°C) ______

Tach Time ______

MAP/RPM ______

V_i (KTS)	"g"	δ_e (IN)	F_e (lb_f)

Remarks:

FLIGHT 3 DATA RECORD

LATERAL-DIRECTIONAL STATIC STABILITY

Trim Conditions:

V_i (KTS) ______

H_i (FT) ______

T_i (°C) ______

δ_R (IN) ______

Tach Time ______

MAP/RPM ______

Remarks:

Turn Coordination: $\phi = 45°$

Right: F_e (lb_f) ______ F_R (lb_f) ______

Left: F_e (lb_f) ______ F_R (lb_f) ______

Remarks:

β_{aim}	$\beta = 0$	-2°	-4°	-6°	-8°	-10°		0	+2°	+4°	+6°	+8°	+10°	
β (deg)														
ϕ (deg)														
δ_R (in)														
*δ_a (left)														
*δ_a (right)														
F_R (right)														
F_R (left)														
F_e (lb_f)														

NOTE: Plot data as recorded. No data reduction required.

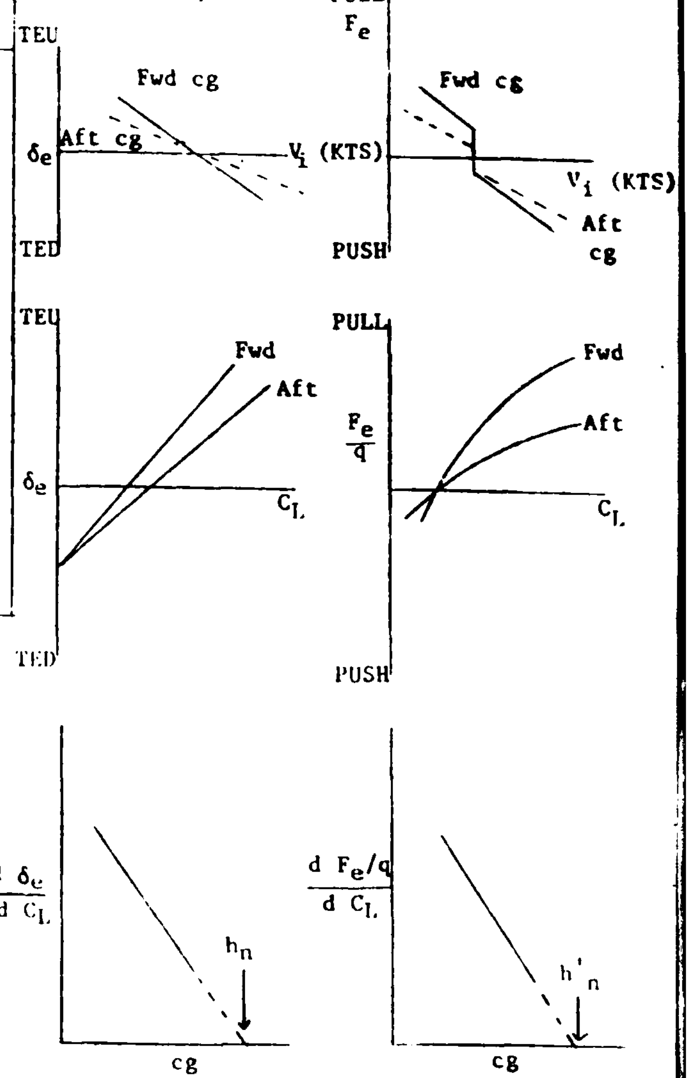
*In ate 1/8, 1/4, 1/2 deflection, etc.

LONGITUDINAL STATIC STABILITY DATA REDUCTION

Aircraft, Sundowner 180 C23 Wing Area: S = 146 ft^2

1	2	3	4	5	6	7
V_i (KTS)	V_e (KTS)	q	C_L	δ_e (inches)	F_e (lb)	F_e/q

Plots Required:



1. V_i (KTS) indicated airspeed.
2. V_c (KTS) ≈ V_e (KTS) equivalent airspeed, p. 5-10 F.M.
3. $q = \frac{1}{2}\rho o\ V_e^2 = \frac{0.002377}{2}\ (② \times 1.69)^2$
4. $C_L = \frac{W}{\frac{1}{2}\rho o\ V_e^2\ S} = \frac{W}{qS} = \frac{W}{③ S}$
5. δ_e (inches) Stick displacement in inches
6. F_e (lb) Elevator force in pounds.
7. $F_e/q = \frac{⑥}{③}$

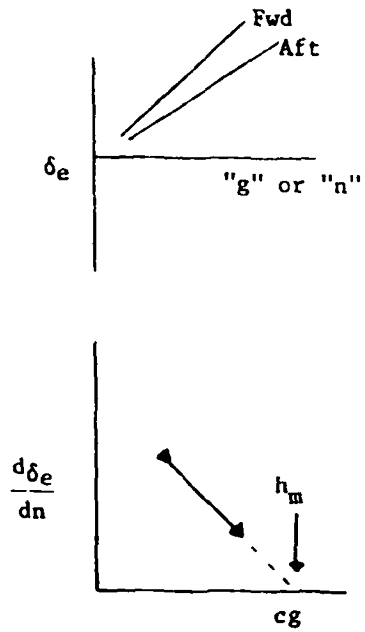
LONGITUDINAL MANEUVERING STABILITY DATA REDUCTION

Aircraft, Sundowner 180 C23

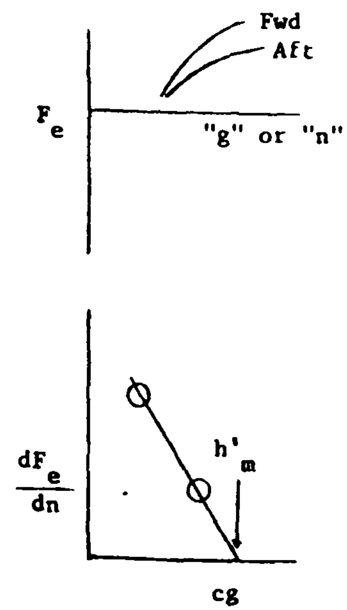
1 c.g.	2 V_i (KTS)	3 δ_e (inches)	4 F_e (lb)	5 "g"

1. Cg in % MAC.
2. V_i indicated airspeed.
3. δ_e (in) Stick displacement in inches
4. F_e (lb) Elevator forces in lb.
5. "g" direct reading off gauge.

Wing Area: S = 146 ft^2



Stick-fixed maneuvering



Stick-free maneuvering

FLIGHT 4

DYNAMIC STABILITY; STALLS

I. OBJECTIVES

A. Determine the lateral control power of the aircraft.

B. Measure the short period, phugoid, Dutch roll and spiral characteristics of the aircraft.

C. Observe the aircraft stall characteristics to include stall warning and verify the 1g stall speeds given in the Flight Manual.

II. AIRCRAFT

Beechcraft Sundowner 180 C23

III. LIMITATIONS

As specified in the test plan.

IV. MISSION EVENTS

A. Pilot

1. Make a no flap, Flight Manual takeoff.

2. Stabilize the aircraft in level flight at a selected altitude and trim airspeed for the first tests to be performed.

3. For stalls, trim the aircraft for 1.2 V_s at a minimum altitude of 8,500 ft MSL. Using the curved flight path method, leave the throttle at the trim setting and use pitch to achieve a bleed rate of 1 to 2 knots per second. The aircraft should stall within ± 500 feet of the desired stall altitude. Initiate recovery when:

a. a definite g-break occurs.

b. a rapid, uncommanded angular motion develops.

c. the aft stick stop has been reached and pitch attitude cannot be increased.

d. sustained heavy buffet develops.

4. Stabilize the aircraft in level flight at one selected altitude and trim airspeed for all remaining tests.

5. For the lateral control power evaluation, perform aileron rolls from 45° to 45° of bank with ½ and full control wheel deflection. This test should be done in both directions with the rudder fixed.

6. For the dynamic tests, use the following techniques:

a. Short Period - Pump the elevator using sinusoidal ramp inputs of $\pm$ .5 "g" until the aircraft response is in phase with the elevator input. Release the control wheel at the trim position. Use small rudder inputs to maintain wings level.

b. Phugoid - From the trim condition, perturb the airspeed by 15 knots and return the control wheel back to the trim position and release. Again, use small rudder inputs to maintain wings level.

c. Dutch Roll - From the trim condition, perturb the aircraft using sinusoidal ramp inputs of ½ rudder deflection, then return the rudder to neutral and release.

d. Spiral - Stabilize the aircraft in a coordinated left or right turn at a 20° bank angle. Neutralize the aileron control and release. Perform the test in both directions. Time for 20 seconds.

B. Students

1. Compute take-off weight, center of gravity and predicted takeoff ground roll.

2. Record the information shown on the attached data record sheets for each test performed.

3. Record both pre-flight and post-flight each time.

V. STUDENT POST-FLIGHT DATA REDUCTION

A. Reduce data where required using the attached data reduction sheets. Use a standard weight of 2,450 lbs for analyzing stall speeds.

B. Plot

1. ϕ versus time.

2. V_i versus time for the phugoid dynamic mode.

C. Using the plots above where appropriate and other test data, determine the following:

1. 1 "g" indicated stall speed for a standard weight of 2,450 lb_f and compare with the Flight Manual.

2. For the phugoid dynamic mode, determine the period, T, the damping ratio, ζ, time to half amplitude, $t_{1/2}$, actual frequency, ω_D, and the undamped natural frequency, ω_n. Use the log decrement method with your plotted data. Compare your flight test, ω_n, with the approximation equation for ω_n.

3. Report the time to double, t2, or time to half, $t_{1/2}$, bank angle for the spiral dynamic mode.

4. Determine the period, T, actual frequency, ω_D, estimate the damping and find the undamped natural frequency of the Dutch Roll oscillation.

