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NASA Rotor System Research Aircraft Flight-Test Data Report: Helicopter and Compound Configuration

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R. E. Erickson
R. M. Kufeld
J. L. Cross, Ames Research Center, Moffett Field, California
R. W. Hodge
W. F. Ericson
R. D. G. Carter, Sikorsky Aircraft Company, Stratford, Connecticut

NASA
National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035

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R. E. Erickson, R. M. Kufeld, J. L. Cross, R. W. Hodge,* W. F. Ericson*
and R. D. G. Carter*

Ames Research Center

SUMMARY

This data report documents the flight-test activities of the Rotor System Research Aircraft (RSRA), NASA 740, from June 30, 1981 to August 5, 1982. Tests were conducted in both the helicopter and compound configurations. Helicopter vertical-drag test results are reported in NASA Contractor Report 166399, December 1981. Compound tests reconfirmed the Sikorsky flight envelope except that main-rotor blade-bending loads reached endurance at a speed about 10 knots lower than previously. Wing incidence changes were made from 0° to 10°.

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*Sikorsky Aircraft Company, Stratford, CT 06601

1. INTRODUCTION AND TEST SUMMARY

This report presents a summary of flight-test results obtained from the Rotor System Research Aircraft (RSRA-A/C 740) in the compound configuration.

The report covers the period from June 1981 to August 1982, during which time 18 test flights were flown and 17 hr 10 min of flight time accumulated. In addition, three high-speed taxi tests were conducted before the flight tests. The flight test plans (FTP) are included in appendices A and B and the flight reports in appendix C.

The purpose of these tests was to provide pilot training for the NASA and Army pilots and to evaluate the flight envelope developed by Sikorsky Aircraft during their testing at Wallops Island before the aircraft was delivered to Ames Research Center. See reference 1 for the Sikorsky report.

In general, all test objectives were attained, and the flight envelope was actually expanded with respect to evaluating various wing angles, collective positions, and rotor-speed scheduling.

The following was the actual envelope evaluated:

1. Airspeed to 181 knots CAS
2. Load factor 1.78 g to 0.37 g
3. Side slip ±15°
4. Rotor speed 105% to 97% (trimmed)
5. Wing angle 0° to 10°
6. Angle of bank ±50°
7. Collective 68% (low speed) to 18%
8. Flap angle 0° to 25°

Tables 1 and 2 are flight logs for the helicopter and compound flight tests, respectively. The following remarks are based on the results obtained during the subject tests.

1. Structures— The maximum airspeed demonstrated was 181 knots CAS at which speed the main-rotor outboard blade stresses were limiting. No unanticipated airframe stress or load problems were encountered and such fatigue damage that was incurred was at a rate low enough to permit additional flight testing in the current configuration. However, it was evident that within the planned airframe life of 600 hr and considering the possible adverse effect of configuration changes, modification to the stabilizer and stabilator attachment areas must be seriously considered. Table 3 is a summary log of cumulative fatigue damage.

2. Handling qualities— Operation of the airframe with 100% rotary and fixed-wing control has been accomplished within the demonstrated envelope without encountering any control margin concerns. The pilot workload was acceptable with

good control harmony. Problems with directional control during the takeoff roll had been expected, but the pilots experienced little difficulty.

3. Airframe vibration— The cockpit environment was very acceptable throughout the envelope. The 11-Hz response reported during the Wallops Island tests was encountered at 150 knots IAS as expected and confirmed as a beat between the tail-rotor blade first edgewise response and rotor speed. The filtered level of the latter response will continue to be monitored on telemetry.

4. Engine vibration— Both the T-58 and TF-34 engines were monitored. Levels were generally acceptable, with the exception of the No. 1 TF-34 vertical accessory gearbox measurement. Troubleshooting indicated a possible instrumentation problem. The measurement system was recalibrated and it is assumed that the problem is resolved; however, these parameters will continue to be monitored.

TABLE 1.- FLIGHT TEST LOG: RSRA 740 FTP2A HELICOPTER MODE

Flight No.	Date	Flight time	Cumulative total	Gross weight, lb	Center of gravity	Comments
1	6-30-81	00:30	45:00	19800	302	Maintenance check flight
2	7-1-81	00:30	45:30	18700	302	Maintenance check flight
3	7-10-81	2:00	47:30	19800	302	Vertical drag and balance system hysteresis
4	7-17-81	2:20	49:50	19800	302	Vertical drag and balance system hysteresis
5	7-21-81	2:05	51:55	19800	302	Vertical drag
6	7-24-81	00:10	52:05	17800	302	Abort
7	7-28-81	00:30	52:35	17800	302	Vertical drag, light weight
8	7-28-81	1:05	53:40	19800	302	Low-speed handling qualities left and right side flight

TABLE 2.- FLIGHT TEST LOG: RSRA 740 FTP2B COMPOUND MODE

Flight no.	Date	Flight time	Cumu-lative total	Compound cumu-lative Ames	Wing angle	% Collec-tive	% NR sweep	Cali-brated airspeed	Load factor	Side-slip	Comments
1	11-5-81	1:26									
2	11-5	:43									
3	11-19	1:40									
4	11-25	:45	54:25	:45	10	40	-	120	-	-	
5	12-9	:45	55:10	1:30	10	40	-	140	-	-	Hysteresis check
6	1-22-82	1:10	56:20	2:40	10	40	-	160	-	-	Flap evaluation
7	2-2	1:15	57:35	3:55	10-5	40	-	140	-	-	Turns
8	2-9	0	57:35	3:55							TF-34 no-start
9	2-18	1:00	58:35	4:55	10-5	40	-	130	-	-	Pilot familiarization
10	3-3	1:05	59:40	6:00	10-5	40	-	140	-	-	Control review
11	3-3	0	59:40	6:00							TF-34 no-start abort
12	3-9	1:10	60:50	7:10	5	40		140			Turns – static stabilizer
13	3-25	1:10	62:00	8:20	5	40	-	140	-	-	Pilot familiarization
14	4-7	1:15	63:15	9:35	10-5	40, 35	-	150	-	-	Speed limited by chase
15	4-16	1:05	64:20	10:40	10-5	40, 35	-	160	-	-	Turbulent air
16	4-22	1:05	65:25	11:45	10-5	40, 35	-	165	-	-	Good data
17	4-29	1:05	66:30	12:50	10-5	40, 35	-	174	-	90,140 K	Good data
18	7-7	1:00	67:30	13:50	10-0	40, 30	-	160	-	-	TF-34 N_F sweep
19	7-22	1:00	68:30	14:50	10-5	30, 25	-	180	-	-	Good data
20	7-22	1:20	69:50	16:10	10-5	35, 25	x	160	x	x	Dive brake, abort, MRGB
21	8-5	1:00	70:50	17:10	7.5	25	x	180	x	x	Good data
22	8-5	1:00	71:50	18:10	7.5	25, 20	x	170	x	x	Good data, low speed

TABLE 3.- RSRA AIRCRAFT 740

Parameter	Endurance as of 3-16-83	Total damage through Flight 22	Total flight time
Tail rotor thrust load cell	±500 lb	10.880%[a]	71:50
Main rotor shaft bending, lower, bridge #1	±12,800 lb/in.^{2}	7.095%	
Drag box #9 load	±2850 lb/in.^{2}	4.239%	
Right aileron control rod	±260 lb	1.410%	
Main rotor stationary scissors load	±220 lb	0.897%	
Elevator control rod, left, load	±305 lb	0.860%	
Elevator control rod, right, load	±305 lb	0.770%	
Main rotor push rod load, upper	±625 lb	0.683%	
Main rotor blade BR-6	±6350 lb/in.^{2}	0.380%	
Main rotor right lateral stationary swashplate load	±1250 lb	0.146%	
Main rotor left lateral stationary swashplate load	±1250 lb[b]	0.112%	
Main rotor blade BR-7	±6350 lb/in.^{2}	0.108%	
Lower horizontal stabilizer #1	±2000 lb/in.^{2}[b]	0.101%	
Tail rotor pitch beam bending #5	±90 lb	0.087%	
Main rotor blade BR-8	±6350 lb/in.^{2}[b]	0.048%	
Drag box #15 load	±2850 lb/in.^{2}	0.0365%	
Upper horizontal stabilizer #1, left	±1130 lb/in.^{2}	0.035%	
Main rotor blade spar (outboard bolt hole)	See S/N Curve[b]	0.032%	
Upper horizontal stabilizer #2, right	±1130 lb/in.^{2}	0.027%	
Main rotor damper moment	±27,500 in.-lb	0.012%	
Tail rotor blade P-2	±4025 lb/in.^{2}	0.00006%	
Main rotor drag cell load[c]	±1640 lb	0.00002%	
Main rotor gear box torque cell F	±1900 lb	0.0	
Main rotor gear box torque cell E	±1900 lb	0.0	
Tail rotor spindle edgewise moment	±5200 in.-lb	0.0	
Main rotor rotating scissors load	±285 lb	0.016%	

[a] Damage occurred during first five flights. Problem resolved. No further change.

[b] No longer monitored. Damage now being calculated. (DAM%/hr × Flt time).

[c] Endurance increased. Now ±1640, was ±1160 lb. Changed 1-25-83.

2. HANDLING QUALITIES

This data section on the handling-qualities attributes is divided into the following parts: Control-System Rigging; Flight Envelope; Takeoff and Landing Procedures; Level Flight Trim; Static Stability; Comparison of Predictions and Flight Data; and Wing-Actuator Imbalance.

Control-System Rigging

Rotary-wing controls— The systems rigging characteristics of the rotary-wing controls for the compound aircraft are shown in figures 1 and 2 for the main and tail rotors, respectively. The longitudinal and lateral CPUs were set at 100% FW/100% RW: The yaw channel CPU was locked to yield 100% FW/100% RW authority, because the CPU cams then available could not yield 100/100 authority in normal operation.

The rigging shown was maintained throughout the test program. The main- and tail-rotor riggings did not fully concur with the ideal rigging, with differences of approximately 3%, but showed satisfactory range and position.

Fixed-wing controls— The rigging characteristics of the fixed-wing controls are shown in figures 3 and 4 for the stabilator and ailerons at CPU settings of 100% FW/100% RW. The stabilator rigging includes the steady 2° bias set during contractor testing, moving the neutral (50%) longitudinal stick position at 10° wing incidence from -1° (trailing edge down) to +1° (trailing edge up) to reduce main-rotor shaft bending moments and to improve tail-cone clearance and pilot comfort by decreasing the negative pitch attitude. The bias was set using the No. 1 (aft) series trim actuator, which was then electrically disconnected. The aileron rigging diagram indicates a discrepancy of some 4% from ideal rigging, but with satisfactory range and position.

Flight Envelope

The flight envelope explored during the test program is shown in figures 5 to 9 for load factors and bank angles (fig. 5), sideslip angles (fig. 6), wing incidence and flap angles (fig. 7), collective settings (fig. 8), and main-rotor speeds demonstrated for wing-incidence angles of 10°, 7.5°, 5° and 0°. Previous contractor testing was performed at 10° only, and figures 5 and 7 show similar demonstrated envelopes for load factor, bank, and sideslip. A wider range of collective settings was explored than previously, but the investigation of flap angle was restricted to establishing configurations for takeoff and landing.

The techniques used to generate the load-factor envelope are illustrated in a series of time-history plots (figs. 10-13) for pull-ups at 130 and 65 knots (figs. 10 and 12) and for pushovers at 140 and 65 knots (figs. 11 and 13). In each case a "roller-coaster" entry was used to reduce pitch attitude excursions; for the 130-knot pull-up and for both pushovers only cyclic stick was used to generate the load factor, whereas additional collective input was used for the 65-knot pull-up. The 130-knot pull-up indicates a peak wing angle of attack of 17°, at or near the stall boundary.

Takeoff and Landing Procedures

The takeoff technique developed during the compound-configuration testing differed slightly from previous testing; a typical example (flight 7) is presented in the time-histories shown in figures 14 and 15. Concern about lower stabilator stress levels resulted in a more gradual application of TF-34 throttles, to a level of 55%-60% N_f fan speed at about 50 knots CAS, with collective stick added gradually to about 40% at a takeoff speed of 80 knots CAS. This gradual application of collective pitch avoided the pitch attitude excursions induced by the more abrupt application of collective pitch in the previous technique. Directional control during ground roll requires 5%-10% pedal movements, with a period of about 2 sec.

A typical approach and landing (flight 10, figs. 16 and 17) was made at a wing incidence of 7.5° and with 25° flap; this configuration reduces wing angle of attack on the approach while offering a body pitch attitude of -2° to -3° nose-down. In the approach, the TF-34 thrust engines are set at idle and the approach path is controlled with collective stick. Longitudinal stick produces a flare of some 5°, and after touchdown collective stick is fully lowered and the right TF-34 engine reduced to stopcock.

Figures 18 and 19 illustrate a typical approach and go-around (flight 7); in the go-around the TF-34 fan speed is increased to 50%-60%, collective raised to 40%, and flaps then raised to 15°.

Level-Flight Trim

Trimmed level-flight data points were achieved using the same technique used in previous testing; that is, setting wing incidence and collective stick position and varying airspeed with TF-34 engine thrust where possible (above about 90 knots IAS) and at lower speeds leaving the TF-34 engines at idle thrust and controlling airspeed with collective stick and pitch attitude. All data were taken at 104% rotor speed and at CPU settings of 100%/100%. Figures 20-47 show trim curves for the tested combinations of wing incidence (10°, 7.5°, 5°, 0°) and collective setting (40%, 35%, 30%, 25%, 20%), thus:

Collective stick, %

Wing incidence, deg	40	35	30	25	20
10	X	X	X	X	
7.5				X	X
5	X	X	X	X	
0	X				

Longitudinal trim- Figures 20 and 21 summarize the trim curves for the pitch axis, showing the effect of collective stick setting at 10° wing incidence and of wing incidence at 40% collective stick. With decreased collective stick, and hence reduced main-rotor torque, higher pitch attitudes result, for the wing takes a higher share of the load; this is reflected in the indicated angle of attack of the fuselage and of the wing, and the reduction in rotor lift means less forward cyclic stick is needed for trim. In each case the longitudinal stick trend with airspeed is flat.

Lower wing incidence at constant 40% collective setting raises the fuselage pitch attitude and angle of attack some 3°-4° over most of the airspeed range for the total 10° incidence change, and the indicated wing angle of attack decreased by approximately 7°-8°. The increased load on the rotor requires increased forward stick for level-flight trim.

The effects of flap and drag brake extension are benign (figs. 33 and 34, respectively). Flap extension from 0° to 25° results in no noticeable change in longitudinal stick position, and the 2°-3° pitch-attitude change caused no problems for the pilot. Drag-brake extension at 140 knots CAS to the manual (independent of EFCS) limit of 30° shows a pitch attitude change of less than 1° and, at constant power, a change in rate of descent of about 250 ft/min.

Lateral-directional trim— Figures 35 and 36 summarize the lateral-directional trim curves for varying collective stick and wing incidence, respectively. The effects of varying collective stick setting are slight: a reduction of collective lowers the anti-torque tail-rotor pitch requirement and thus the wings-level sideslip angle required to produce the balancing side force. Paradoxically, reduced collective settings also result in increased left pedal, probably because of overcompensation in the collective to tail-rotor mixing ratio.

With reduction of wing incidence at constant (40%) collective setting, the reduced main-rotor torque requirement results in less tail rotor impressed pitch and sideslip angle. The reduced sideslip angle is reflected in the reduction of right lateral stick and of left pedal.

Static Stability

Longitudinal— Longitudinal static stability was evaluated at two combinations of collective setting and wing incidence, by varying airspeed ±10 knots CAS about a trim point using longitudinal cyclic stick only (figs. 48 and 49). In each case the stick curve is nearly flat and, thus, for the cases tested, the stability characteristic is nearly neutral, possibly slightly negative at the 90-knot IAS case and slightly positive for the higher speeds. The pitch attitude cue is distinctly positive in all cases.

Lateral-directional— The limited lateral-directional static stability points tested at 7.5° (160 and 50 knots IAS) and 10° (150 and 80 knots IAS) wing incidence are shown in figures 50-53 and summarized in figure 54. The responses for airspeeds of 80 to 160 knots IAS are positive; that is, an established right sideslip requires left pedal, a right bank in roll attitude, and right lateral stick to maintain this bank angle. The 50-knot IAS point was very difficult for the pilots to control for steady side slip; this is evident in the data which show slightly positive lateral stick and pedal curves but a neutral or slightly negative roll-attitude slope. Data for 50-knot IAS had to be extracted from time-history formats, whereas the other cases rendered satisfactory steady-state points.

With increased airspeed, the gradients of roll attitude and pedal position become increasingly positive, as they do with a conventional helicopter. Unlike a conventional helicopter, however, the gradient for lateral stick does not increase at higher airspeeds, but stays fairly constant, evidence of lower overall effective dihedral.

Comparison of Predictions and Flight Data

Compound flight testing has been supported by extensive off-line computer simulations, using the GenHel program adapted by Sikorsky Aircraft for the several RSRA configurations. Trimmed flight cases were run for wing incidence changes and can be compared with flight data.

Figures 55 and 56 show an example for wing incidence changes from 10° to 0° at 40% collective stick, showing predicted (fig. 55) and flight data (fig. 56) for pitch attitude, longitudinal stick, TF-34 engine fan speed, T-58 engine torque, and main-rotor flapping. There is good correlation in slope for the parameters other than main-rotor flapping and good correlation for all parameters in sensitivity to wing incidence changes. The numerical values do not correlate so well, however, with the predictions showing 1°-2° less pitch attitude than the flight data, 5% more forward stick, and a slightly different power sharing between TF-34 fan speed and T-58 engine torque. These results confirm that the simulations are useful for extrapolations of existing data and sensitivities to the new configurations and less useful for determining absolute values.

Wing-Actuator Imbalance

During flight 6 on 22 January 1982, there was an incident involving a large imbalance force between the left and right wing incidence actuators: actuator load-cell values and cylinder pressures are shown for the first 52 min of flight 6 in figure 57 in time-history format.

After takeoff and climb, the right actuator takes an increasing share of the wing load as this load increases with airspeed, to a difference of approximately 3,500 lb at 28 min; this difference is attributed to leakage rate differences between the controlling valves. At 29 min, the left upper cylinder underwent a sudden (0.5 sec) decrease of about 120 lb/in.^{2}, increasing the load difference to 5,000 lb and activating the wing force warning light in the cockpit. The pilots attempted to rebalance the actuators using the bypass procedure (at 30 min) but this resulted in an opposite difference of 9,400 lb, with the left actuator carrying much more load than the right. No further action was taken, and the normal leakage reduced the difference, with the warning light going out when the difference fell below 5,000 lb at 42 min.

A time-history of a typical wing incidence change from 5° to 7.5° to 5° is included as figure 58.

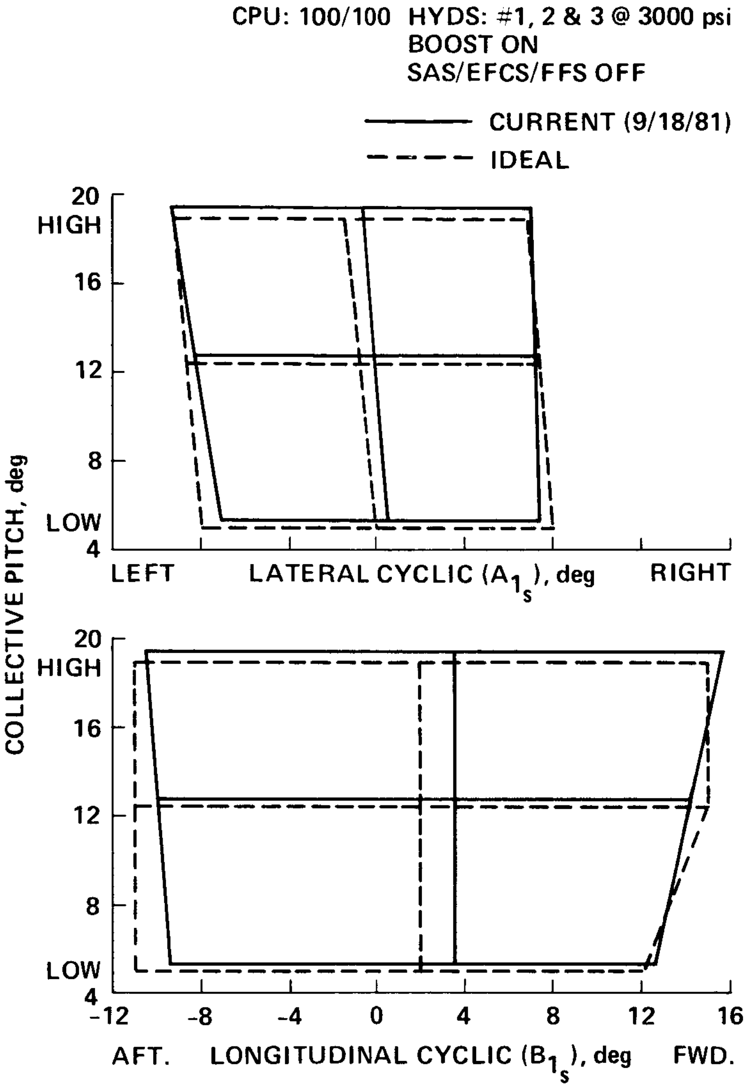


Figure 1.- Main-rotor rigging characteristics: full compound configuration.

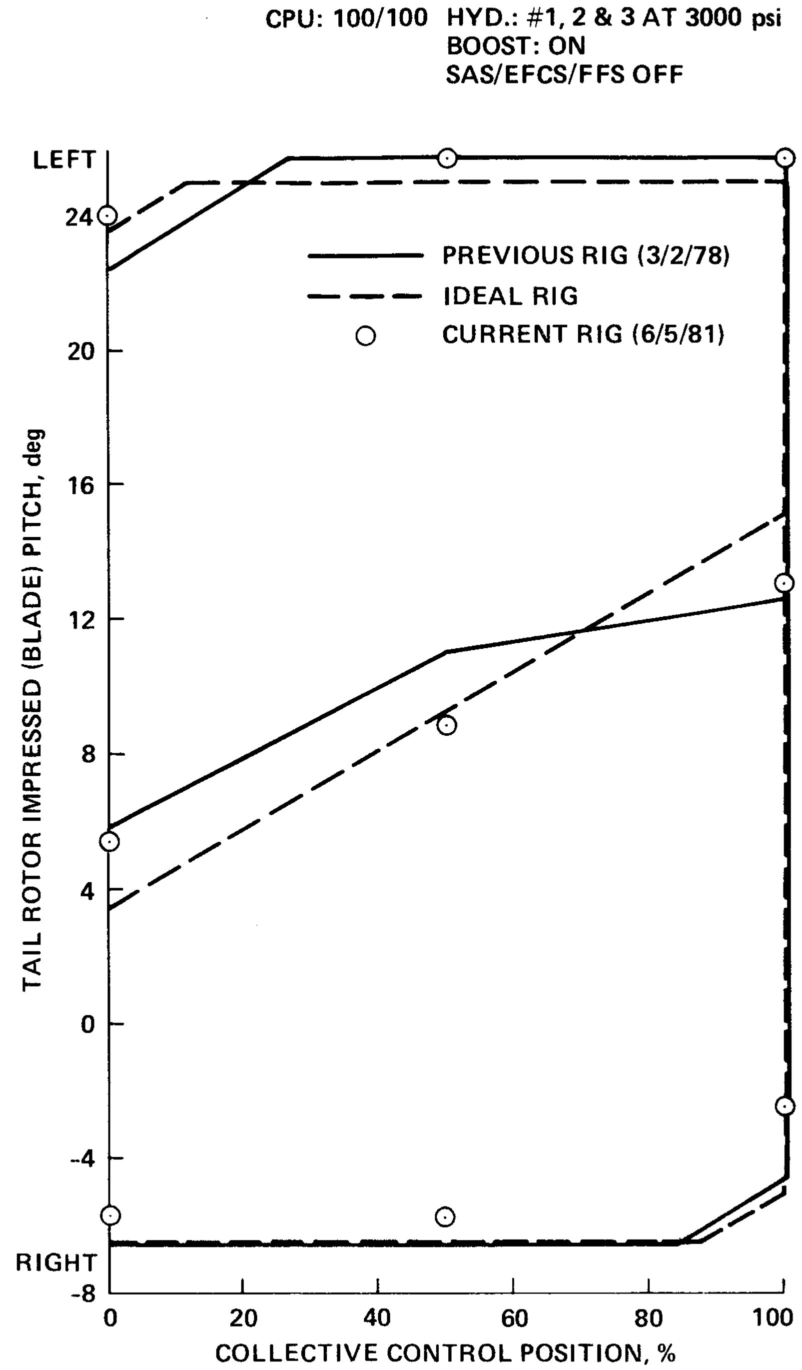


Figure 2.- Tail-rotor rigging characteristics: full compound configuration.

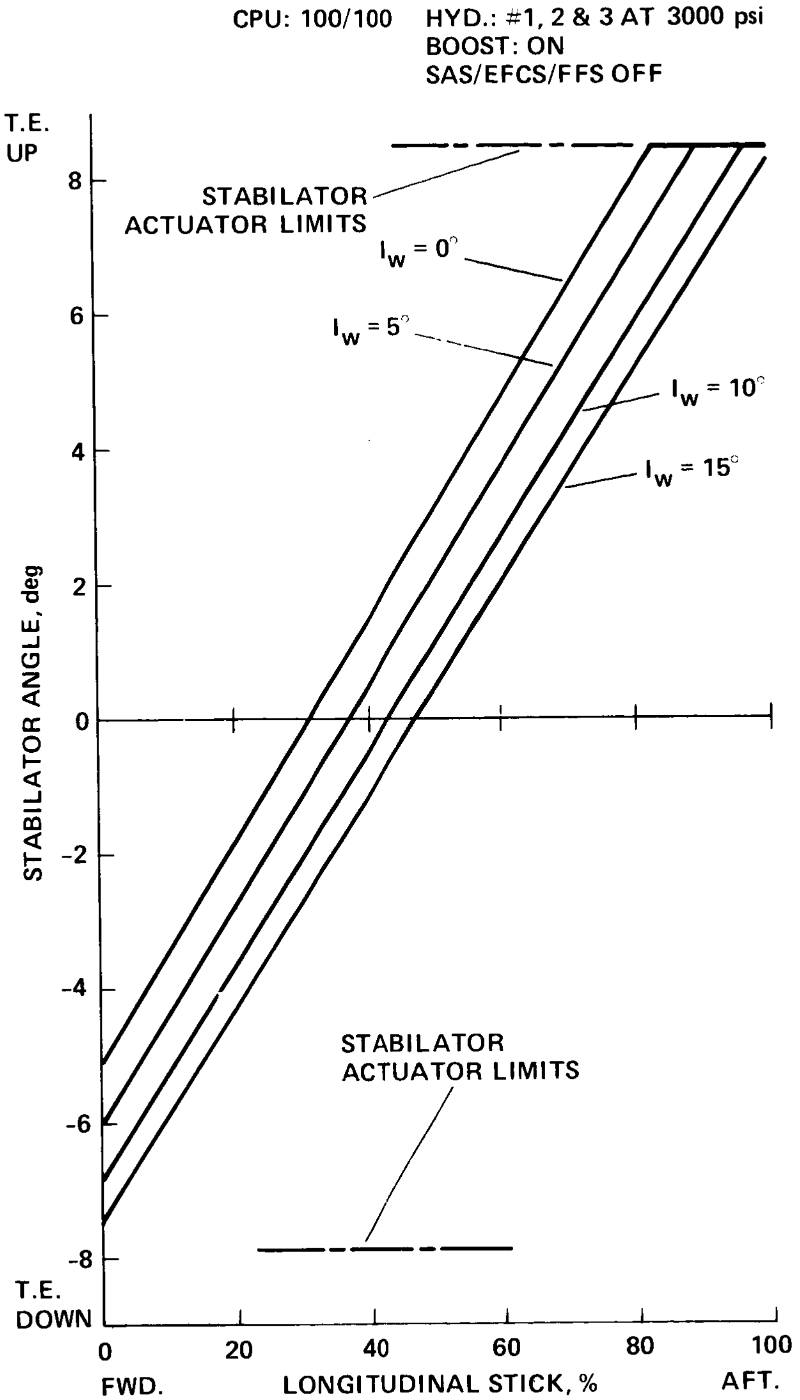


Figure 3.- Stabilator rigging characteristics: full compound configuration.

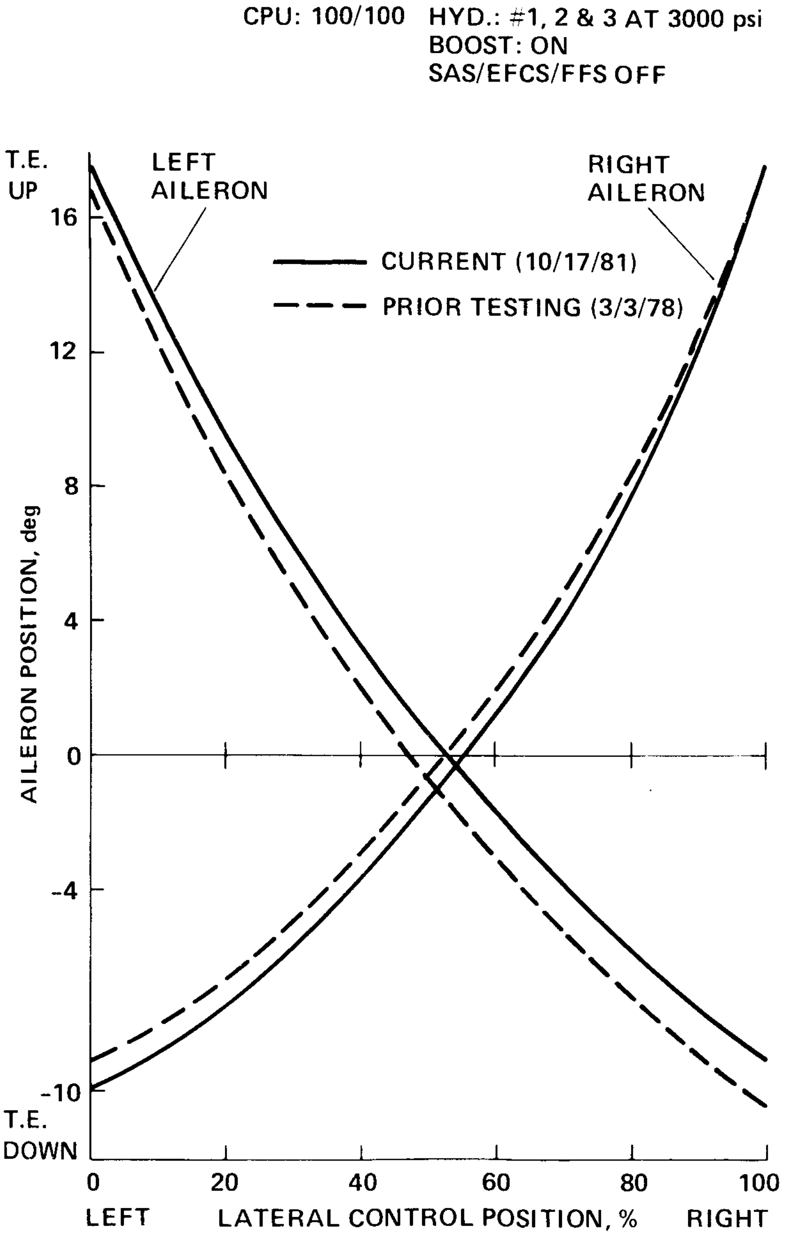


Figure 4.- Aileron rigging characteristics: full compound configuration.

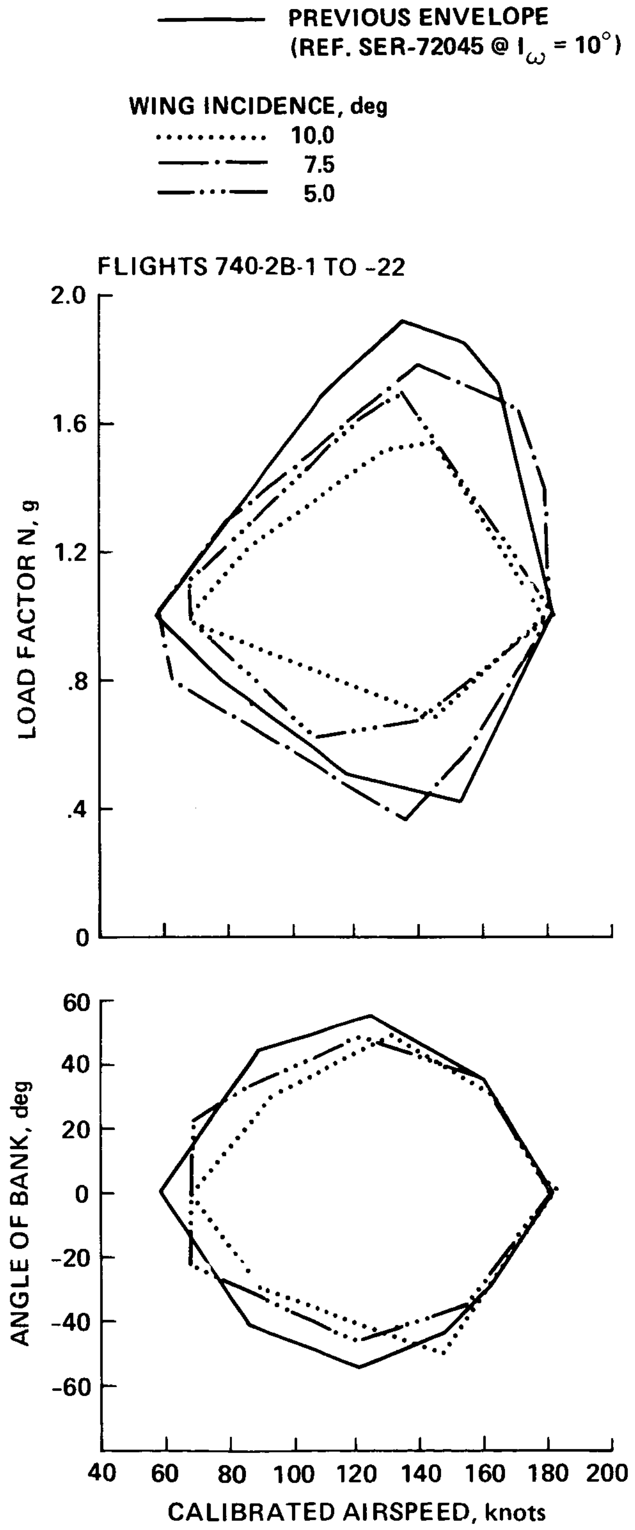


Figure 5.- Flight envelope for compound configuration: load factor and angle of bank versus calibrated airspeed (flights 740-2B-1 to -22).

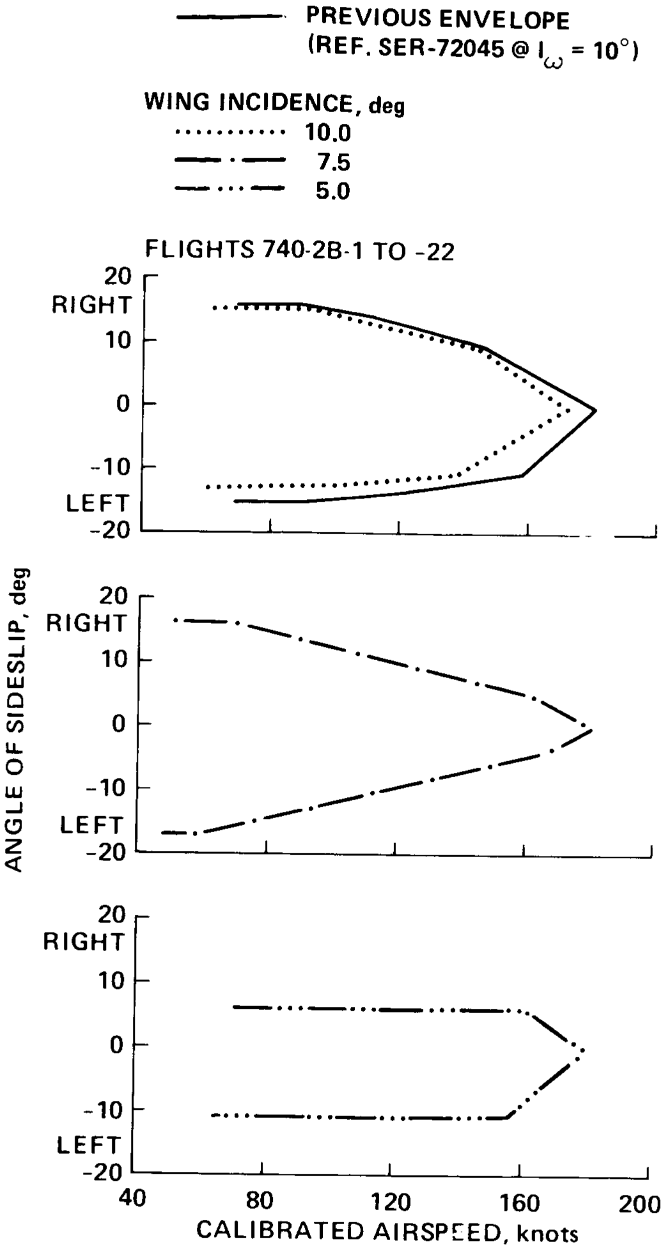


Figure 6.- Flight envelope for compound configuration: angle of sideslip versus calibrated airspeed (flights 740-2B-1 to -22).

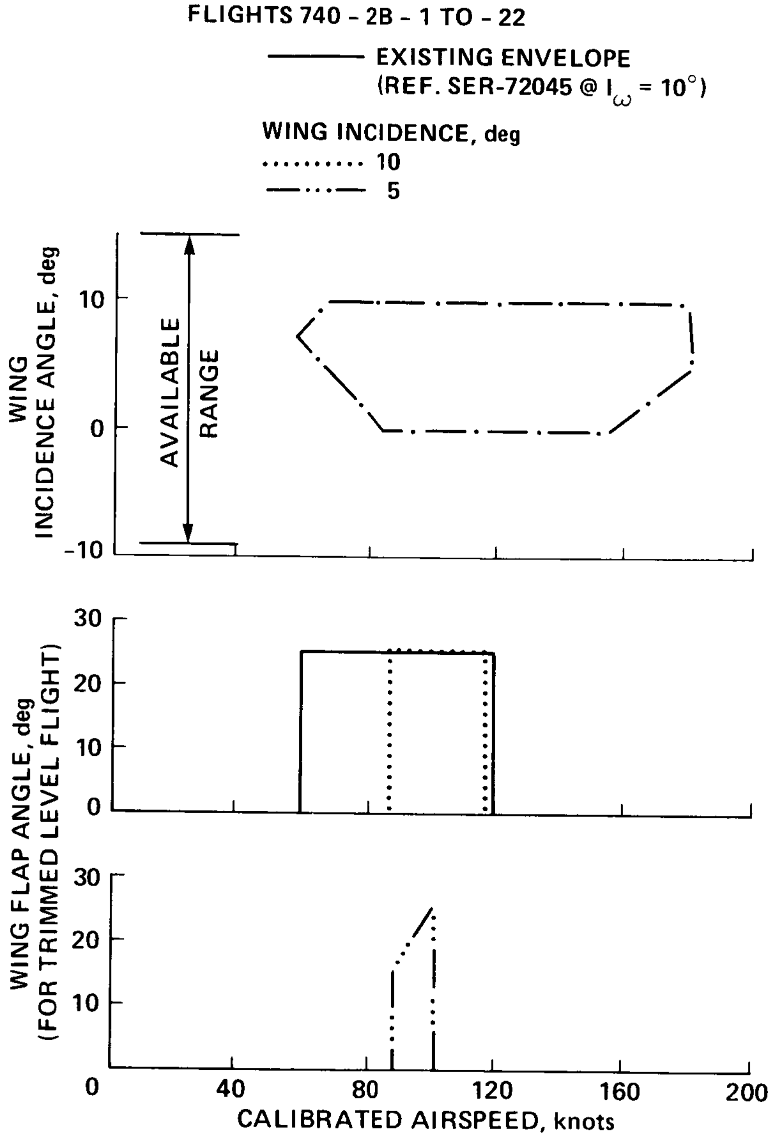


Figure 7.- Flight envelope for compound configuration: wing incidence (I_ω) and flap angle (δ_F) versus calibrated airspeed (flights 740-2B-1 to -22).

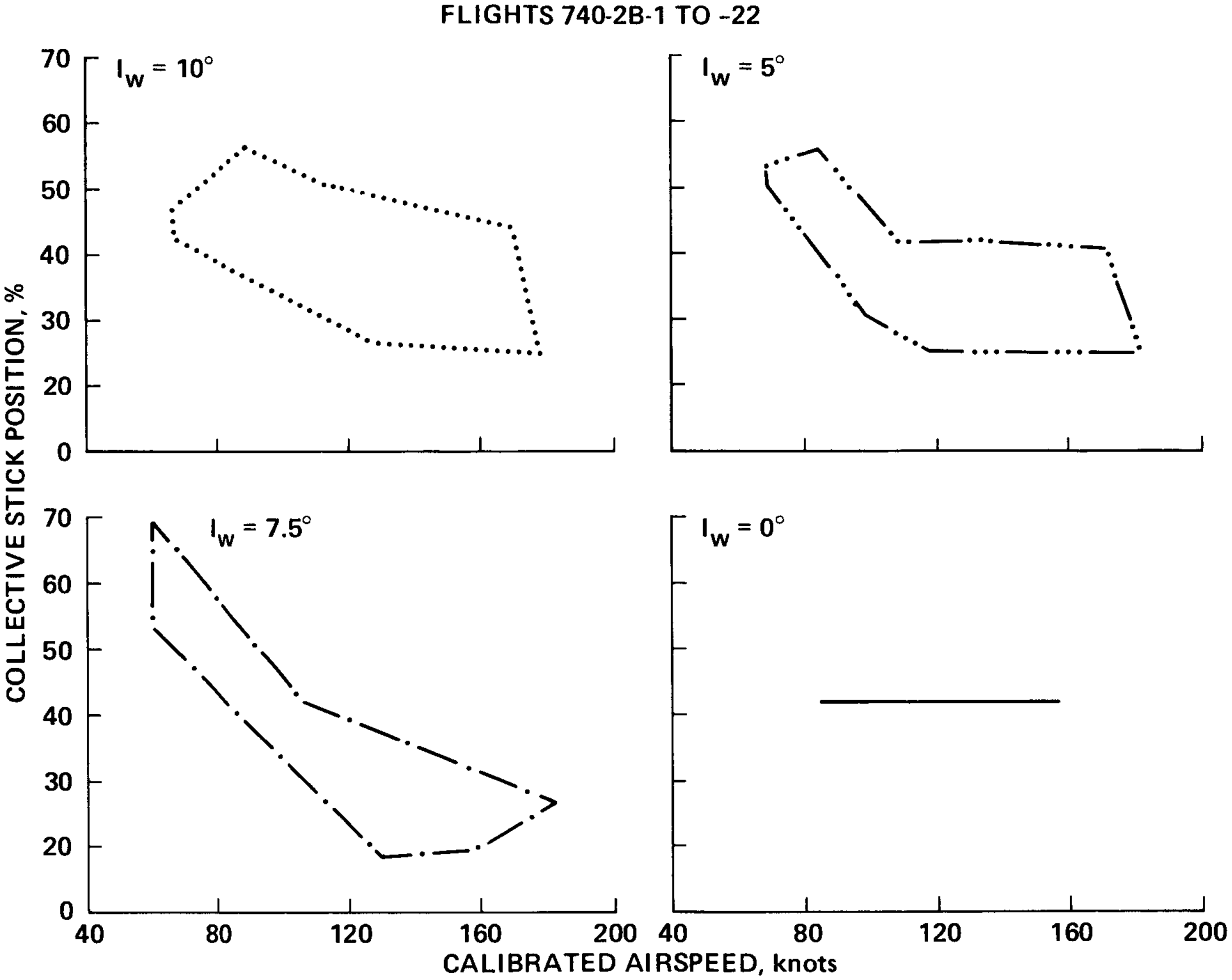


Figure 8.- Flight envelope for compound configuration: collective stick position versus calibrated airspeed for trimmed level flight (flights 740-2B-1 to -22).