5. Report the time to roll through 60° of bank. Find the roll mode time constant.

D. Evaluate the aircraft against the following paragraphs of MIL-F-8785C:

1. Dynamic Stability:

3.2.1.2 Phugoid Stability
3.2.2.1 Short Period Response
3.3.1.1 Lateral-Directional Oscillations (Dutch Roll)
3.3.1.2 Roll Mode
3.3.1.3 Spiral Stability
3.3.4 Roll Control Effectiveness
3.3.4.5 Wheel Control Throw
3.3.2.5 Control of Sideslip in Rolls

2. High AOA Tests:

3.4.2.1.1 Stalls Approach
3.4.2.1.1.1 Warning Speed for Stalls at 1g Normal to the Flight Path
3.4.2.1.2 Stall Characteristics
3.4.2.1.3 Stall Prevention and Recovery

E. Complete the "Initial Flight Test Report".

F. Complete a set of sample calculations.

G. Turn in the "Initial Flight Test Report", MIL-F-8785C evaluation results, recorded data sheets, data reduction sheets, sample calculations, and plots using the format specified in the "Guidelines for Flight Reports" handout.

FLIGHT 4 DATA RECORD

DATE ____________________

INSTRUCTOR ____________________

STUDENTS: OBSERVER - ____________________

RECORDER - ____________________

AIRCRAFT NU. N- ____________________

PRE-FLIGHT TACH TIME ____________________

REMARKS:

TAKEOFF DATA: FIELD ELEVATION - 6,172 FEET

ALTIMETER ____________________

WINDS ____________________

PRESS. ALT. ____________________

TEMP. ____________________

GD ROLL (P) ____________________

FUEL ____________ OIL ____________

POST-FLIGHT TACH TIME ____________________

LATERAL CONTROL POWER

Trim Conditions

V_i (KTS) ____________ H_i (FT) ____________

T_i (°C) ____________ Tach Time ____________

MAP/RPM ____________

V_i (KTS)	δ_a (L)	δ_a (R)	Total Time	Time to $\Delta\phi = 60°$

Remarks:

STALL TESTING

Trim Conditions: V_i (KTS) ____________

H_i (FT) ____________ T_i (°C) ____________

Tach Time ____________ RPM ____________

V_i (horn) ____________ H_i (horn) ____________

V_i (buffet) ____________ H_i (buffet) ____________

V_i (stall) ____________ H_i (stall) ____________

Alt. Loss in Recovery ____________ Bleed Rate ____________

Remarks:

AIRCRAFT DYNAMICS

Trim Conditions: V_i (KTS) ____________ H_i (FT) ____________ T_i (°C) ____________

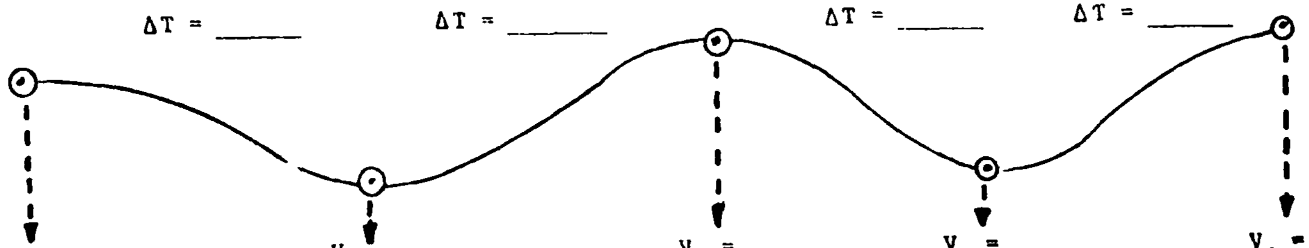
Tach Time ____________ MAP/RPM ____________

Short Period Damping ____________ O/S ____________ Time ____________

Remarks:

Phugoid

ΔT = ______ ΔT = ______ ΔT = ______ ΔT = ______



V_i = ______ V_i = ______ V_i = ______ V_i = ______ V_i = ______

H_i = ______ H_i = ______ H_i = ______ H_i = ______ H_i = ______

Remarks: **Record V_i and H_i each time VVI passes zero.**

Dutch Roll Damping ____________ O/S ____________ Time ____________

ϕ/β ____________

Remarks:

Spiral (Left) ______ °ϕ to ______ °ϕ ____________ secs

(Right) ______ °ϕ to ______ °ϕ ____________ secs

Remarks:

Lateral Control Power Data Reduction

Aircraft, Sundowner 180 C23 Wing Area = 146 ft^2

1	2	*3	*4	*5	*6
δ_a (R)	δ_a (L)	t (sec) (L)	t (sec) (R)	ϕ (deg) (L)	ϕ (deg) (R)

*Use tape recorder to get these. Recommend in-flight handwritten record as a backup.

1. δ_a (R) Right aileron deflection
2. δ_a (L) Left aileron deflection
3. Successive time to roll $\Delta\phi = 90°$ to the left
4. Successive time to roll $\Delta\phi = 90°$ to the right
5. Successive bank angle ϕ to the left
6. Successive bank angle ϕ to the right
7. Plot ϕ versus t for both left and right turn for each δ_a tested

STALL TESTING DATA REDUCTION

① H_{pi}	② V_i	③ V_e	④ W_t	⑤ C_L	⑥ V_{iw}

1. H_{pi} (ft) Indicated pressure altitude
2. V_i (Kts) Indicated airspeed
3. V_c (Kts) $\approx$ V_e (Kts) Equivalent airspeed; P. 5-10 F.M.
4. W_t (lbs) Aircraft test weight: empty weight + fuel + people
5. $C_L = \frac{2W}{\rho V^2 S} = \frac{2 \times ④}{.002377\ (③ \times 1.689)^2 S}$

   where S is wing area.
6. Calculate C_L for each speed
7. $V_{iw} = ③ \sqrt{\frac{W_s}{④}}$

   (W_s = 2,450 lbs)

NOTE: Do this for speed where horn comes on, buffet speed and stall speed.

REFERENCES

1. Pilot's Operating Handbook and FAA Approved Airplane Flight Manual for the Beechcraft Sundowner 180 C23, Beech Aircraft Corporation, Wichita, Kansas, August 1980.

2. Military Specification, Flying Qualities of Piloted Airplanes, Department of the Air Force, Washington, D.C., MIL-F-8785C, 5 November 1980.

3. Roberts, Sean C., Flying Qualities Flight Testing of Light Aircraft for Test Pilots and Flight Test Engineers, Flight Research, Inc., Mojave, California, September 1981.

4. Military Specifications, Stall/Post-Stall/Spin Flight Test Demonstration Requirements for Airplanes, Department of the Air Force, Washington, D.C., MIL-S-83691A (USAF), 15 April 1972.

INITIAL FLIGHT TEST REPORT	1. AIRCRAFT TYPE	2. SERIAL NUMBER

3. CONDITIONS RELATIVE TO TEST		
a. DATE:	e. CONFIGURATION:	i. FUEL LOAD:
b. PILOT:	f. INSTRUMENTATION:	j. SURFACE WIND:
c. OBSERVERS:	g. START UP GR WT:	k. WEATHER:
d. SORTIE TIME/T.O. TIME:	h. START UP C.G.:	l. GROUND BLOCK:

4. TESTS PERFORMED

5. RESULTS OF TESTS (Continue on reverse side if needed)

6. REMARKS (Continue on reverse side if needed)

Reference: AFFTC Form 353 APR '74

INITIAL FLIGHT TEST REPORT	1. AIRCRAFT TYPE	2. SERIAL NUMBER

3. CONDITIONS RELATIVE TO TEST

a. DATE:	e. CONFIGURATION:	i. FUEL LOAD:
b. PILOT:	f. INSTRUMENTATION:	j. SURFACE WIND:
c. OBSERVERS:	g. START UP GR WT:	k. WEATHER:
d. SORTIE TIME/T.O. TIME:	h. START UP C.G.:	l. GROUND BLOCK:

4. TESTS PERFORMED

5. RESULTS OF TESTS (Continue on reverse side if needed)

6. REMARKS (Continue on reverse side if needed)

Reference: AFFTC Form 365 APR '74

APPENDIX G

Sample Flying Qualities Data Records, Data Reduction and Plots

Contents

FLIGHT 3 DATA RECORD

DATE 10 Nov '82

INSTRUCTOR Crenshaw

STUDENTS: OBSERVER - Webster

RECORDER - Goodwin

AIRCRAFT NO. N-18325

PRE-FLIGHT TACH TIME 570.62

REMARKS: Aircraft flown with 50 lb weight in baggage compartment in order to obtain data with aft center of gravity

TAKEOFF DATA: FIELD ELEVATION - 6,172 FEET

ALTIMETER 30.09

WINDS 140/8 knots

PRESS. ALT. 6000 feet

TEMP. 36 °F

GD ROLL (P) 1700 feet

FUEL 50 gallons OIL 8 quarts

POST-FLIGHT TACH TIME 571.70

LONGITUDINAL STATIC STABILITY

Trim Conditions: (RUN 1)

V_i (KTS)	90
H_i (FT)	8000
T_i (°C)	+6
Tach Time	570.94
~~MAP~~/RPM	2350

V_{aim} (KTS)	V_i (KTS)	δ_e (IN)	* F_e (lb_f)
V_{trim}	90	7	0
Pull	85	7 3/16	.015
Pull	80	7 1/4	.49
Pull	75	7 9/16	.75
V_{trim}	90	7	0
Push	95	6 15/16	0
Push	100	6 13/16	.05
Push	105	6 3/4	.38

Remarks: * Values converted to force using calibration curve

Trim Conditions: (RUN 2)

V_i (KTS)	
H_i (FT)	
T_i (°C)	
Tach Time	
~~MAP~~/RPM	

V_{aim} (KTS)	V_i (KTS)	δ_e (IN)	F_e (lb_f)
V_{trim}			
V_{trim}			

MANEUVERING STABILITY

Trim Conditions: (Right Turn)

V_i (KTS)	90
H_i (FT)	8000
T_i (°C)	+5
Tach Time	571.15
~~MAP~~/RPM	2350

V_i (KTS)	"g"	δ_e (IN)	* F_e (lb_f)
90	1.0	7	0
90	1.2	7 5/16	.06
90	1.4	7 5/8	.55
90	1.8	8 3/8	2.63

Remarks: * Values converted to force using calibration curve

Trim Conditions: (Left Turn)

V_i (KTS)	90
H_i (FT)	8000
T_i (°C)	+5
Tach Time	571.31
~~MAP~~/RPM	2350

V_i (KTS)	"g"	δ_e (IN)	* F_e (lb_f)
90	1.0	7 1/32	0
90	1.2	7 9/32	.18
90	1.4	7 5/8	.81
90	2.0	8 1/2	Max

Remarks: * Values converted to force using calibration curve

FLIGHT 3 DATA RECORD

LATERAL-DIRECTIONAL STATIC STABILITY

Trim Conditions:

- V_i (KTS) 90
- H_i (FT) 8000
- T_i (°C) -1
- δ_R (IN) 16 1/8
- Tach Time 1324.87
- ~~MAP~~/RPM 2400

Remarks: Started at 8500 ft to stay within ±500 ft of 8000 ft. Mission flown 2Dec'82 in N6014M.

Turn Coordination: ϕ = 45°

- Right: F_e (lb_f) 7 F_R (lb_f) 7
- Left: F_e (lb_f) 7 F_R (lb_f) 0

Remarks:

β_{aim}	β = ~~0~~ -5°	~~-2°~~ -10°	~~-4°~~ -15°	~~-6°~~ -20°	~~-8°~~	~~-10°~~		~~0~~ +5°	~~+2°~~ +10°	~~+4°~~ +15°	~~+6°~~ +20°	~~+8°~~	~~+10°~~	
β (deg)	"	"	"	"	Right Rudder			"	"	"	"	Left Rudder		
ϕ (deg)	-2	-5	-10	-15				2	5	9	12			
δ_R (in)	16 3/8	16 5/8	16 7/8	17 1/8				-16	-15 7/8	-15 1/2	-15 3/8			
* δ_a (left)	-1/8	-1/4	-3/8	-3/8										
* δ_a (right)								1/16	1/8	1/4	3/8			
F_R (right) (lbs)	15.5	20	24	27										
F_R (left) (lbs)								-18	-21	-23	-25			
F_e (lb_f)	0	0	0	0				0	0	0	0			

NOTE: Plot data as recorded. No data reduction required.
*Indicate 1/8, 1/4, 1/2 deflection, etc.

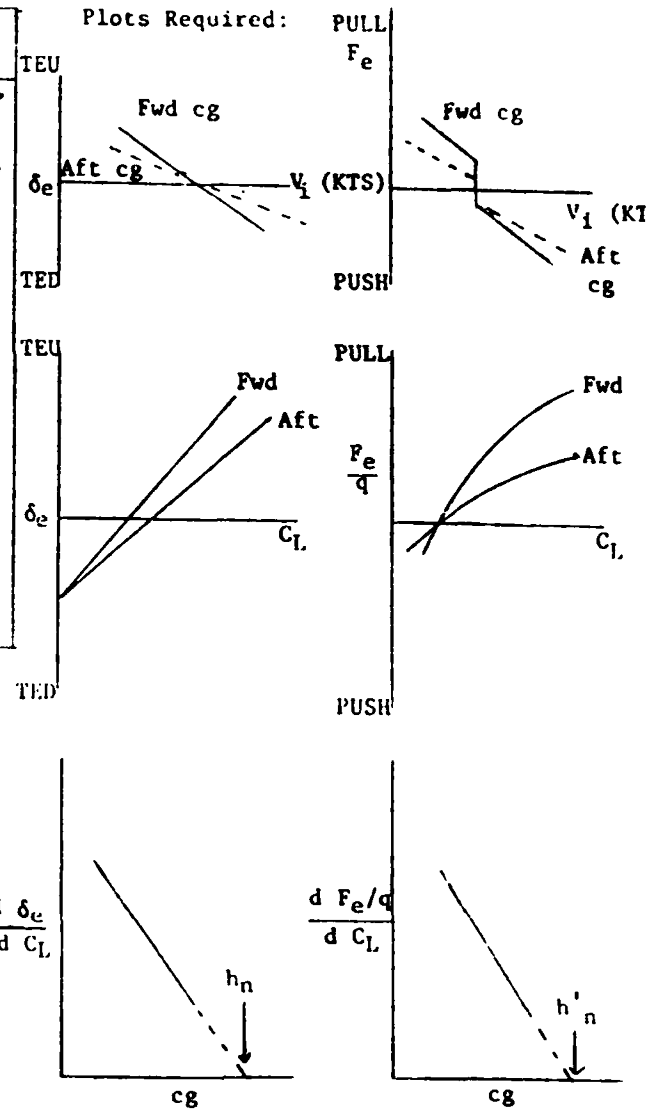
LONGITUDINAL STATIC STABILITY DATA REDUCTION

Aircraft, Sundowner 180 C23 Wing Area: $S = 146\ ft^2$

1 V_i (KTS)	2 V_e (KTS)	3 q (psf)	4 C_L	5 δ_e (inches)		6 F_e (lb)	7 F_e/q
75	75	19.1	.88	7.44		6.6	.35
80	79	21.2	.80	7.25	Pull	5.5	.26
85	84	24.0	.70	7.19		0	0
90	89	26.9	.63	7.00	Trim	0	0
95	94	30.0	.56	6.94		0	0
100	99	33.3	.51	6.81	Push	2.5	.08
105	104	36.7	.46	6.75		5.0	.14

1. V_i (KTS) indicated airspeed.
2. V_e (KTS) $\approx V_e$ (KTS) equivalent airspeed, p. 5-10 F.M.
3. $q = \frac{1}{2}\rho_0 V_e^2 = \frac{0.002377}{2}$ (② × 1.69)^2
4. $C_L = \frac{W}{\frac{1}{2}\rho_0 V_e^2 S} = \frac{W}{qS} = \frac{W}{③ S}$
5. δ_e (inches) Stick displacement in inches
6. F_e (lb) Elevator force in pounds.
7. $F_e/q = \frac{⑥}{③}$

Plots Required:



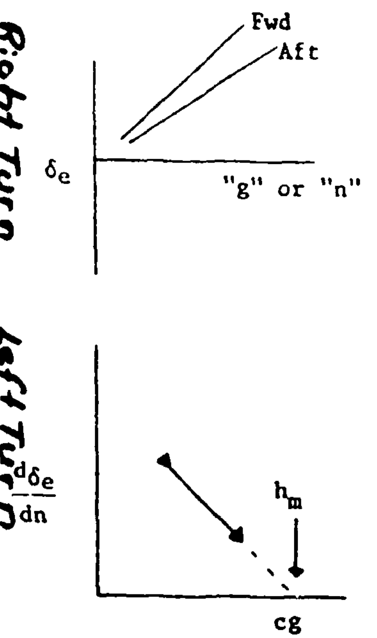
LONGITUDINAL MANEUVERING STABILITY DATA REDUCTION

Aircraft, Sundowner 180 C23

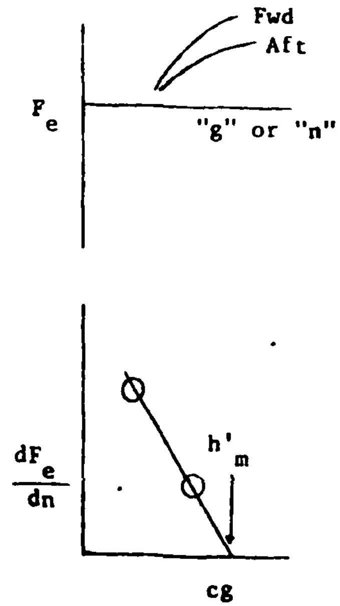
1 c.g.	2 V_i (KTS)	3 δ_e (inches)	4 F_e (lb)	5 "g"	
24.2	90	7.00	0	1.0	Right Turn
24.2	90	7.31	2.5	1.2	
24.2	90	7.63	5.75	1.4	
24.2	90	8.38	15.00	1.8	
24.2	90	7.03	0	1.0	Left Turn
24.2	90	7.28	4.2	1.2	
24.2	90	7.63	6.7	1.4	
24.2	90	8.50	15.00	2.0	

1. Cg in % MAC.
2. V_i indicated airspeed.
3. δ_e (in) Stick displacement in inches
4. F_e (lb) Elevator forces in lb.
5. "g" direct reading off gauge.