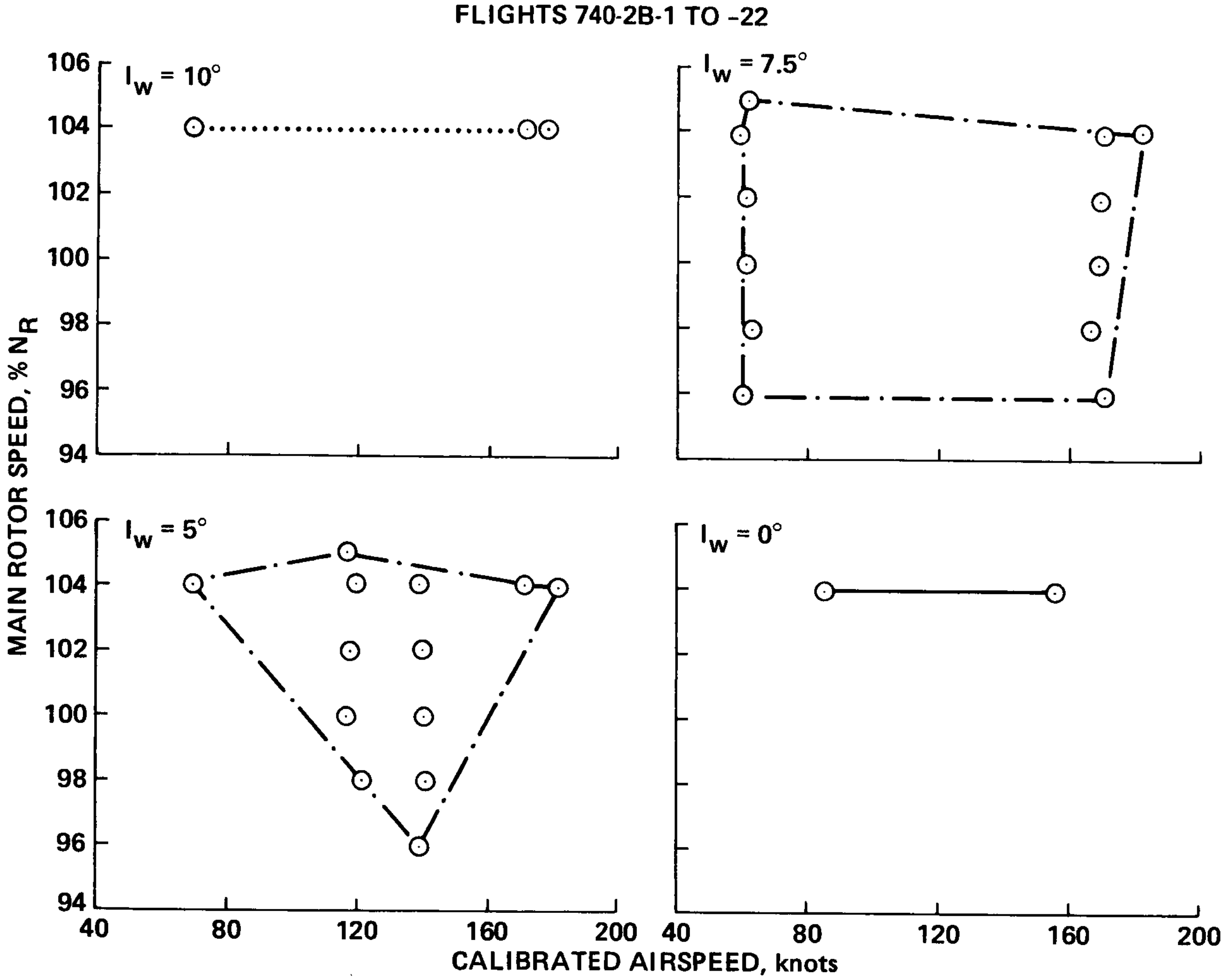


Figure 9.- Flight envelope for compound configuration: main-rotor speed versus calibrated airspeed for trimmed level flight (flights 740-2B-1 to -22).

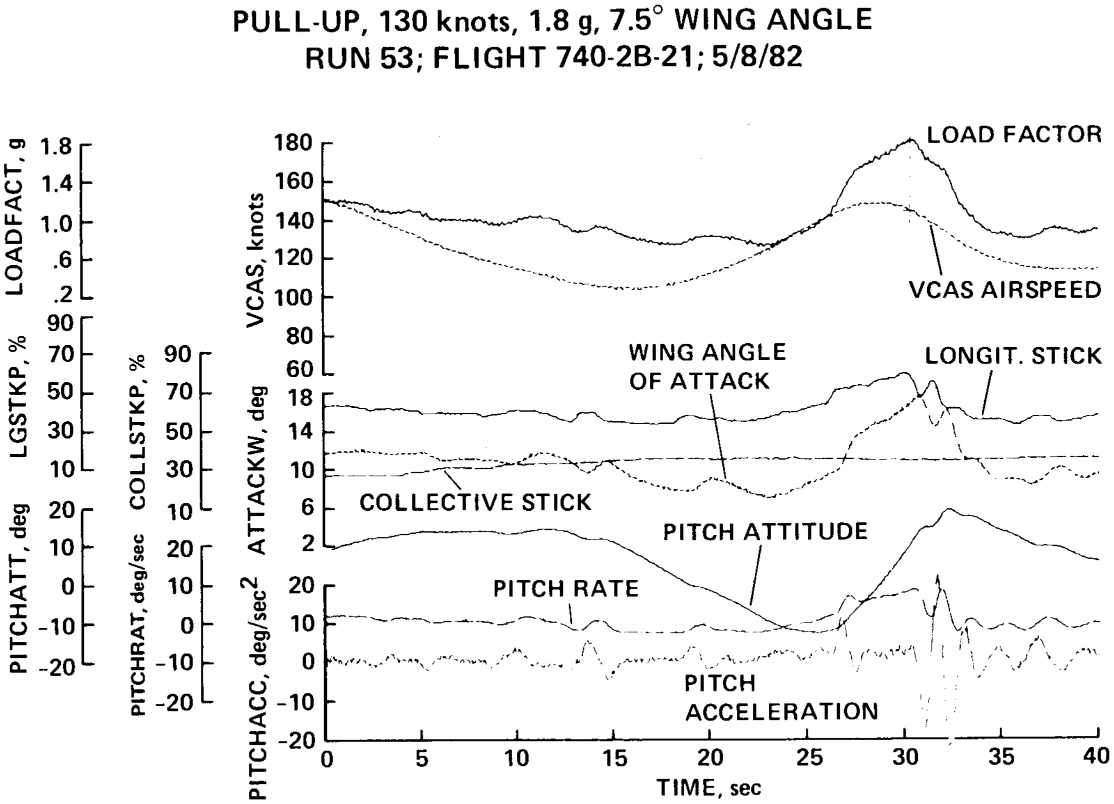


Figure 10.- Pull-up: 130 knots, 1.8 g, 7.5° wing angle.

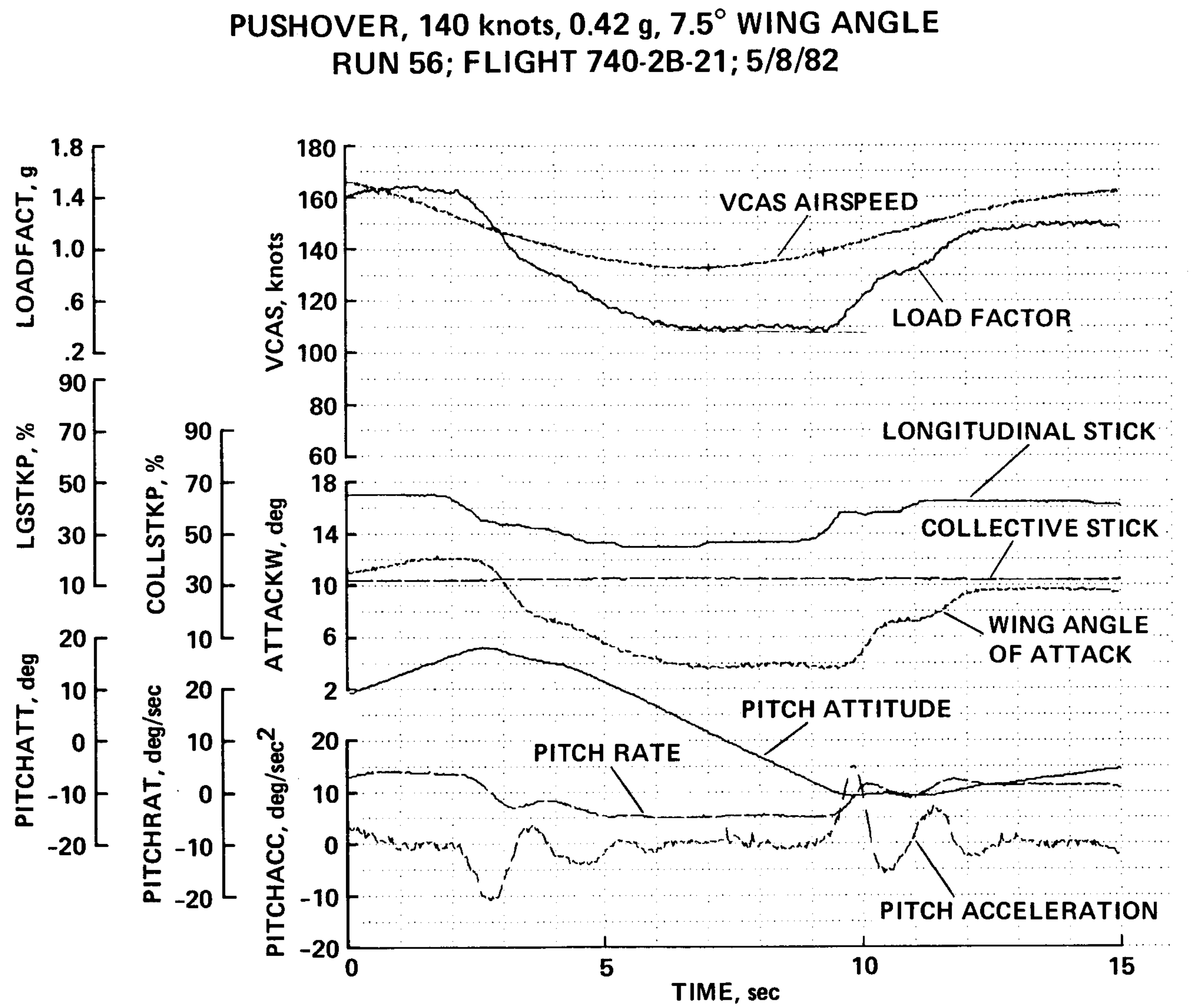


Figure 11.- Pushover: 140 knots, 0.142 g, 7.5° wing angle.

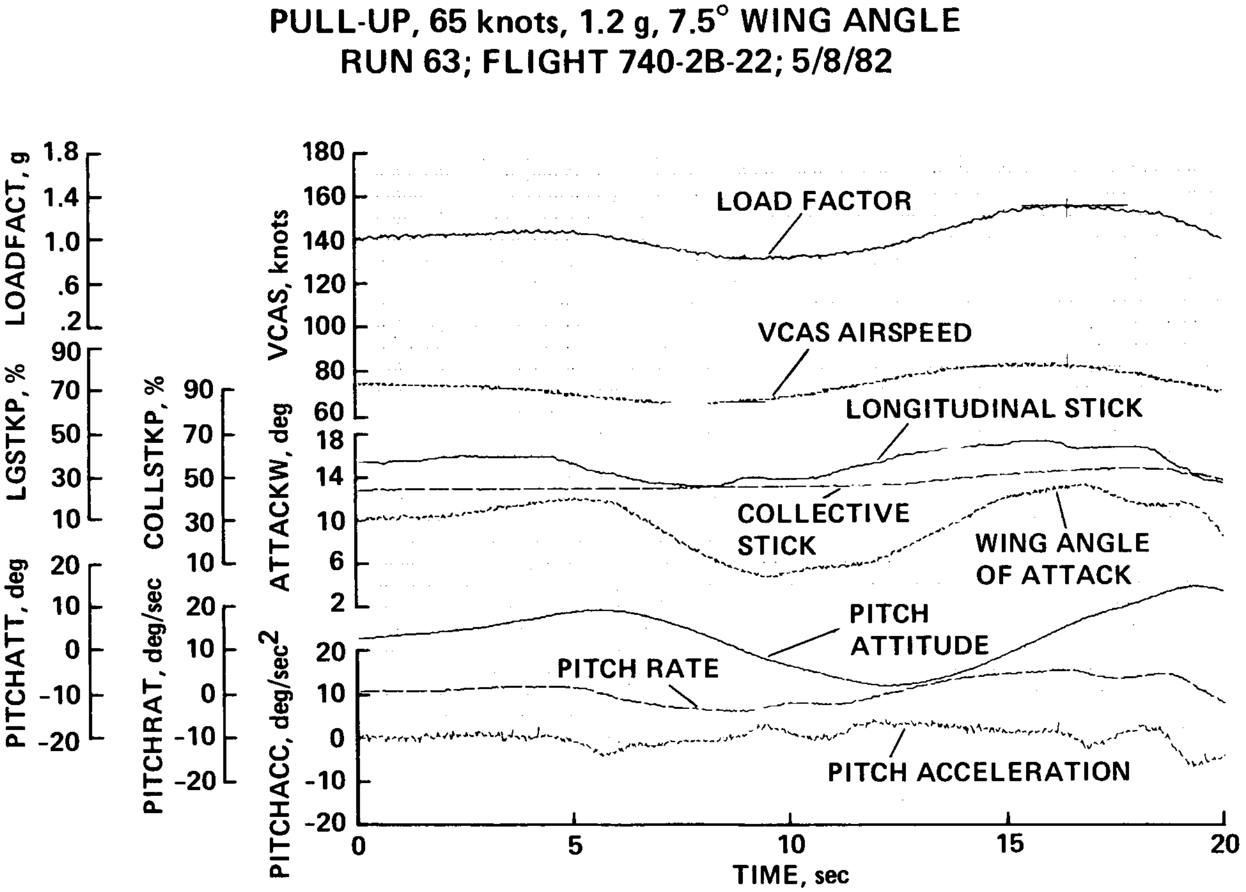


Figure 12.- Pull-up: 65 knots, 1.2 g, 7.5° wing angle.

PUSHOVER, 65 knots, 0.74 g, 7.5° WING ANGLE
RUN 65; FLIGHT 740-2B-22; 5/8/82

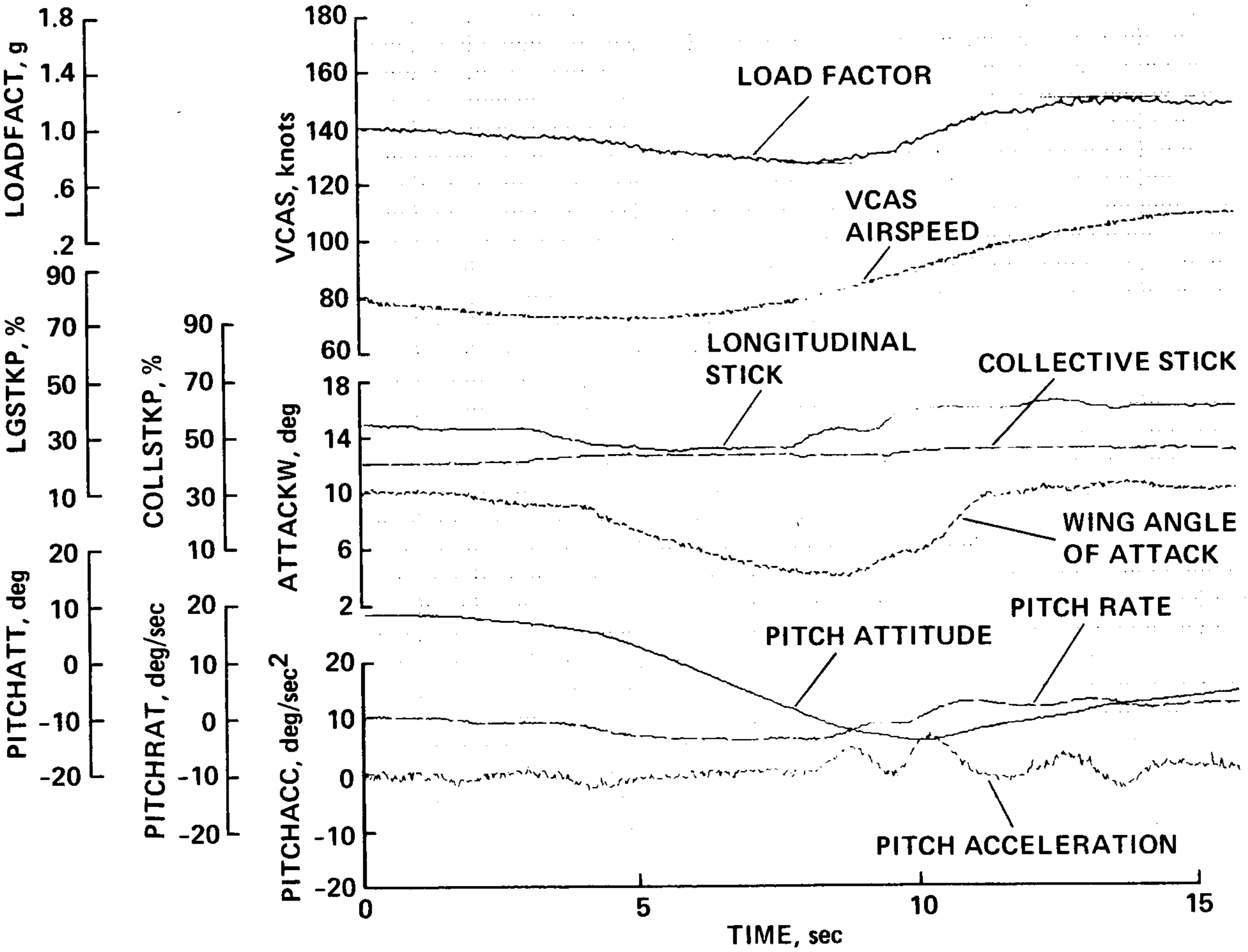


Figure 13.- Pushover: 65 knots, 0.74 g, 7.5° wing angle.

TAKEOFF, 10° WING ANGLE: HANDLING QUALITIES
RUN 16; FLIGHT 740-2B-7; 2/2/82

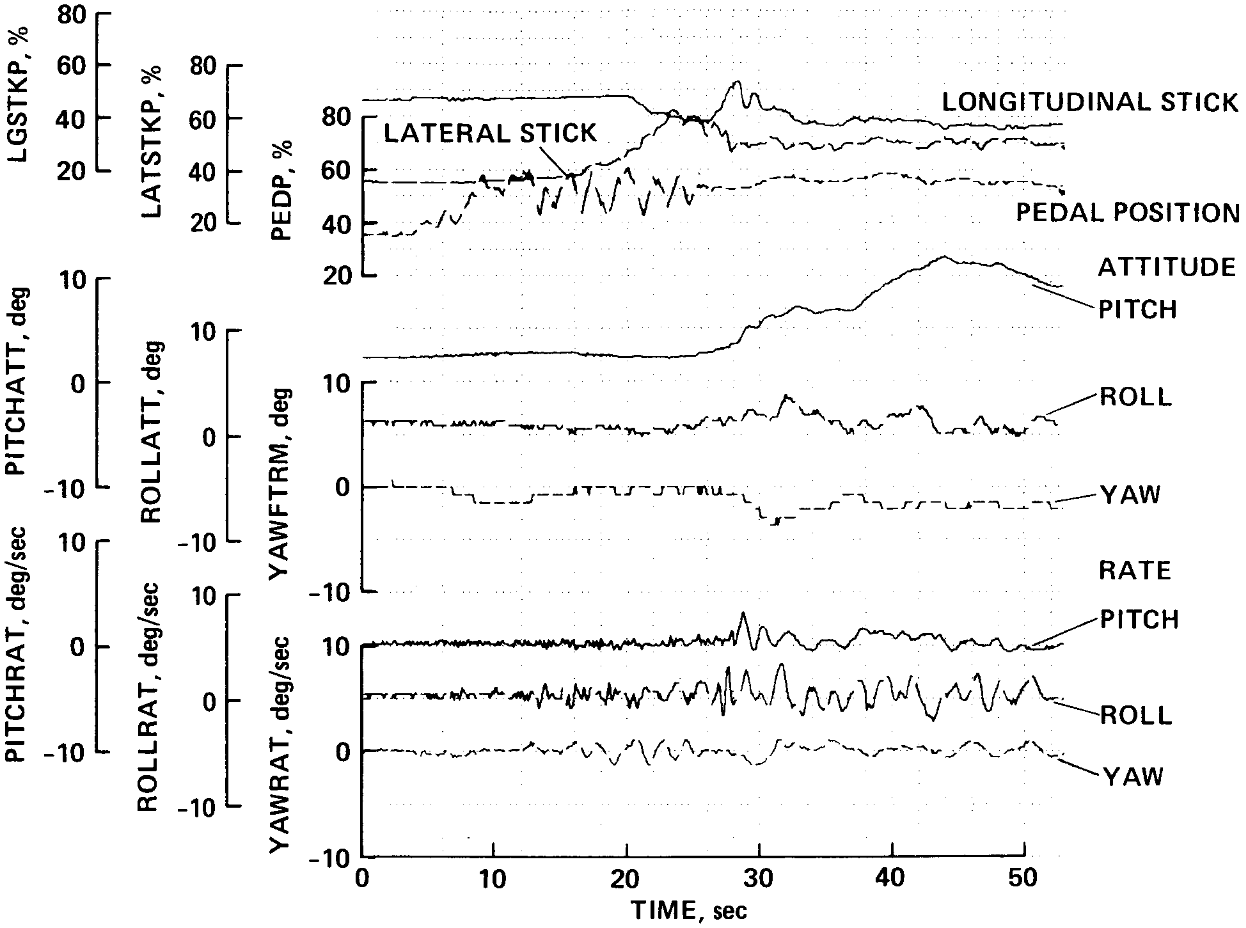


Figure 14.- Takeoff, 10° wing angle: handling qualities.

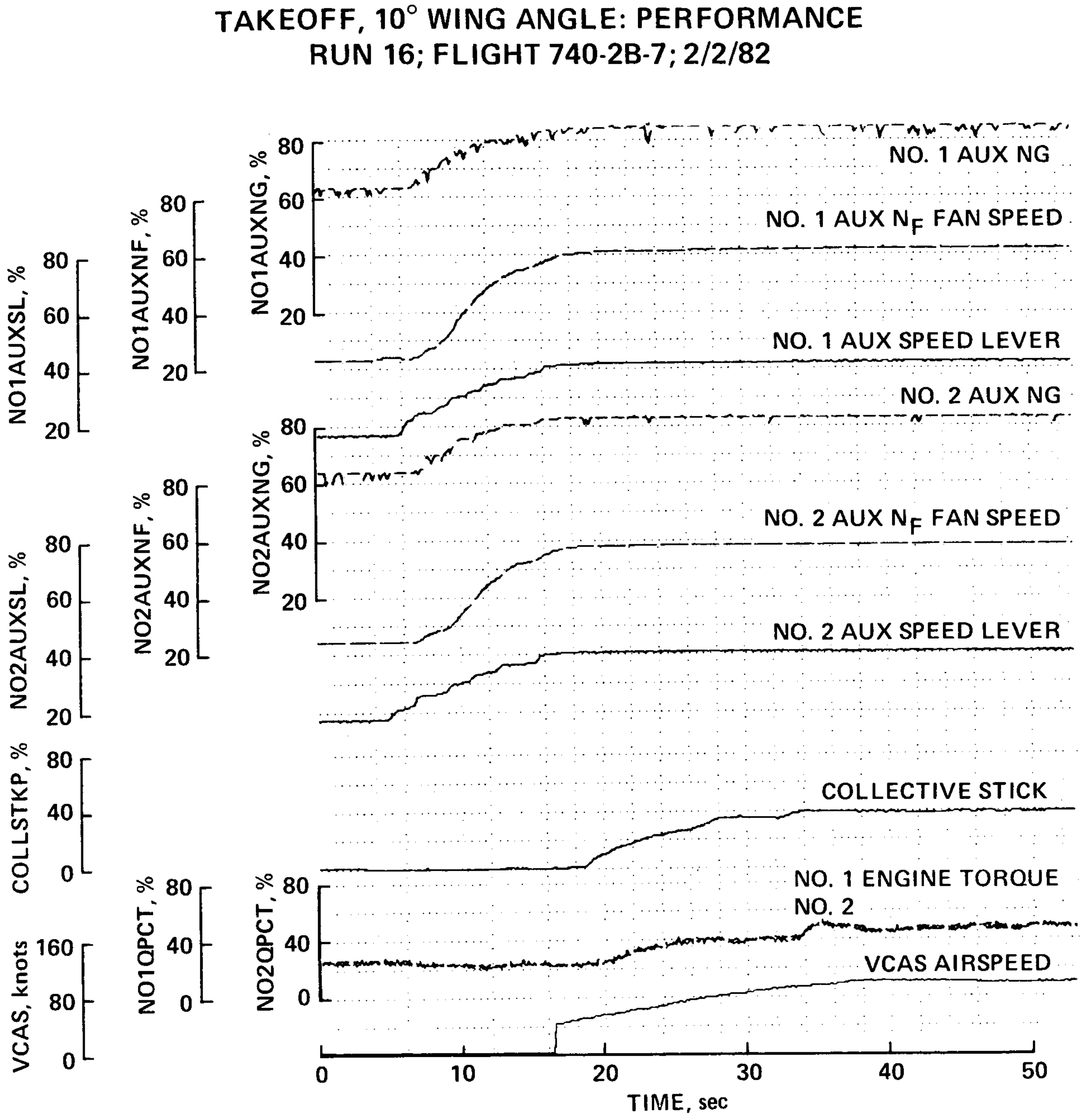


Figure 15.- Takeoff, 10° wing angle: performance.

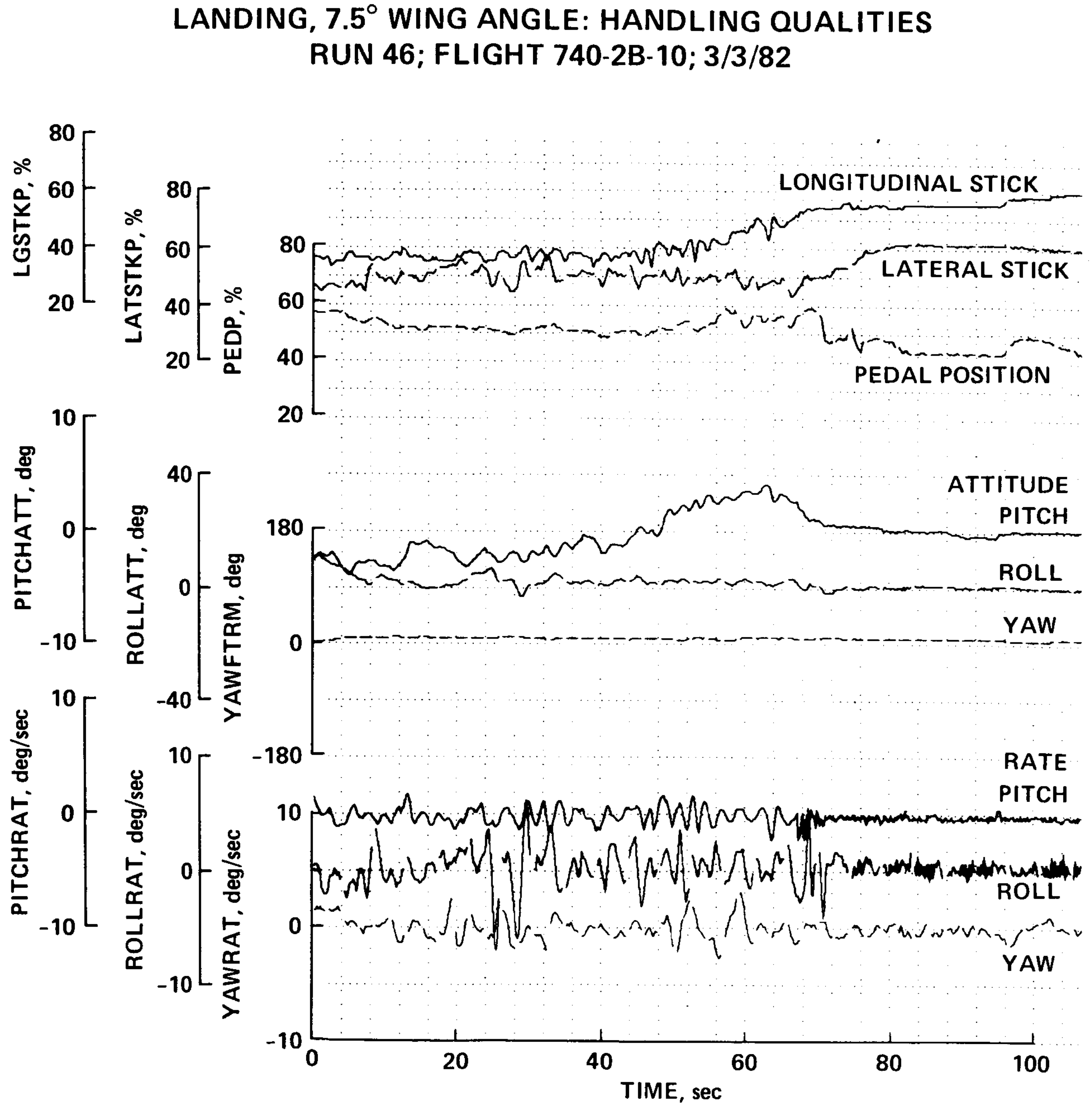


Figure 16.- Landing, 7.5° wing angle: handling qualities.

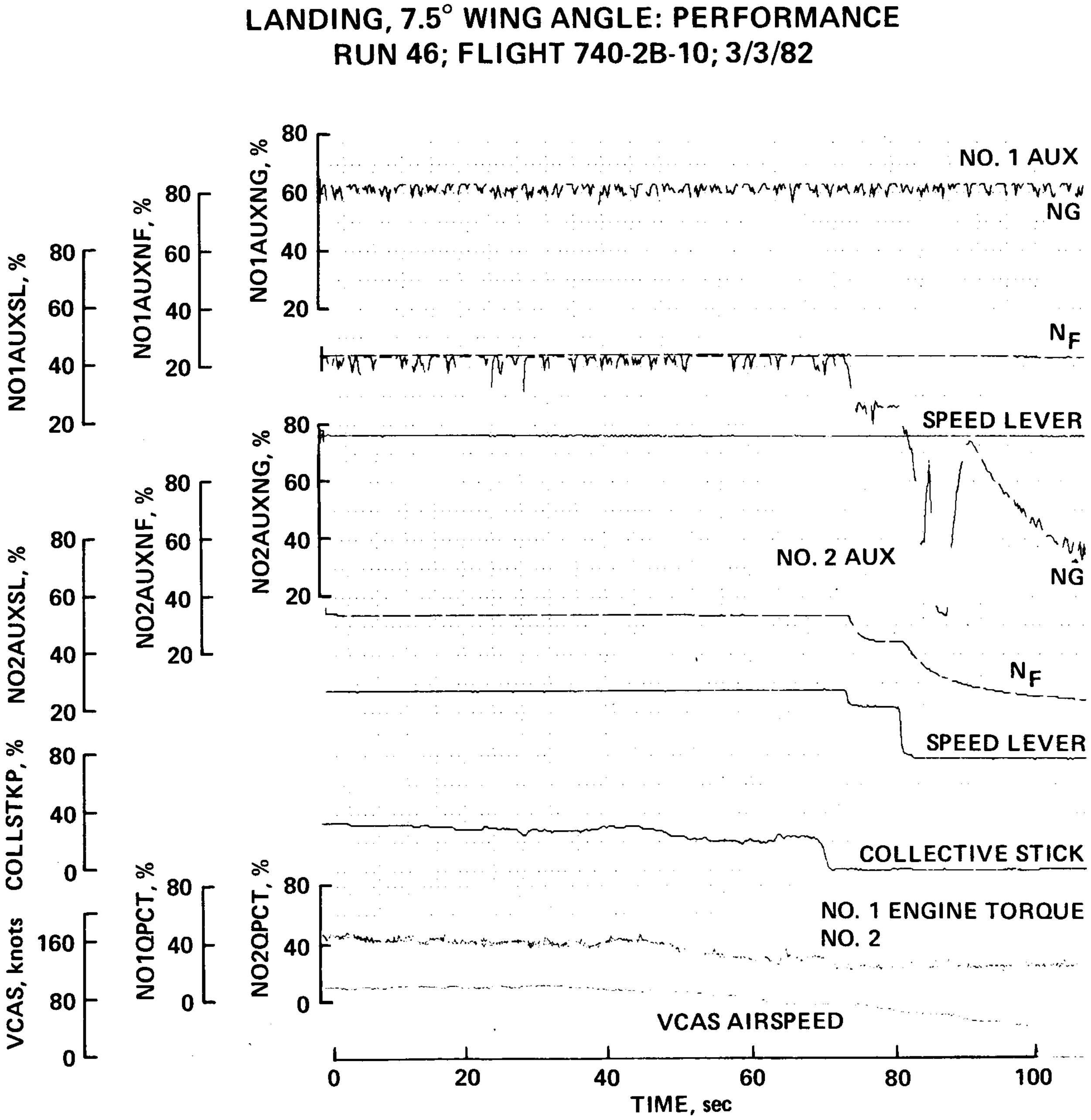


Figure 17.- Landing, 7.5° wing angle: performance.

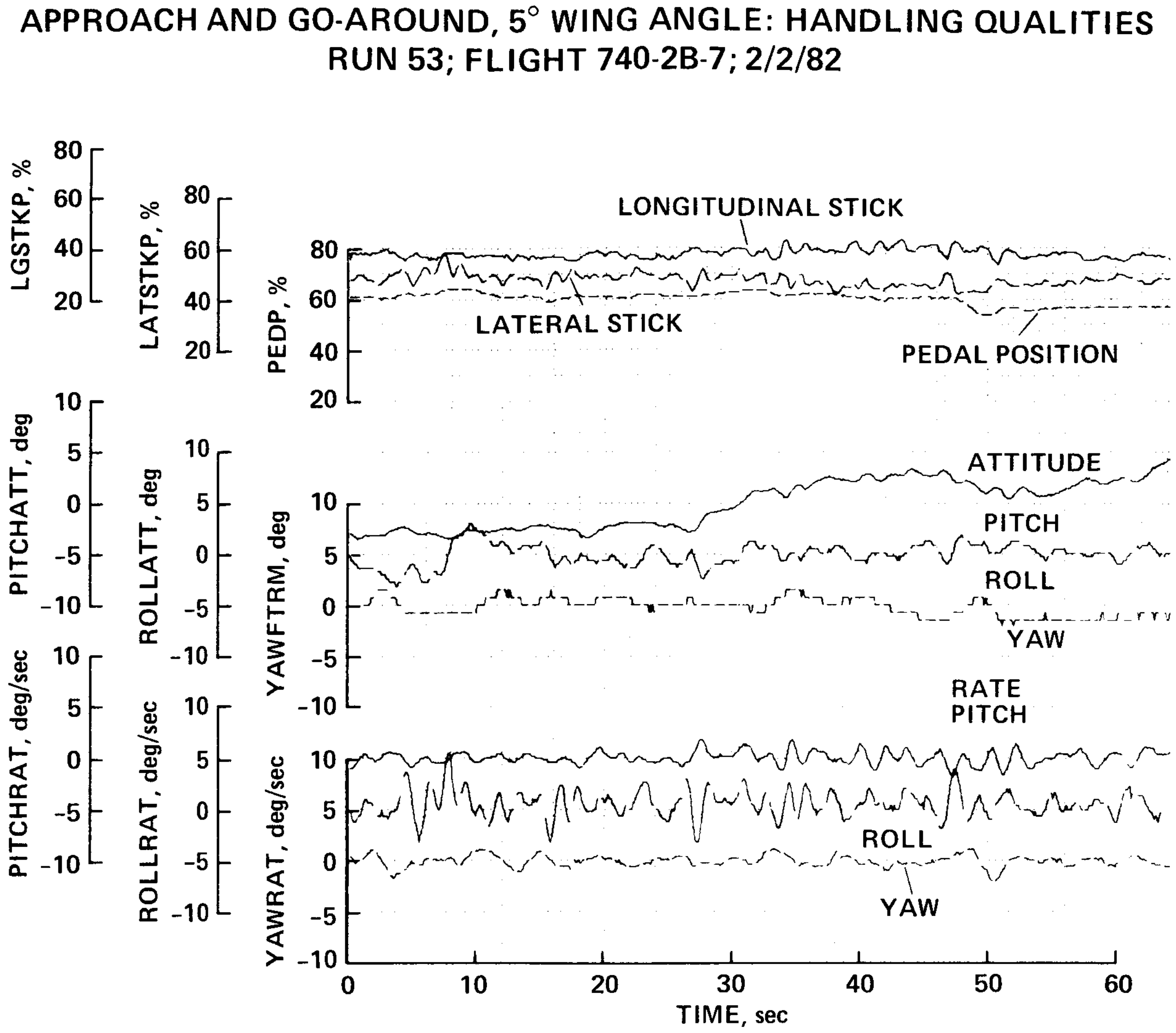


Figure 18.- Approach and go-around, 5° wing angle: handling qualities.

APPROACH AND GO-AROUND, 5° WING ANGLE: PERFORMANCE
RUN 53; FLIGHT 740-2B-7; 2/2/82

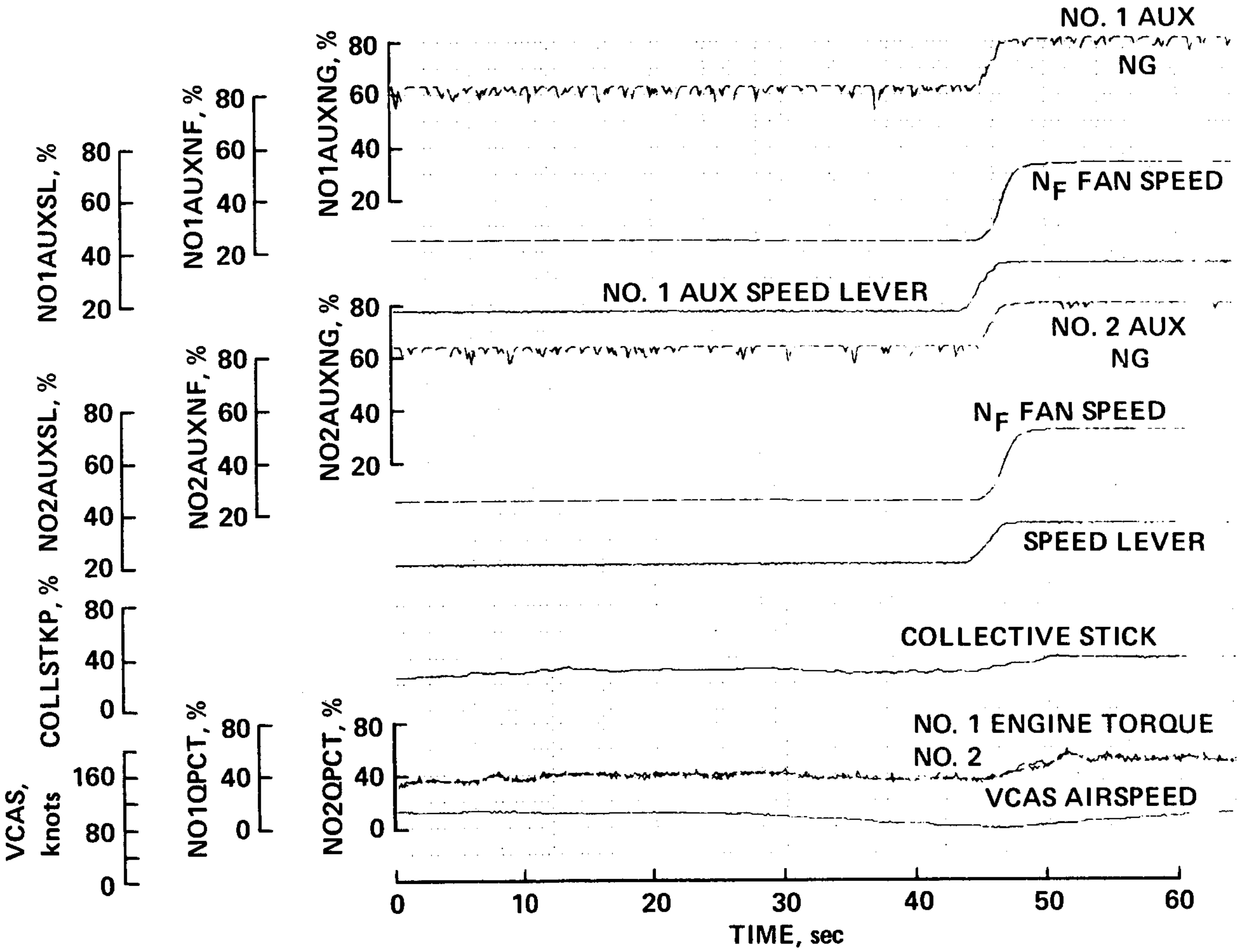
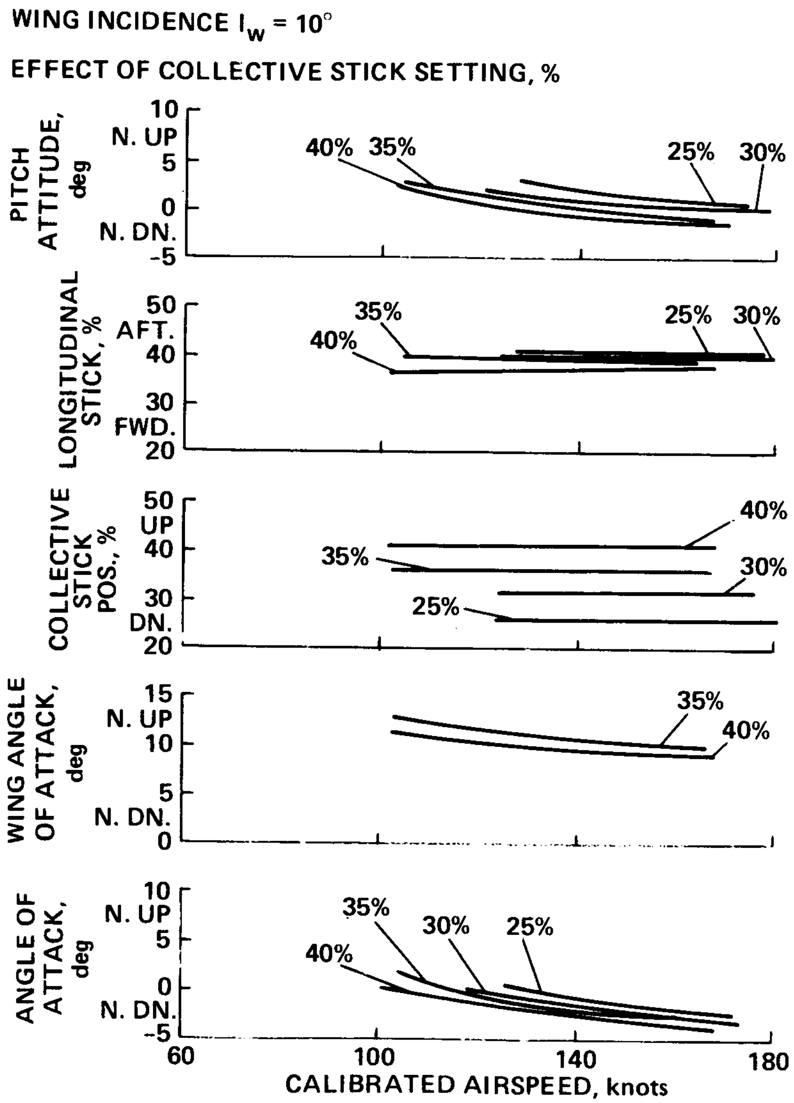


Figure 19.- Approach and go-around, 5°wing angle: performance.


WING INCIDENCE $I_w = 10^\circ$

EFFECT OF COLLECTIVE STICK SETTING, %

Figure 20.- Level flight trim, effect of collective stick setting: wing incidence 10°: longitudinal parameters.

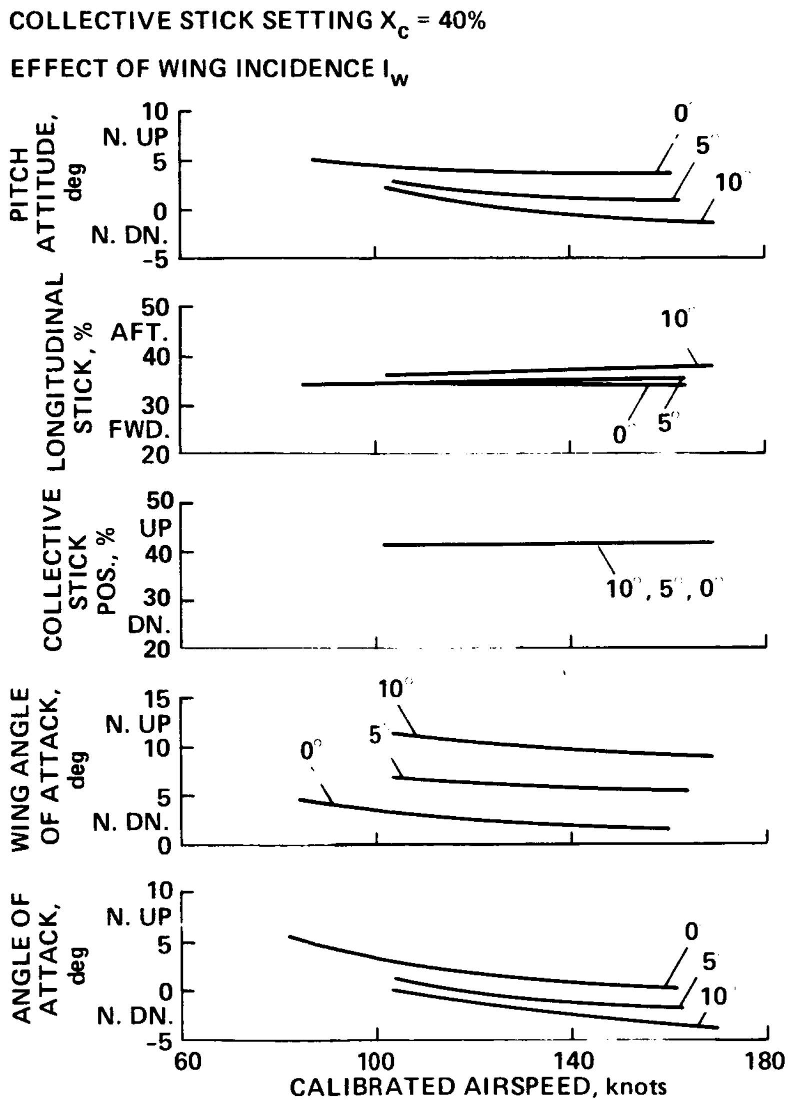


Figure 21.- Level flight trim, effect of wing incidence: collective stick setting 40%: longitudinal parameters.

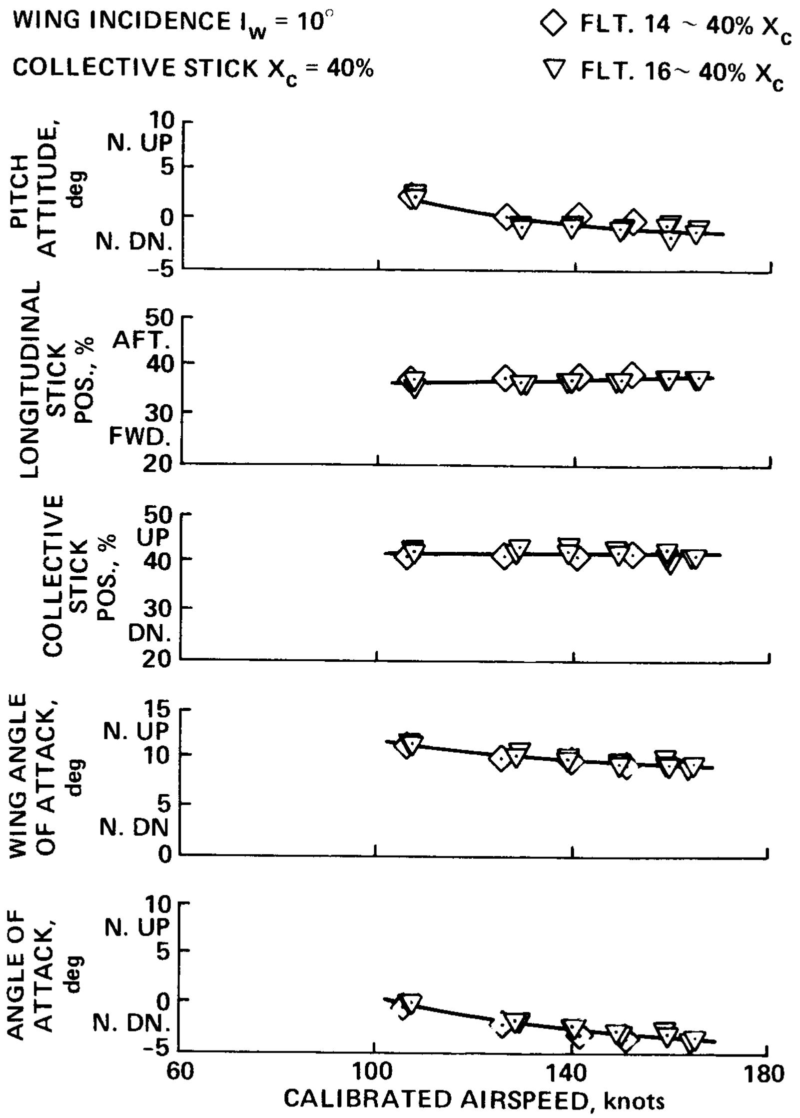


Figure 22.- Level flight trim: wing incidence 10°, collective stick 40%: longitudinal parameters.

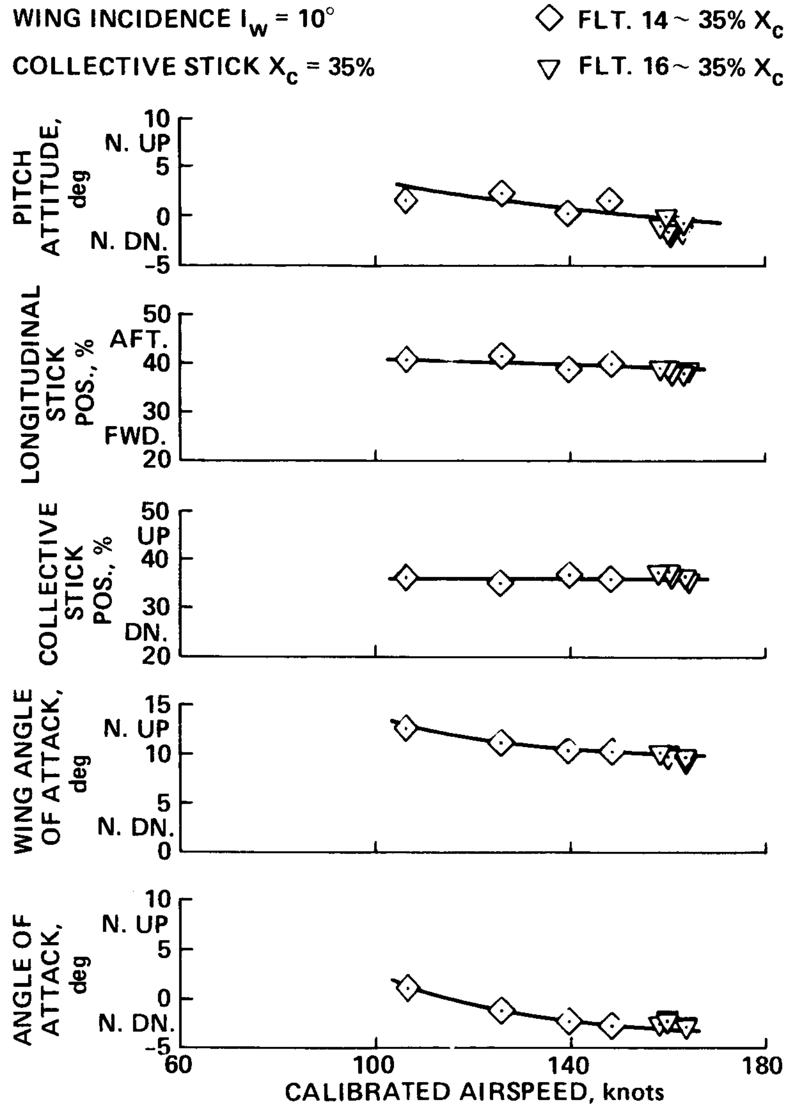


Figure 23.- Level flight trim: wing incidence 10°, collective stick 35%: longitudinal parameters.

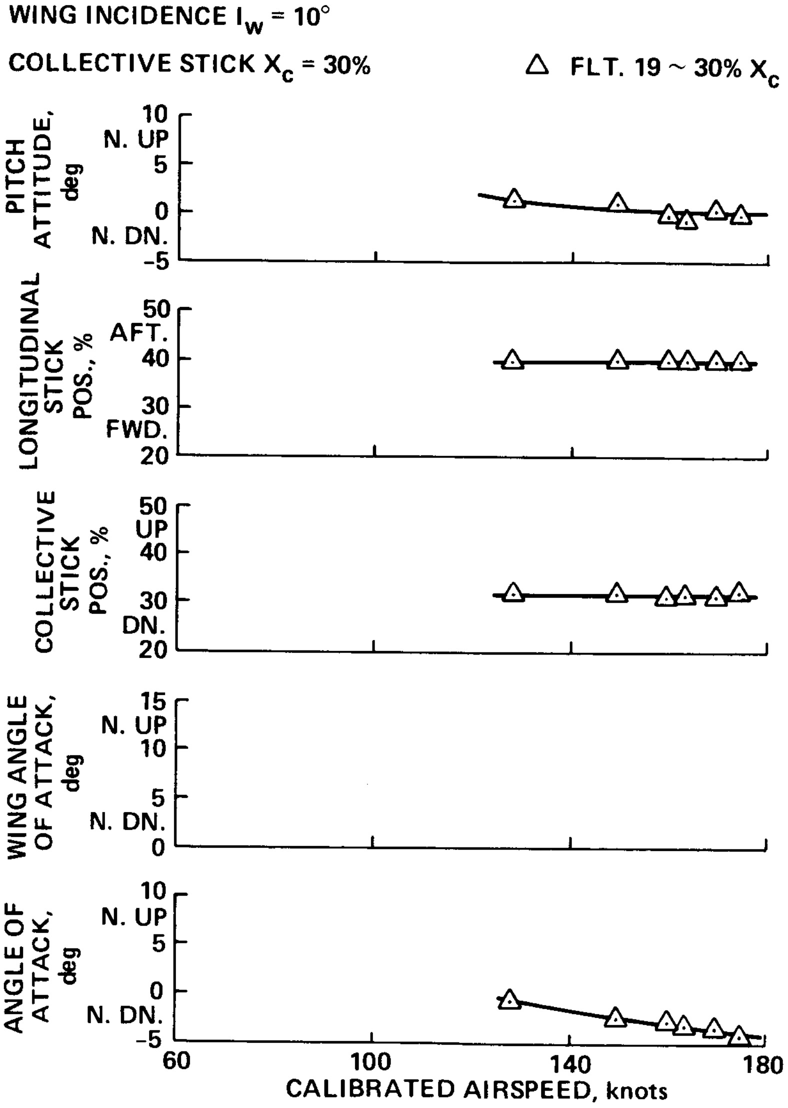


Figure 24.- Level flight trim: wing incidence 10°, collective stick 30%: longitudinal parameters.

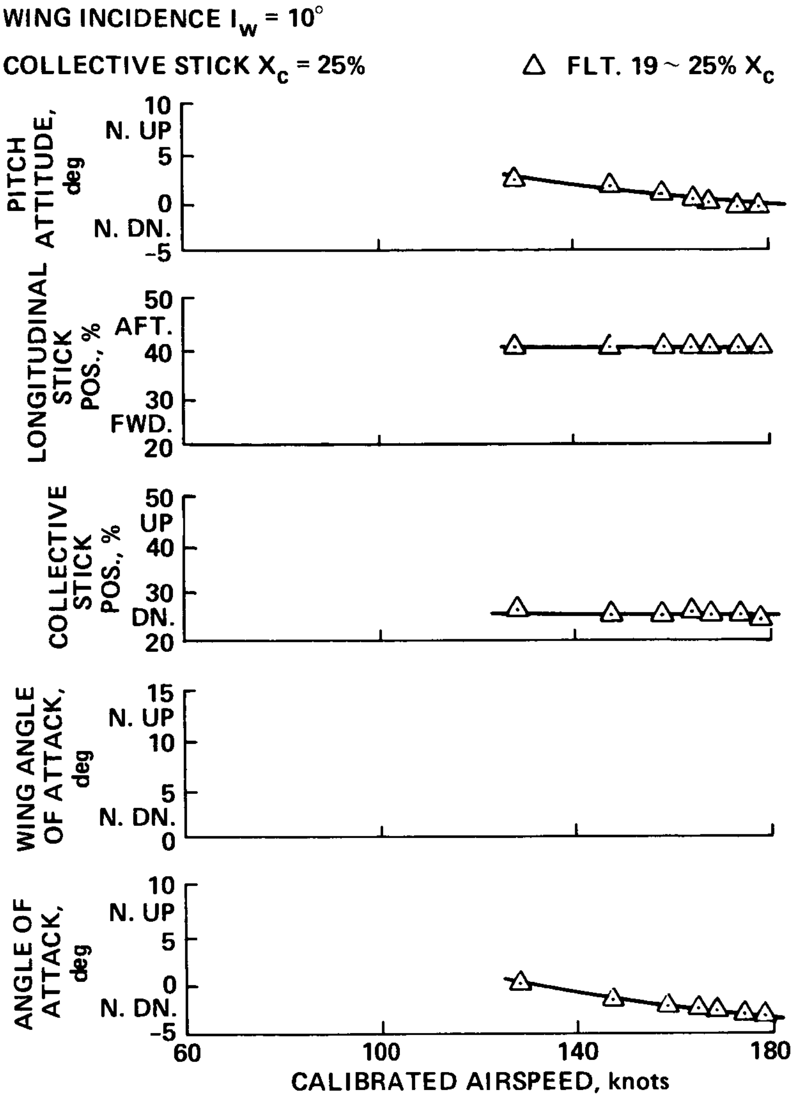


Figure 25.- Level flight trim: wing incidence 10°, collective stick 25%: longitudinal parameters.

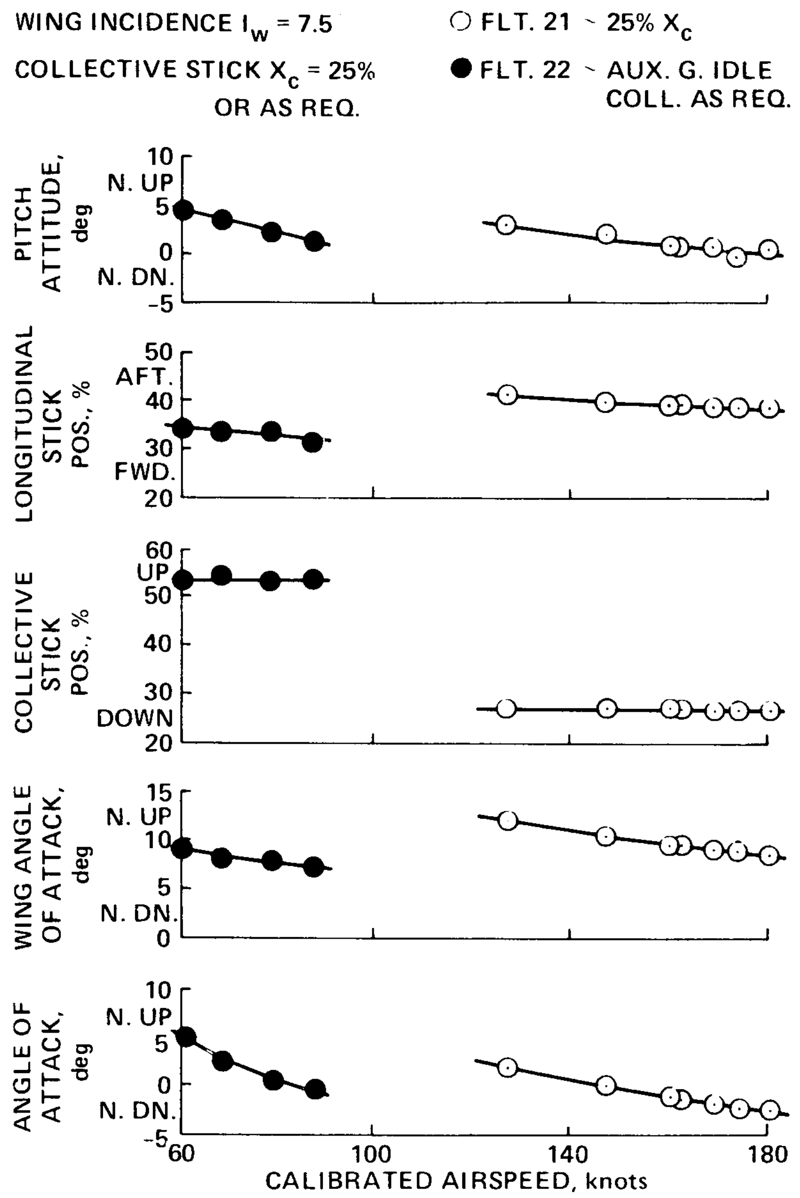


Figure 26.- Level flight trim: wing incidence 7.5°, collective stick 25% (or as required): longitudinal parameters.

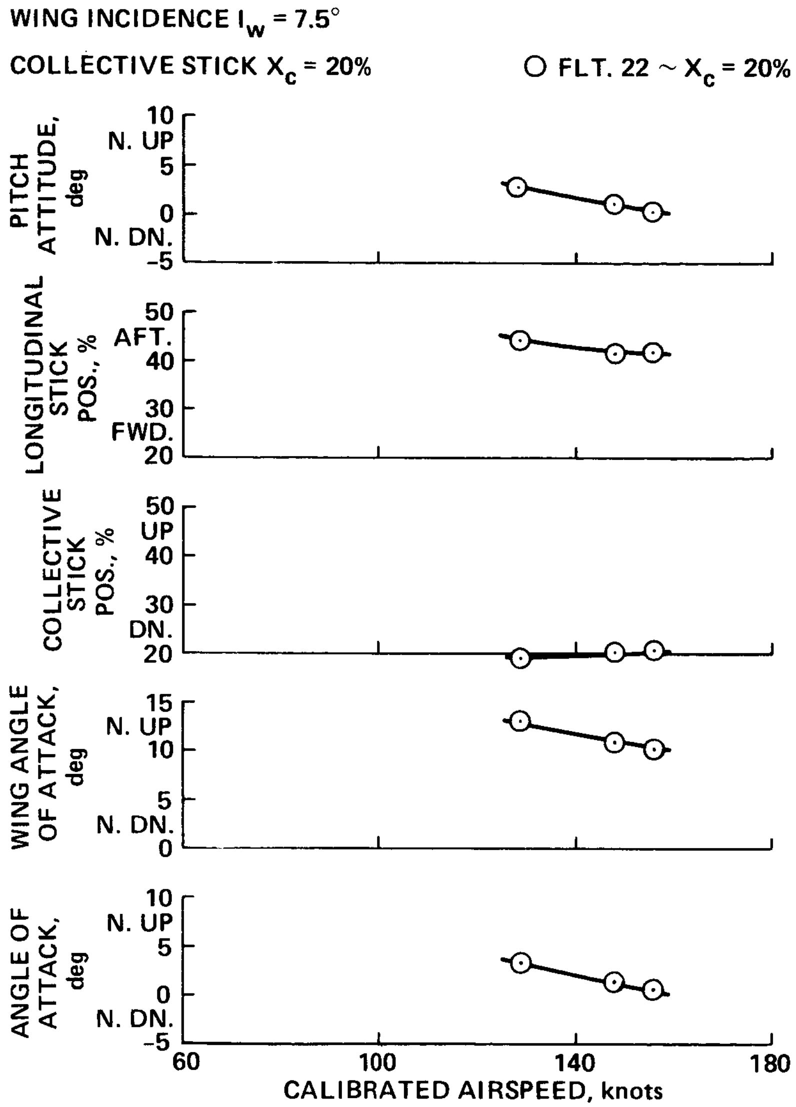


Figure 27.- Level flight trim: wing incidence 7.5°, collective stick 20%: longitudinal parameters.

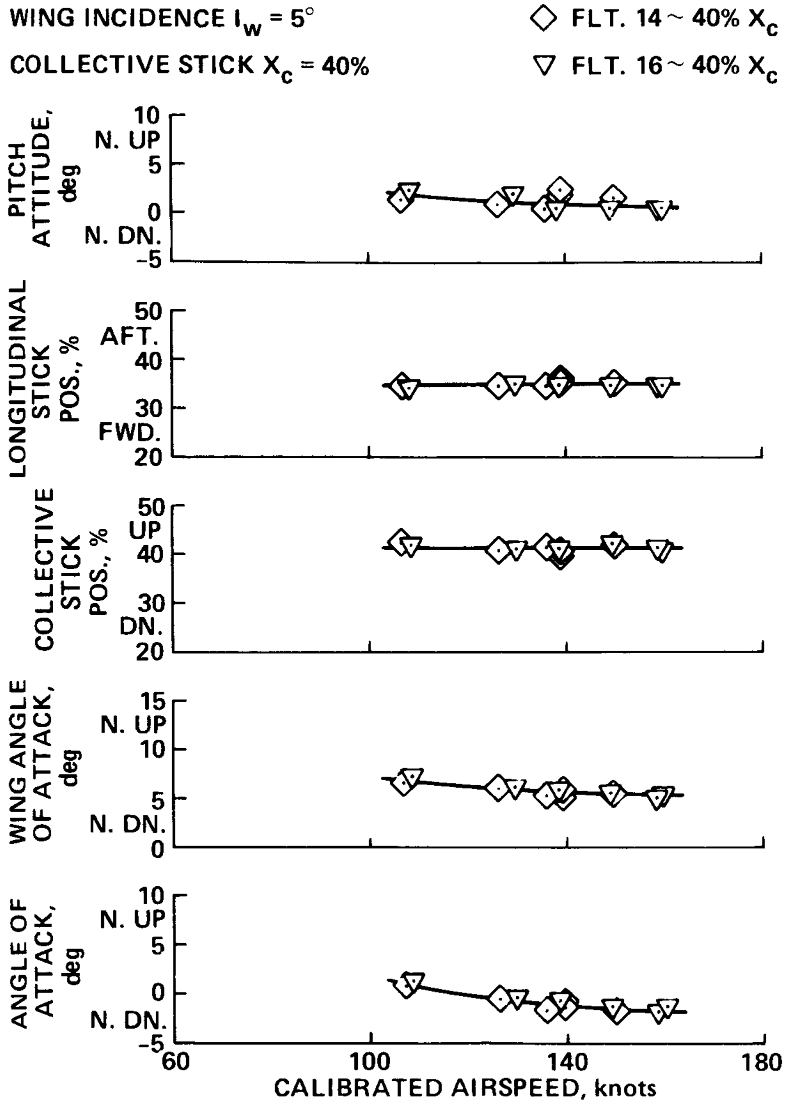


Figure 28.- Level flight trim: wing incidence 5°, collective stick 40%: longitudinal parameters.

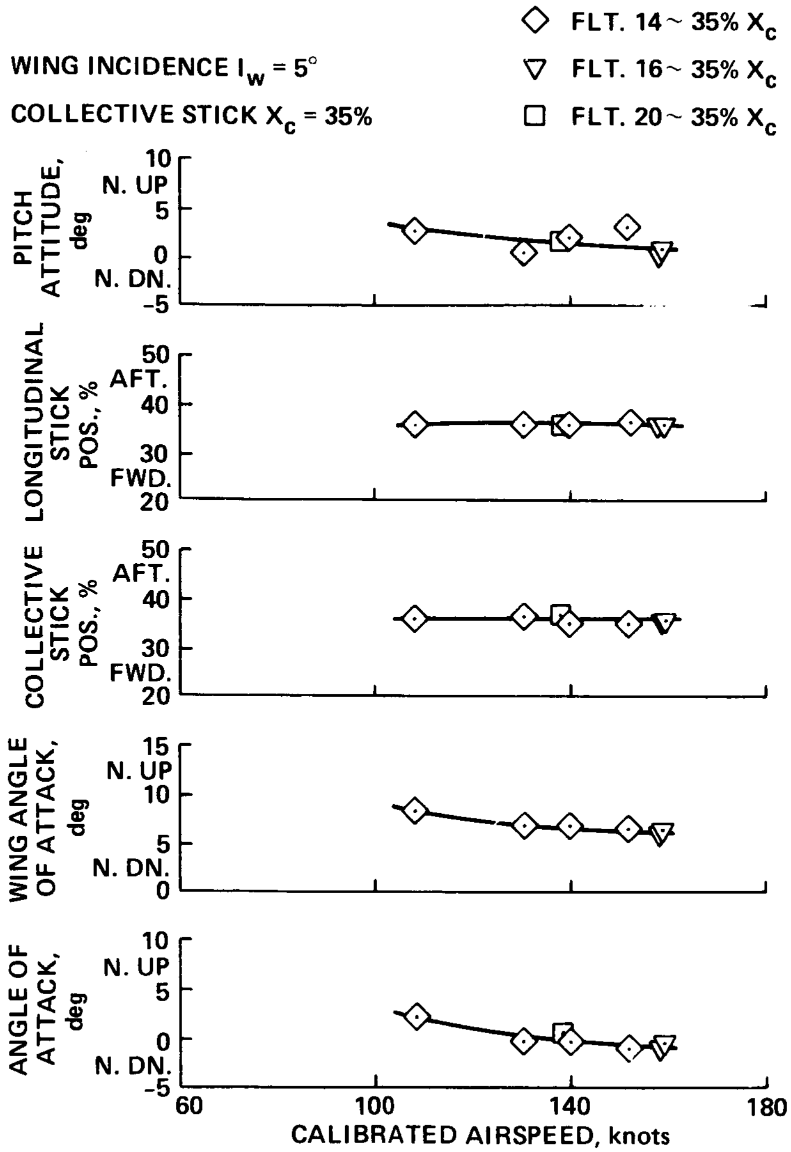


Figure 29.- Level flight trim: wing incidence 5°, collective stick 35%: longitudinal parameters.

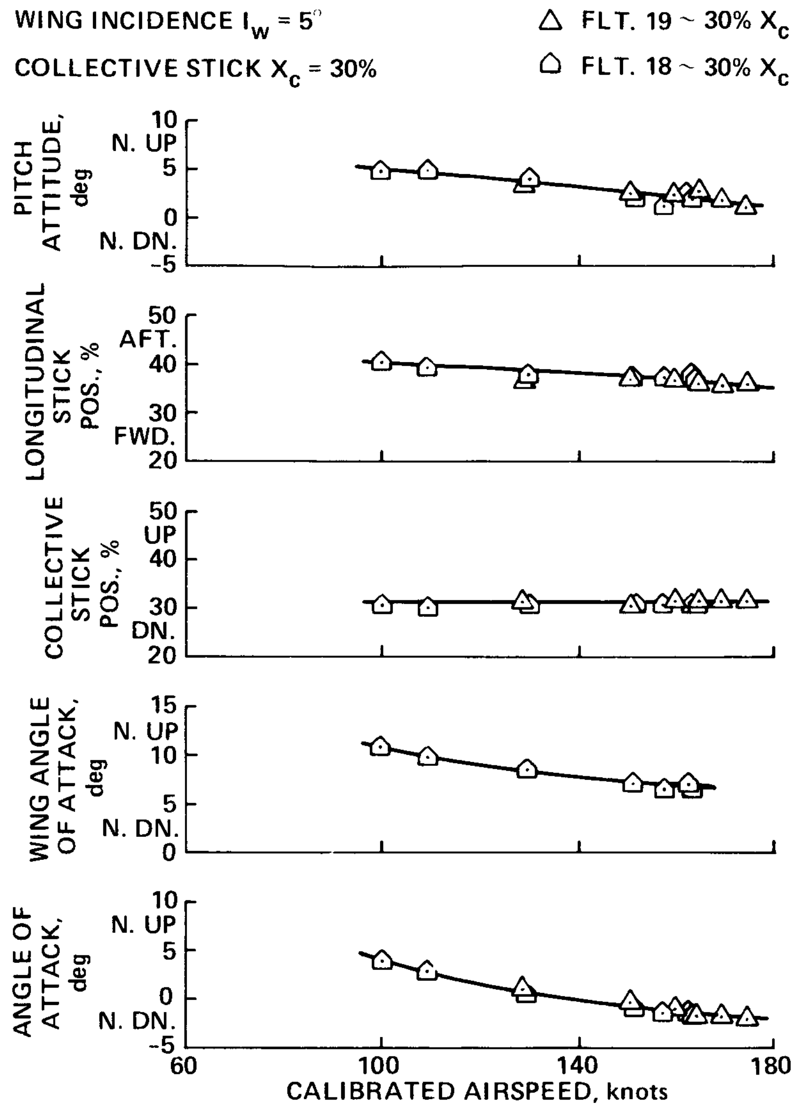


Figure 30.- Level flight trim: wing incidence 5°, collective stick 30%: longitudinal parameters.

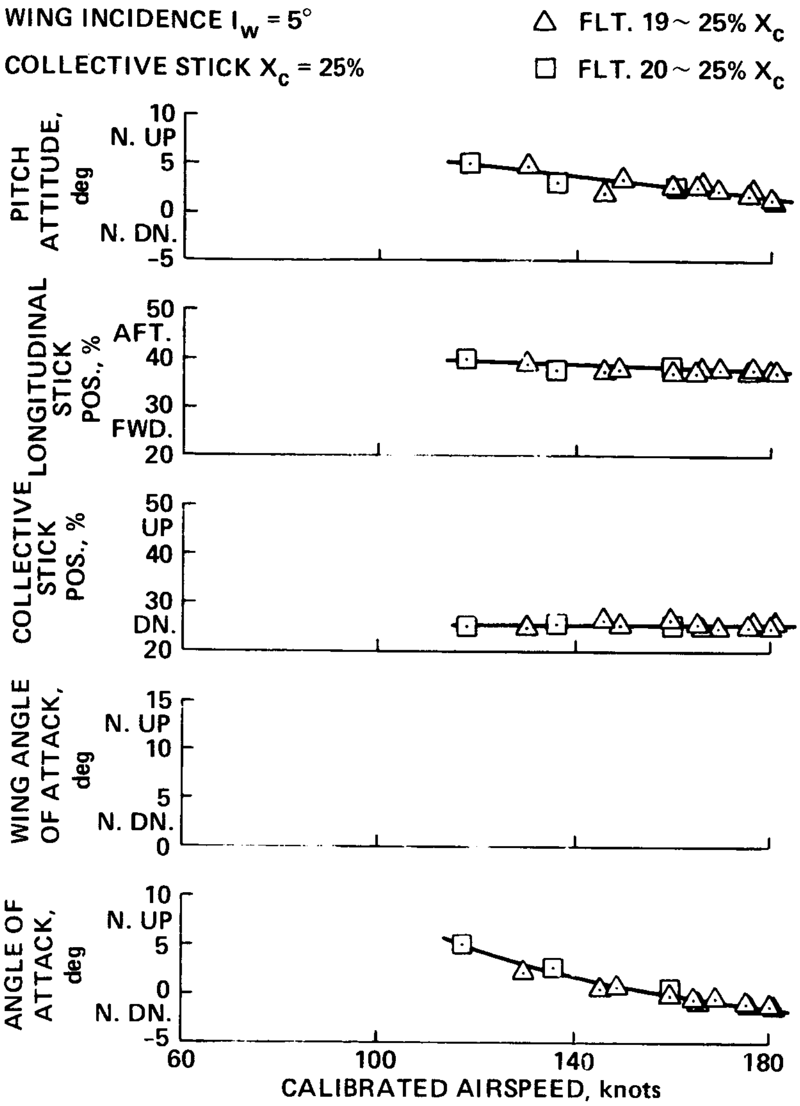


Figure 31.- Level flight trim: wing incidence 5°, collective stick 25%: longitudinal parameters.

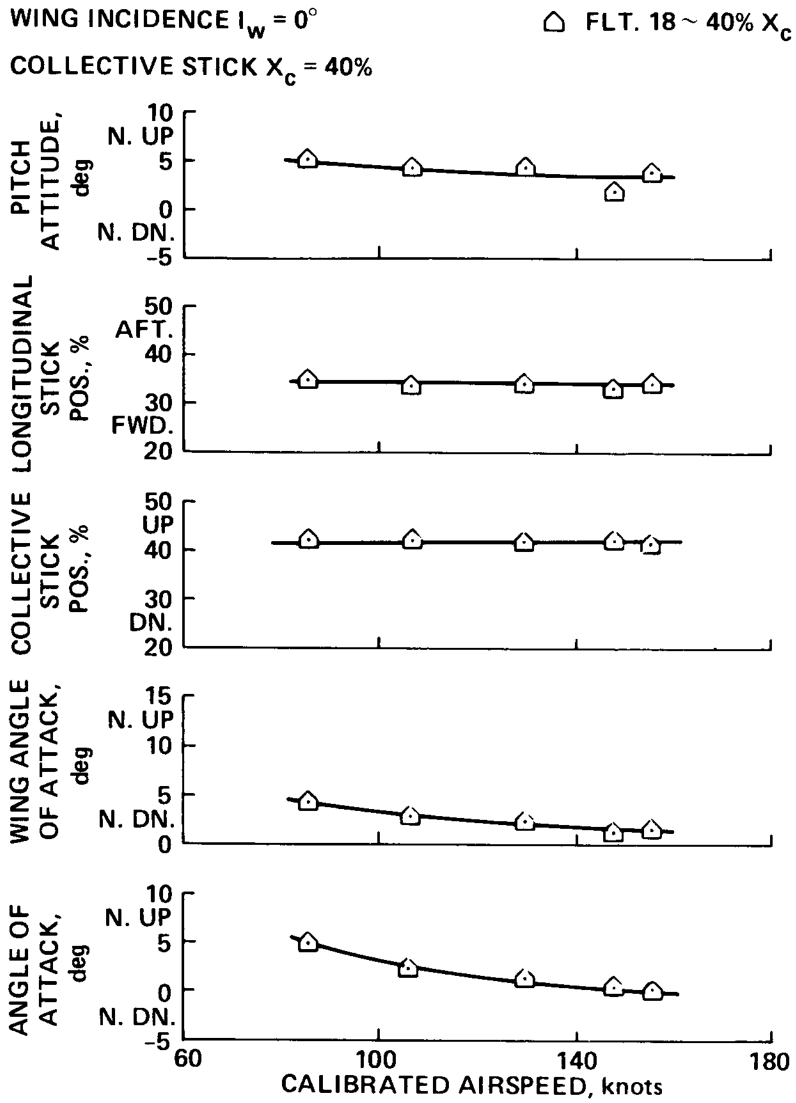


Figure 32.- Level flight trim: wing incidence 0°, collective stick 40%: longitudinal parameters.

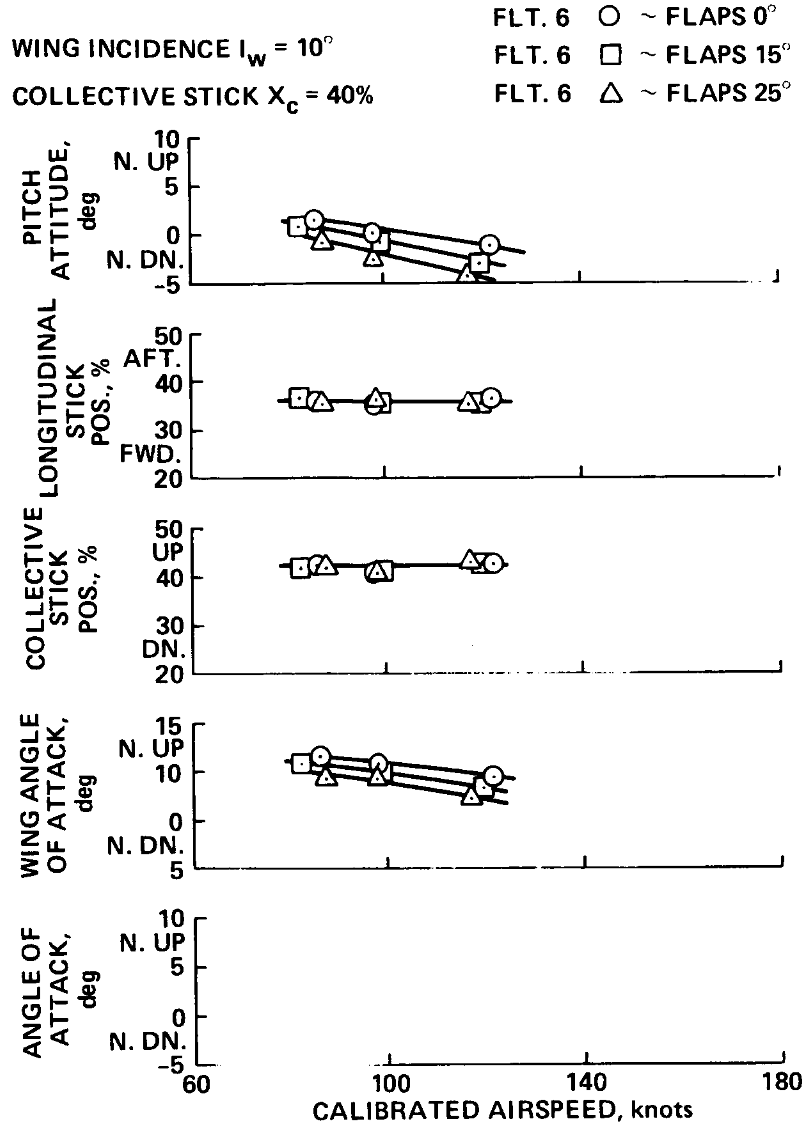


Figure 33.- Trimmed flight; effect of flap extension at wing incidence of 10°, collective stick: 40%.

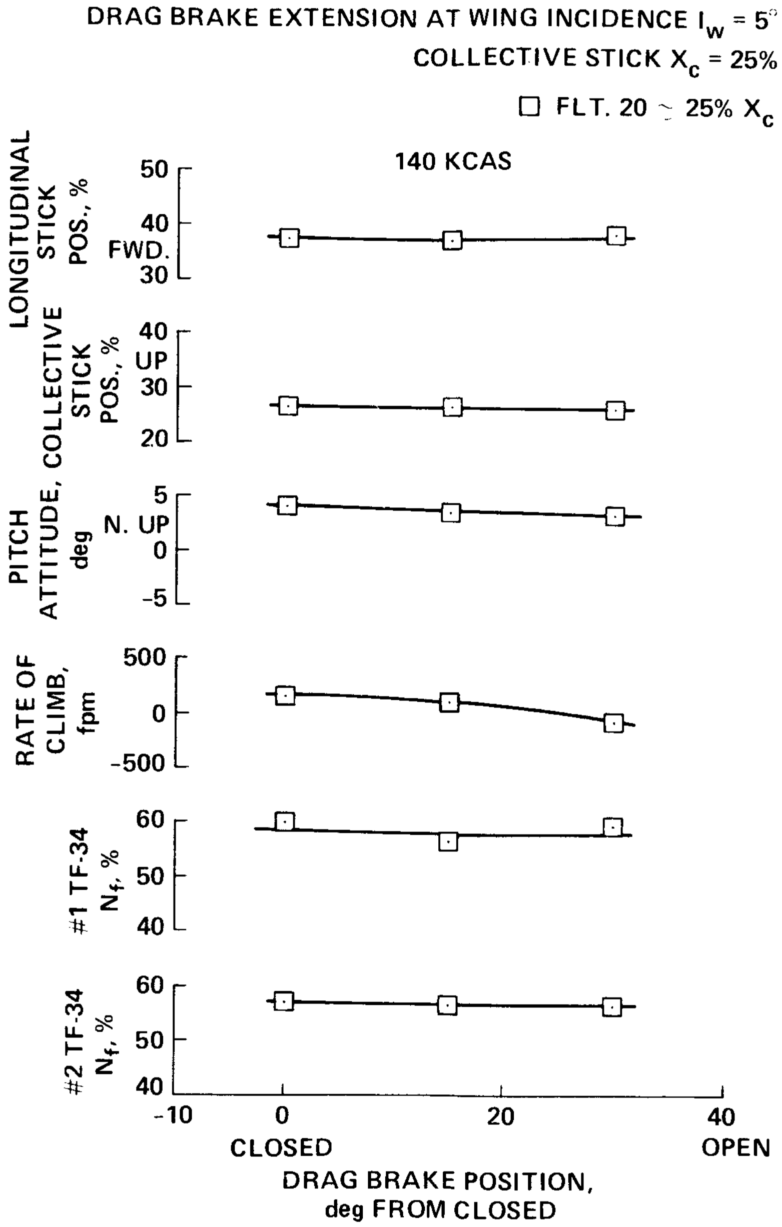


Figure 34.- Trimmed flight: effect of drag brake extension at wing incidence 5° and collective stick 25%.