Wing Area: $S = 146\ ft^2$



Stick-fixed maneuvering

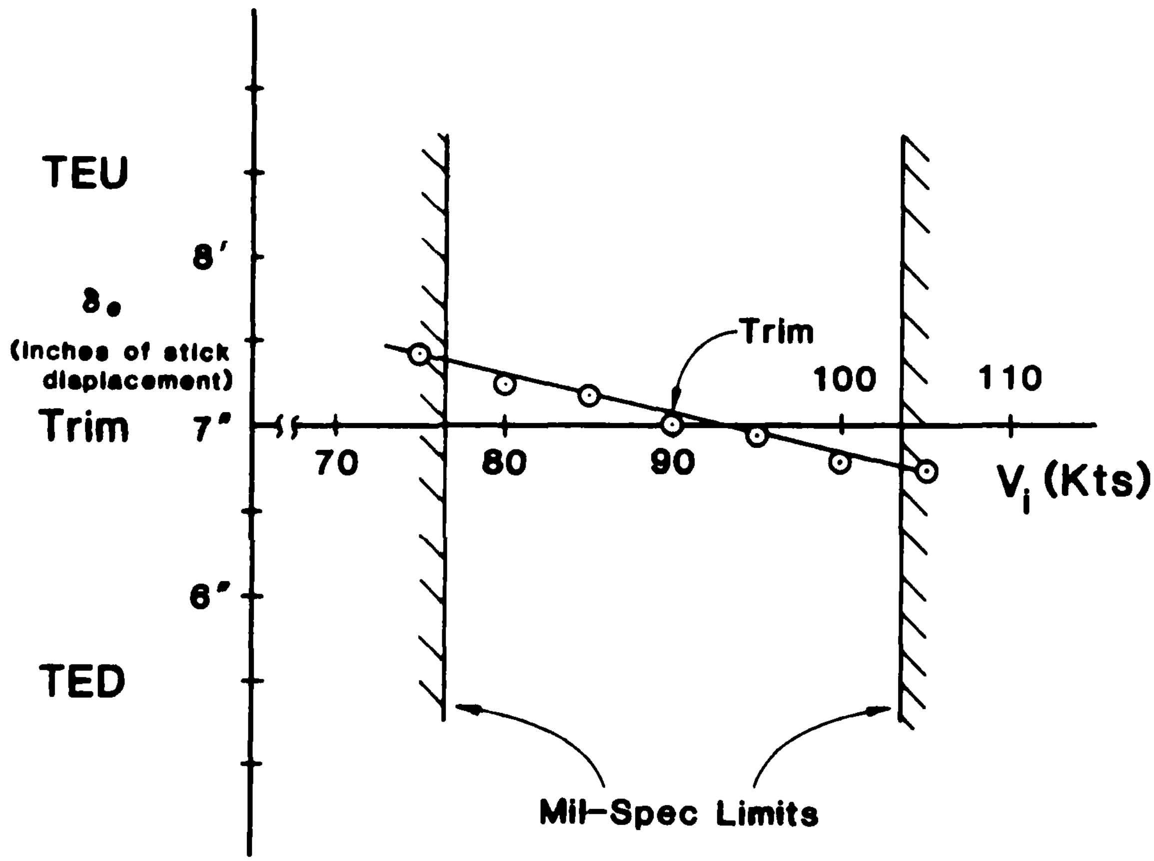


Stick-free maneuvering

Beechcraft Sundowner N18325

10 Nov'82 Alt=8,000 feet 2350 RPM

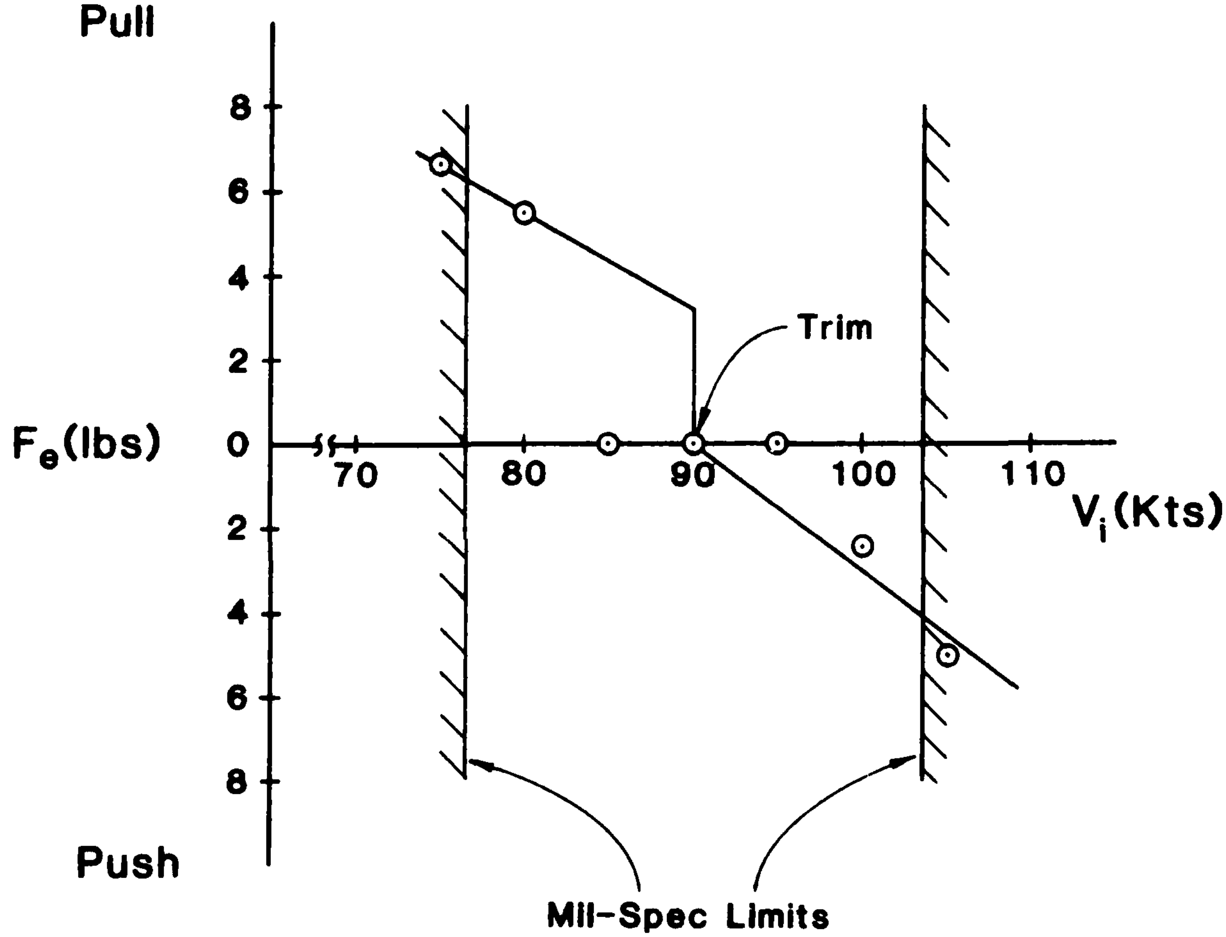
V_t=90 kts 24% CG



Beechcraft Sundowner N18325

10 Nov'82 Alt=8,000 feet 2350 RPM

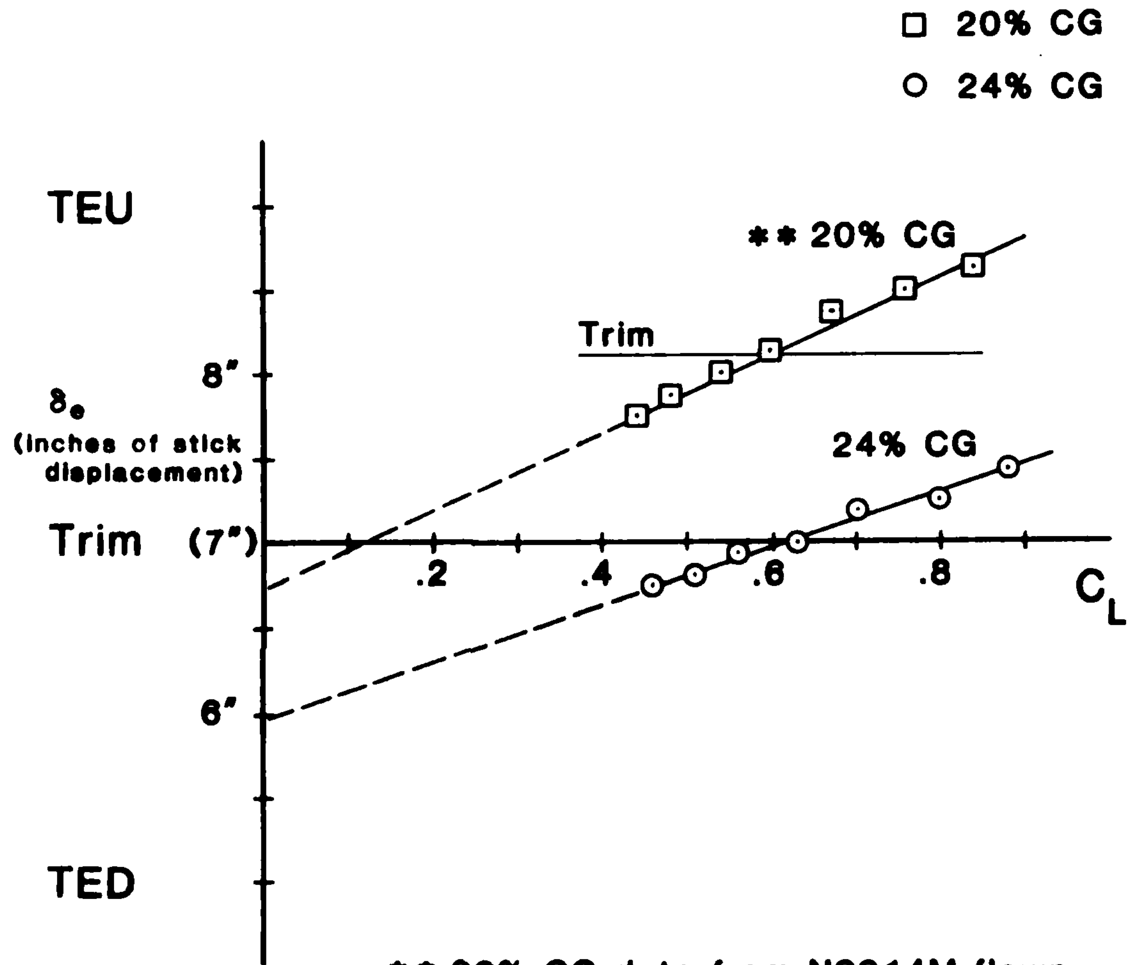
V_t=90 kts 24% CG



Beechcraft Sundowner N18325