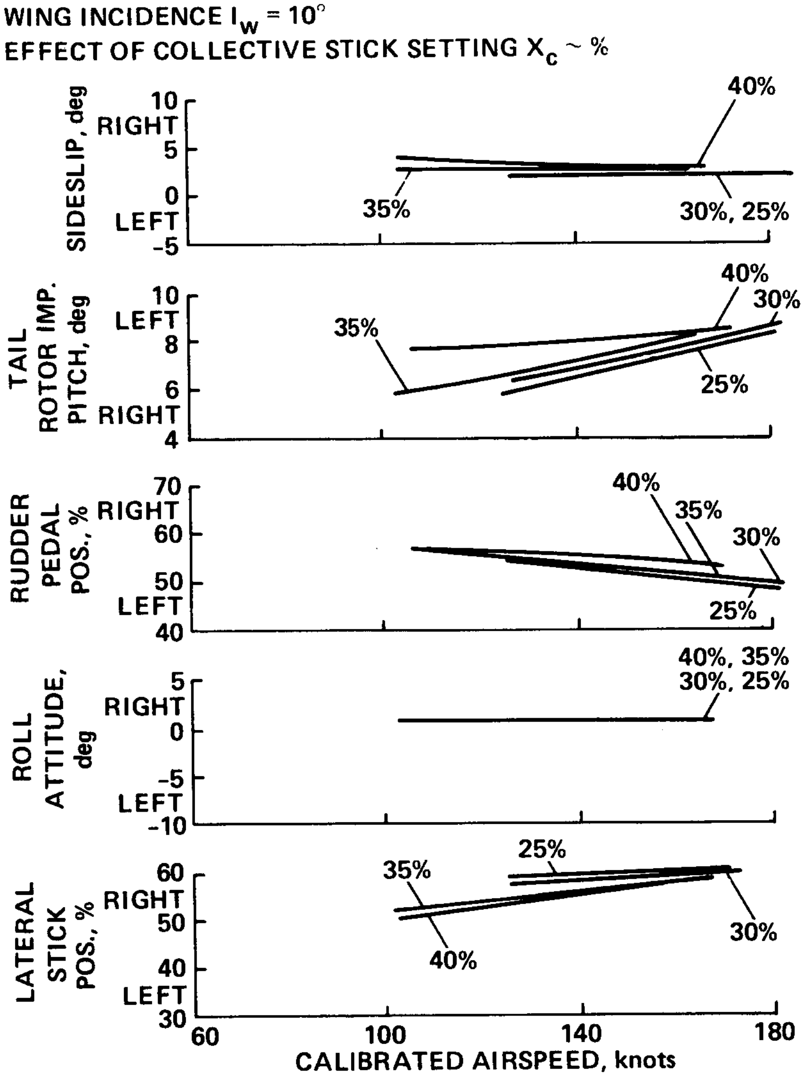


Figure 35.- Level flight trim, effect of collective stick setting: wing incidence 10°: lateral-directional parameters.

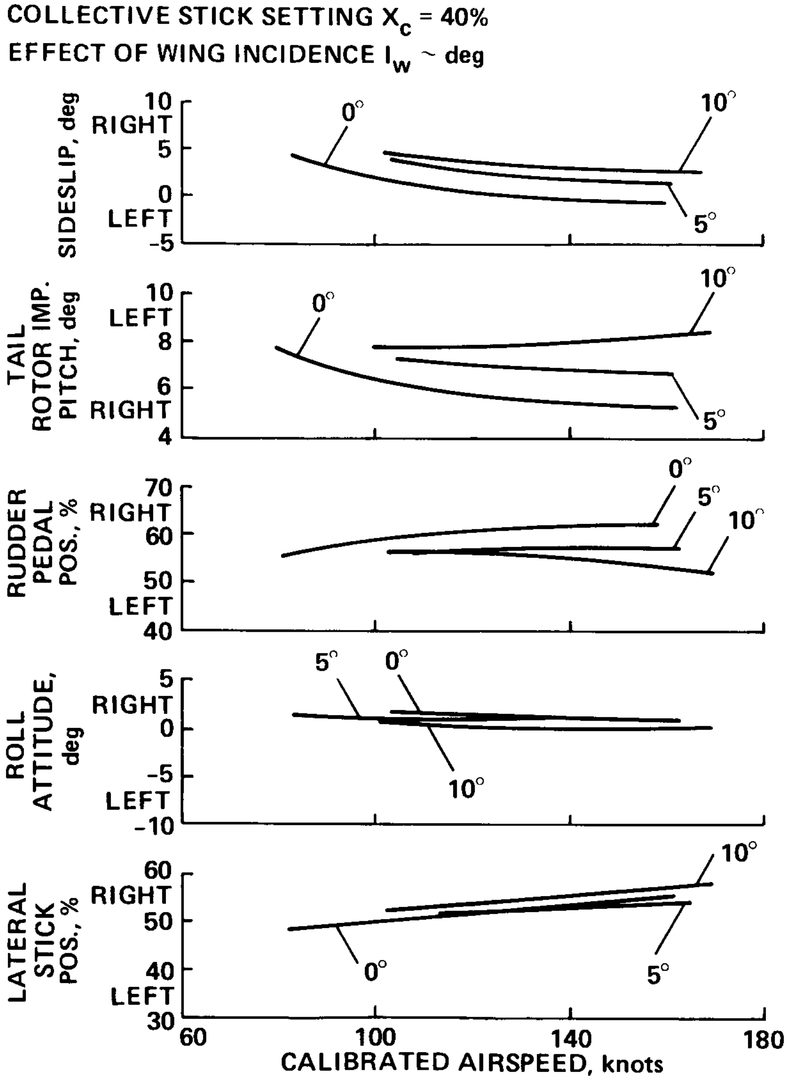


Figure 36.- Level flight trim, effect of wing incidence: collective stick 40%: lateral-directional parameters.

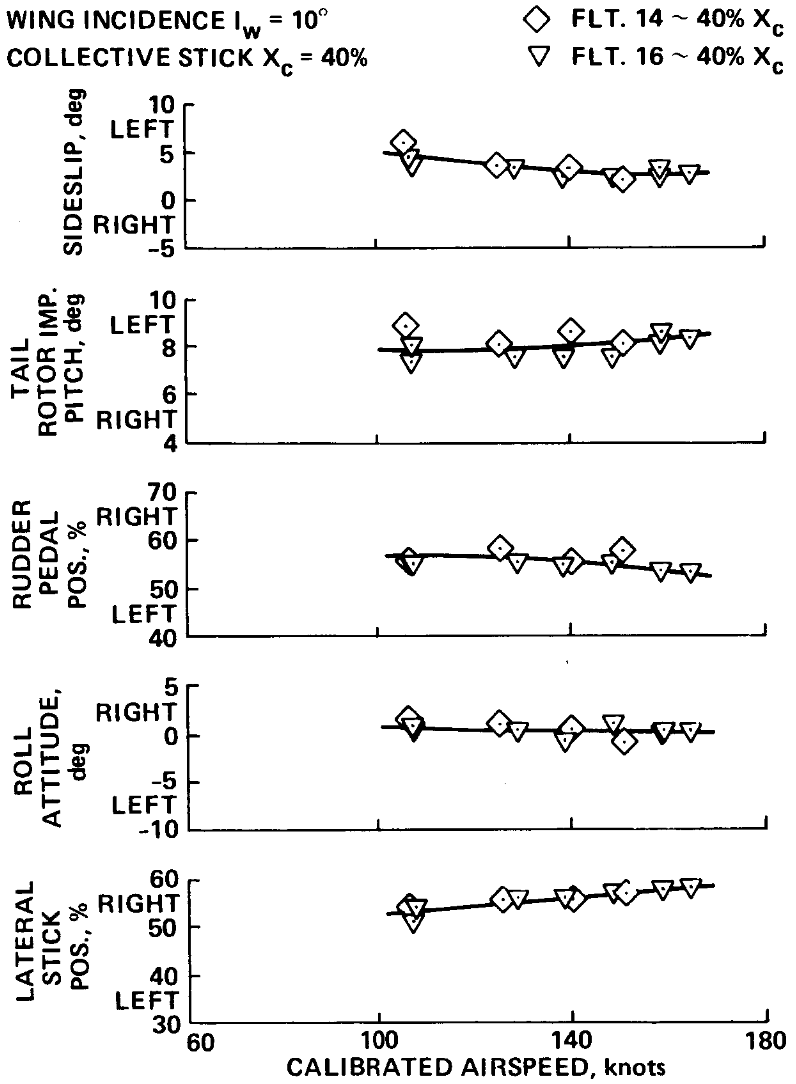


Figure 37.- Level flight trim: wing incidence 10°, collective stick 40%: lateral-directional parameters.

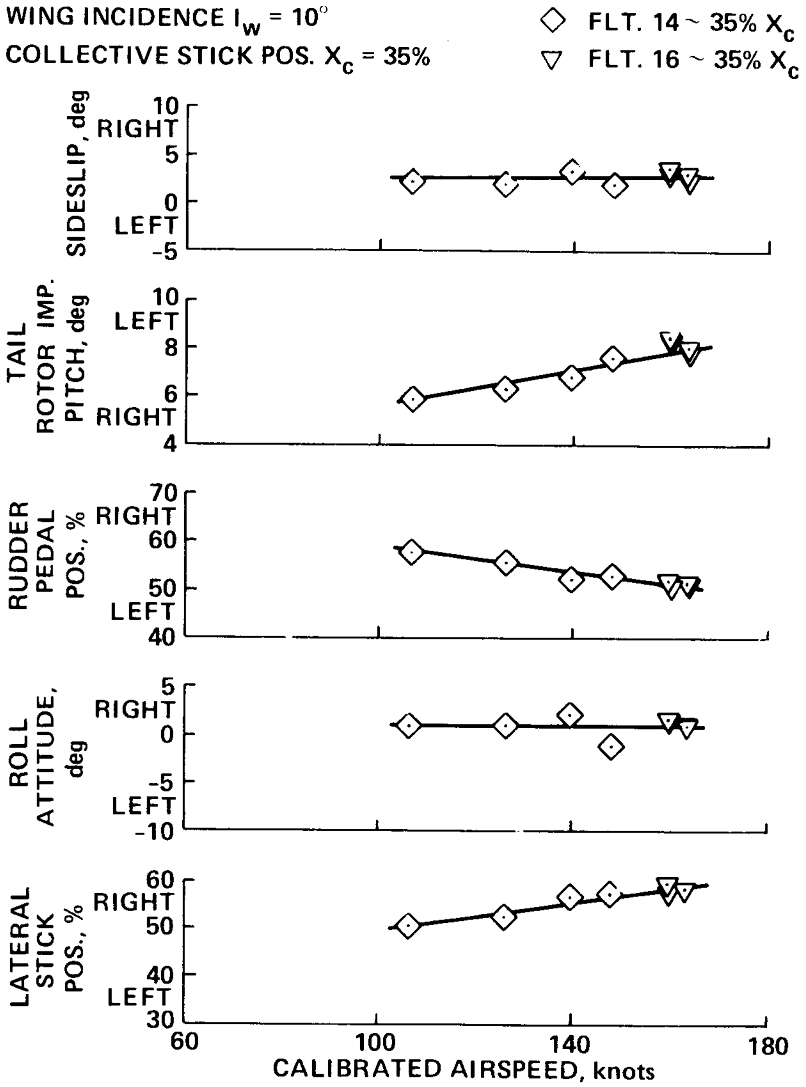


Figure 38.- Level flight trim: wing incidence 10°, collective stick 35%: lateral-directional parameters.

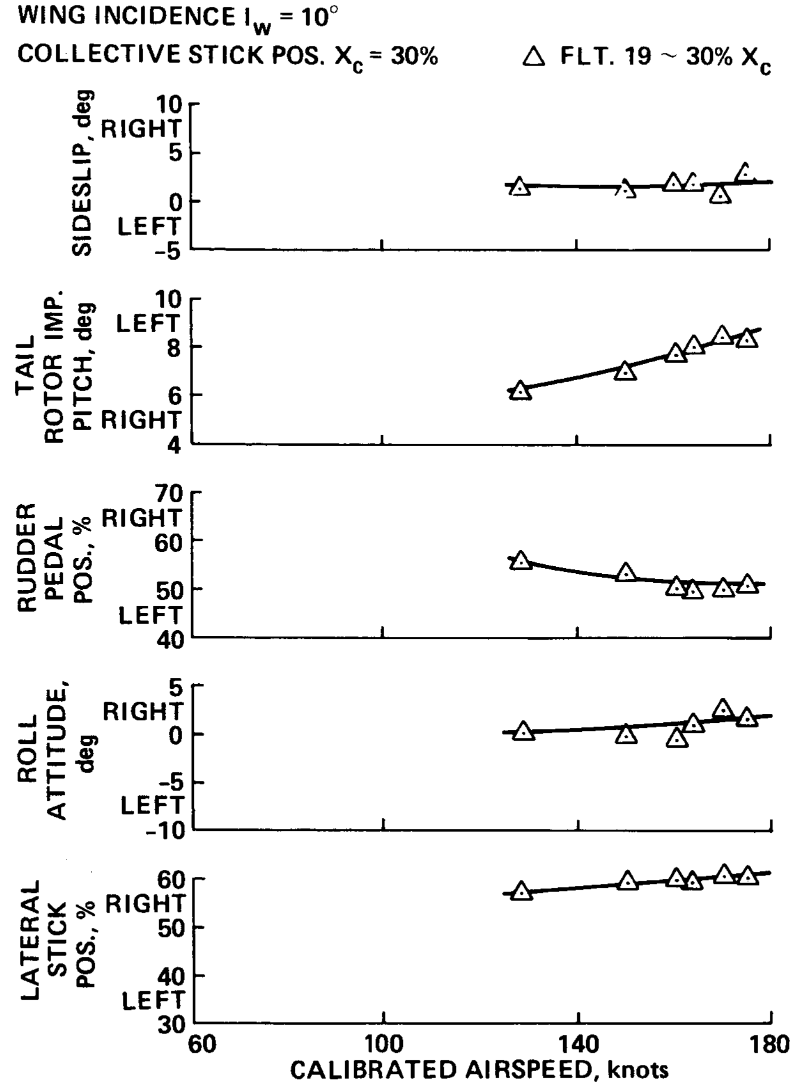


Figure 39.- Level flight trim: wing incidence 10°, collective stick 30%: lateral-directional parameters.

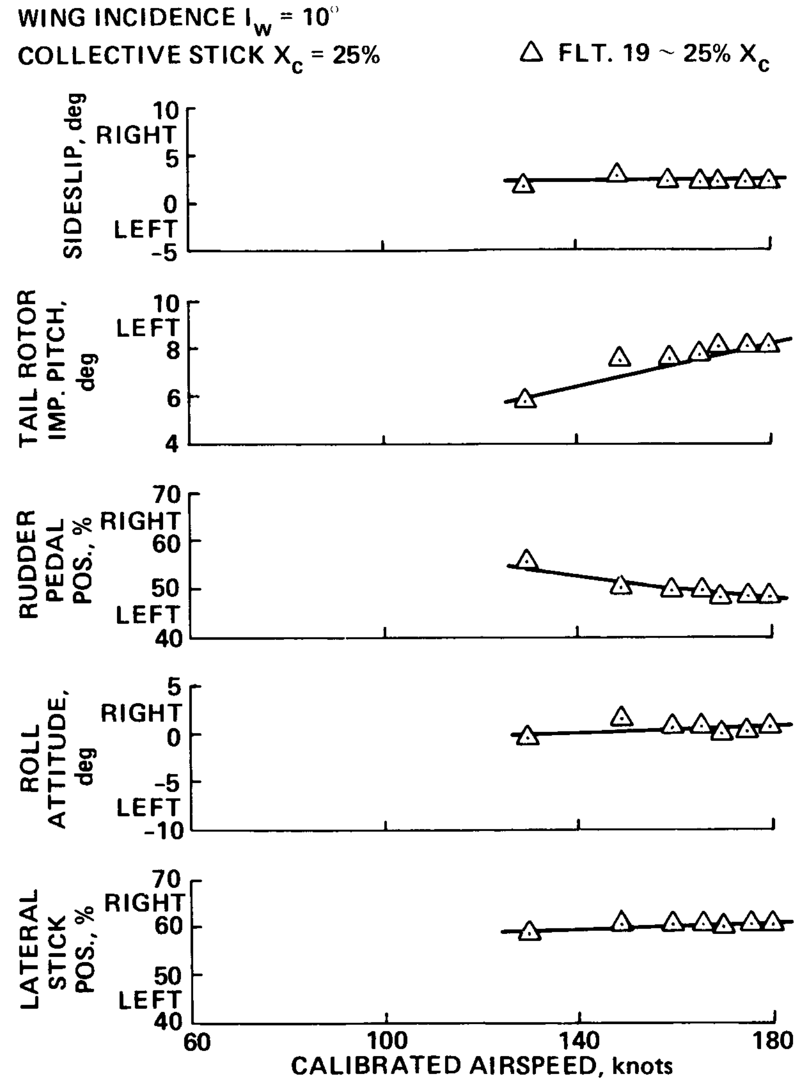


Figure 40.- Level flight trim: wing incidence 10°, collective stick 25%: lateral-directional parameters.

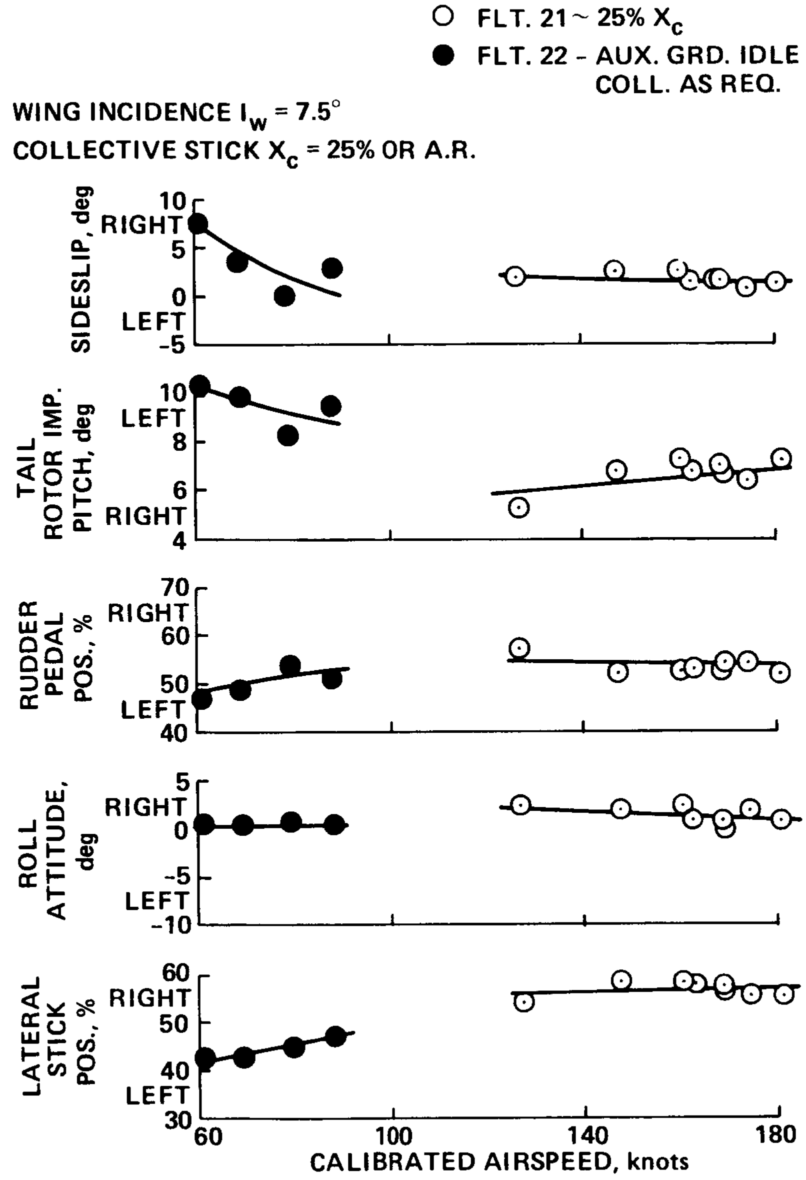


Figure 41.- Level flight trim: wing incidence 7.5°, collective stick 25% (or as required): lateral-directional parameters.

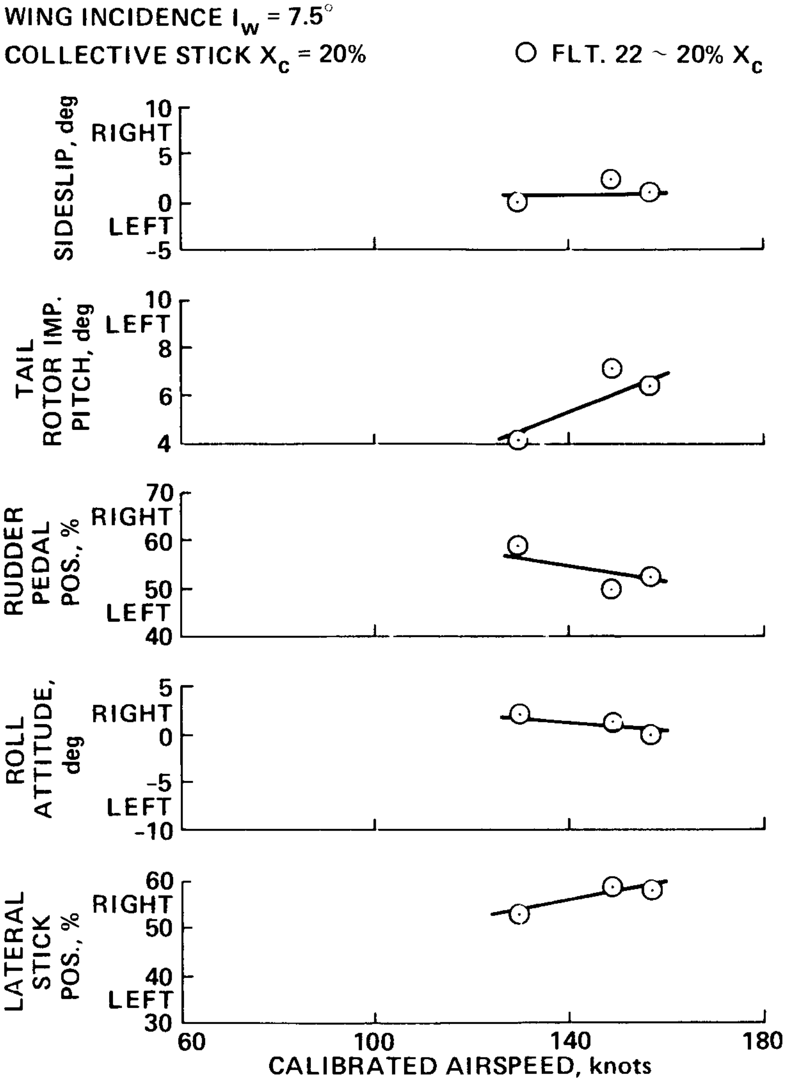


Figure 42.- Level flight trim: wing incidence 7.5°, collective stick 20%: lateral-directional parameters.

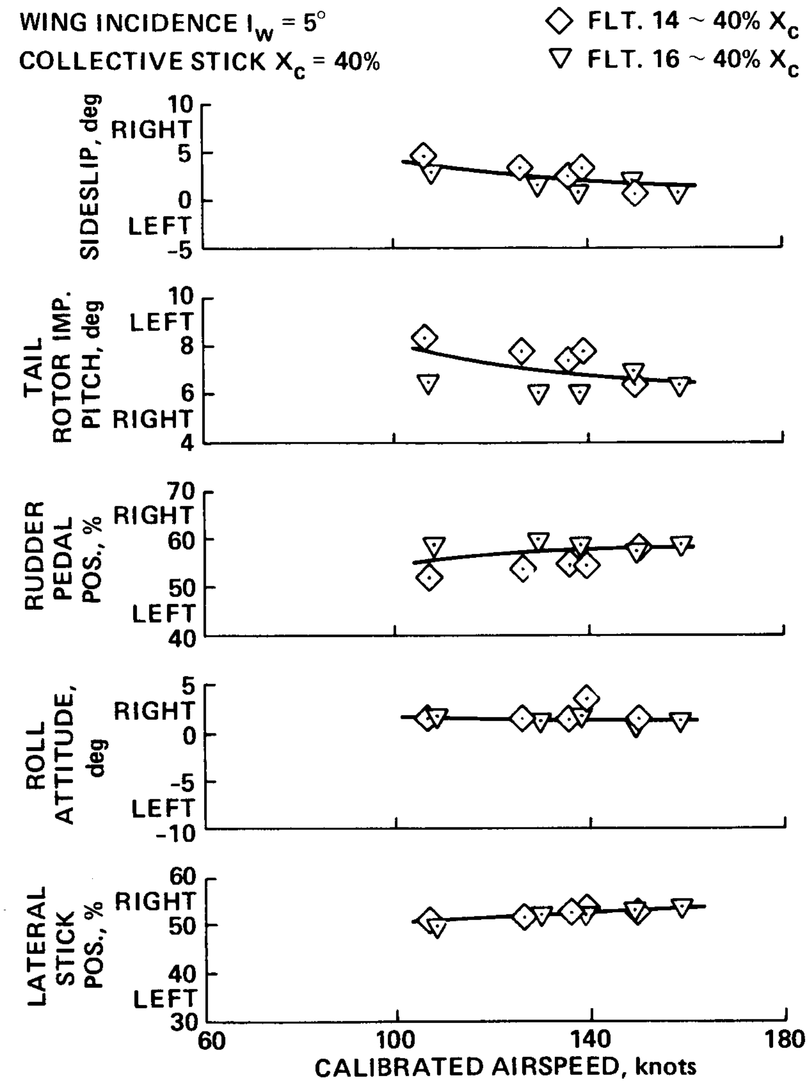


Figure 43.- Level flight trim: wing incidence 5°, collective stick 40%: lateral-directional parameters.

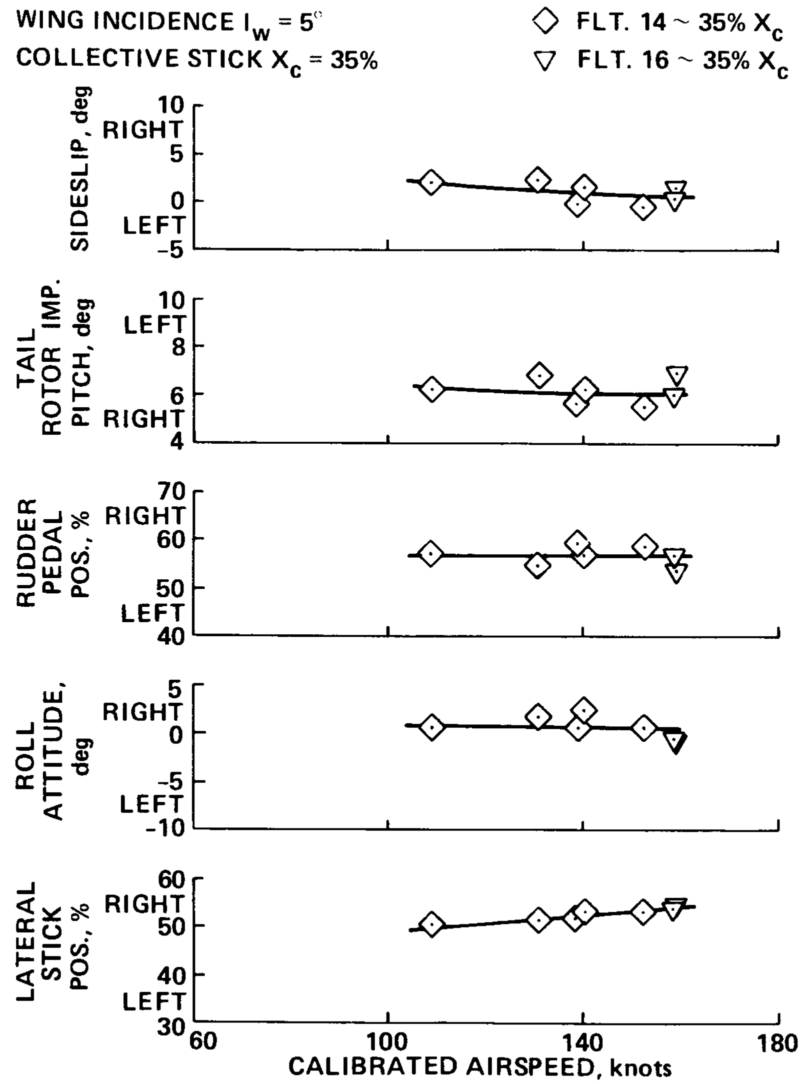


Figure 44.- Level flight trim: wing incidence 5°, collective stick 35%: lateral-directional parameters.

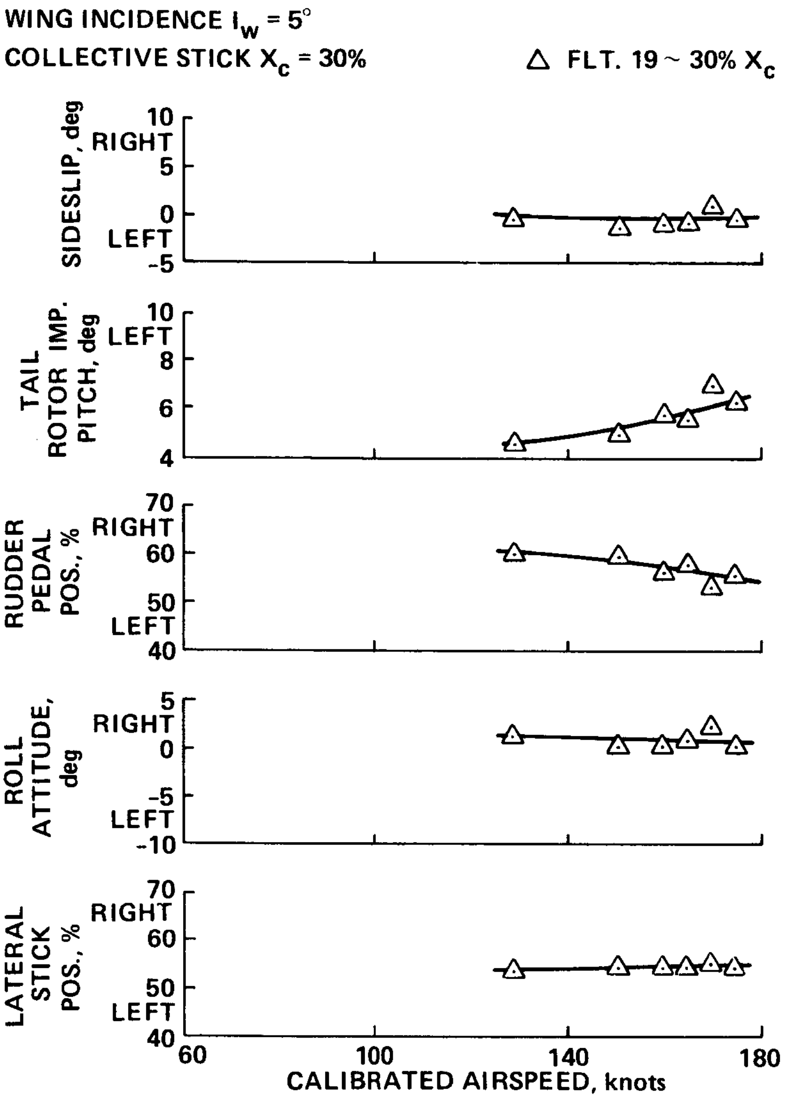


Figure 45.- Level flight trim: wing incidence 5°, collective stick 30%: lateral-directional parameters.

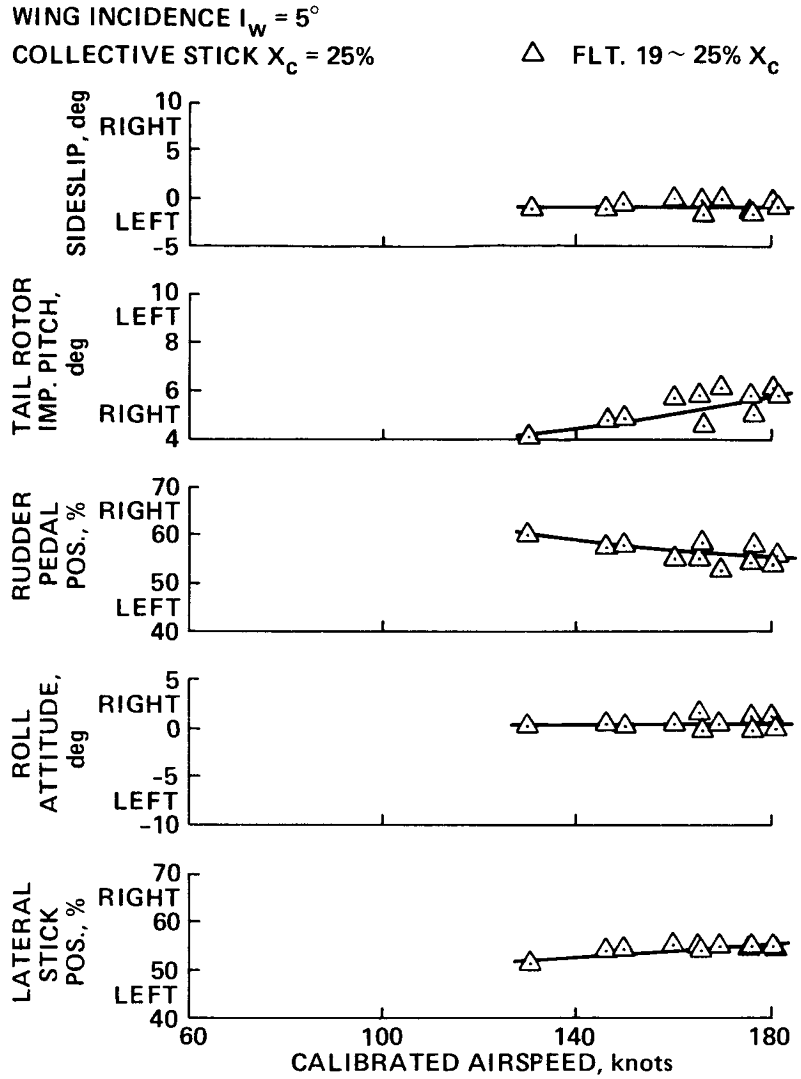


Figure 46.- Level flight trim: wing incidence 5°, collective stick 25%: lateral-directional parameters.

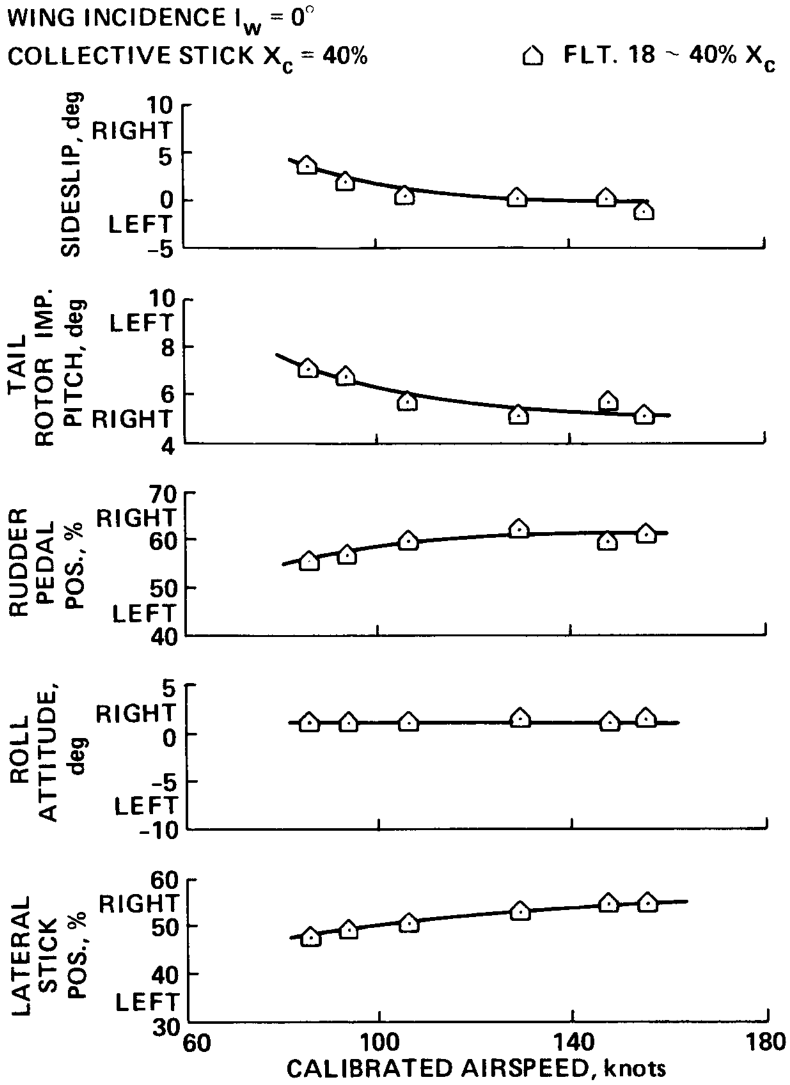


Figure 47.- Level flight trim: wing incidence 0°, collective stick 40%: lateral-directional parameters.

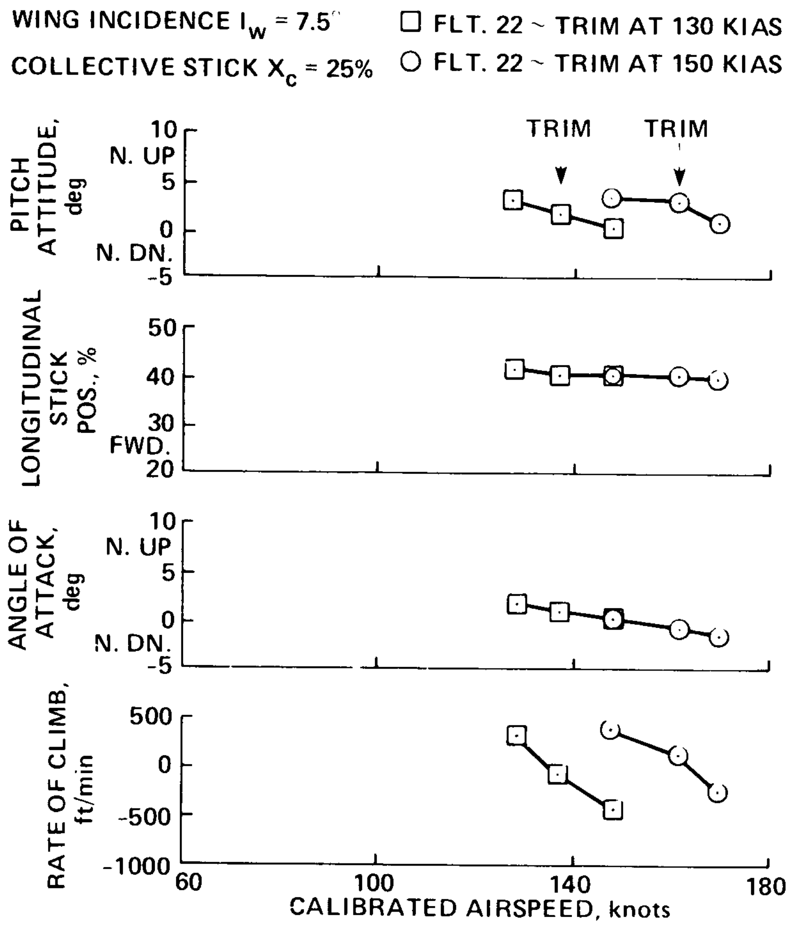


Figure 48.- Longitudinal static stability: constant TF-34 throttle and collective setting, wing incidence 7.5°, collective stick 25%: 130 and 150 knots IAS.

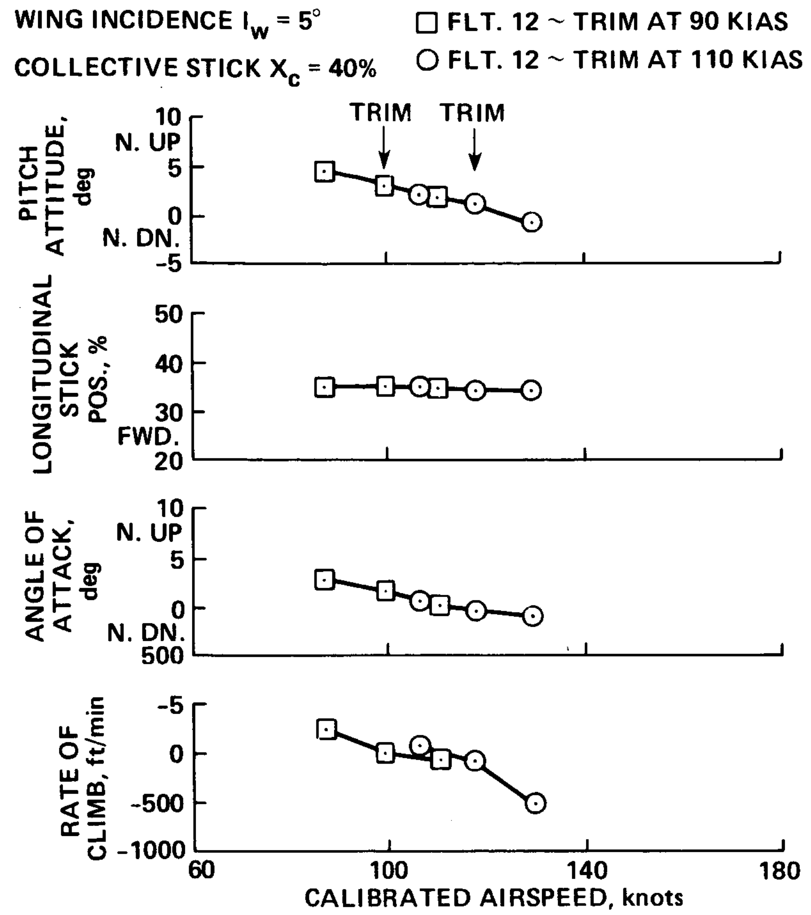


Figure 49.- Longitudinal static stability: constant TF-34 throttle and collective setting, wing incidence 5°, collective stick 40%: 90 and 110 knots IAS.

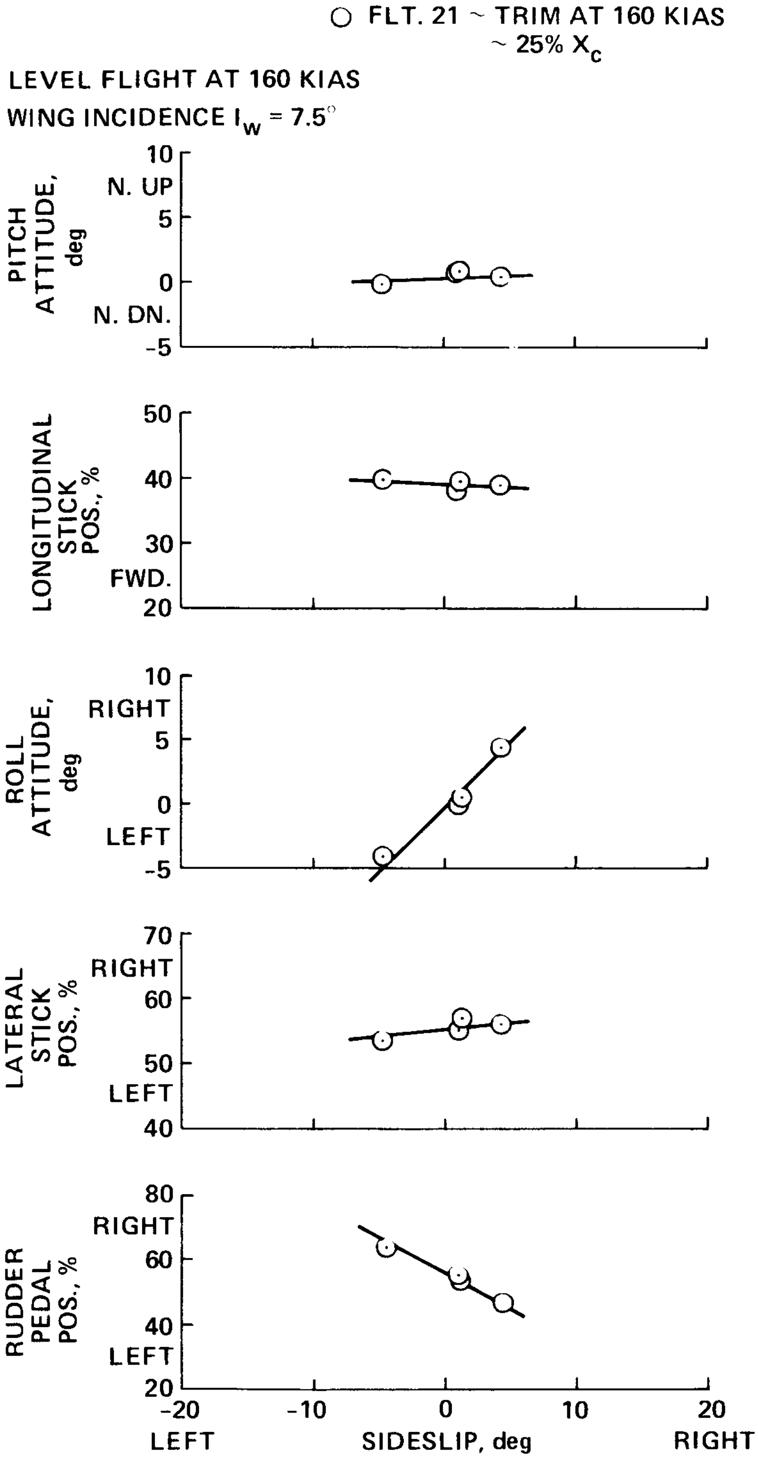


Figure 50.- Lateral-directional static stability: constant TF-34 throttle and collective setting, level flight at 160 knots IAS, wing incidence 7.5°.

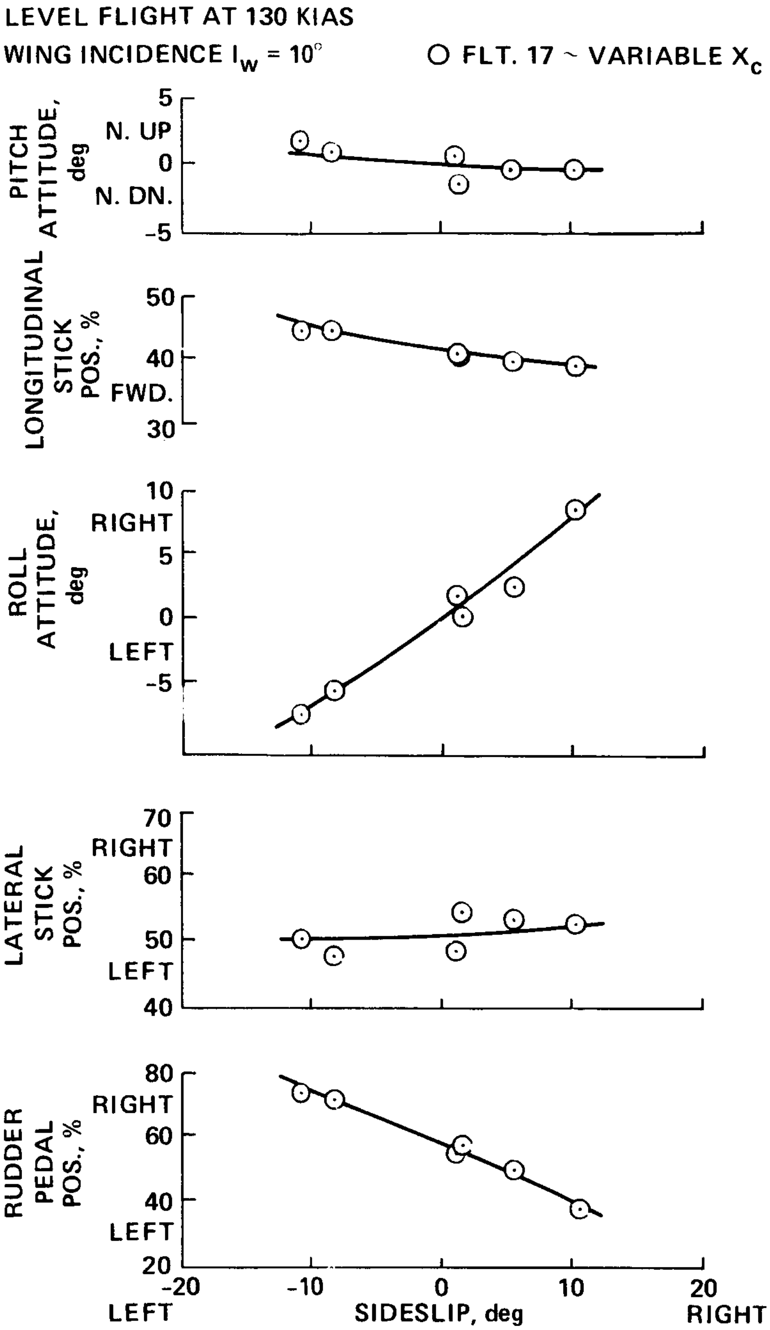


Figure 51.- Lateral-directional static stability: constant TF-34 throttle and collective setting, level flight at 130 knots IAS, wing incidence 10°.

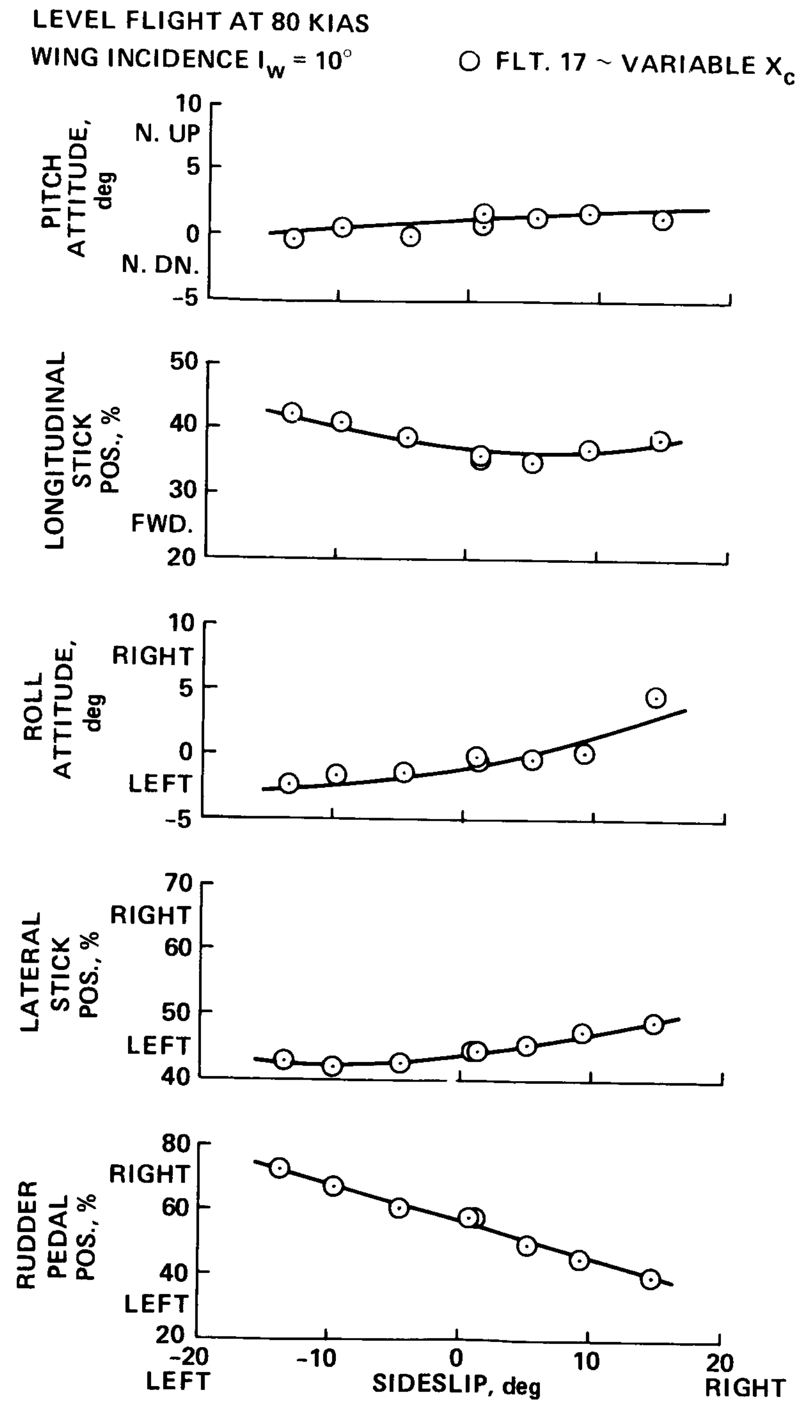


Figure 52.- Lateral-directional static stability: constant TF-34 throttle and collective setting, level flight at 80 knots IAS, wing incidence 10°.

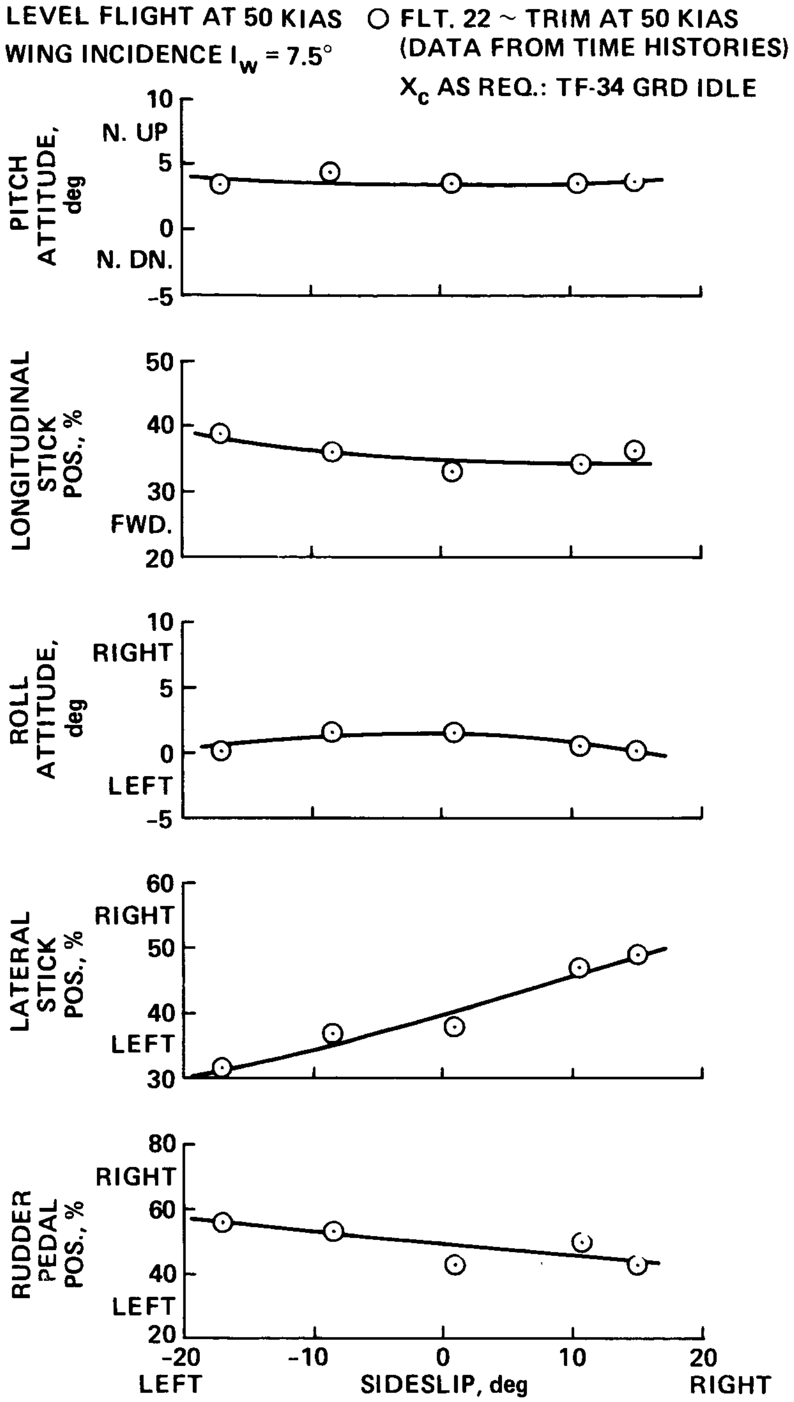


Figure 53.- Lateral-directional static stability: constant TF-34 throttle and collective setting, level flight at 50 knots IAS, wing incidence 7.5°.

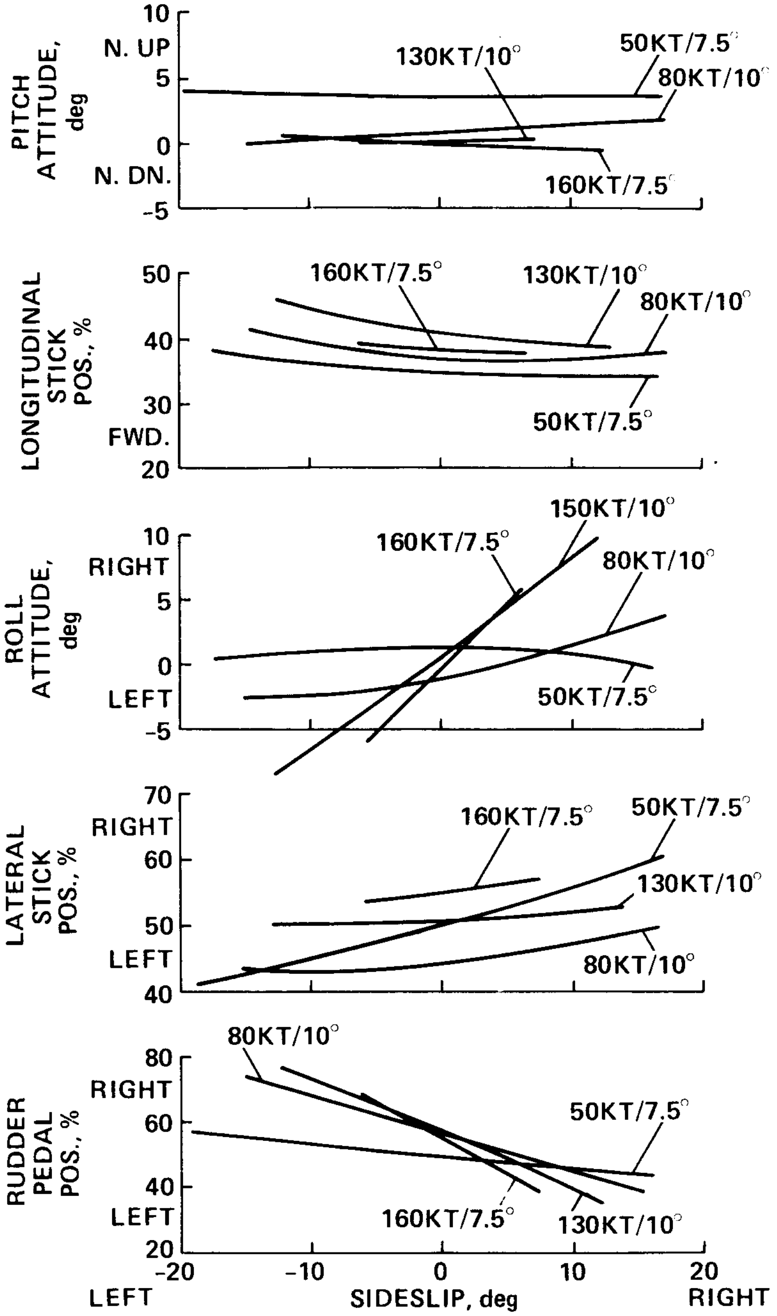


Figure 54.- Summary of lateral-directional static stability: constant TF-34 throttle and collective setting.

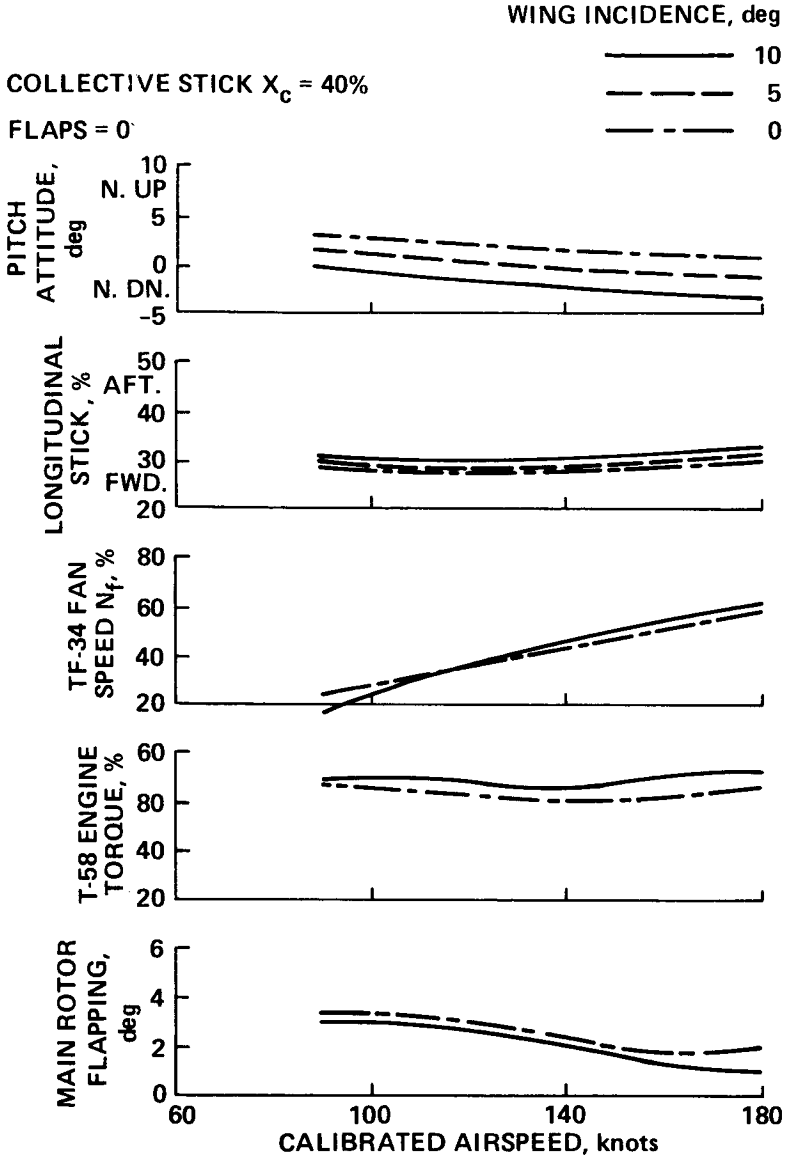


Figure 55.- Level flight trim, predicted data: wing incidence 0°, 5°, and 10°; collective stick 40%; flaps 0°.

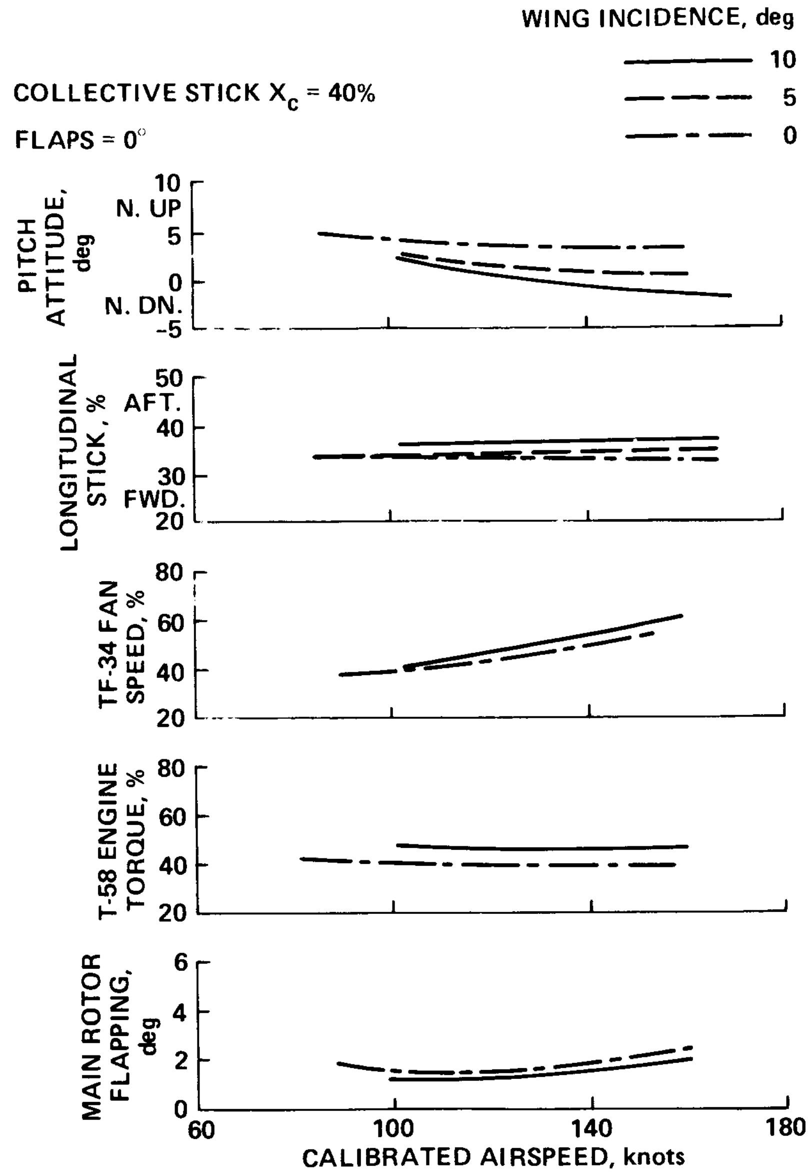


Figure 56.- Level flight trim, flight data: wing incidence 0°, 5°, and 10°; collective stick 40%; flaps 0°.

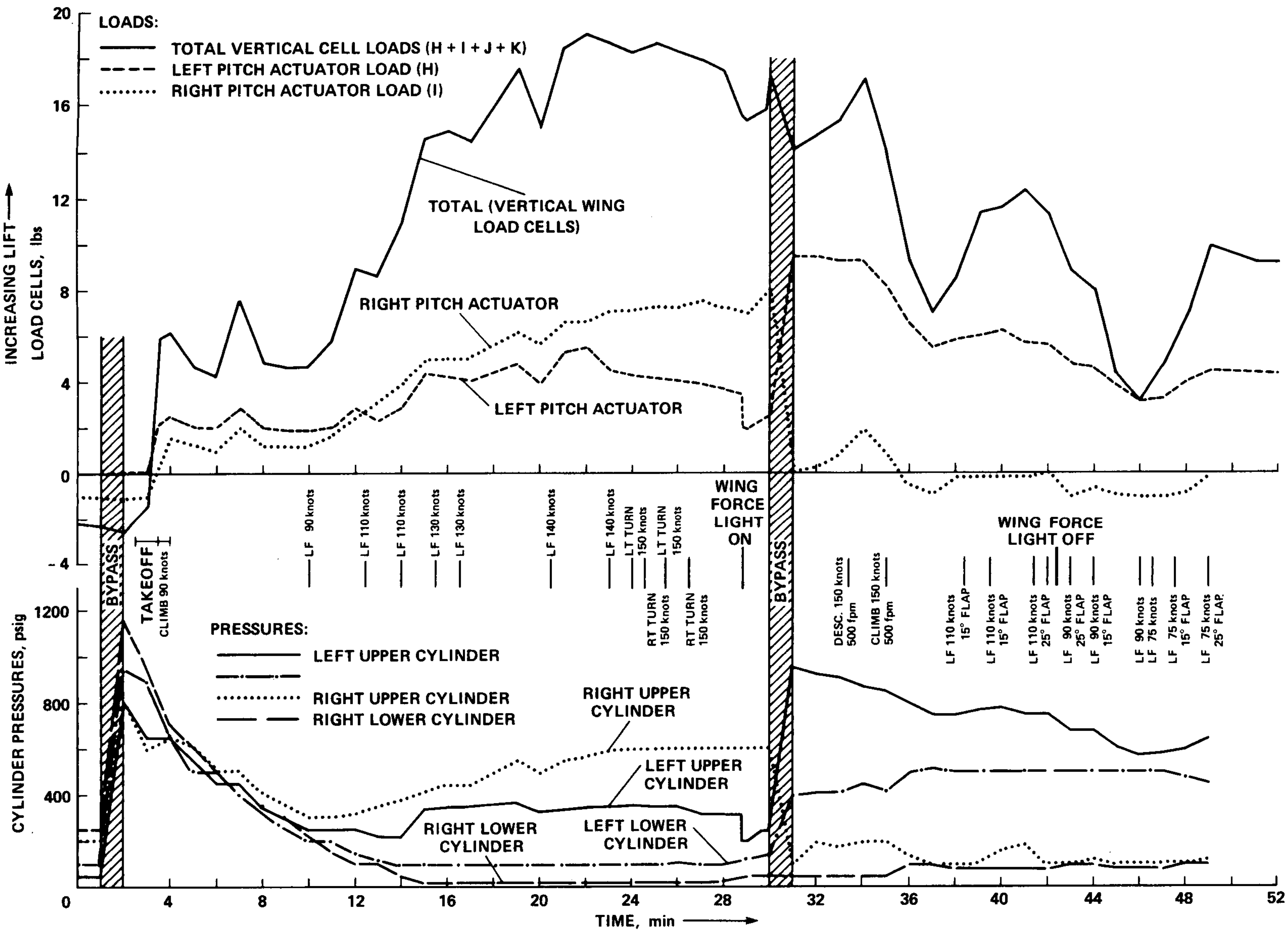


Figure 57.- Time-history of wing-actuator imbalance, flight 740-2B-6.

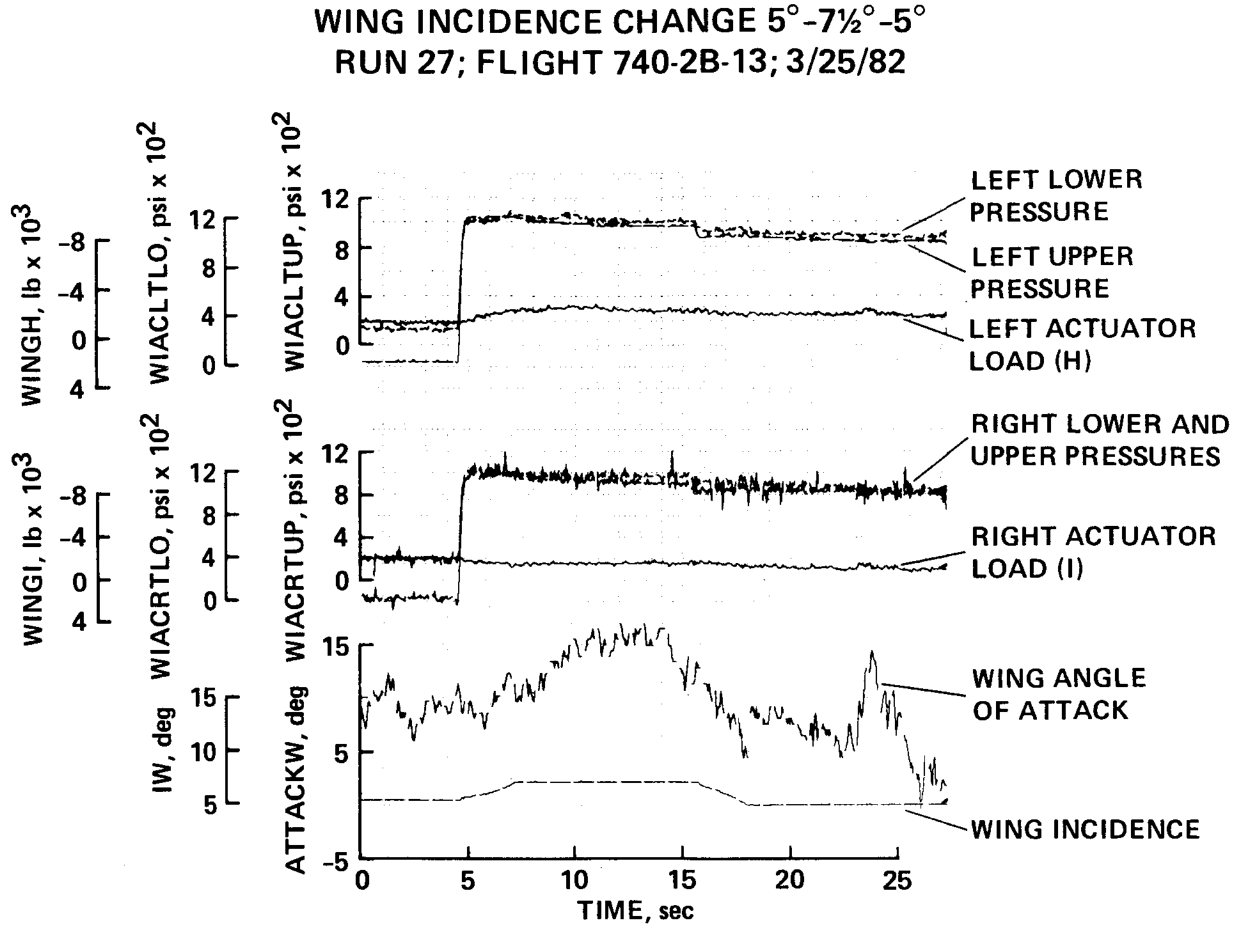


Figure 58.- Time-history of wing incidence change from 5° to 7.5° to 5°.

3. VIBRATIONS

This section covers vibration data recorded at various locations in the aircraft — engine vibration, crew comfort, airframe vibration, and frequency analysis.

Engine Vibration

Both T-58 and TF-34 engines were monitored at high reading locations and at monitor locations specified by General Electric. These data are included in the tabulated data and represent the amplitude of the complex waveform. Selected data are presented in figures 59 through 62 which also include the frequency analysis required to investigate an anomaly concerning TF-34 accessory gearbox response.

Figure 59 shows the vertical and lateral vibration at the torque tube of the left-hand T-58 engine as a function of airspeed and indicates a reduction in levels when compared with typical data from the Wallops Island testing.

Vibration data from the TF-34 thrust engines are shown in figure 60; they compare well with the Wallops Island data. It was evident, however, that an N_f excited resonance existed for both Wallps Island and Ames (through flight number 2B-18) data at the left-hand engine vertical accessory gearbox location at 47.5% N_f (62.1 Hz), as shown in figure 61. An investigation revealed a defective transducer which was replaced. The data from 2B-21 and 22 were recorded with the replacement transducer and are considered accurate.

Crew Comfort

Figures 62 and 63 show cockpit vibration data as a function of airspeed and represent the complex waveform. These data reflect a relatively comfortable environment. From figure 64, it can be seen that the vertical response increases with reduced rotor speed.

Airframe Vibration

Figures 65 through 67 present tail gearbox (fig. 65), stabilizer (fig. 66), and wing vibration (fig. 67) versus airspeed and show reasonable agreement with the Wallops Island data. Of most interest was the effect of 0° wing incidence on stabilizer response. There was a significant increase owing to the change in aircraft attitude relative to the main-rotor tip path and the resulting rotor-wake impingement on the stabilizer.

Frequency Analysis

Various frequency analysis data generated during the program are included in figures 68-74 for documentation.

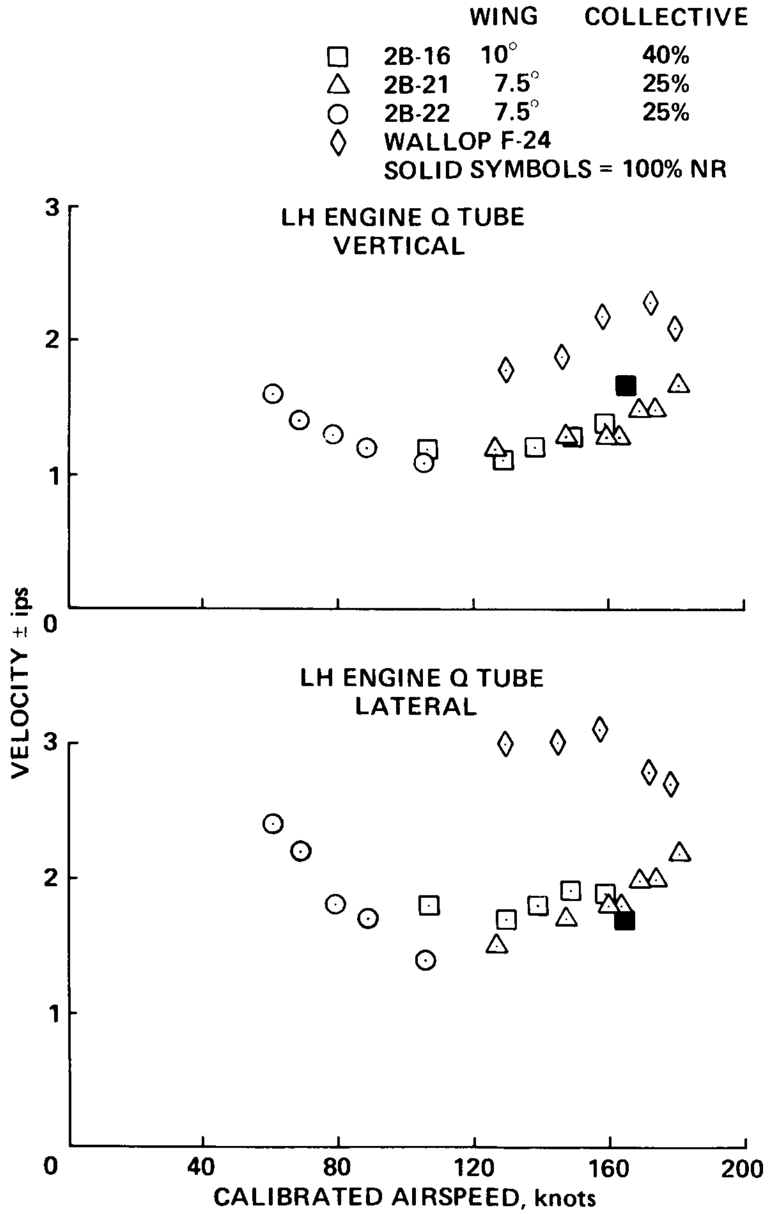


Figure 59.- T-58 engine vibration versus calibrated airspeed.

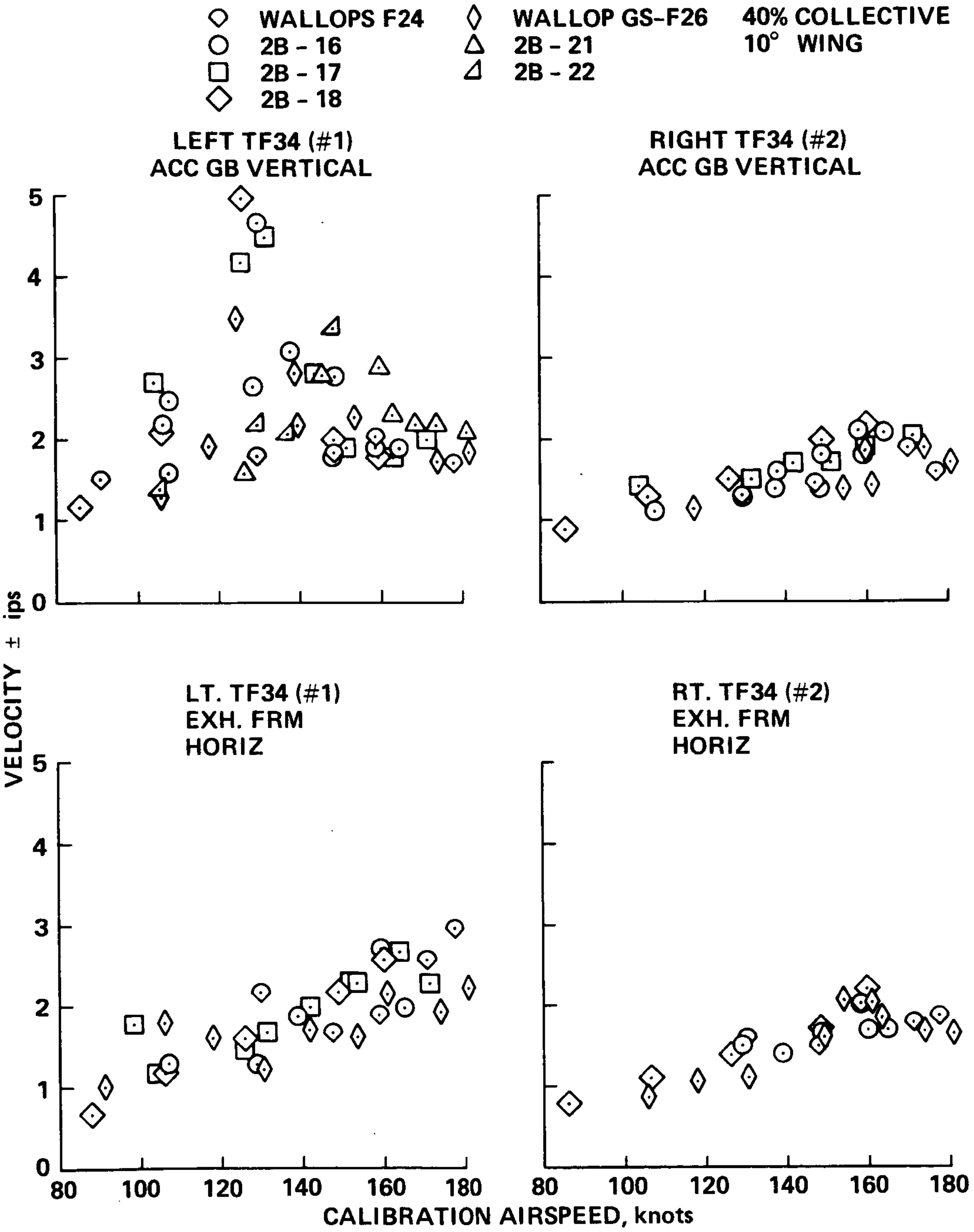


Figure 60.- TF-34 vibration.

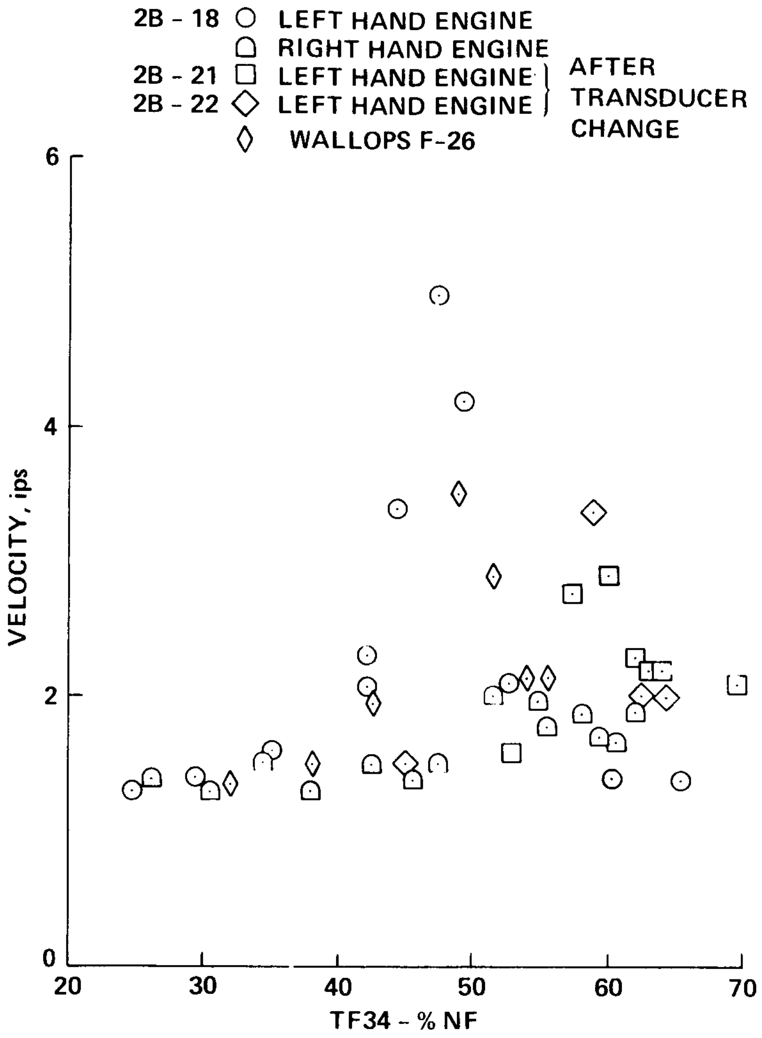


Figure 61.- TF-34 accessory gearbox vertical vibration versus fan speed.

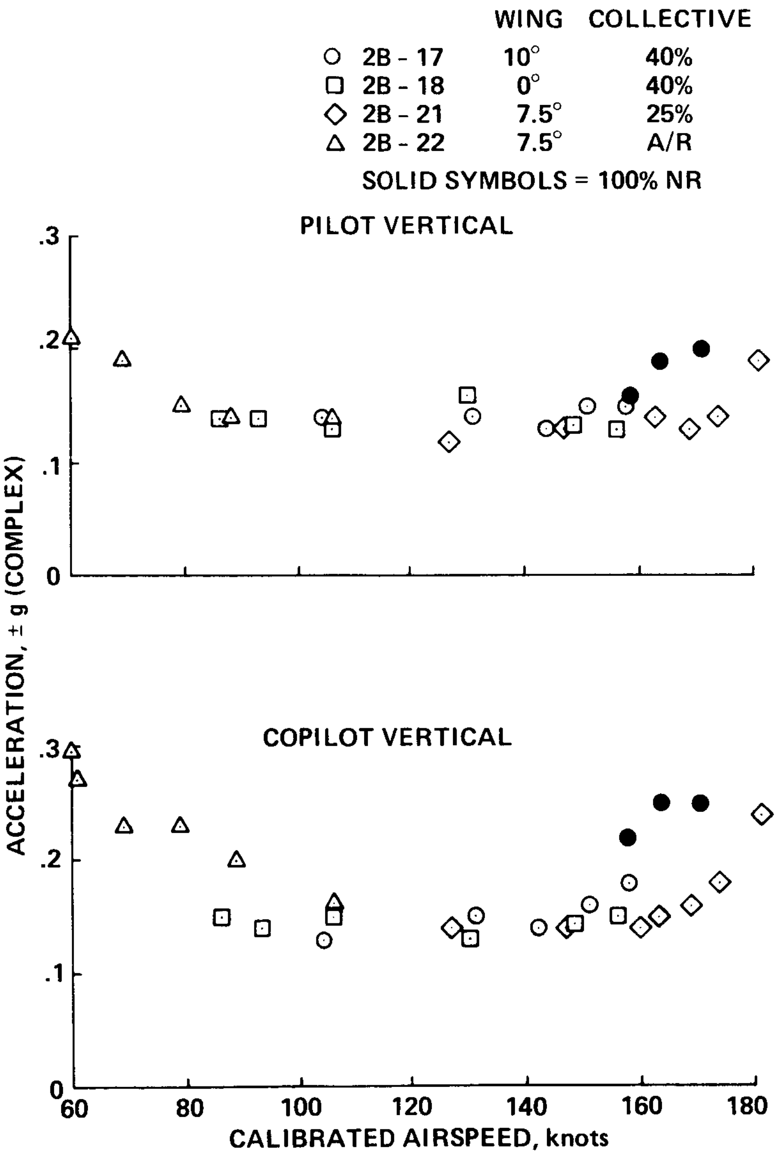


Figure 62.- Vertical cockpit vibration versus calibrated airspeed.