10 Nov'82 Alt=8,000 feet 2350 RPM

V_t=90 kts 24% CG

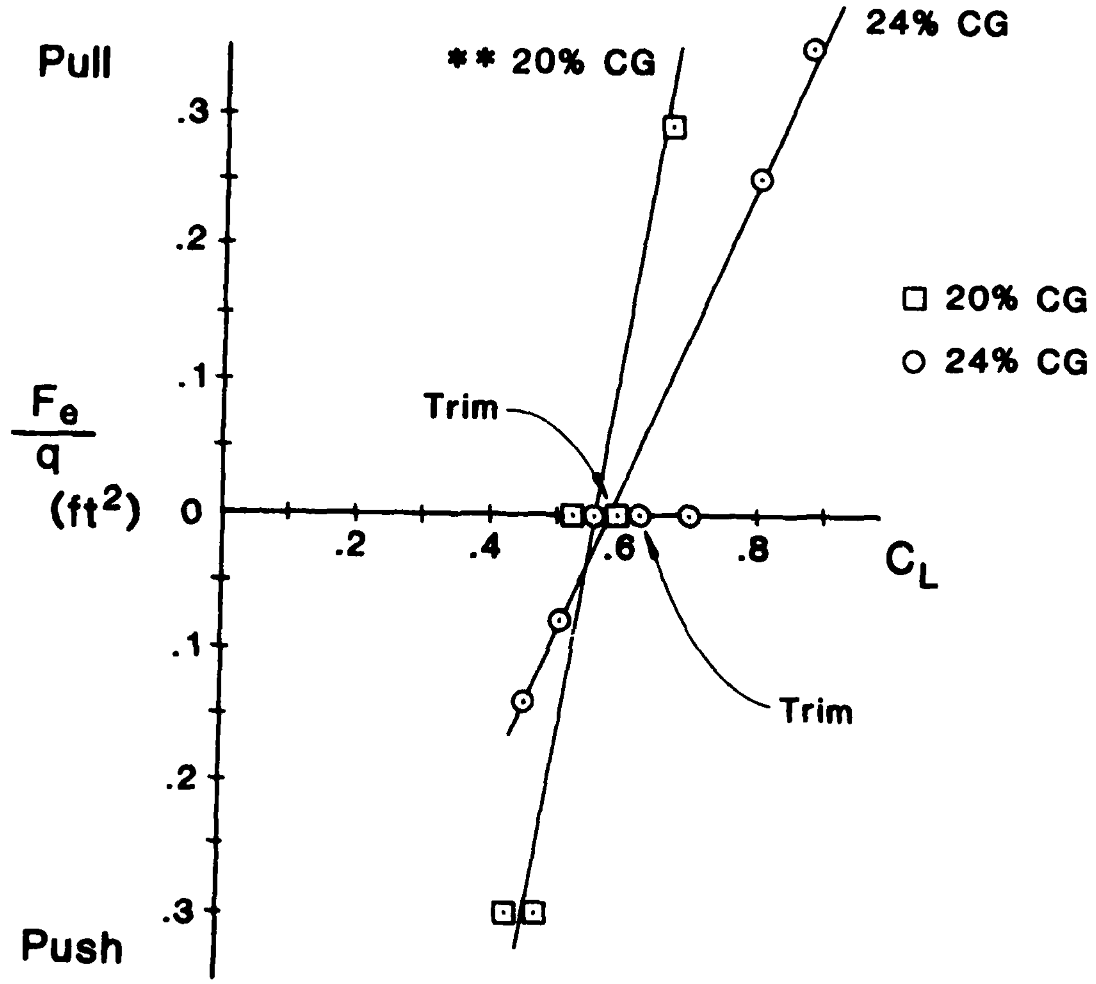


** 20% CG data from N6014M flown on 1 Nov at 8,000 feet and 90 kts

Beechcraft Sundowner N18325

10 Nov'82 Alt=8,000 feet 2350 RPM

V_t=90 kts 24% CG

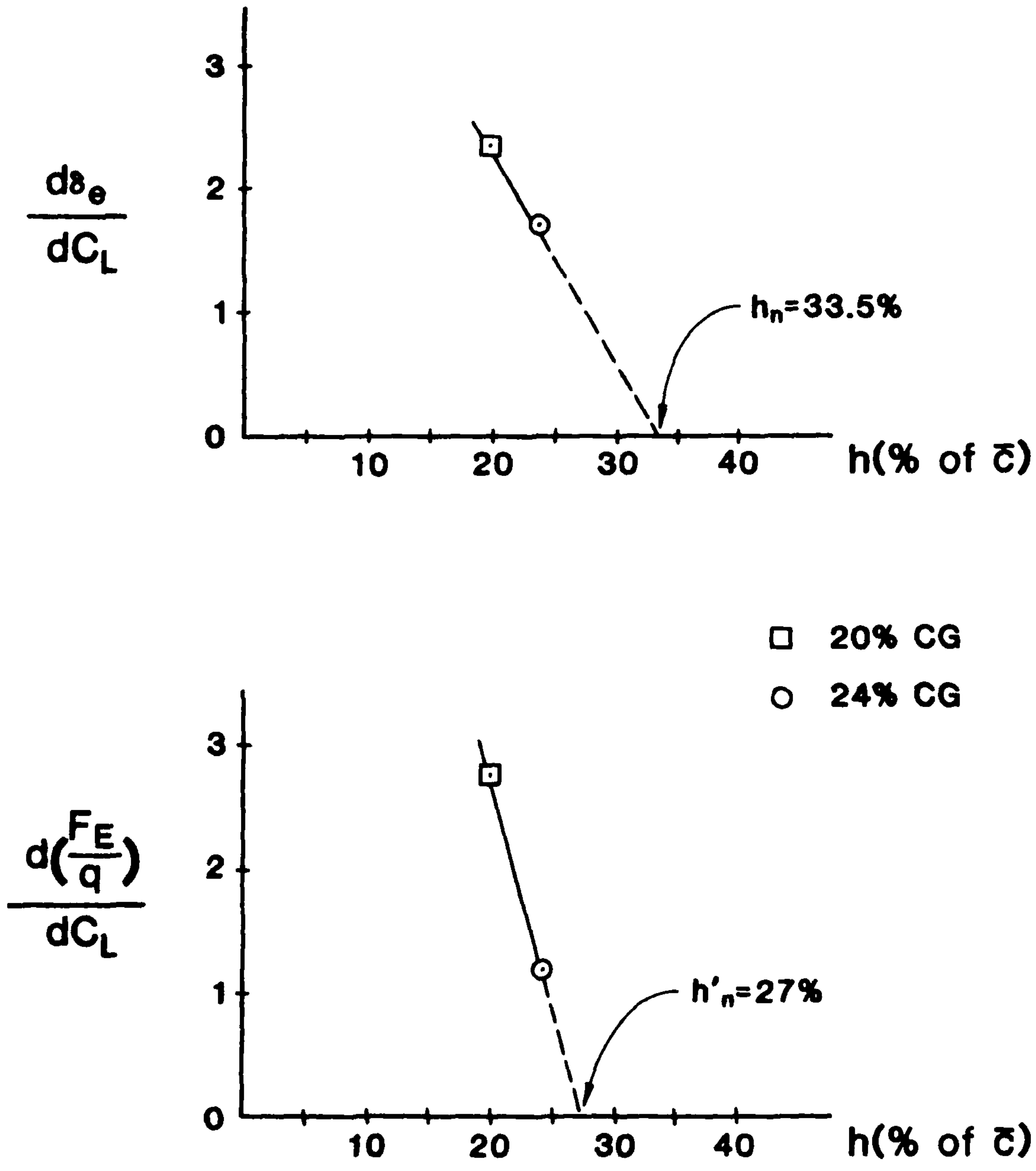


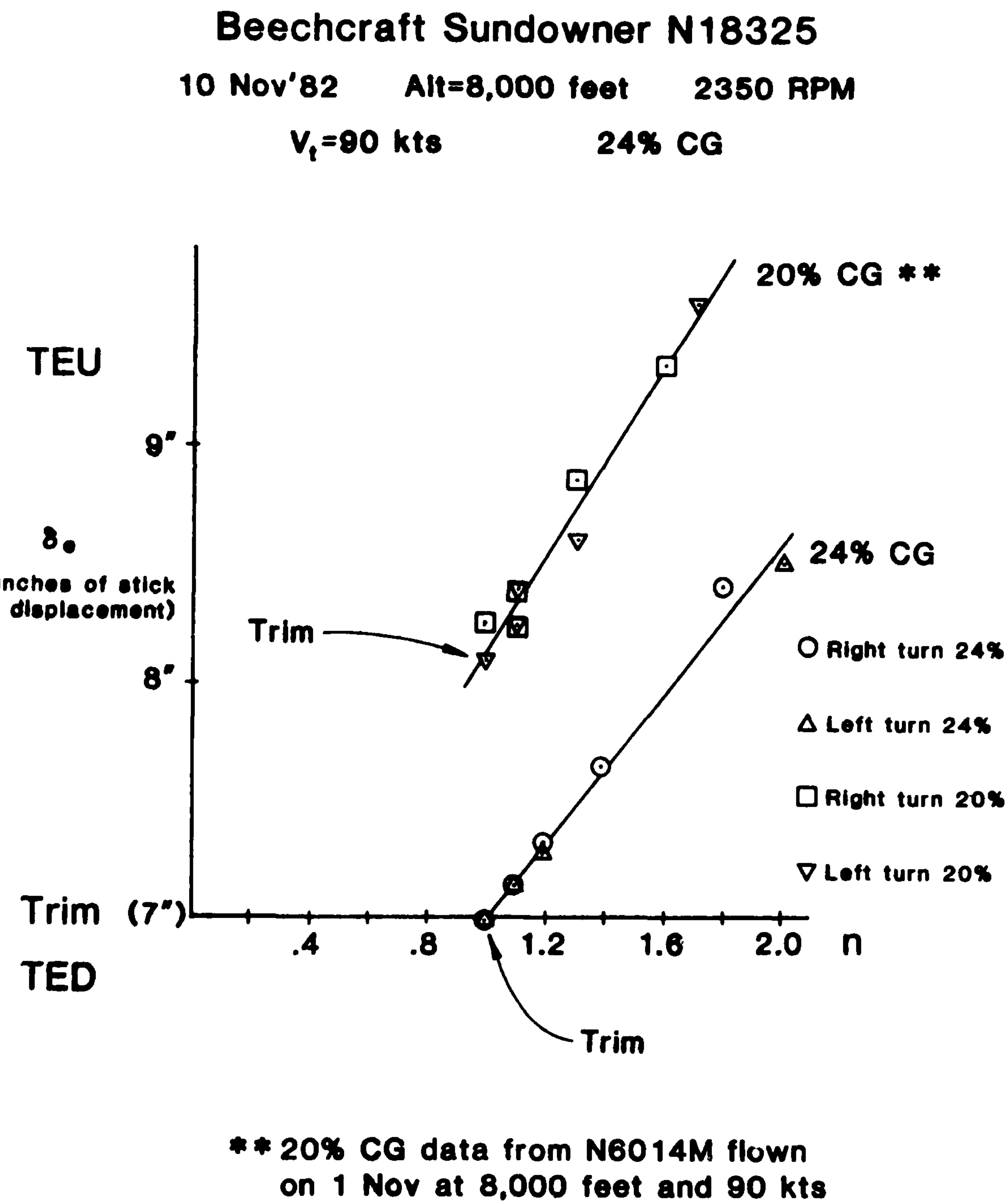
**20% CG data from N6014M flown on 1 Nov at 8,000 feet and 90 kts

Beechcraft Sundowner N18325

10 Nov'82   Alt=8,000 feet   2350 RPM

V_t=90 kts   24% CG



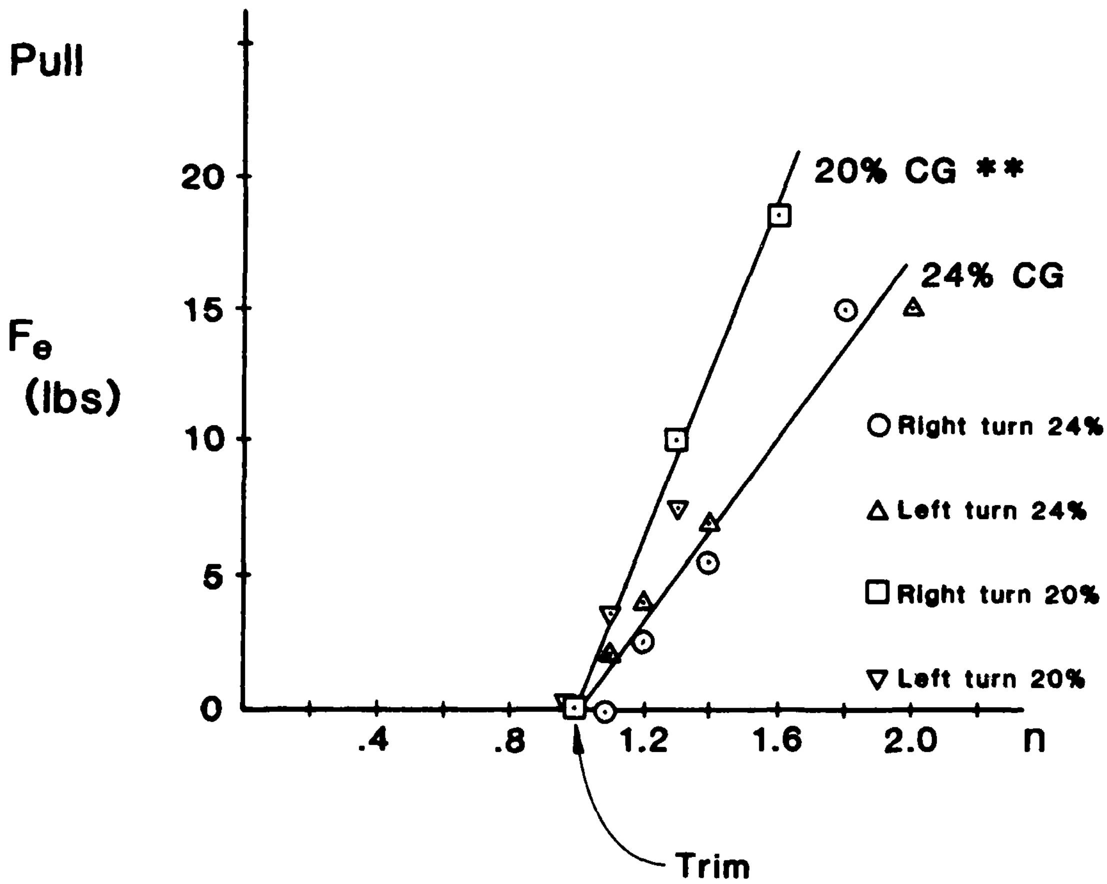


Beechcraft Sundowner N18325
10 Nov'82 Alt=8,000 feet 2350 RPM
V_t=90 kts 24% CG
20% CG **
24% CG
TEU
9"
δ_e
(inches of stick displacement)
Trim
8"
Trim (7")
TED
.4
.8
1.2
1.6
2.0
n
Trim
O Right turn 24%
Δ Left turn 24%
□ Right turn 20%
∇ Left turn 20%
** 20% CG data from N6014M flown on 1 Nov at 8,000 feet and 90 kts

Beechcraft Sundowner N18325

10 Nov'82 Alt=8,000 feet 2350 RPM

V_t=90 kts 24% CG

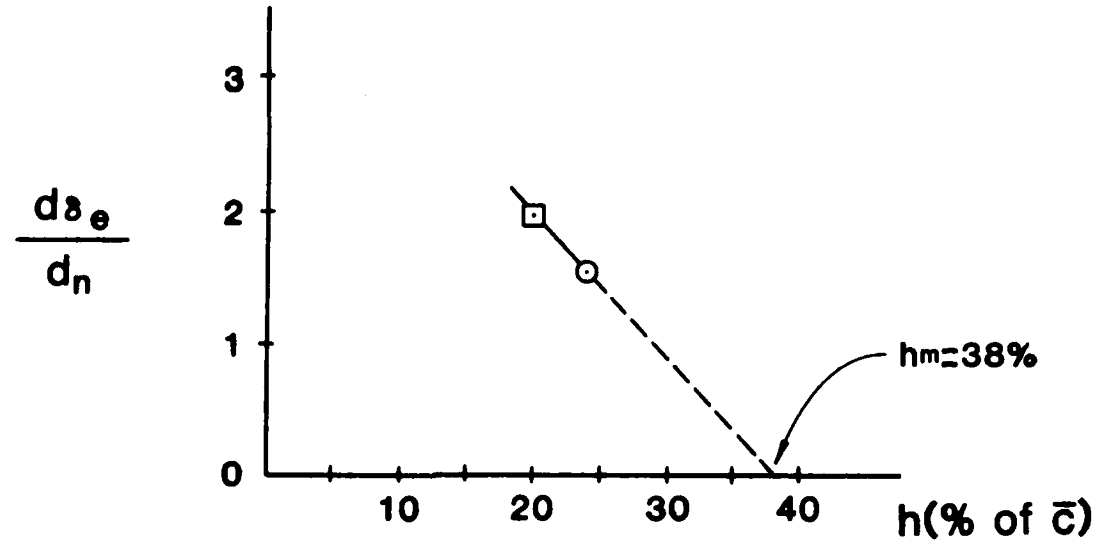


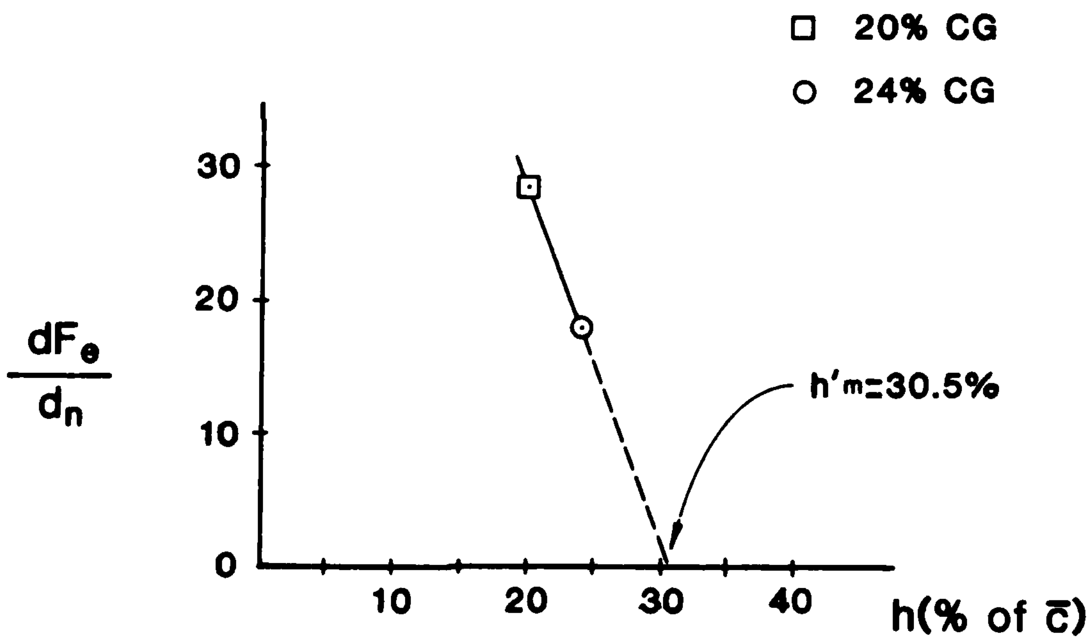
** 20% CG data from N6014M flown on 1 Nov at 8,000 feet and 90 kts