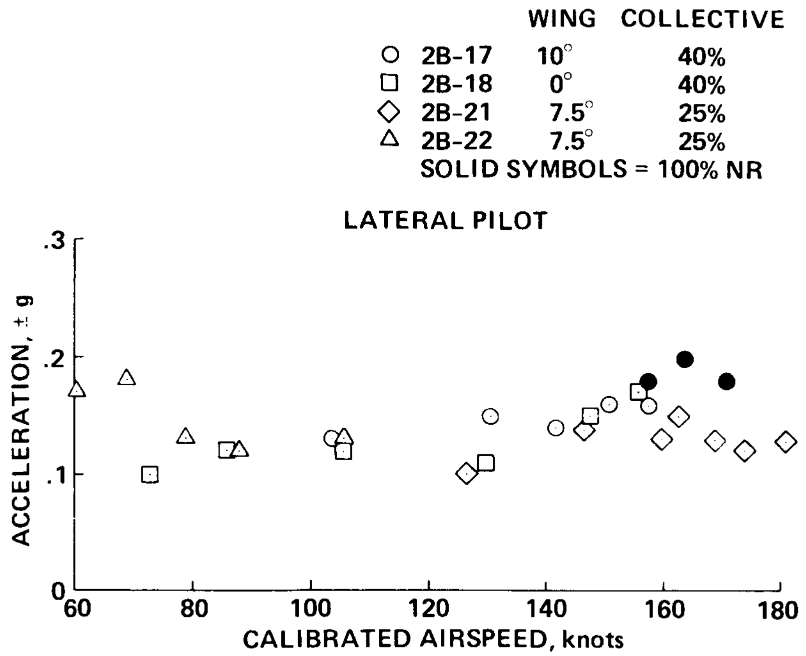


Figure 63.- Cockpit vibration versus calibrated airspeed.

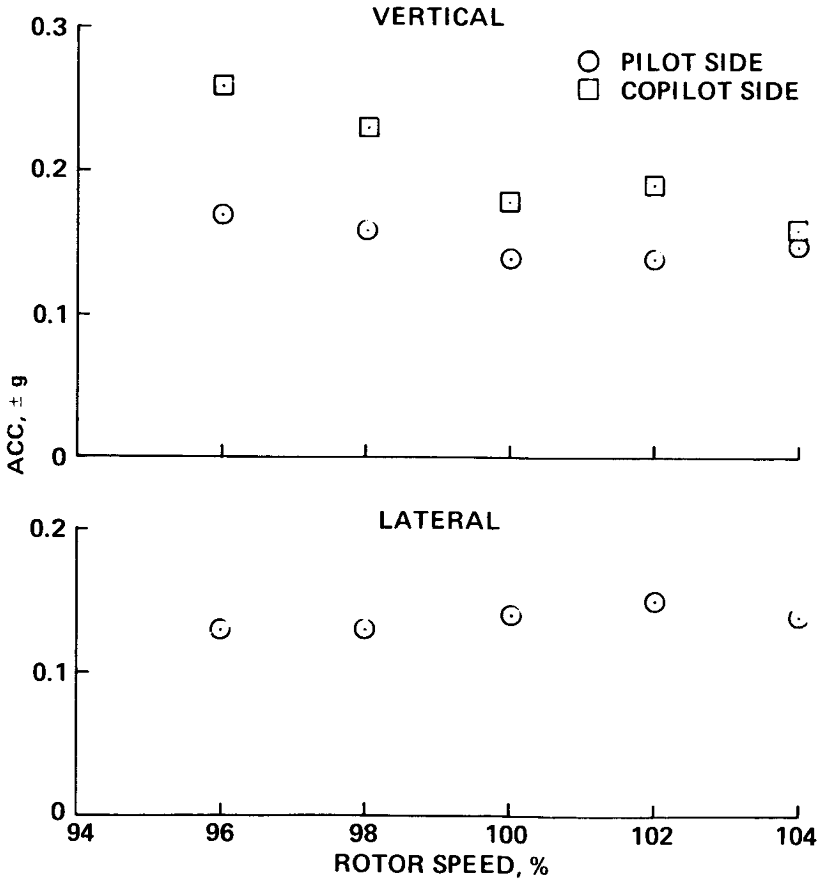


Figure 64.- Cockpit vibration versus rotor speed.

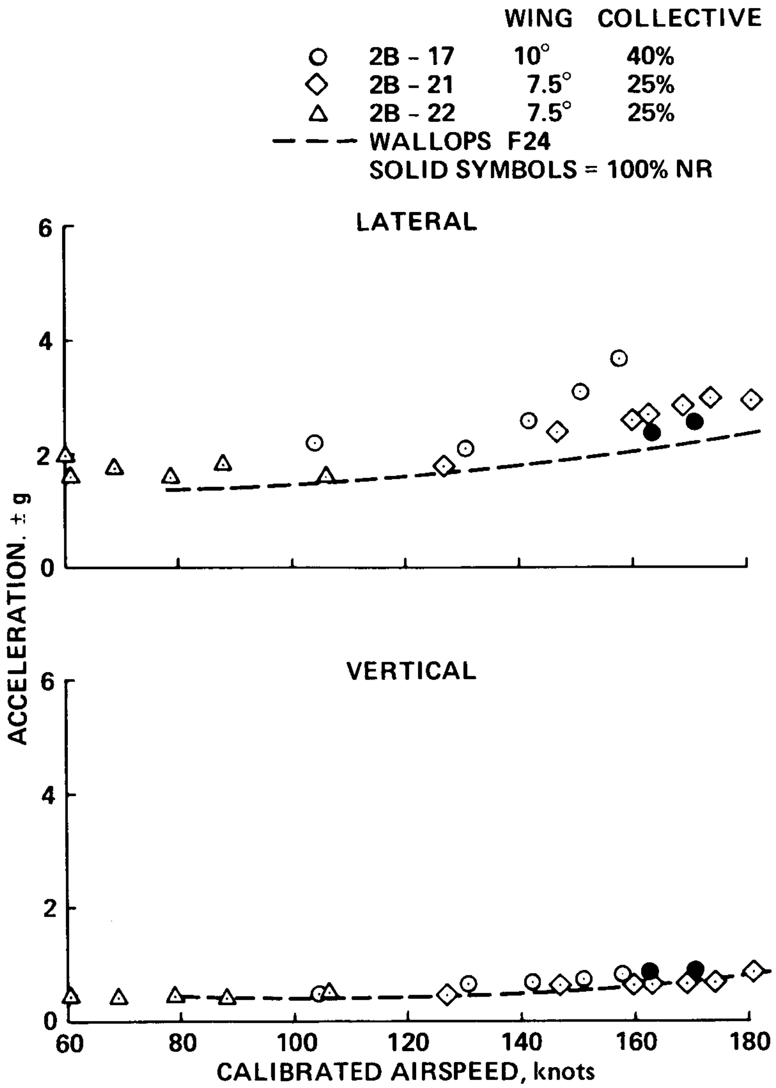


Figure 65.- Tail-rotor gearbox vibration versus calibrated airspeed.

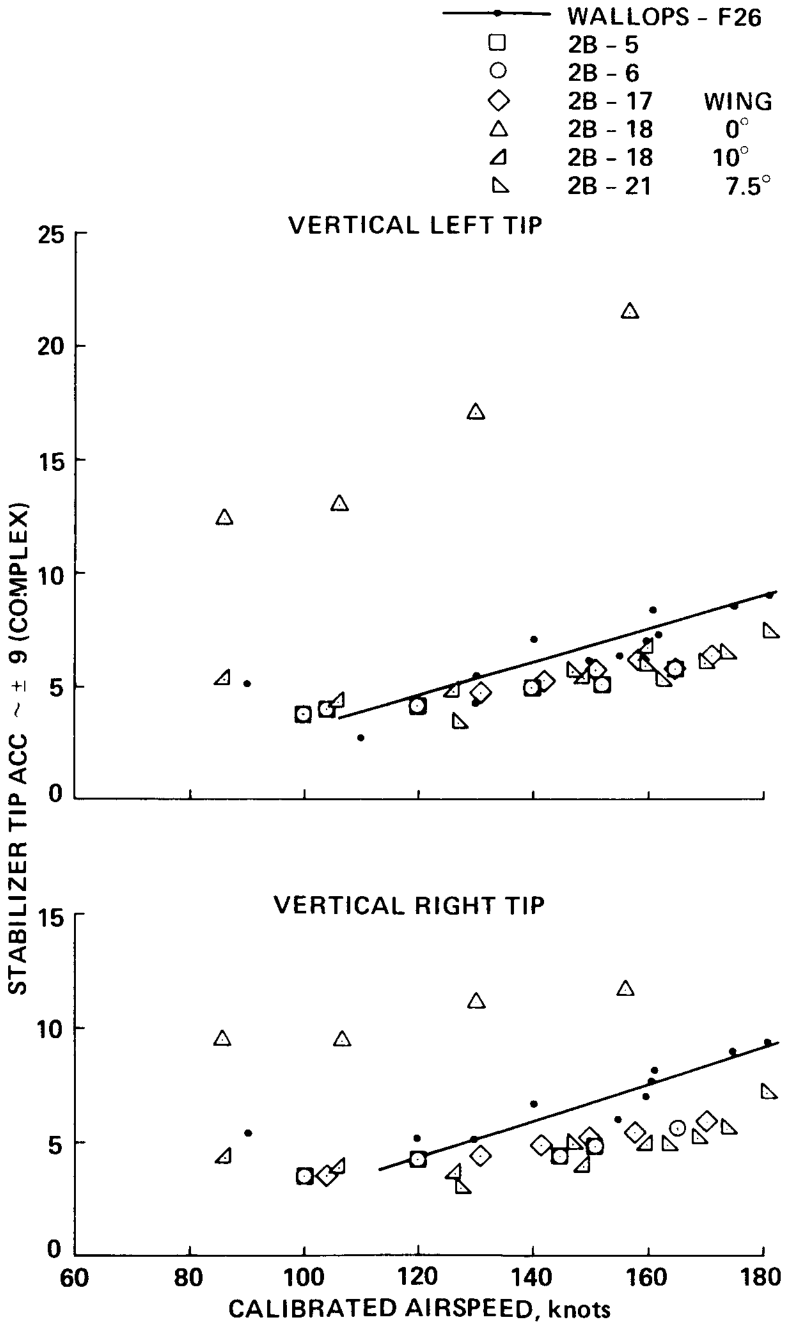


Figure 66.- Upper horizontal stabilizer (complex) versus calibrated airspeed.

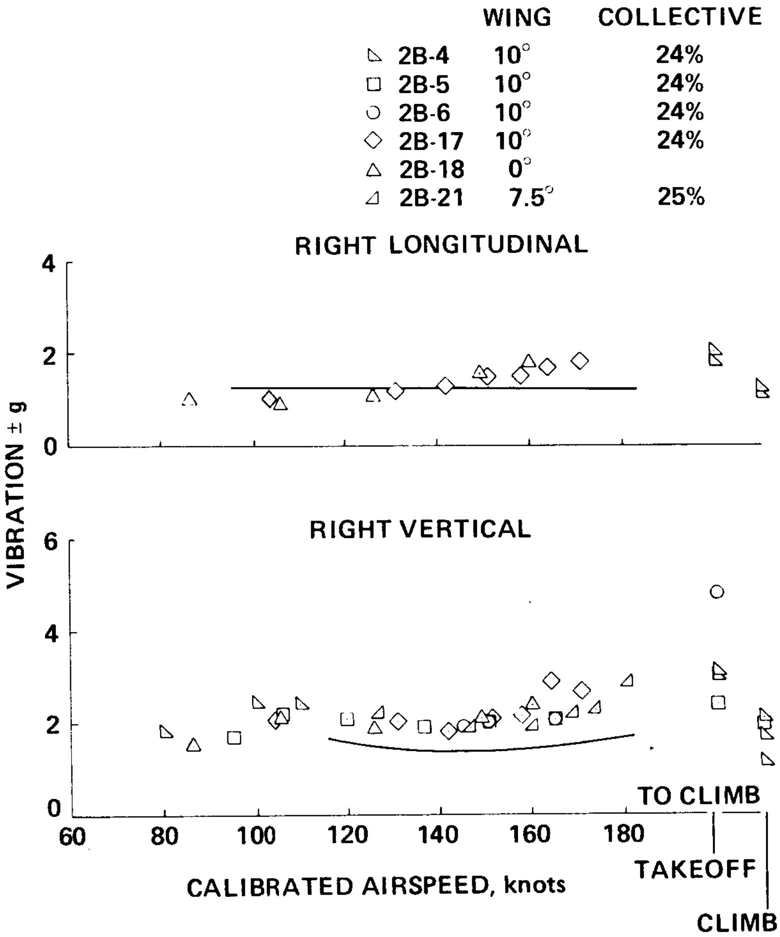


Figure 67.- Wing-tip vibration (complex).

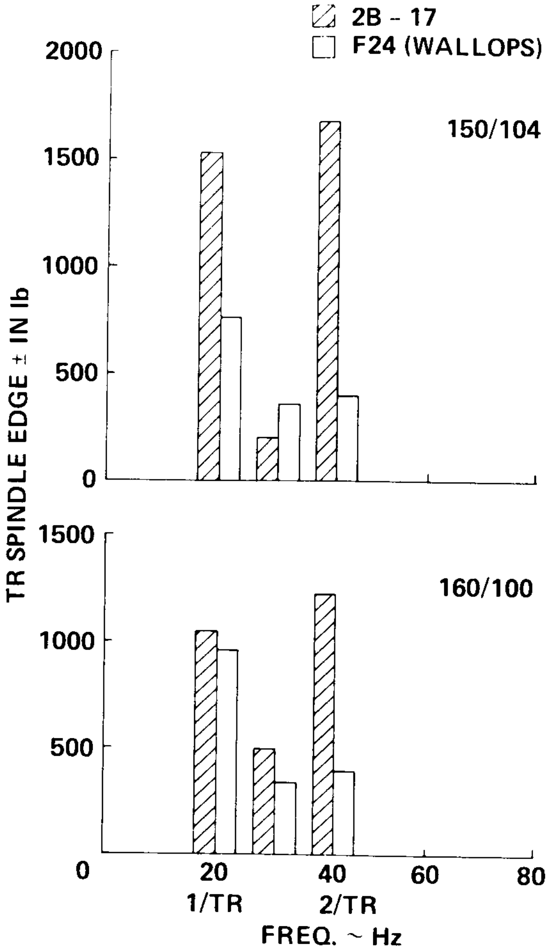


Figure 68.- Tail-rotor spindle edge bending frequency content.

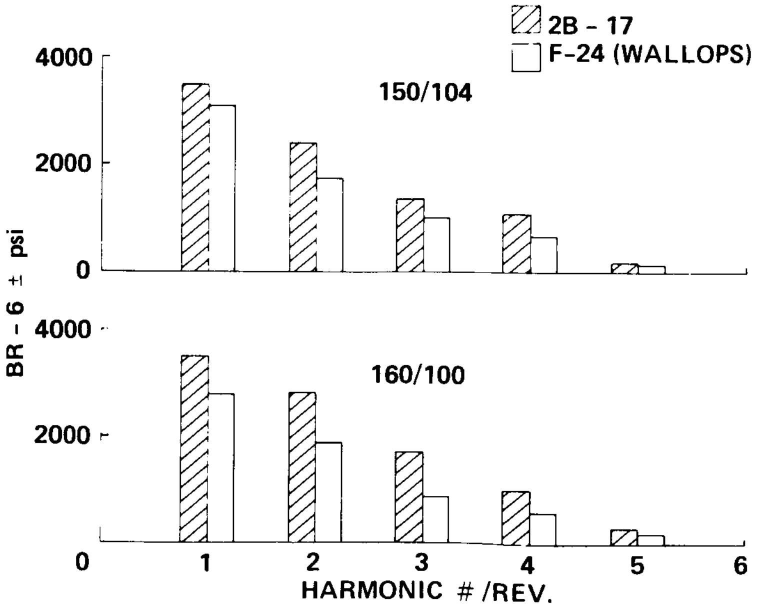


Figure 69.- BR-6 harmonic content.

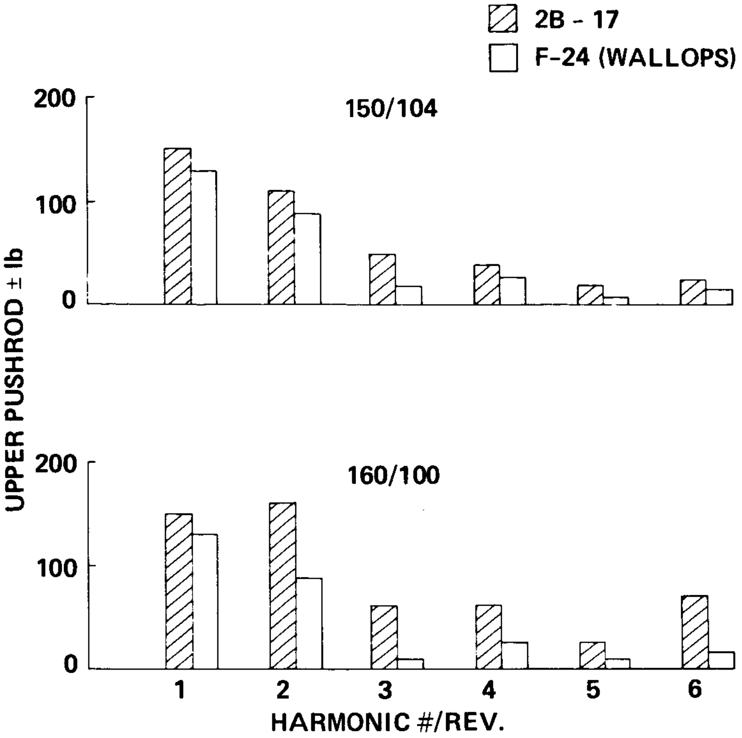


Figure 70.- Upper main-rotor push rod harmonic content.

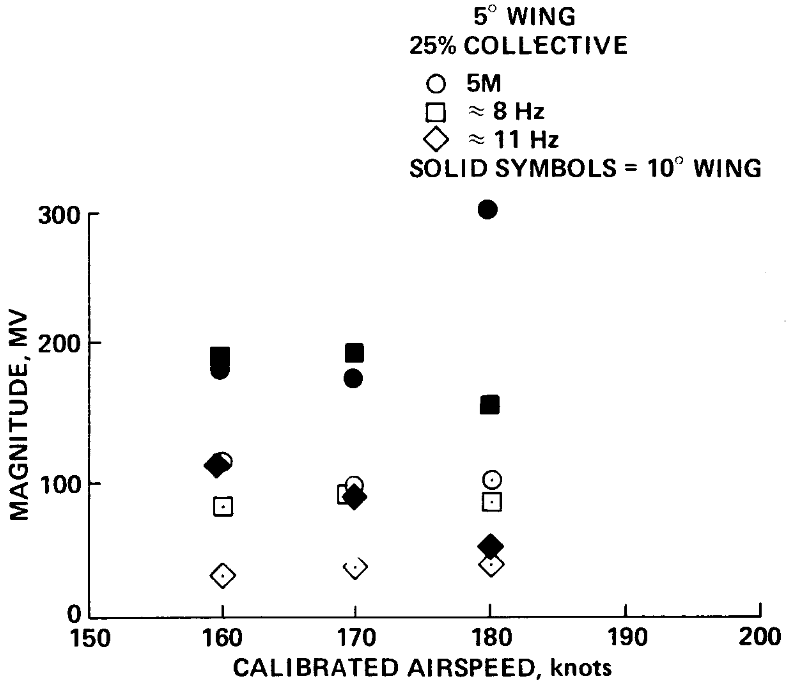


Figure 71.- Frequency analysis, 2B-19: Stabilator lift bridge (Rv).

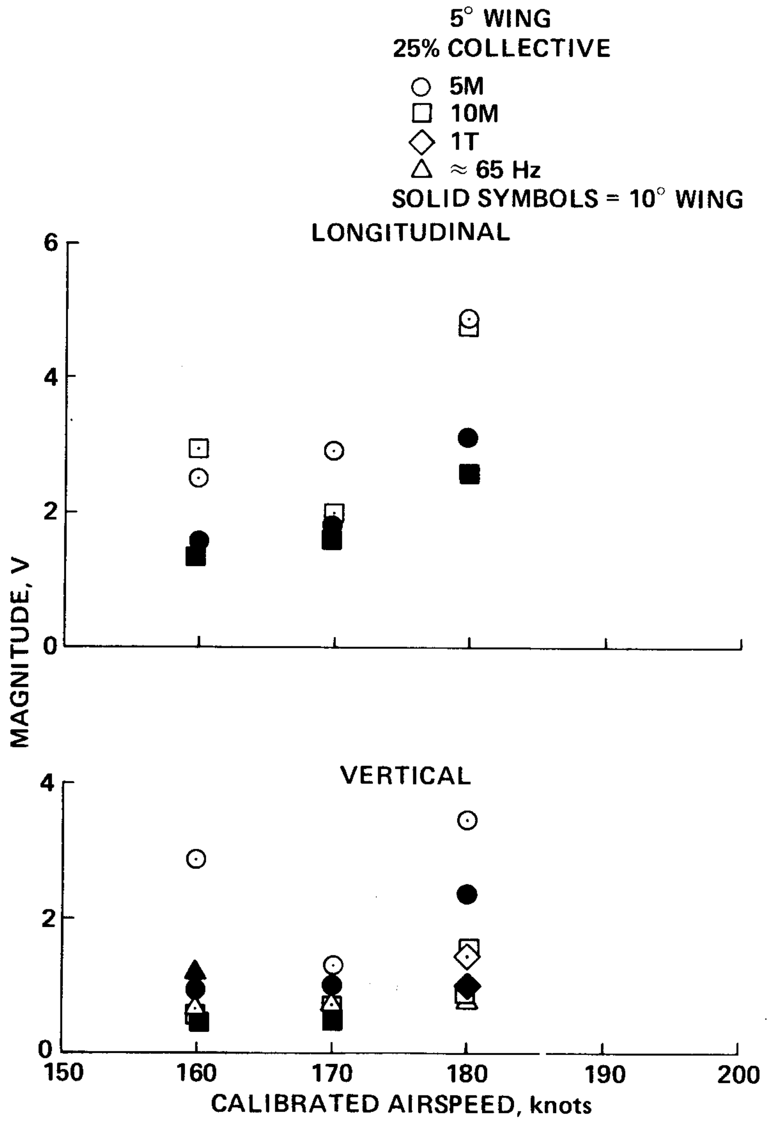


Figure 72.- Frequency analysis, 2B-19: Stabilator tip accelerometers.

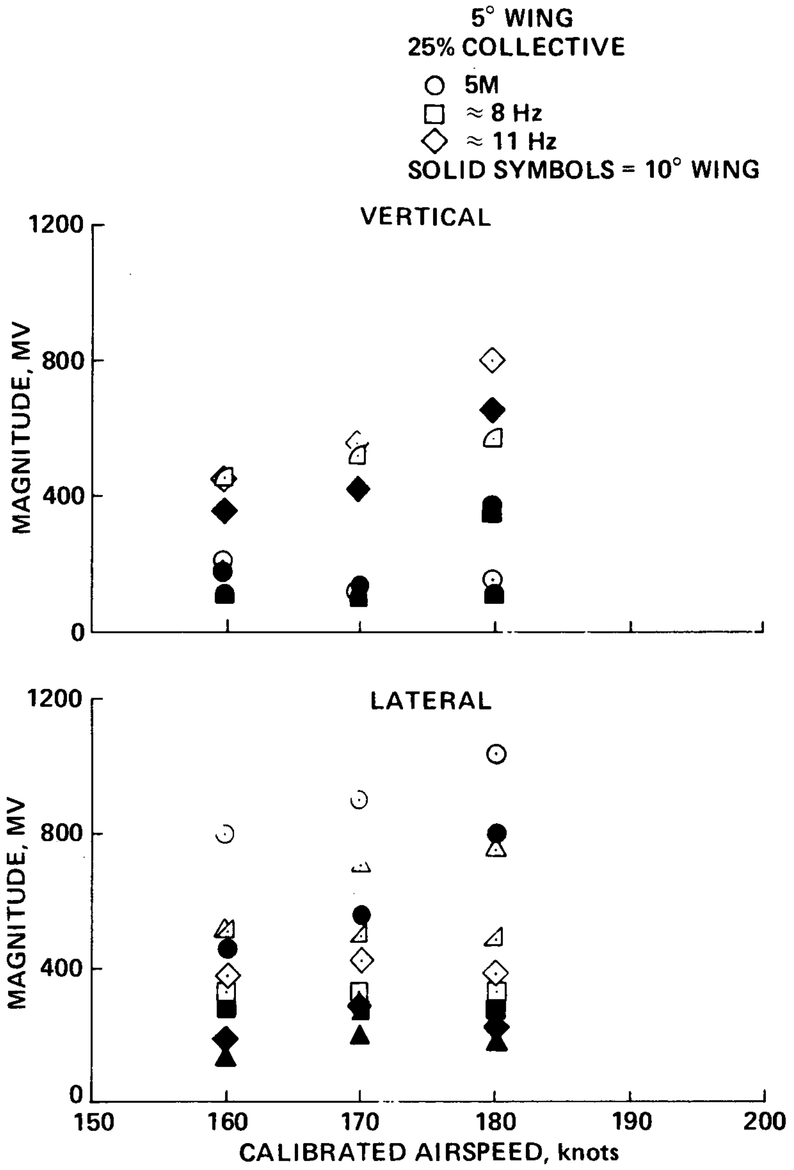


Figure 73.- Frequency analysis, 2B-19, tail-rotor gearbox accessory.

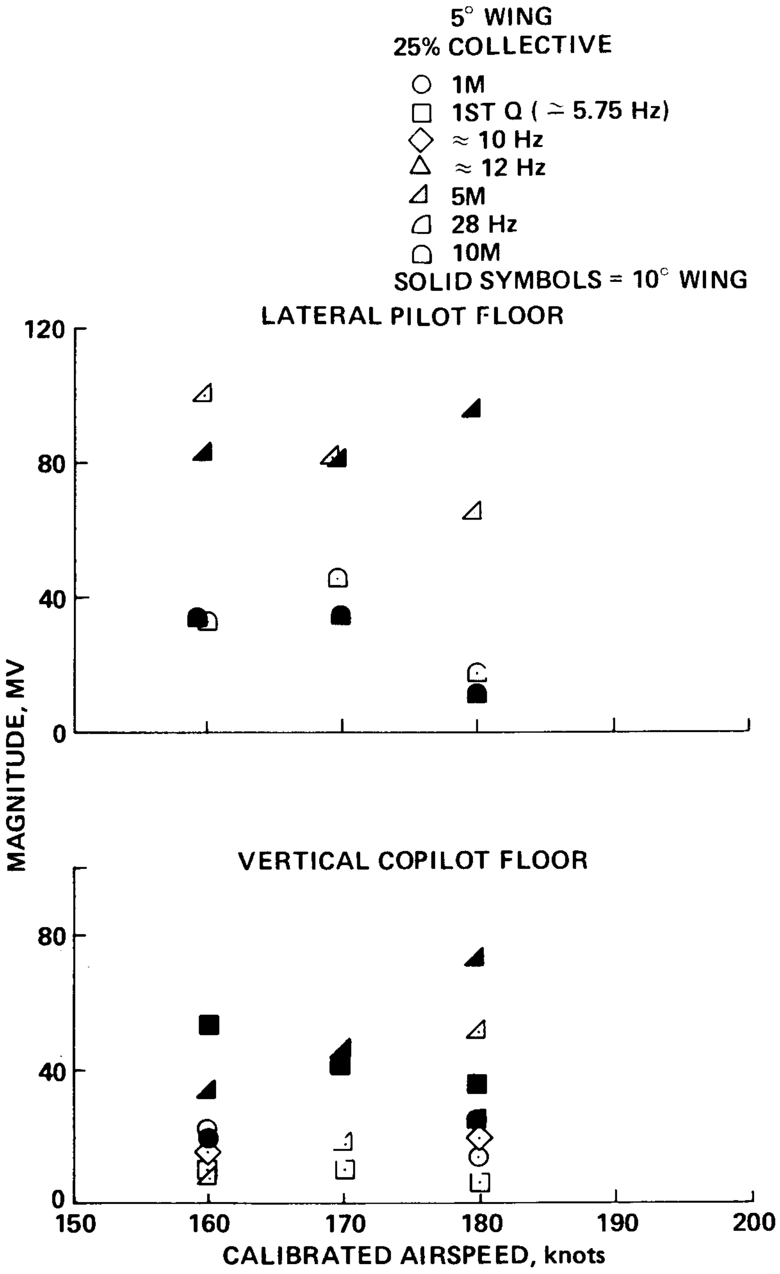


Figure 74.- Frequency analysis, 2B-19, cockpit accessories.

4. STABILATOR AND STABILIZER

Stabilator Stress and Loads

General— The Wallops Island flight tests had shown that the stabilator attachment structure (fig. 75) had marginal strength. Methods were therefore developed to determine past fatigue damage and the mechanism of loading, improve the fatigue properties of the structure, and record and process future data as accurately as possible. To this end Sikorsky was instructed to perform the above tasks, the results of which are contained in reference 2. The main requirements may be summarized as follows:

1. Remove the Teflon-lined bushings and replace them with phosphorus-bronze bushings machined to obtain maximum allowable interference fit and, thereby, maximum fatigue strength. The lugs were checked for fretting (none was evident) and line-reamed to remove any possible remnant fatigue damage. The latter procedure was also applied to other appropriate areas where holes were reamed and oversized fasteners used.

2. The stabilator and backup structure were statically calibrated to permit the calculation of derived loads and stresses. Computer programs were written to obtain these data utilizing 60/main rotor digitizing rate; the data were truncated and Goodman-corrected, and the damage was calculated at the three most significant sample rates and added algebraically as follows: 2/M + (1/3)3/M + (2/5)5/M.

The above method of processing the data was somewhat more elaborate than normally used; however, because of the random complex character of the yaw waveform this procedure was required to avoid unreasonable conservatism. The primary modes of the stabilator were defined from shake tests to be as follows:

Rigid body (antisymmetric):

Flapwise, 6.9 Hz
Edgewise, 7.3 Hz (yaw about attachment)

First mode (symmetric):

Flapwise, 18.4 Hz
Edgewise, not defined

During ground runs and low-speed tests, the highest loads were a function of TF-34 thrust. The waveform had a beat character with a well-defined response at about 10 Hz which was probably caused by the wake shed from the engine afterbody. At higher speeds, the wake appears to have been diverted by the free-stream flow, and other forces increased, mainly 5 per main and random airframe induced turbulence.

To reduce the former loads, a takeoff technique was developed by the Ames pilots which involved release of the brakes, then a gradual increase in TF-34 thrust. Concern had been expressed regarding the poor response of the throttles and the effect on directional control; however, this did not cause any excessive pilot workload.

Results— Figure 76 shows the accumulated damage of the lugs, dragbox, and tang compared with the predicted damage extracted from reference 2. It can be seen that the rate of damage was lower than predicted, primarily a result of the change in takeoff procedure and, to a lesser extent, of operating at wing angles of less than 10°, the effect of which will be seen in the following figures.

Figures 77-80 present the derived vibratory and steady loads and stresses in the lug, dragbox, and tang. Two points are of most interest; namely, the effect of wing angle and the relatively large degree by which the working endurance level (E_w) was exceeded.

With respect to wing angle — since the data were truncated and Goodman-corrected, which means that only tension loads were considered damaging — steady loads were significant in controlling the damaging vibratory loads and stresses. These data show that as the wing angle was reduced from 10°, the steady load decreased and, consequently, the truncated vibratory levels were reduced. In addition, there was a reduction in overall vibratory levels because of a decrease in vibratory forces as the wing angle was decreased. This is shown more clearly in figure 81. Regarding the second point, the degree by which the E_w were exceeded, inadequately represents the integrity of the structure because of the random character of the excitation. As stated previously, it was decided to monitor the cycle-by-cycle damage by the method described.

Figures 81-84 present the measured stress data, which include the stresses from which the Wallops Island data were derived. These data were monitored to trend the Ames and Wallops Island data and showed good agreement. As stated previously, there was a reduction in truncated vibratory stresses with wing angle of less than 10° at speeds up to 170 knots CAS.

Upper Horizontal Stabilizer

The attachment stresses were monitored, with levels generally remaining below the E_w throughout the flight envelope; such excesses as did occur were at a low damage rate. It was apparent, however, that at a wing angle of 0°, the accompanying change in the aircraft attitude relative to the main-rotor-tip path caused a significant increase in attachment vibratory stress because of main-rotor-wake impingement. As shown in figure 85, the levels peaked at 130 knots and gradually decreased to almost normal levels at high speed. Since operation at this wing angle is not currently anticipated, the planned program is not affected; however, in future programs this characteristic will have to be considered.

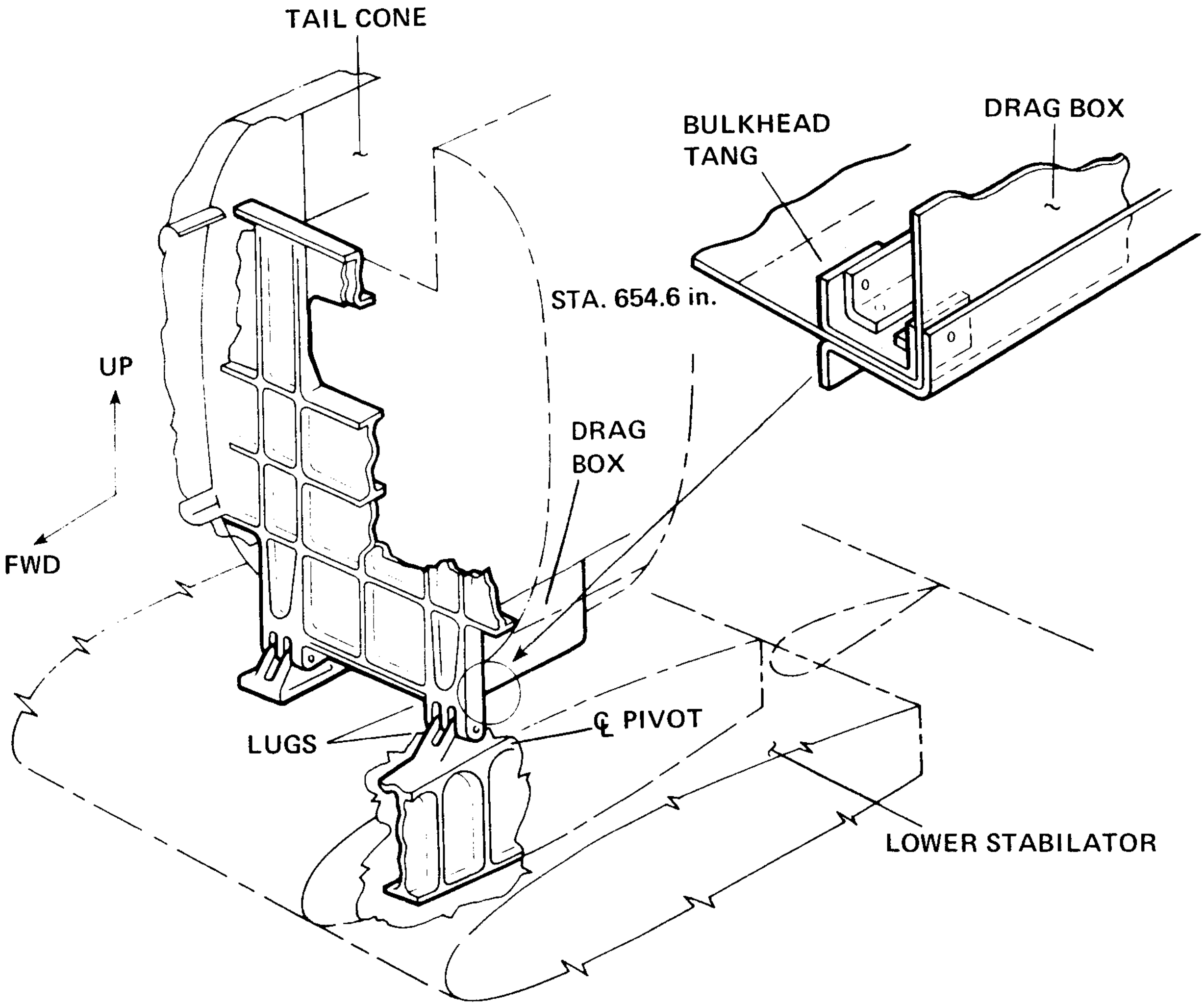
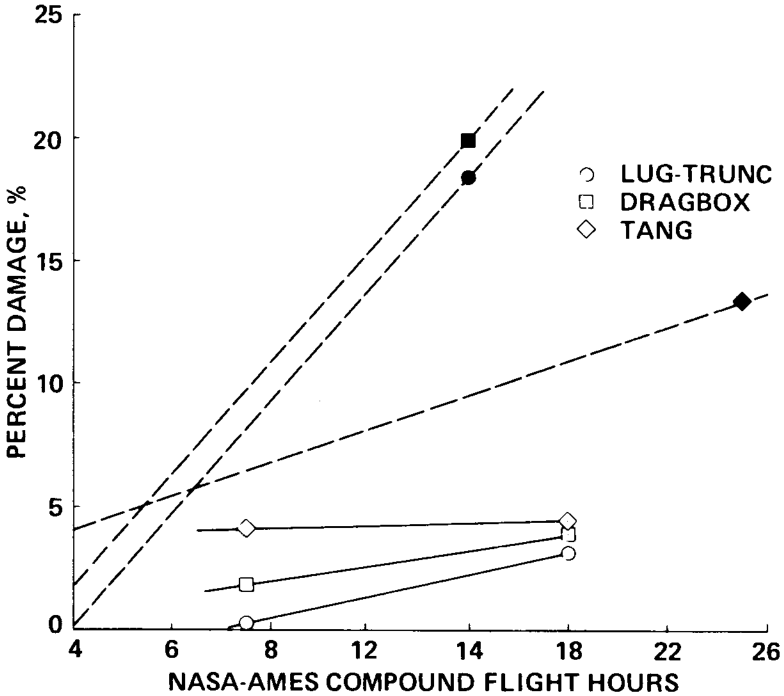


Figure 75.- Lower stabilator attachment structure.



SOLID SYM - PREDICTED

Figure 76.- Predicted and actual stabilator structure damage.

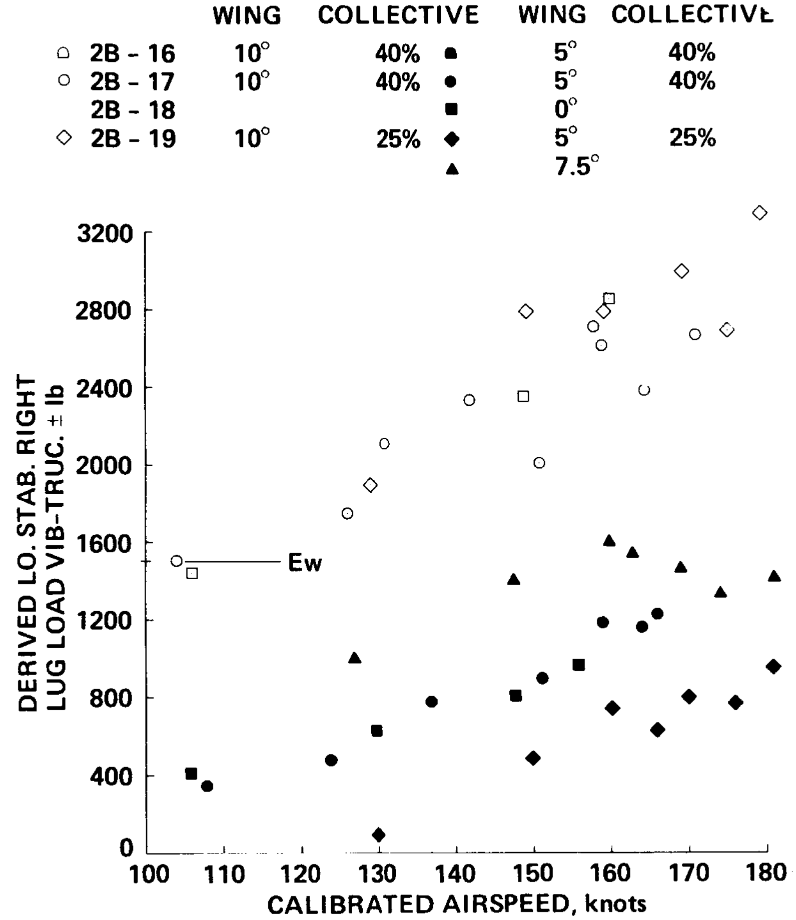


Figure 77.- Derived lower stabilizer rotor lug load vibration versus calibrated airspeed: effect of wing angle and collective.

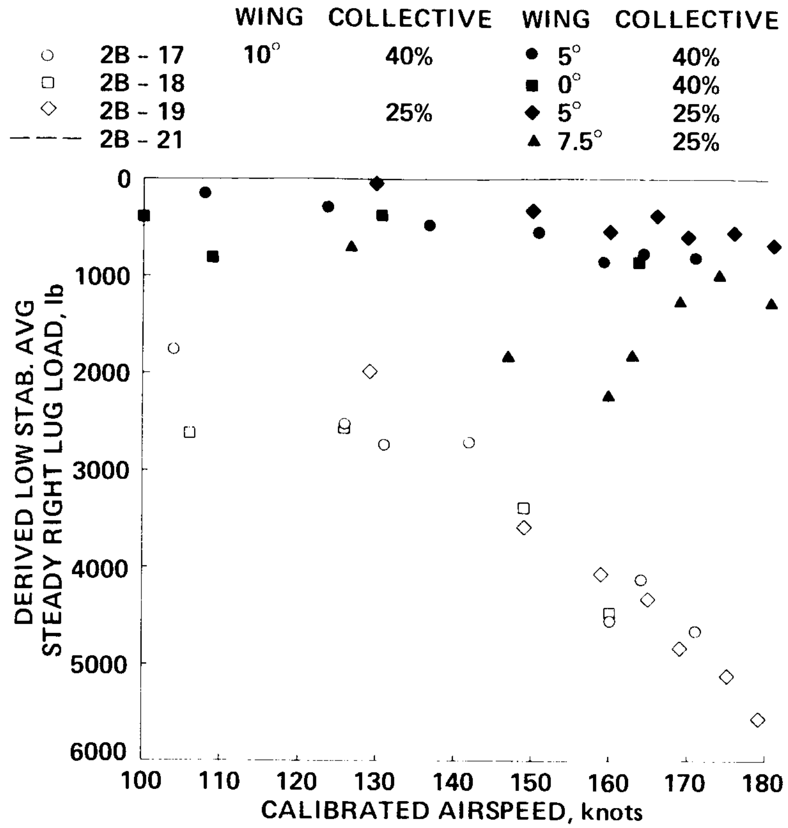


Figure 78.- Derived lower stabilizer average steady rotor lug load versus calibrated airspeed: effect of wing angle and collective.