Beechcraft Sundowner N18325

10 Nov'82 Alt=8,000 feet 2350 RPM

V_t=90 kts 24% CG

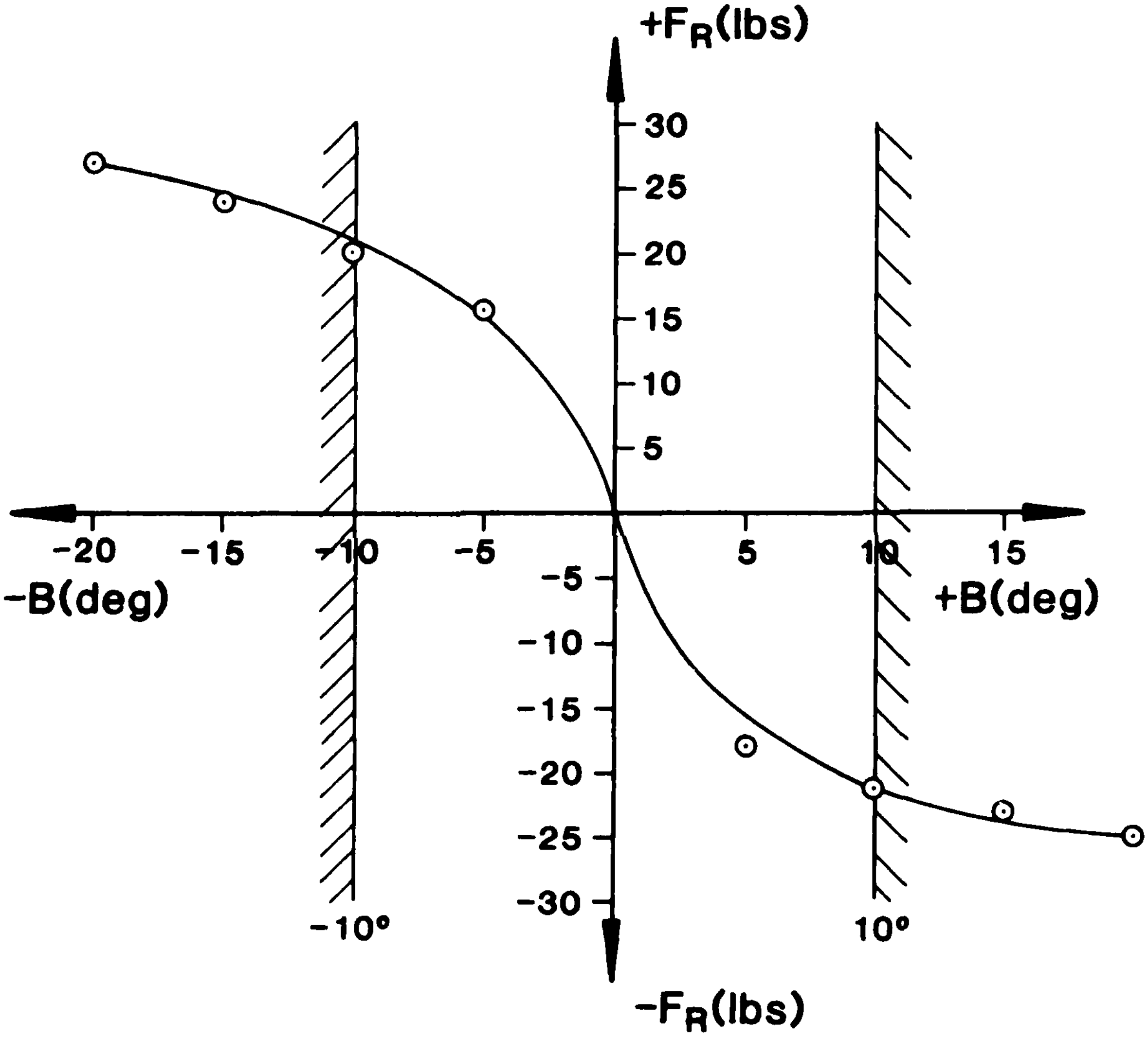




Rudder Force (F_R) vs Sideslip Angle (B)

Beechcraft Sundowner 180

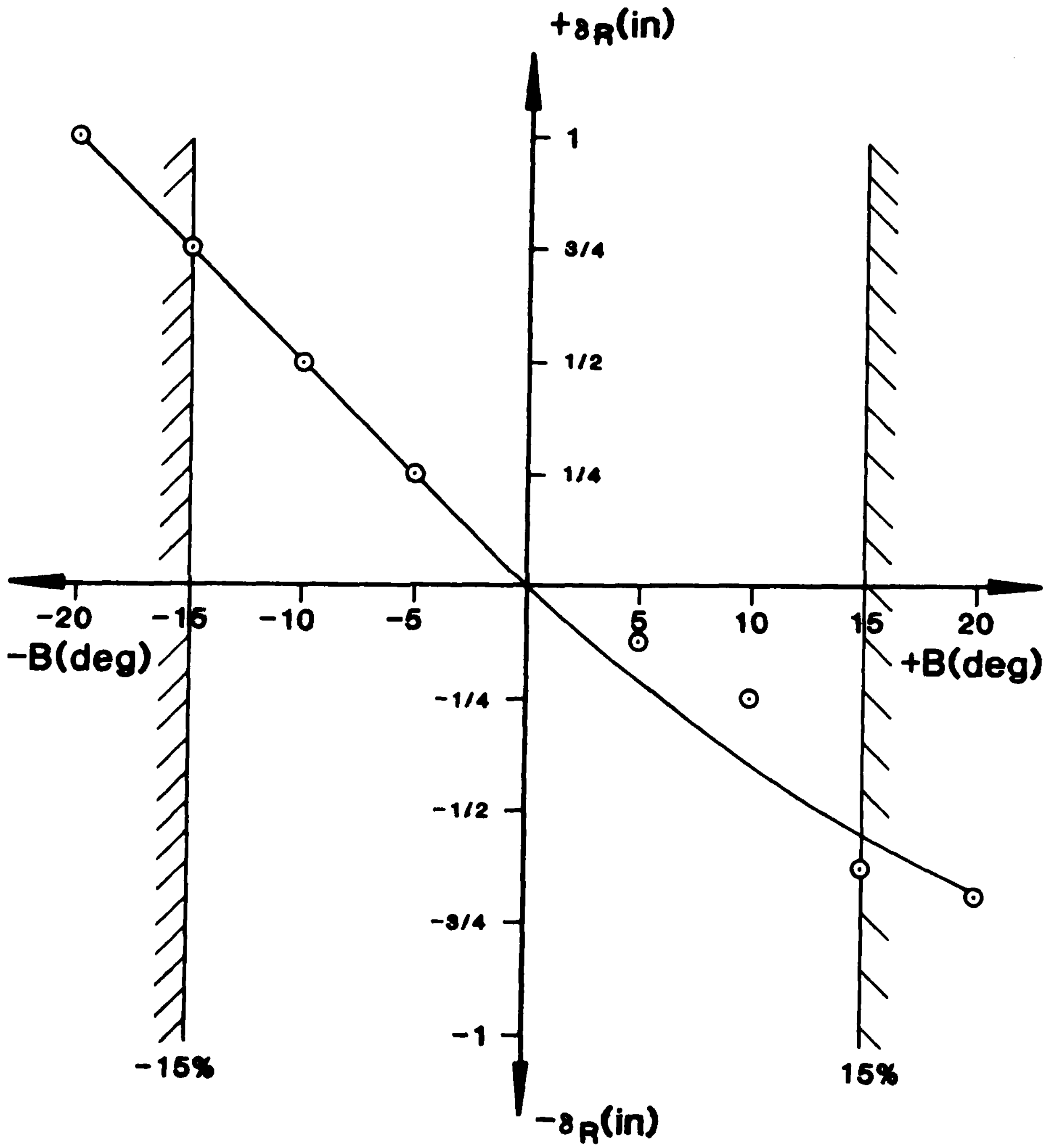
Test Alt=8,000 feet V_i=90 kts



Rudder Deflection (δ_R) vs Sideslip Angle (B)

Beechcraft Sundowner 180

Test Alt=8,000 feet V_i=90 kts



FLIGHT 4 DATA RECORD

DATE 30 Nov '82

INSTRUCTOR Crenshaw

STUDENTS: OBSERVER - Nordin

RECORDER - Dingley

AIRCRAFT NU. N- 6014M

PRE-FLIGHT TACH TIME 1322.36

REMARKS:

TAKEOFF DATA: FIELD ELEVATION - 6,172 FEET

ALTIMETER 29.63

WINDS 070/6 knots

PRESS. ALT. 6350 feet

TEMP. 32°F

GD ROLL (P) 1545 feet

FUEL 57 gallons OIL 8 quarts

POST-FLIGHT TACH TIME 1323.24

LATERAL CONTROL POWER

Trim Conditions

V_i (KTS) 80 H_i (FT) 8000

T_i (°C) +3 Tach Time 1322.89

~~MAP~~/RPM 2150

V_i (KTS)	δ_a (L)	δ_a (R)	Total Time (sec's)	Time to $\Delta\phi = 60°$ (sec's)
80		1/2	6.7	4.5
80	1/2		5.2	3.3

Remarks: Rolls done from 45° to 45° of bank.

STALL TESTING

Trim Conditions: V_i (KTS) 76

H_i (FT) 9000 T_i (°C) +2

Tach Time 1322.62 RPM 2200

V_i(horn) 68 H_i (horn) 9100 ft

V_i(buffet) 62 H_i (buffet) 9150 ft

V_i (stall) 60 H_i (stall) 9200 ft

Alt. Loss in Recovery 175 ft Bleed Rate 2 kts/sec

Remarks: Recovery complete by 9025 ft. Stall characterized by aircraft fall off on right win

AIRCRAFT DYNAMICS

Trim Conditions: V_i (KTS) 80 H_i (FT) 8000 T_i (°C) +3

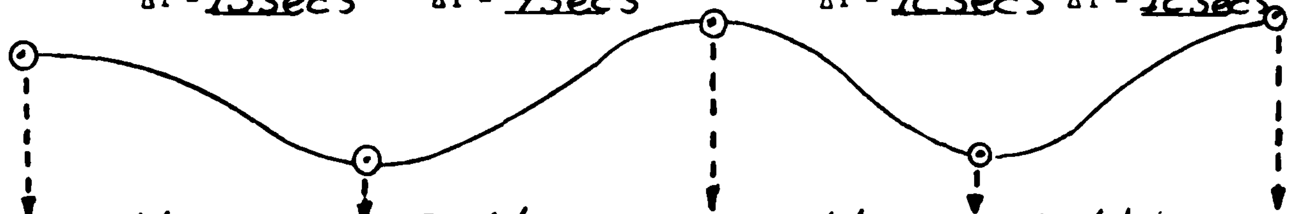
Tach Time 1323.00 ~~MAP~~/RPM 2150

Short Period Damping >.6 O/S — Time —

Remarks: Deadbeat

Phugoid

ΔT = 15sec's ΔT = 9sec's ΔT = 12sec's ΔT = 12sec's



V_i = 70kts	V_i = 85kts	V_i = 72kts	V_i = 85kts	V_i = 76kts
H_i = 8060ft	H_i = 7900ft	H_i = 7960ft	H_i = 7880ft	H_i = 7900ft

Remarks: Record V_i and H_i each time VVI passes zero.