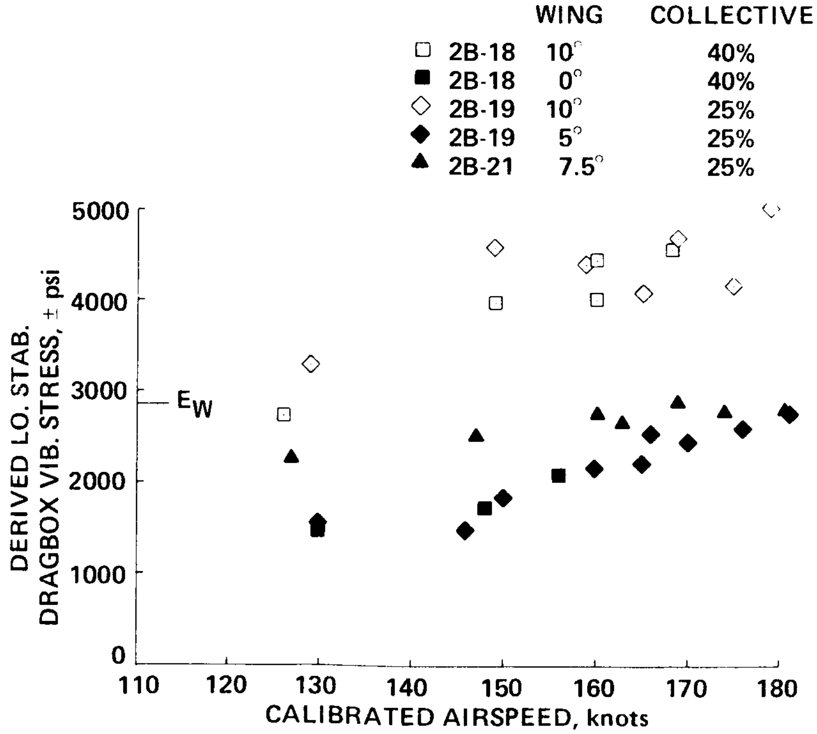


Figure 79.- Derived lower stabilizer dragbox vibration stress: effect of wing angle and collective.

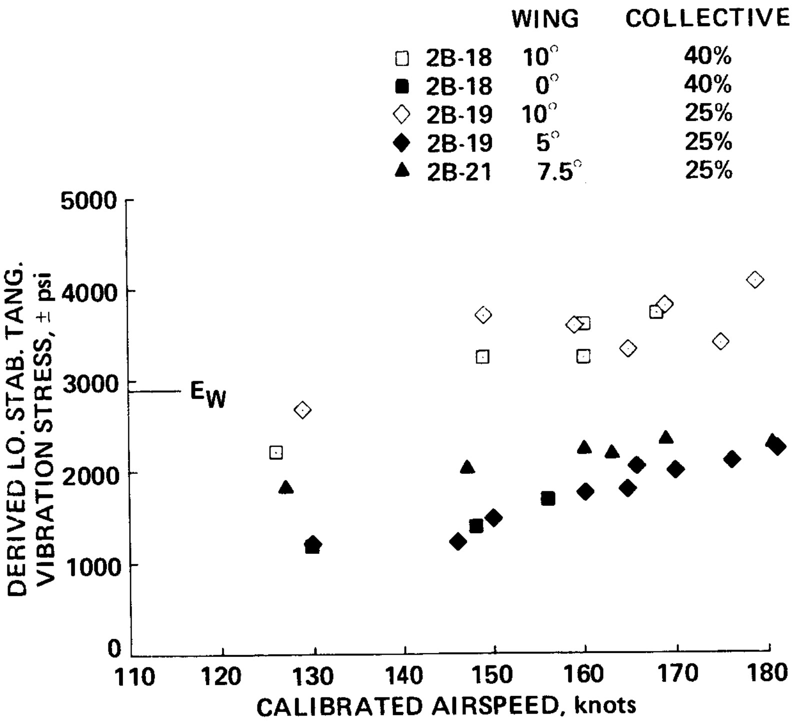


Figure 80.- Derived lower stabilizer tang vibration stress: effect of wing angle and collective.

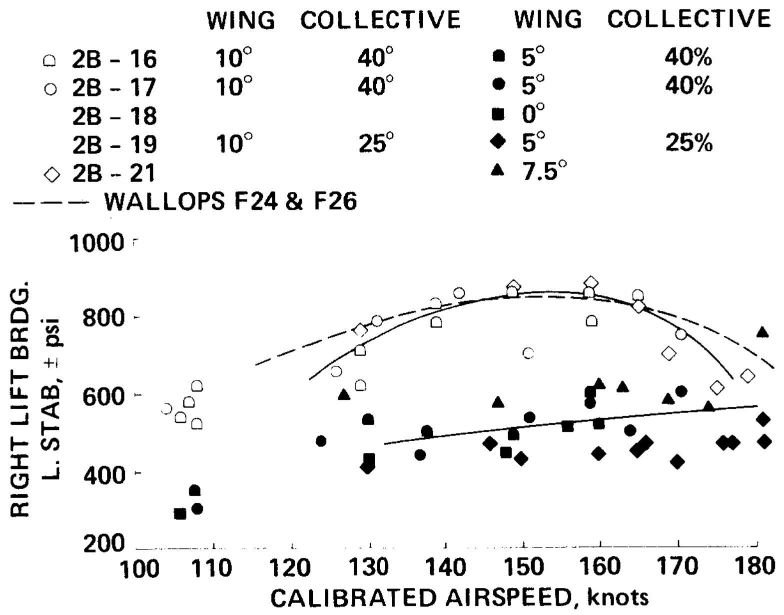


Figure 81.- Lower stabilizer rotor lift bridge vibration versus calibrated airspeed: effect of wing angle and collective.

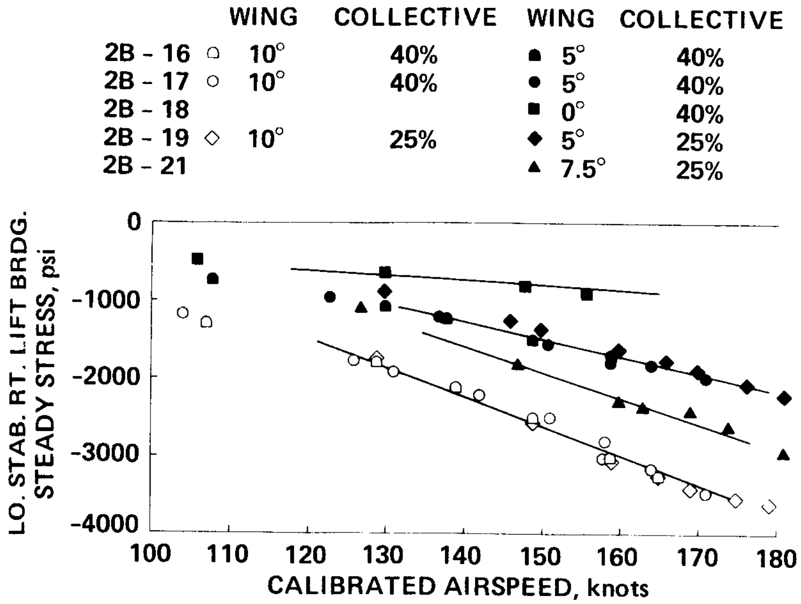


Figure 82.- Lower stabilizer rotor lift bridge steady versus calibrated airspeed: effect of wing angle and collective.

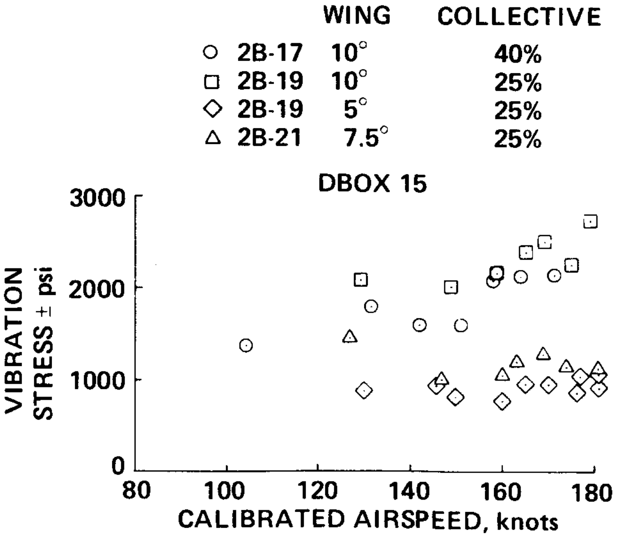


Figure 83.- Stabilator drag box vibration stress versus calibrated airspeed: effect of wing angle and collective.

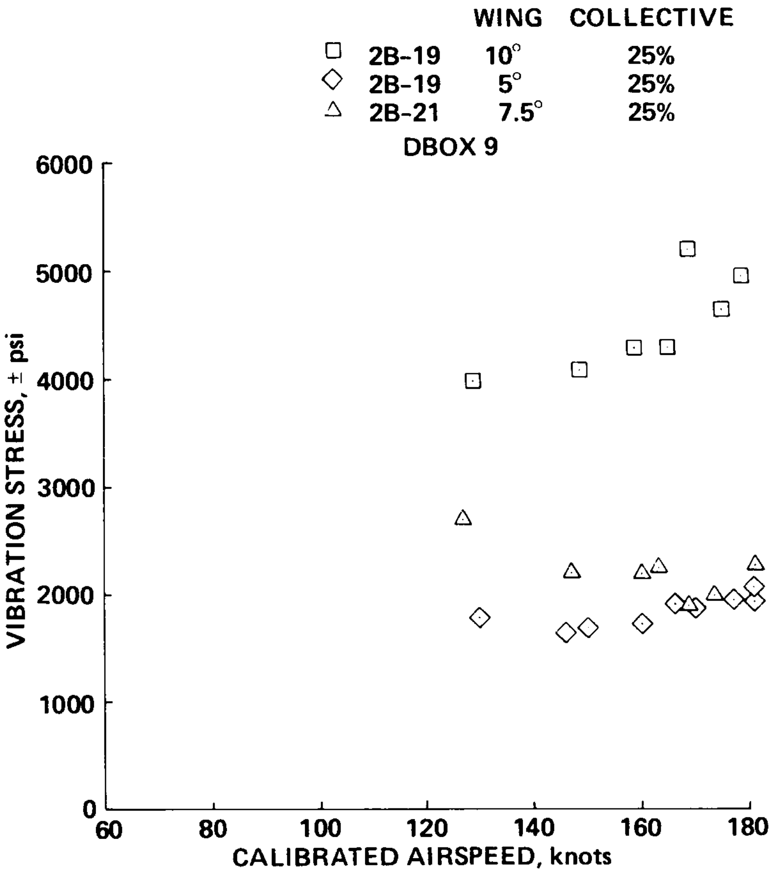


Figure 84.- Stabilator drag box vibration stress versus calibrated airspeed: effect of wing angle and collective.

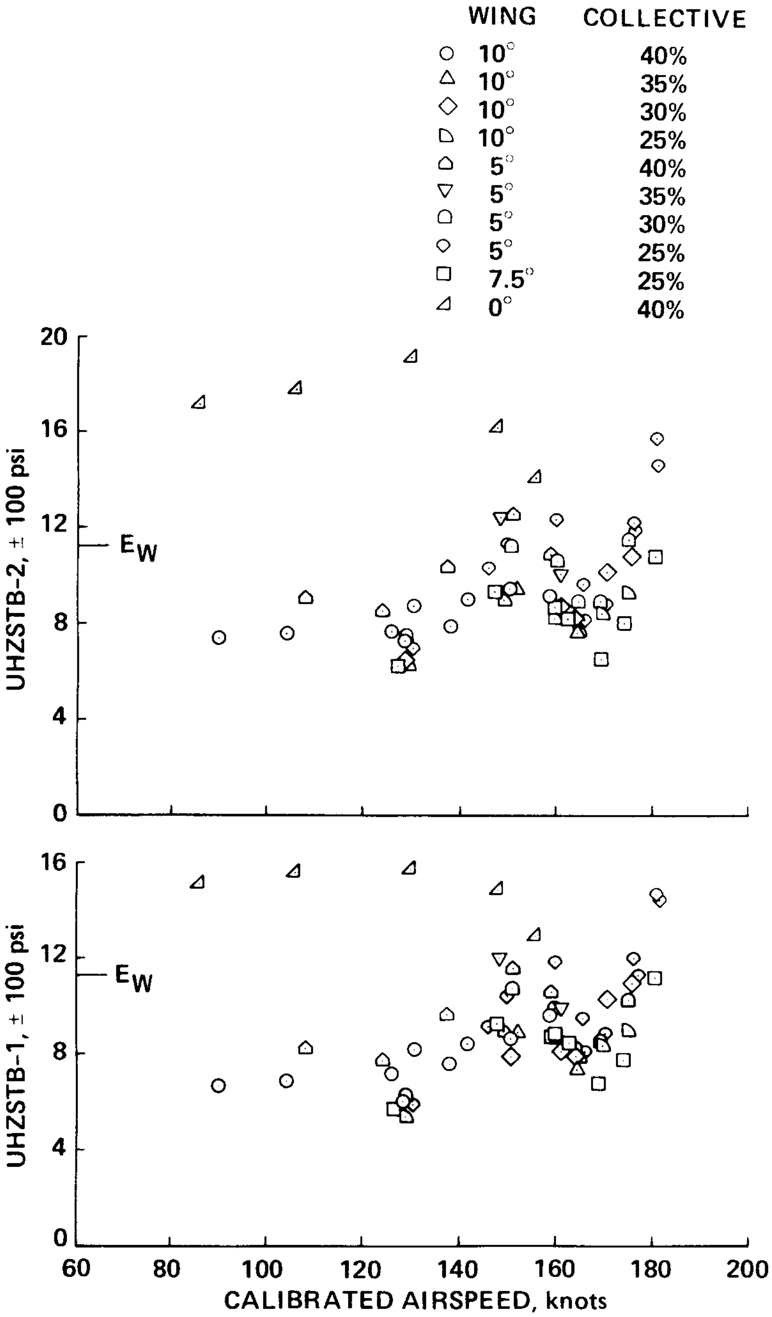


Figure 85.- Upper horizontal stabilizer survey at various wing angles and collective settings.

5. MAIN- AND TAIL-ROTOR LOADS AND STRESSES

Monitor parameters were recorded throughout the program for comparison with Wallops Island data and to evaluate the effect of wing angle and collective changes. Figure 86 compares the Wallops Island shaft bending to flapping ratio of 2317 psi per degree, to the Ames ratio. They are identical. Total down-flapping of the main rotor (coning minus cyclic flapping) is shown in figures 87 and 88. These data were tracked to determine the proximity to the droop stop as collective was reduced and the "blow back" as forward speed was increased. Adequate clearance was maintained, and these data will continue to be monitored as the envelope is expanded.

Figure 89 shows a comparison of the stationary and rotating control loads. Throughout the level-flight speed range, the rotating and stationary control loads appear slightly elevated. At 165 knots CAS, current push-rod loads are ±290 lb; the Wallops Island loads are ±275 lb, an increase of 5%; at 165 knots CAS, current right-lateral stationary swashplate loads are ±350 lb; the Wallops Island loads are ±292 lb, an increase of about 20%. Damage on the rotating and stationary controls has remained unchanged since the Wallops Island testing.

In figure 90, the current main-rotor rotating and stationary scissors data are compared with previous data. Rotating scissors data at Ames is slightly elevated from 165 knots CAS to 175 knots CAS. At 180 knots CAS, it is again identical with the Wallops Island data. Because of an instrumentation problem, stationary scissor data were only obtained for flights 21 and 22. These data are shown; they are well below the E_W limit.

Figures 91-93 compare main-rotor blade outboard stress data. In comparing wing incidence angle of 10° and a collective setting of 40% for the Wallops Island and current test data, figure 91 shows that current BR-6 and BR-7 vibratory stresses are slightly elevated (about 9%) from Wallops Island data. The endurance level (E_W) for BR gages is ±6350 lb/in.^{2}. With the above-mentioned "elevated stresses," the BR-6 stresses-plot intercepts the E_W at 170 knots CAS; the Wallops Island test data intercept at 186 knots CAS. In an endeavor to determine the reason for this increase in vibratory stress levels, a thorough investigation was conducted into the instrumentation wiring setup and calibration and system airspeed and aircraft airspeed calibration; in addition, because of the rotating and stationary control load "slight increase," all data were corrected to a 1500-ft density altitude. When corrected to a 1500-ft density, the control loads of both programs were identical, and blade stresses were within a narrow scatter band.

Testing continued with flight envelope expansion to collective settings of 35%, 30%, 25%, and a few sample points at 20%. The curves in figure 91 are all plotted at test-day pressure altitudes.

Figure 92 was plotted identically to figure 91 except that the wing incidence angle was 5° leading edge up. From this plot, it appears that a 25% collective setting and 5° wing incidence is approximately equal to a 40% collective setting with a 10° wing incidence angle.

The steady stress values for the main-rotor-blade gages BR-6 and BR-7 are presented in figure 93. Because only a 10° wing incidence was tested at Wallops Island, this plot shows current 10° wing incidence data for comparison, as well as current 7.5° and 5° wing incidence angle steady stress data.

Figure 94 is a plot of the main-rotor-blade gage BR-6 vibratory stress versus calibrated airspeed with a 25% collective setting with various wing incidence angles. It is apparent that at airspeed in excess of 145 knots CAS, a wing incidence angle of 7.5° permits airspeeds through 180 knots CAS with stresses below endurance levels.

Figure 95 presents interpolated data which define the wing-angle/collective-position envelope to avoid exceeding the outboard blade-stress working endurance limit. It should be noted that these data are for 104% N_R only, and any reduction in rotor speed to 100% will reduce the speed envelope, as shown in figure 96.

Figure 97 compares current test data on the tail-rotor pitch beam load and spindle edgewise moment, throughout the level-flight speed range, for all wing angles and collective settings with the Wallops Island data at 10° wing angle and 40% collective setting. Both parameters remain well below their prescribed endurance limits.

Figure 98 presents tail-rotor steady torques, from Pulse Code Modulated recorded data, and tail-rotor-blade gage P-2 vibratory stresses versus calibrated airspeed. The tail-rotor torque plot from the Wallops Island testing continues to decrease at and above 140 knots CAS, probably because the main rotor rpm was reduced from 104% N_R to 100% N_R at all airspeeds above 160 knots CAS. Current testing shows tail-rotor torque increasing above 140 knots CAS with a constant 104% N_R.

Tail-rotor-blade gage vibratory stresses were slightly elevated during the current testing at 10° wing angle and 40% collective setting relative to the Wallops Island data at these conditions. A current increase in density altitude may explain these increases. A wing incidence angle of 7.5° and 25% collective setting would require an airspeed in excess of 200 knots CAS to intercept the endurance level.

Figure 99 compares tail-rotor spindle edgewise vibratory moments versus sideslip angles at various airspeeds. Figure 100 presents tail-rotor pitch beam-bending vibratory loads versus sideslip angles at various airspeeds. Any differences between the Wallops Island and current testing data are negligible. Figure 101 compares tail-rotor steady torque versus sideslip angle. As shown on the tail-rotor spindle edgewise moment and the tail rotor pitch-beam bending load plots, the tail-rotor torque changes that were noted in the current testing are negligible compared with the Wallops Island data.

Figures 102 and 103 show the effect of load factor on main-rotor vibratory control loads, both stationary and rotating controls, and on main-rotor-blade vibratory stresses. Figure 102 presents main-rotor lateral stationary swashplate vibratory loads and main-rotor push-rod load vibratory loads with load factor. No major damage was incurred, for these pull-ups and pushovers resulted in very few high load cycles. From figure 103, it can be seen that the stresses generated in the main-rotor blade during load-factor maneuvers were higher relative to the E_W. There again, the high cycles were few and the damage rate low. The apparent high stresses during the negative load factor points actually occurred during the entry and recovery phase of the maneuver.

Damage tracking on all rotor components was equal to or less than that recorded at Wallops Island. The component that incurred the most damage was the main-rotor shaft; its bending stress rate is 0.0988%/hr. Recorded damage on all components except the stabilator is given in table 2.

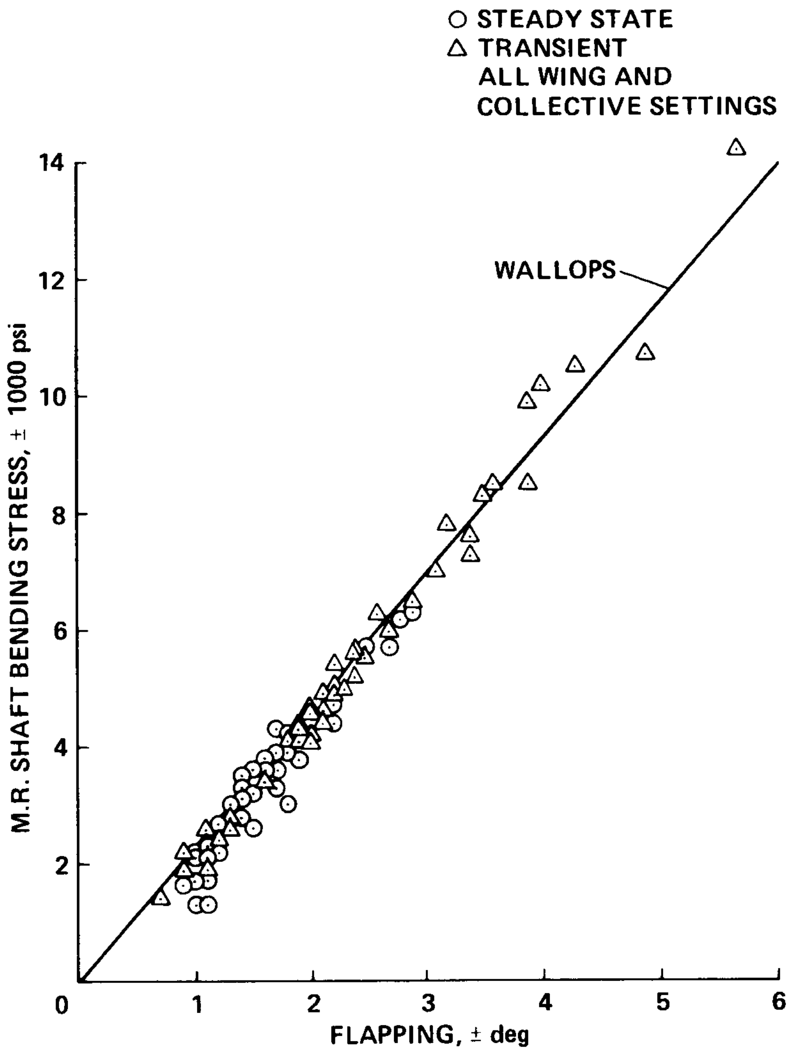


Figure 86.- Main-rotor shaft bending stress versus main-rotor blade flapping.

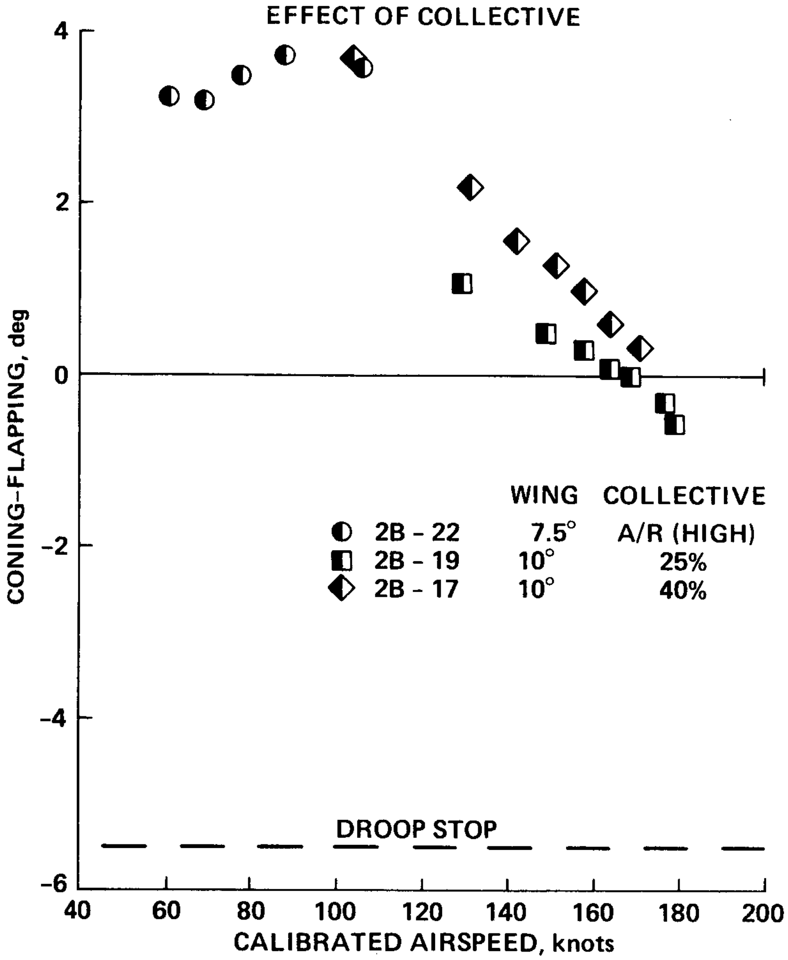


Figure 87.- Main-rotor total flapping — down: effect of collective.

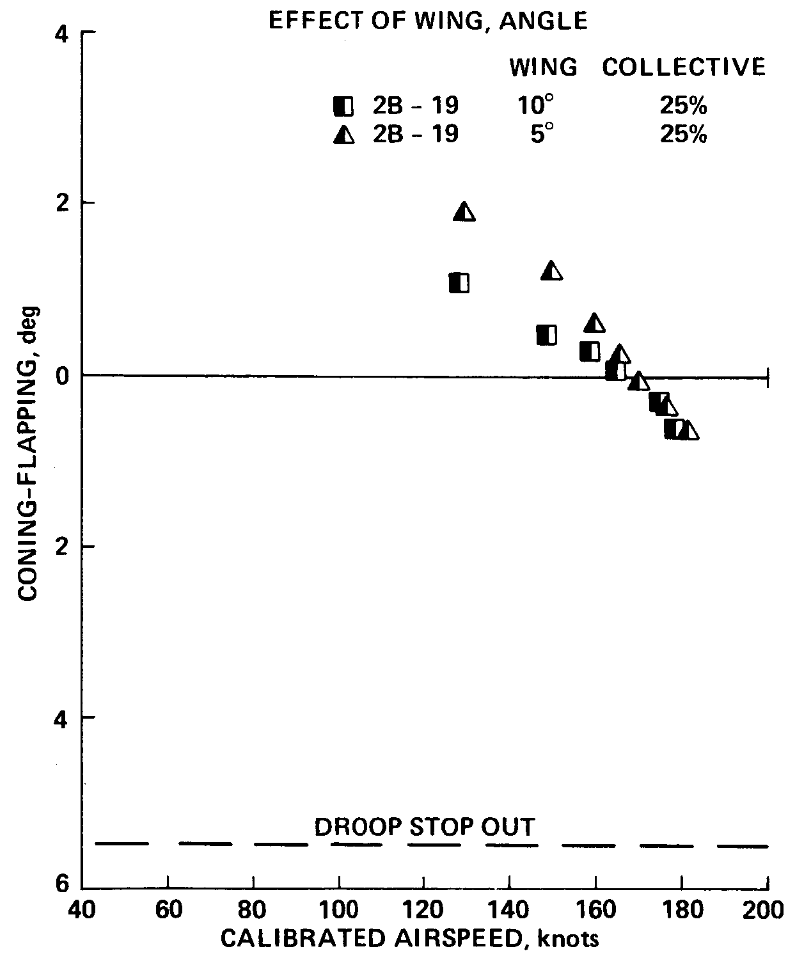


Figure 88.- Main-rotor total flapping — down: effect of wing angle.

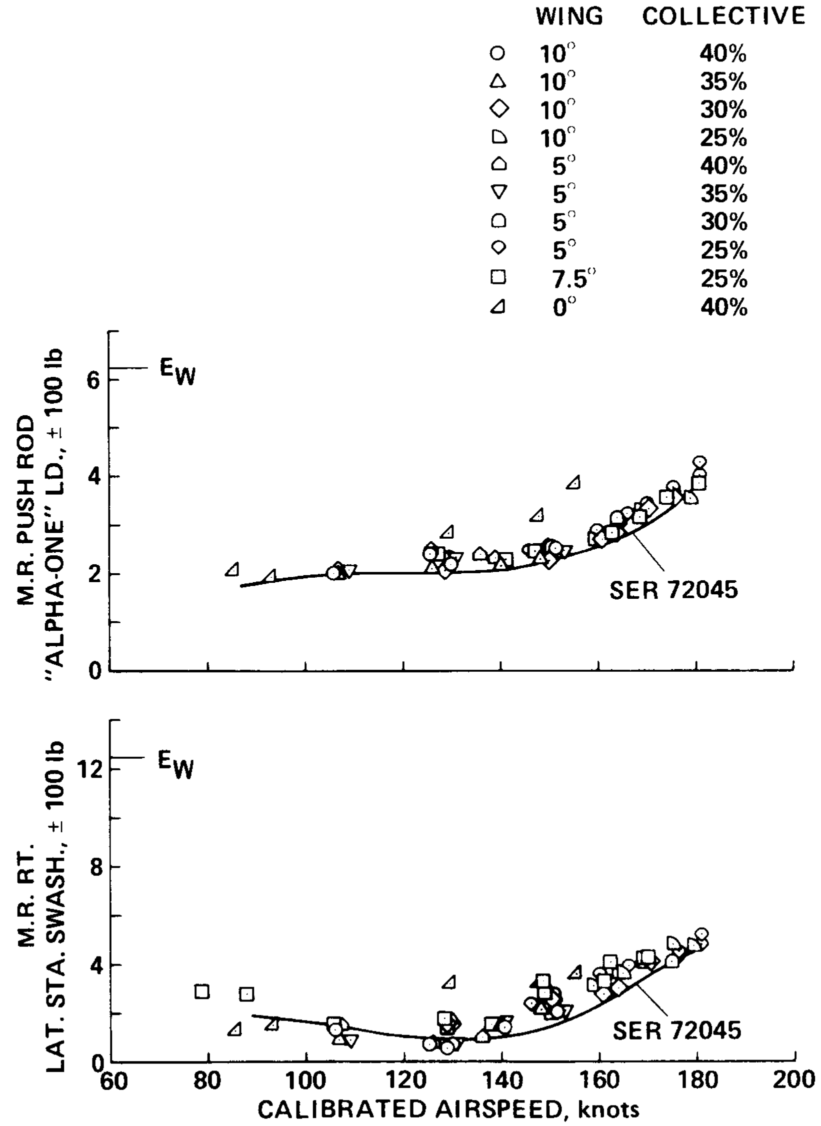


Figure 89.- Main-rotor control loads versus calibrated airspeed.

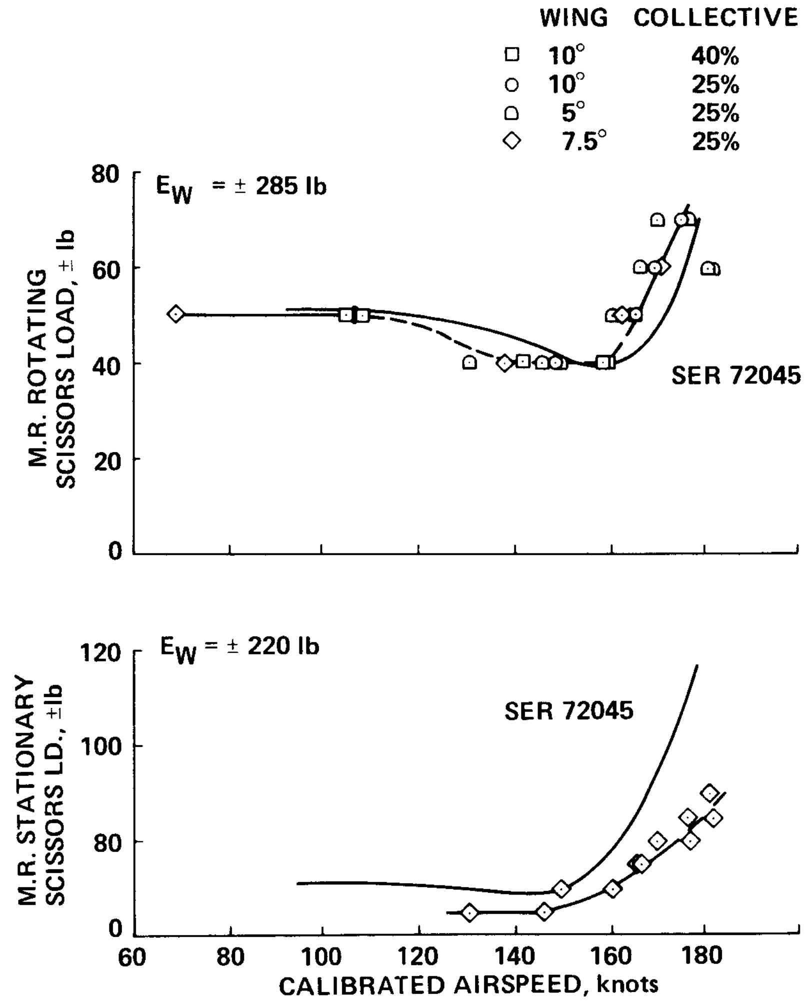


Figure 90.- Main-rotor rotating and stationary scissors loads versus calibrated airspeed.

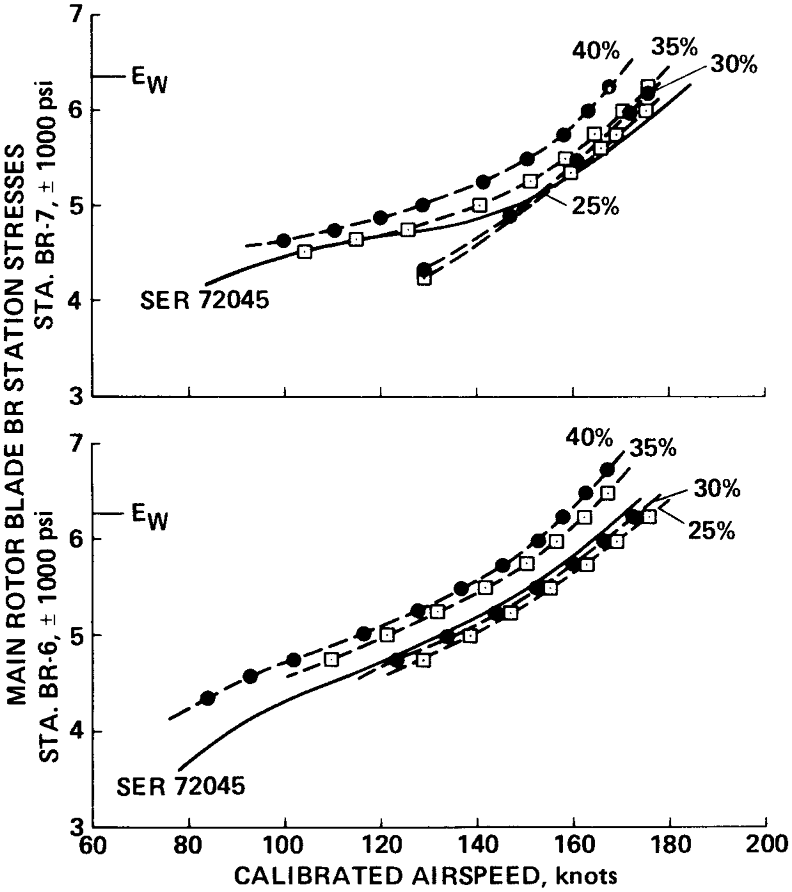


Figure 91.- Main-rotor blade outboard station stress: wing incidence 10°.

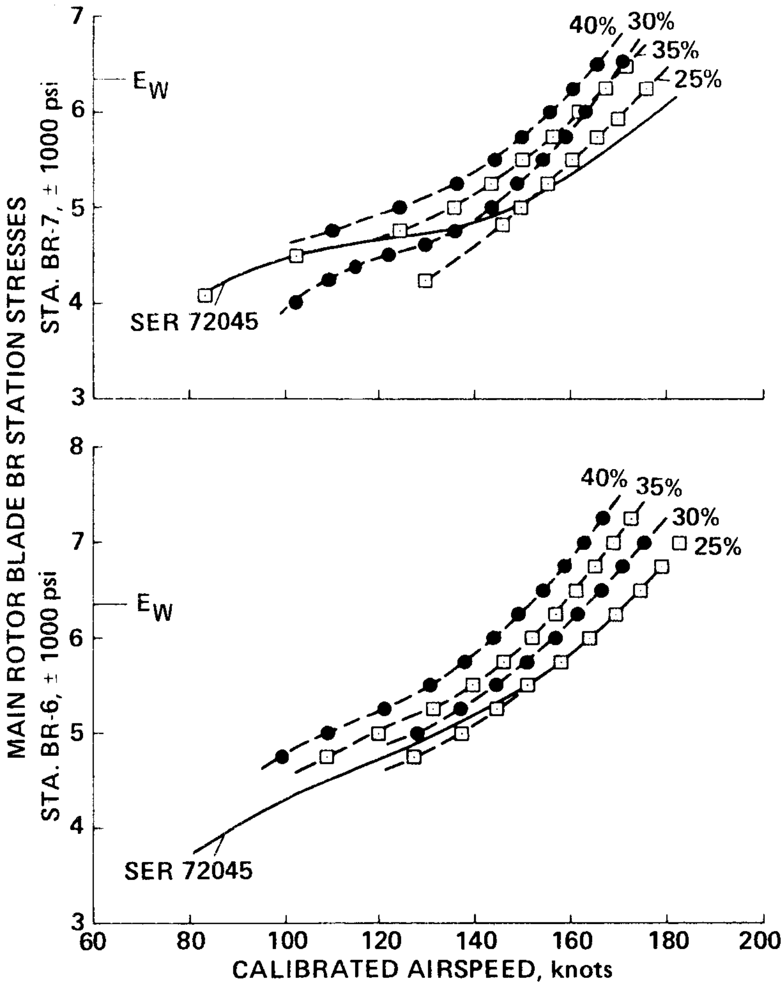


Figure 92.- Main-rotor blade outboard station stress: wing incidence 5°.

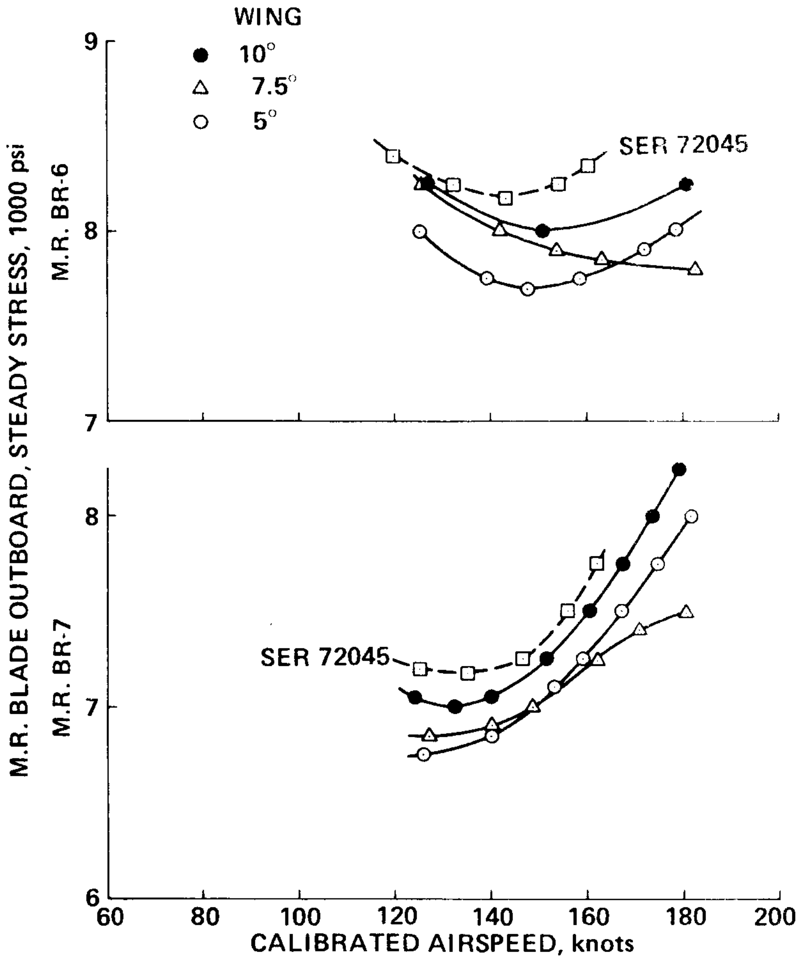


Figure 93.- Main-rotor blade outboard station stress: collective setting 25%.

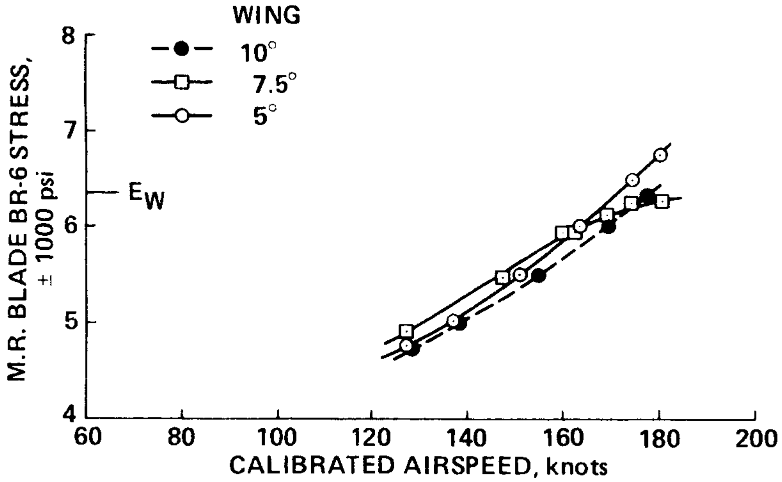


Figure 94.- Main-rotor blade station BR-6 stress: collective setting 25%.