Dutch Roll Damping .1 O/S 6 Time 10.3 sec's

ϕ/β >1

Remarks:

Spiral (Left) 20 °ϕ to 26 °ϕ 20 secs

(Right) 20 °ϕ to 32 °ϕ 20 secs

Remarks: Spiral stability affected by lateral center of gravity location.

Lateral Control Power Data Reduction

Aircraft, Sundowner 180 C23 Wing Area = 146 ft^2

① δ_a (R)	② δ_a (L)	*③ t (sec) (L)	*④ t (sec) (R)	*⑤ ϕ (deg) (L)	*⑥ ϕ (deg) (R)
1/2			1.3		25
1/2			2.3		45
1/2			3.6		65
1/2			5.2		90
	1/2	1.7		25	
	1/2	3.3		45	
	1/2	4.8		65	
	1/2	6.7		90	

*Use tape recorder to get these. Recommend in-flight handwritten record as a backup.

1. δ_a (R) Right aileron deflection
2. δ_a (L) Left aileron deflection
3. Successive time to roll $\Delta\phi$ = 90° to the left
4. Successive time to roll $\Delta\phi$ = 90° to the right
5. Successive bank angle ϕ to the left
6. Successive bank angle ϕ to the right
7. Plot ϕ versus t for both left and right turn for each δ_a tested

STALL TESTING DATA REDUCTION

1	2	3	4	5	6
H_{pi} (ft)	V_i (kts)	V_e (kts)	W_t (lbs)	C_L	V_{iw} (kts)
9100 (horn)	68	69	2459	1.0434	69
9150 (buffet)	62	63	2459	1.2516	63
9200 (stall)	60	62	2459	1.8923	62

1. H_{pi} (ft) Indicated pressure altitude
2. V_i (Kts) Indicated airspeed
3. V_c (Kts) $\approx$ V_e (Kts) Equivalent airspeed; P. 5-10 F.M.
4. W_t (lbs) Aircraft test weight: empty weight + fuel + people
5. $C_L = \frac{2W}{\rho V^2 S} = \frac{2 \times 4}{.002377\ (3 \times 1.689)^2 S}$ where S is wing area.
6. Calculate C_L for each speed
7. $V_{iw} = 3\sqrt{\frac{W_s}{4}}$ (W_s = 2,450 lbs)

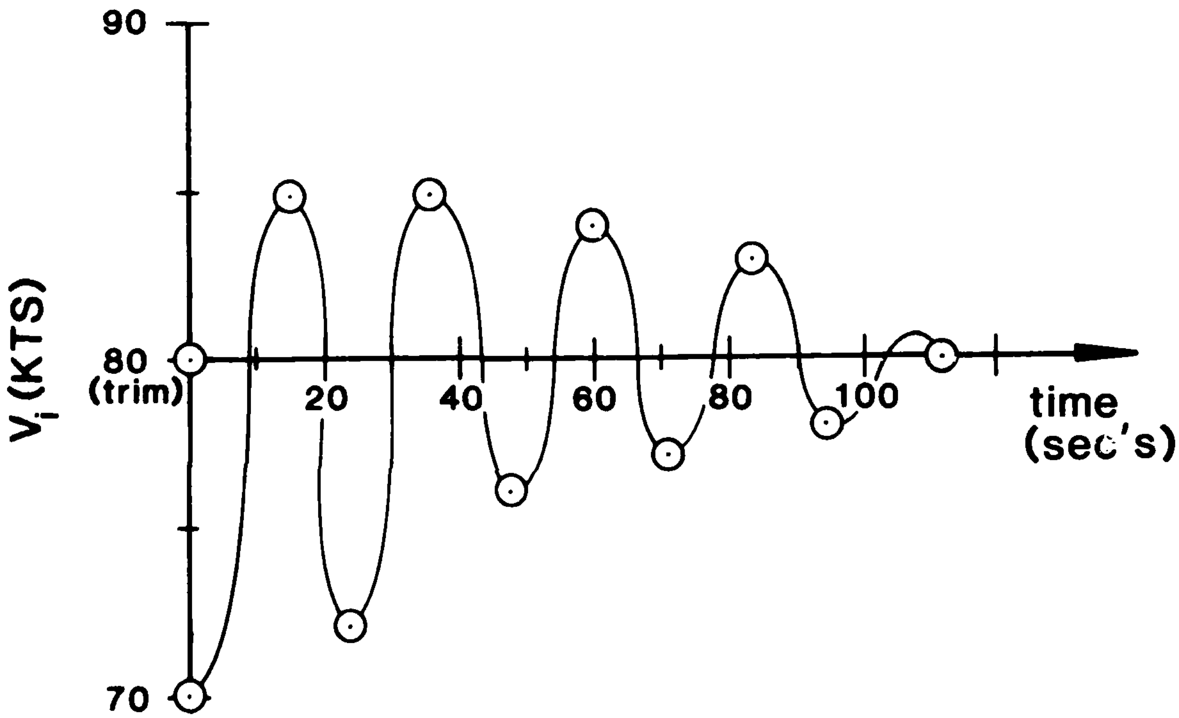
NOTE: Do this for speed where horn comes on, buffet speed and stall speed.

Beechcraft Sundowner N6014M

30 Nov'82 V_{trim}=80 kts H=8000 feet

C.G.=21.7% MAC

Phugoid Dynamic Mode



Data reduced using log decrement:

Period T=12 sec's

Damping z=.065

Actual Frequency W_d=.5236 rad/sec

Natural Frequency W_n=.5247 rad/sec

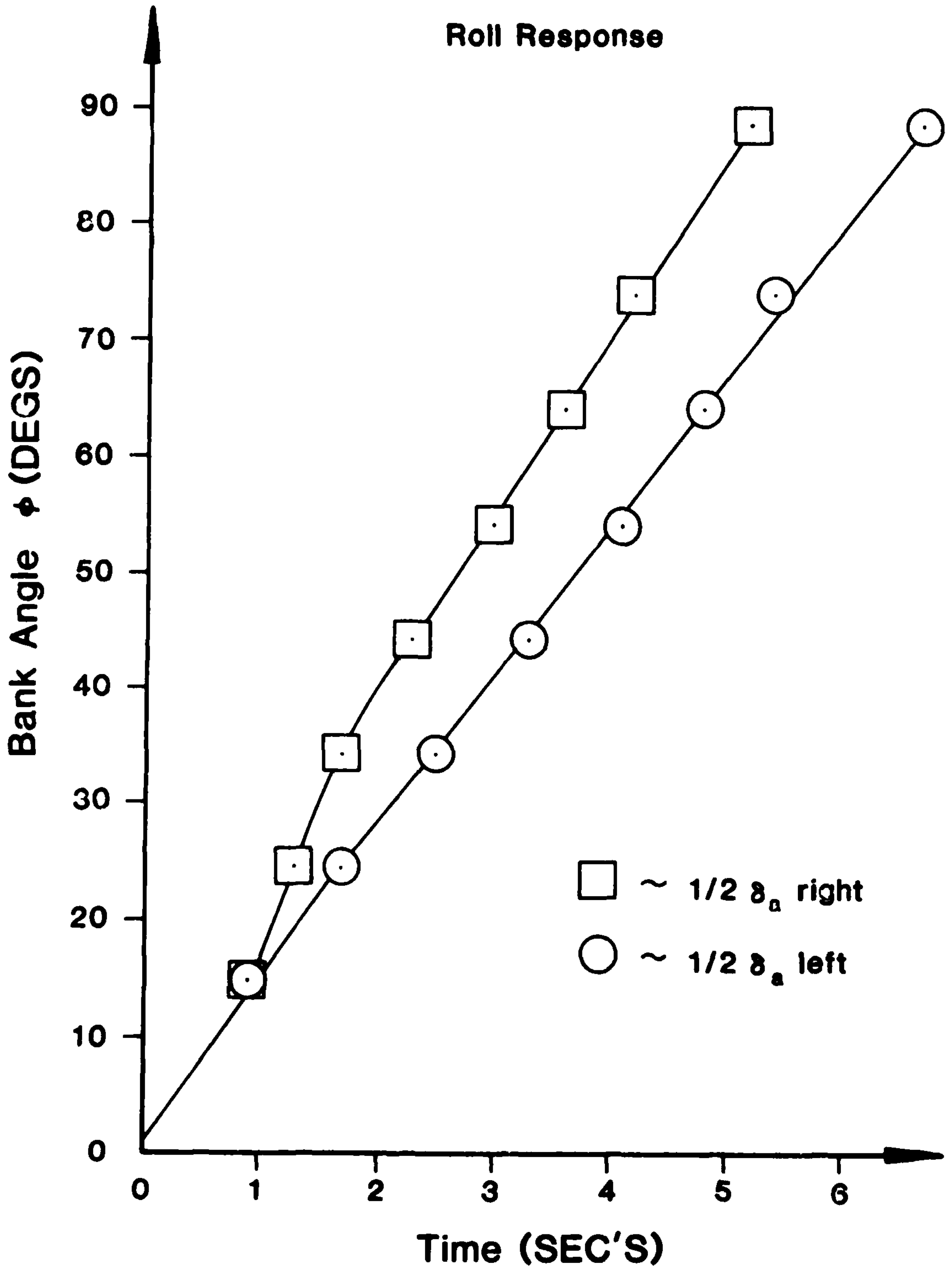
Time to half amplitude $t_{1/2}$=20.23 sec's

Beechcraft Sundowner N6014M

30 Nov'82 V_{trim}=80 kts H=8000 feet

C.G.=21.7%

Roll Response



END

DATE
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