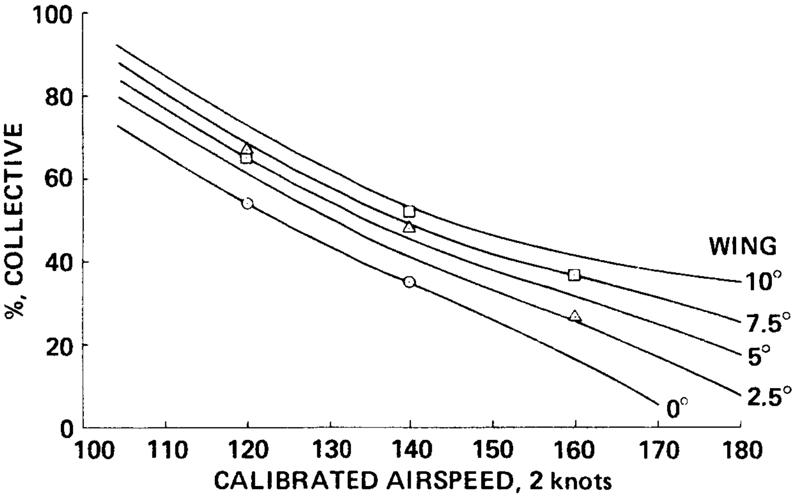


Figure 95.- Collective and wing incidence airspeed envelope.

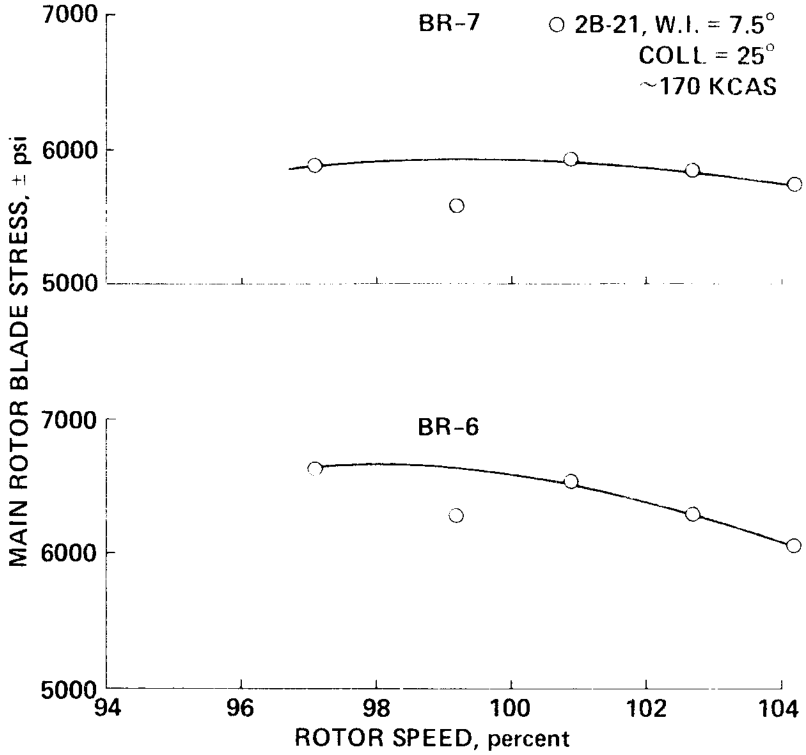


Figure 96.- Main-rotor outboard vibration blade stress versus rotor speed.

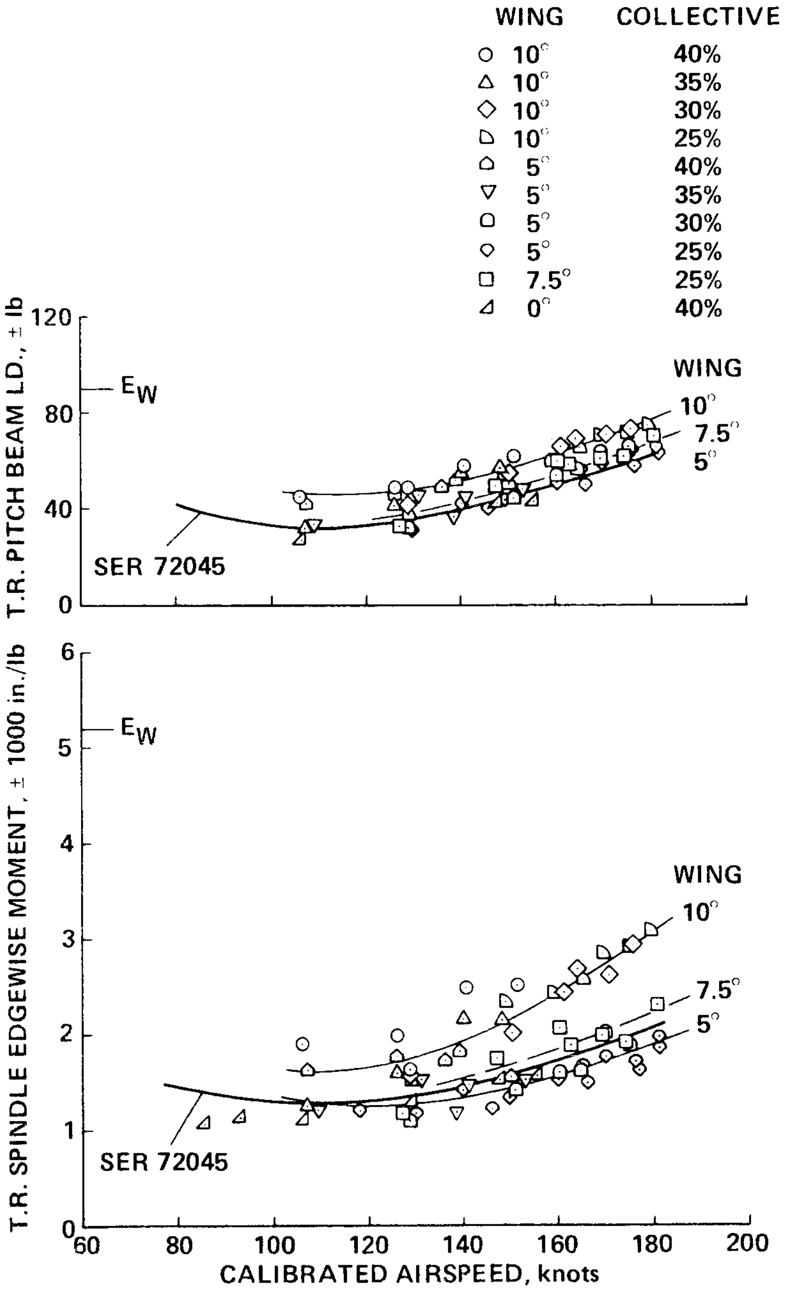


Figure 97.- Tail-rotor survey.

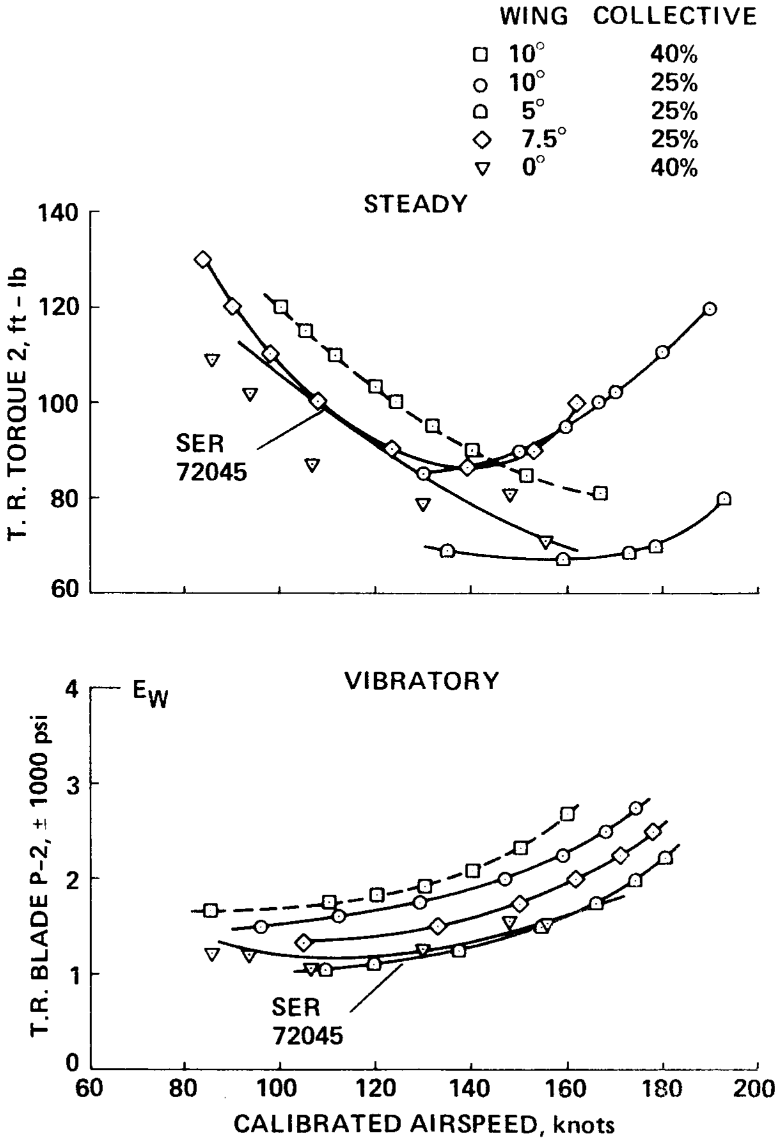


Figure 98.- Tail-rotor torque and vibratory stresses.

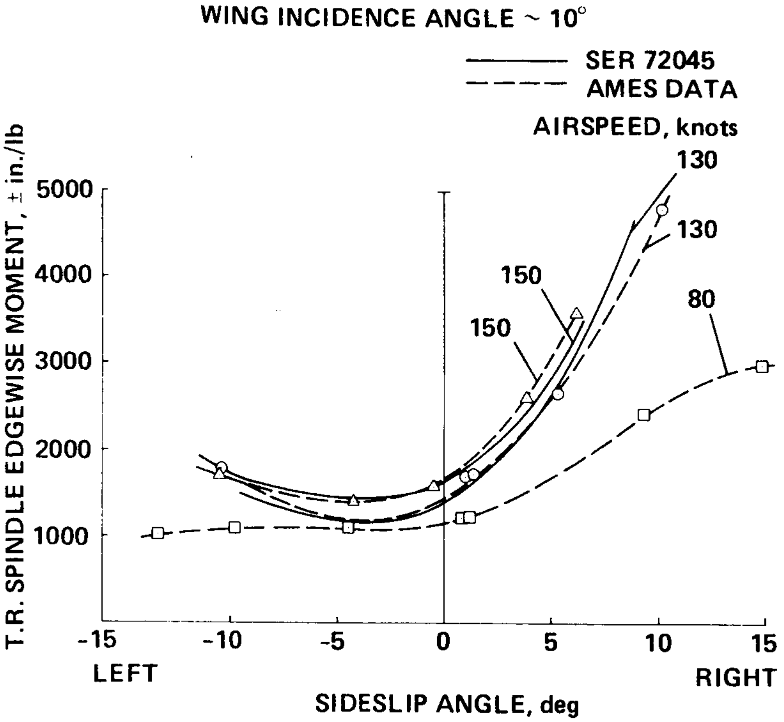


Figure 99.- Tail-rotor spindle edgewise moment versus sideslip angle.

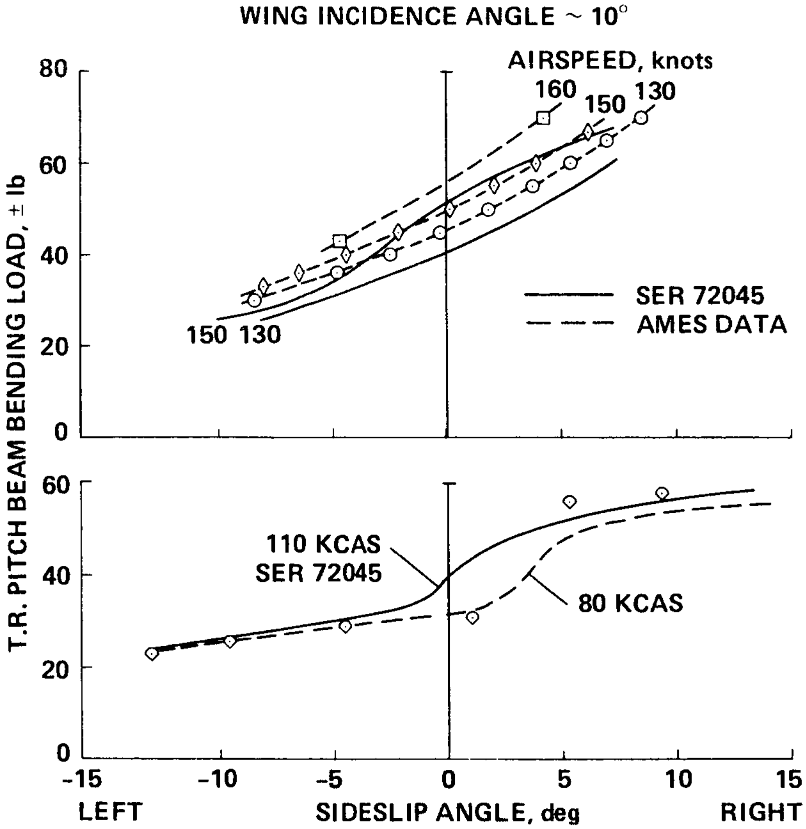


Figure 100.- Tail-rotor pitch beam bending load versus sideslip angle.

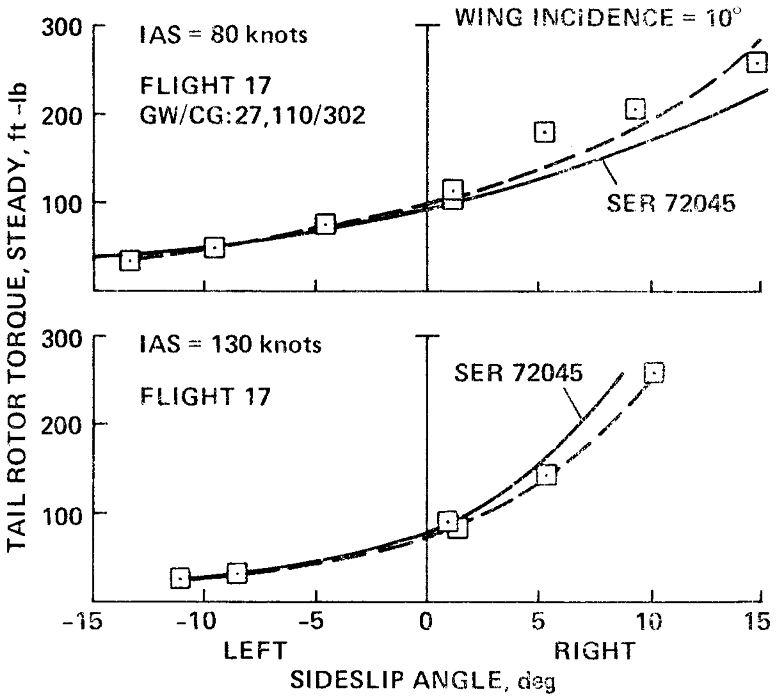


Figure 101.- Tail-rotor torque versus sideslip angle.

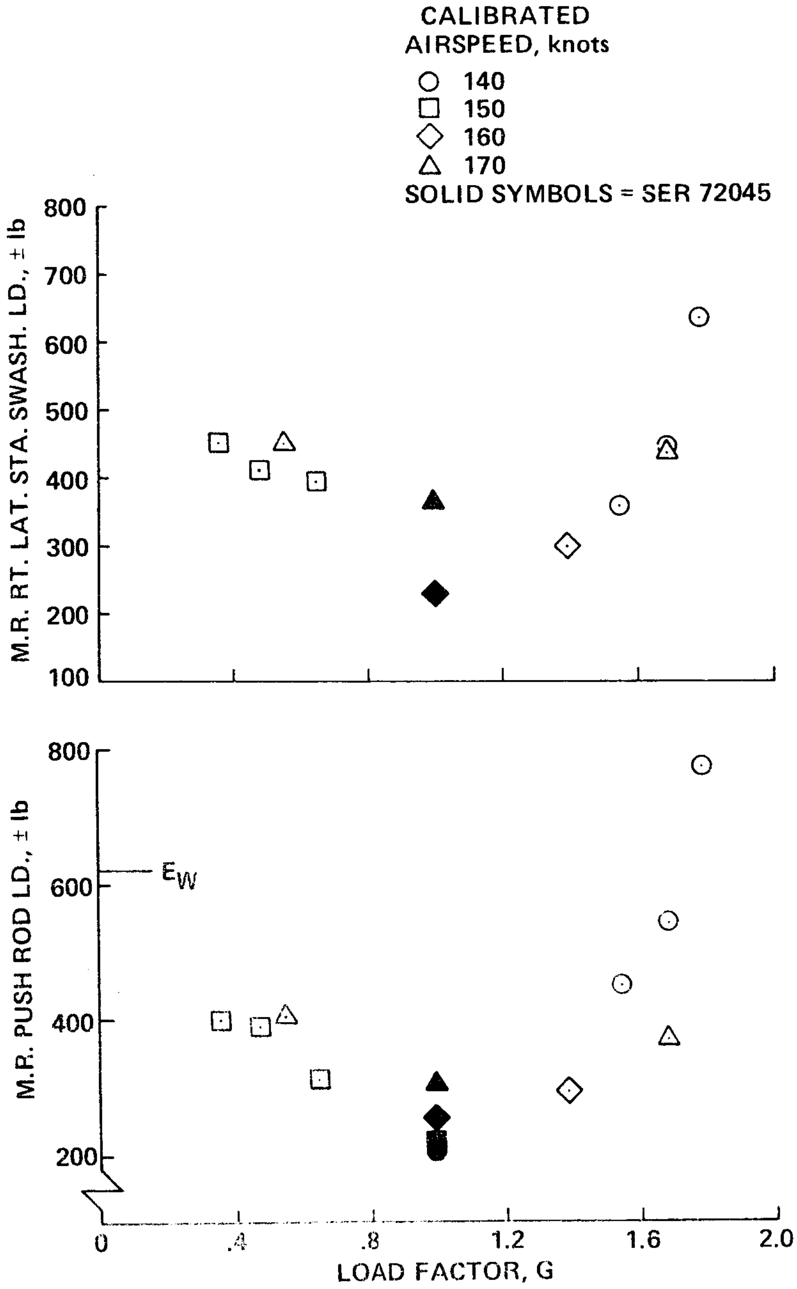


Figure 102.- Effect of load factor on main-rotor control loads.

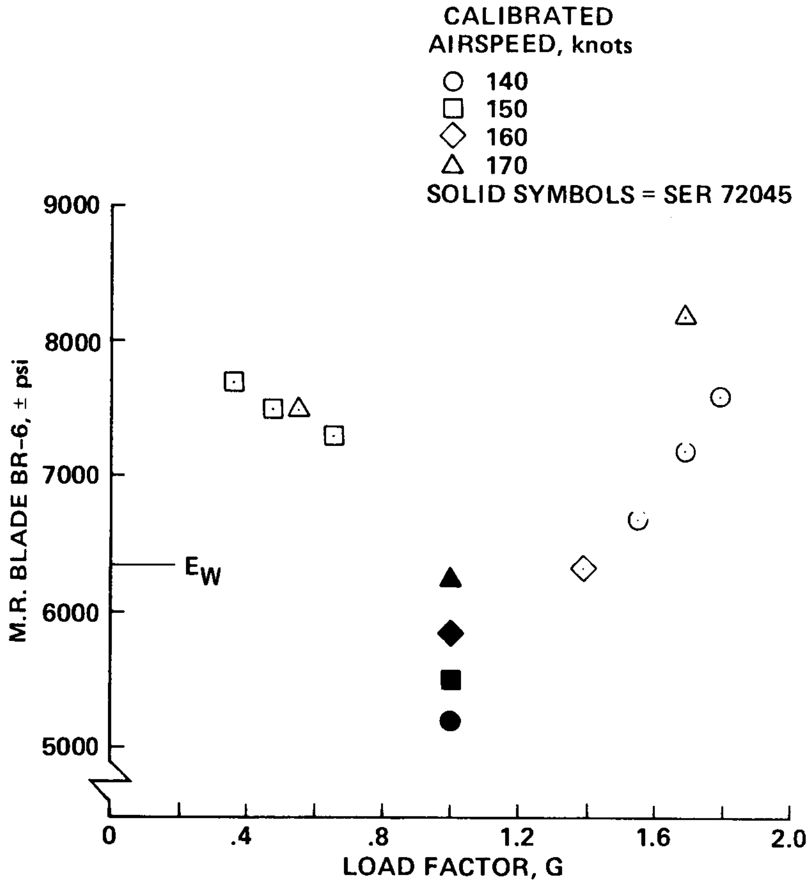


Figure 103.- Effect of load factor on main-rotor blade outboard BR-6 vibratory stress.

6. LOAD-CELL SYSTEM

The RSRA load-cell system consists of seven load cells that measure main-rotor forces and moments, six load cells that measure wing forces and moments, and one load cell that measures tail-rotor thrust. Figures 104 and 105 show the load-cell layout.

The vertical output from the calibrated main-rotor forces and moments load measuring system ZTRUE, is plotted versus calibrated airspeed (CAS) (figs. 107 and 108), showing the effects of collective and wing incidence on rotor thrust. ZTRUE is referenced to the main-rotor-shaft axis, positive pointing down, and excludes the blade-flapping mass. The trend shows a decrease in upward thrust with a decrease in collective and an increase in upward thrust with a decrease in wing incidence.

The wing-load measuring system has yet to be calibrated because of interferences with redundant fittings. A redesign is in process to resolve this problem. In order to trend the wing lift, the sum of the four vertical wing load cells was plotted versus CAS (figs. 109 and 110). Wing lift was mainly dependent on wing angle, being only slightly affected by rotor collective position.

The effect that the collective has on individual main-rotor and tail-rotor load-cells (figs. 111-118) shows only negligible subsequent effect on vibratory loads. The drag load-cell is the only load cell that exceeds the newly established endurance limits. The main-rotor and tail-rotor load-cells steady loads show a decrease in force with a decrease in collective except for the drag load-cell.

The effect that the collective has on individual wing load-cells (figs. 119-124) shows only negligible subsequent effect on vibratory loads. The vibratory loads of all the wing load-cells are below endurance limits.

The effect of wing incidence on the main rotor and tail rotor load cells are plotted versus CAS in figures 125-132. Again, no significant changes in vibratory loads are shown except for the tail-rotor load-cell, which shows lower vibration with lower wing incidences. The latter was caused by the change in main-rotor tip-path plane relative to the airframe and consequently the probable impact area of the tip vortex.

The steady load of the four main-rotor vertical load cells increased with a decrease in wing incidence. The steady loads of the main-rotor lateral/torque load cells and the tail-rotor load cells decrease with a lower wing incidence, indicating lower torque requirements. The drag load-cell is not affected by changes in wing incidence.

The effect of wing incidence on the wing load-cells is plotted versus CAS in figures 133-138. The wing biaxial load-cells show a decrease in vibratory loads with a decrease in wing incidence. The wing actuator load-cells also show a decrease in vibratory load with a decrease in wing incidence from 10° to 5°, but the vibratory loads increase with a further decrease in wing incidence from 5° to 0°.

The redundancy of the wing-load measuring system, interference with redundant fittings, and drift in the actuator cylinders make it difficult to predict individual load-cell response; as a result, only a general statement of individual load-cell response can be made. The general trend of the individual load cells is to decrease in steady load with a decrease in wing incidence.

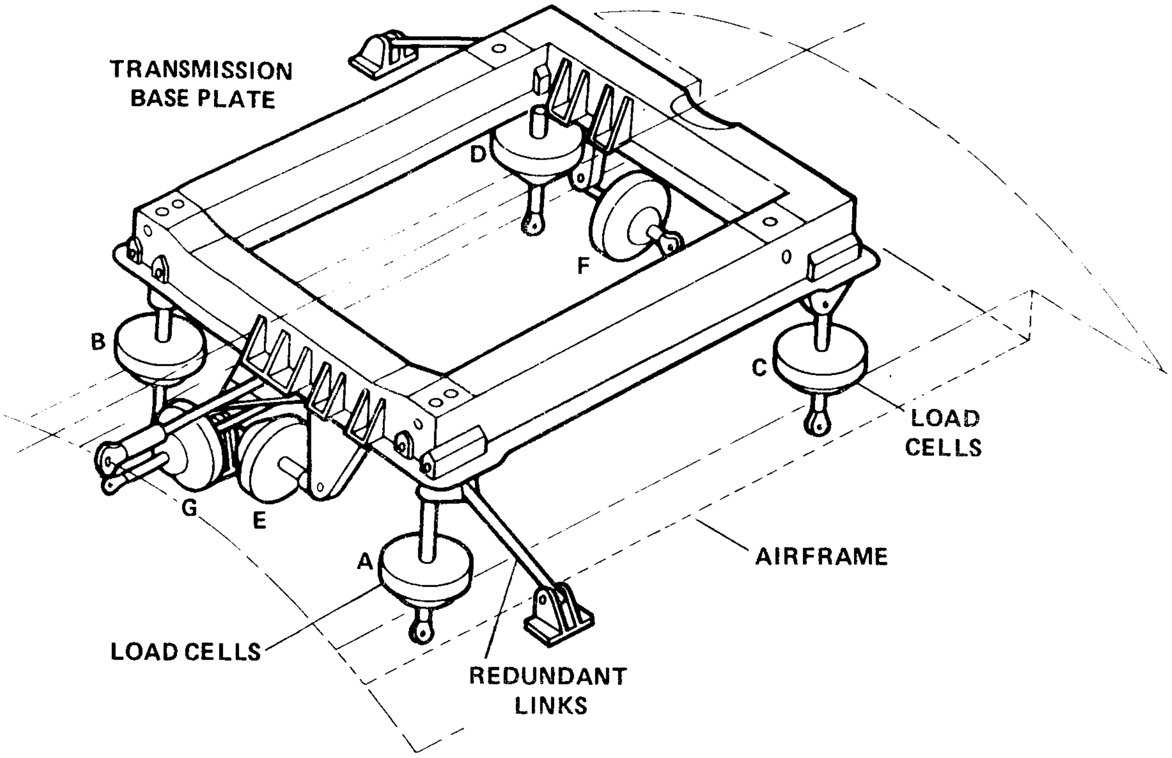


Figure 104.- Baseline load-cell system.

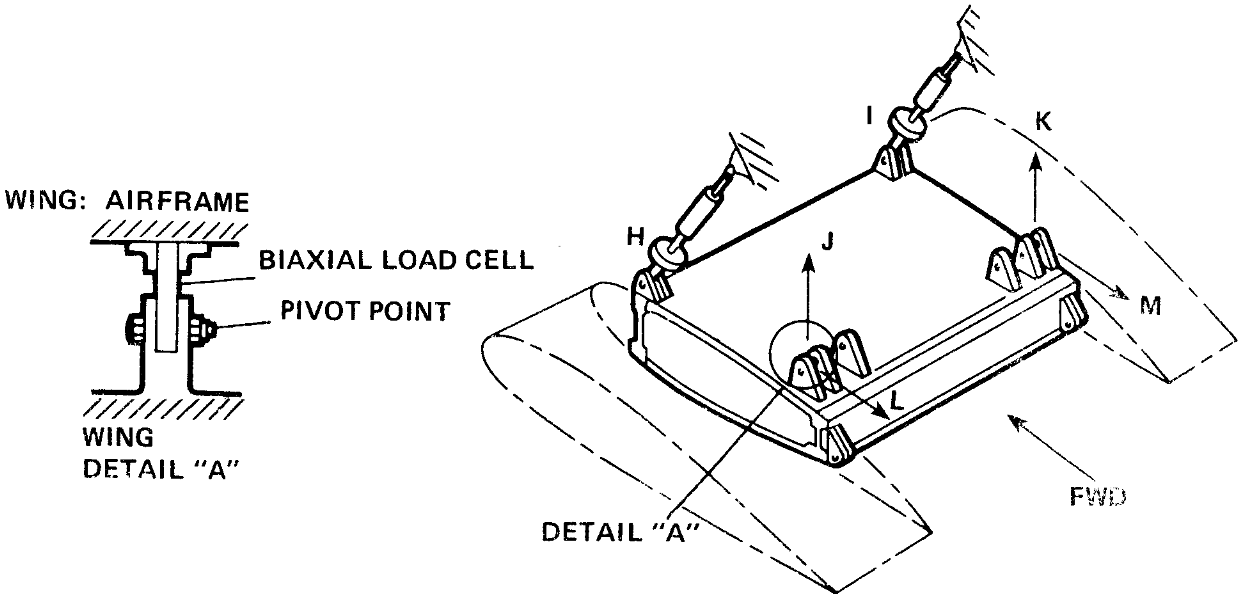


Figure 105.- Wing-force measurement configuration.

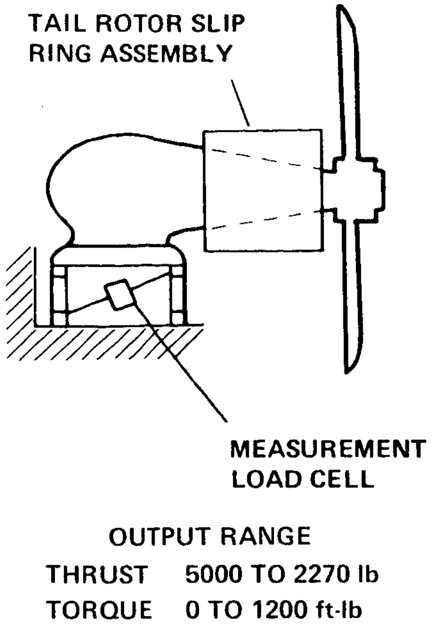


Figure 106.- Tail-rotor thrust measurement systems configuration.

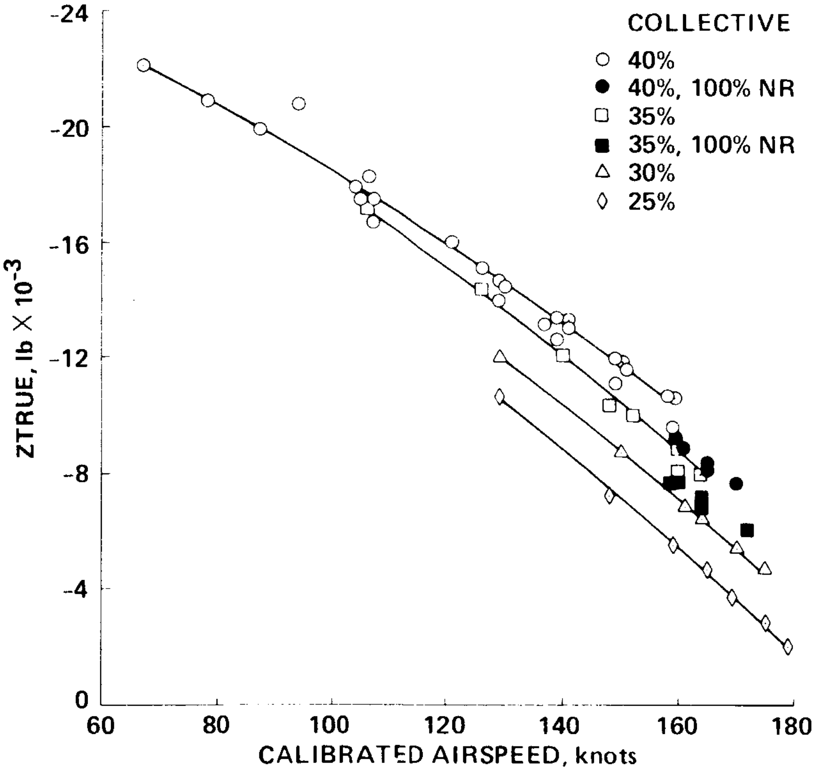


Figure 107.- Effect of collective on ZTRUE versus calibrated airspeed for 10° wing angle.

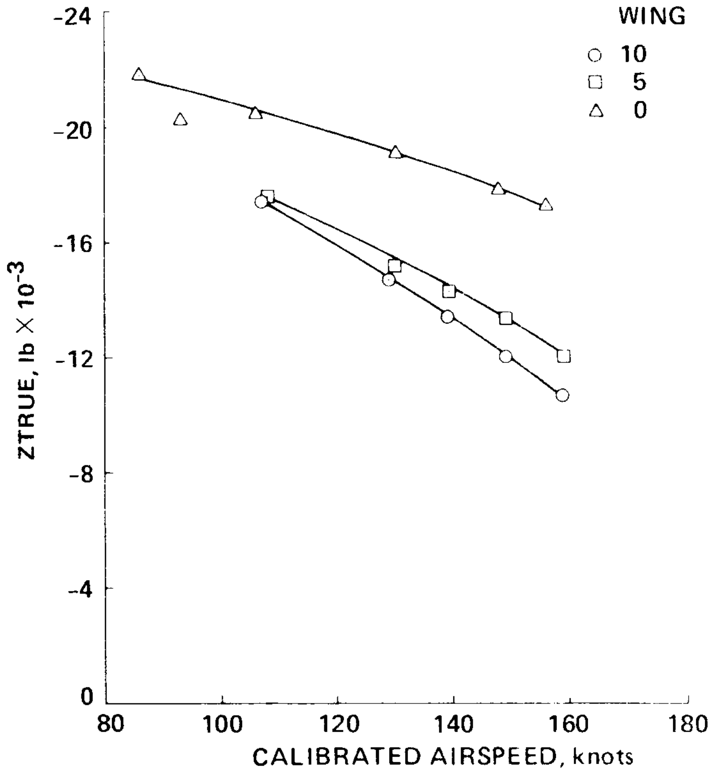


Figure 108.- Effect of wing incidence on ZTRUE versus calibrated airspeed: 40% collective.

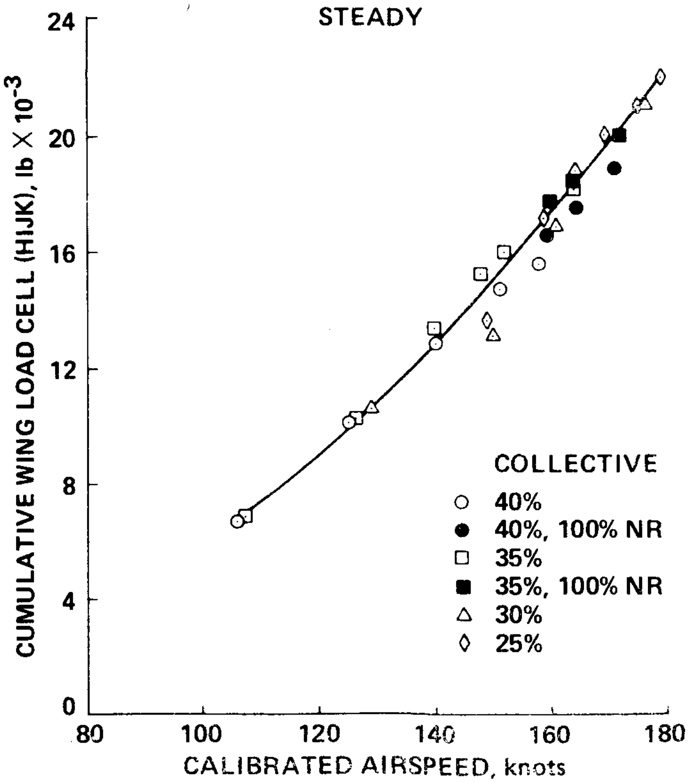


Figure 109.- Effect of collective on cumulative wing lift load cells versus calibrated airspeed: 10° wing angle.

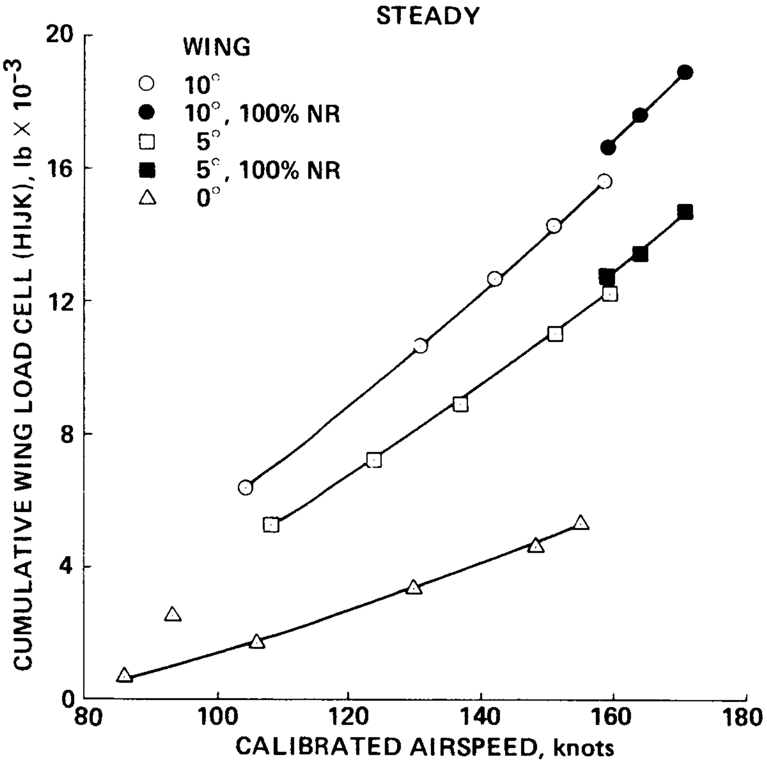


Figure 110.- Effect of wing incidence on cumulative wing lift load cells versus calibrated airspeed: 40% collective.

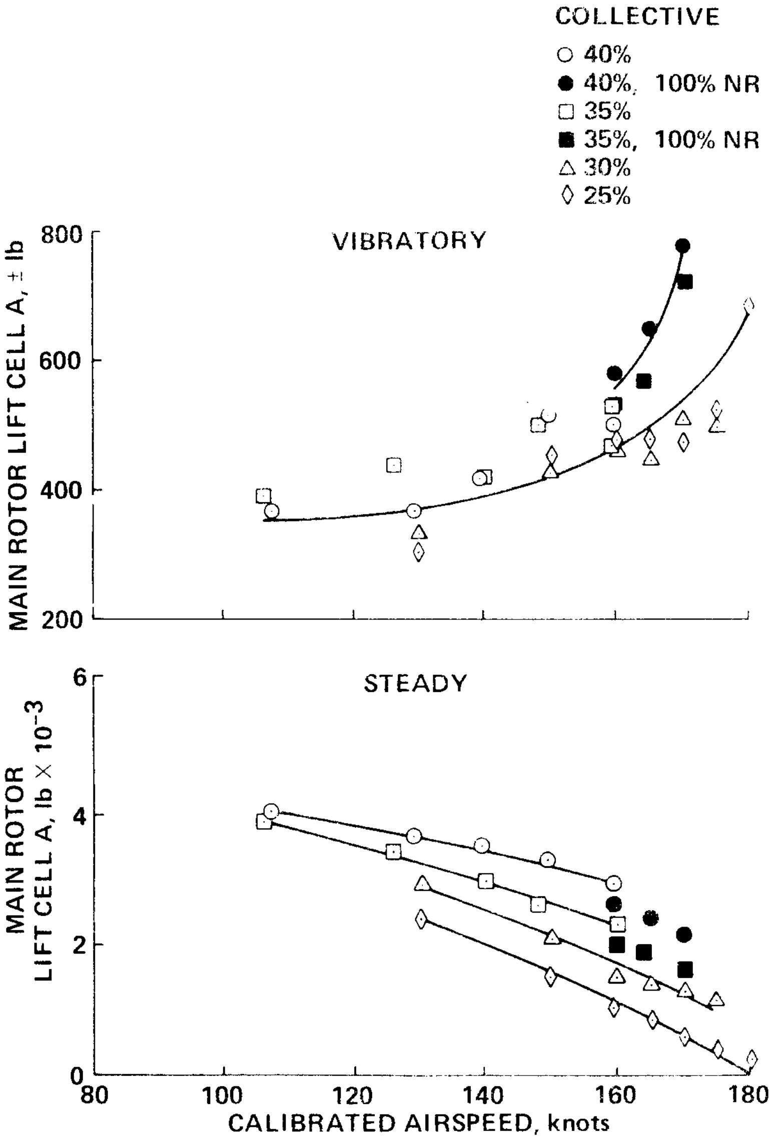


Figure 111.- Effect of collective on left forward load cell versus calibrated airspeed: 10° wing angle.

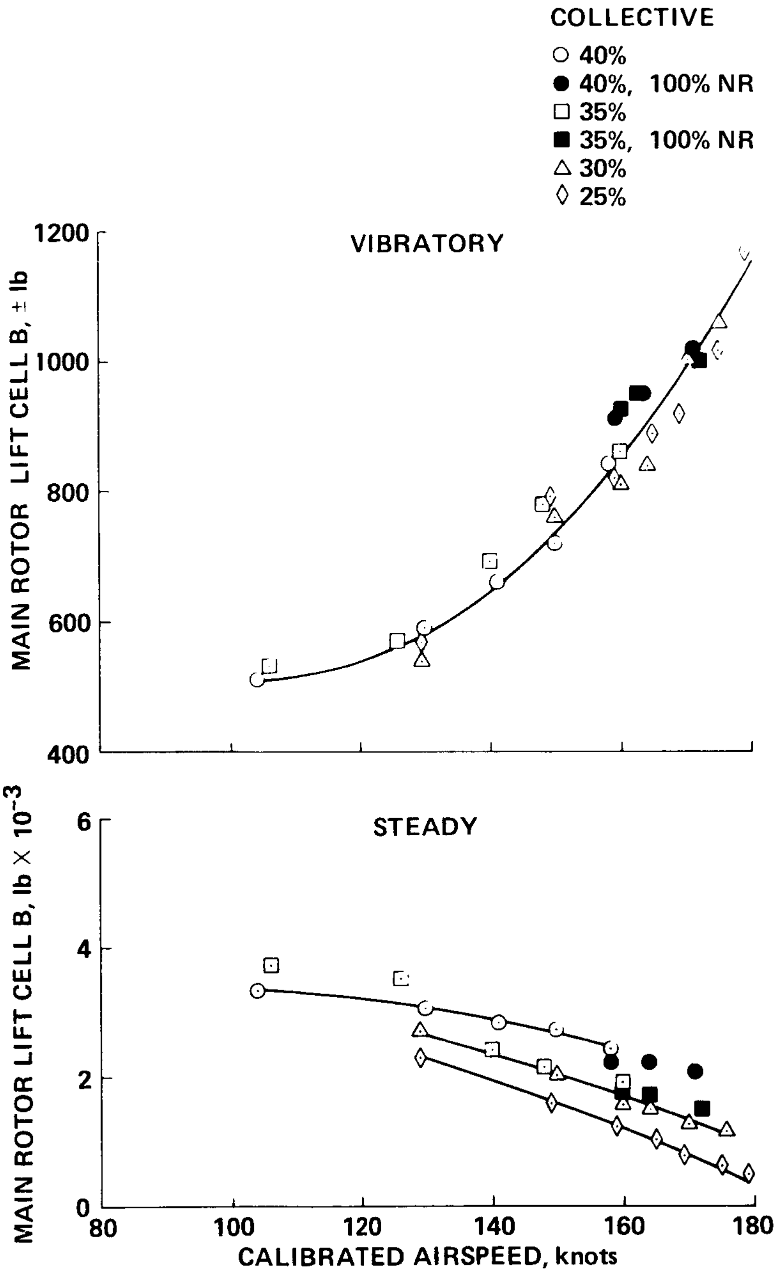


Figure 112.- Effect of collective on right forward vertical load cell versus calibrated airspeed: 10° wing angle.

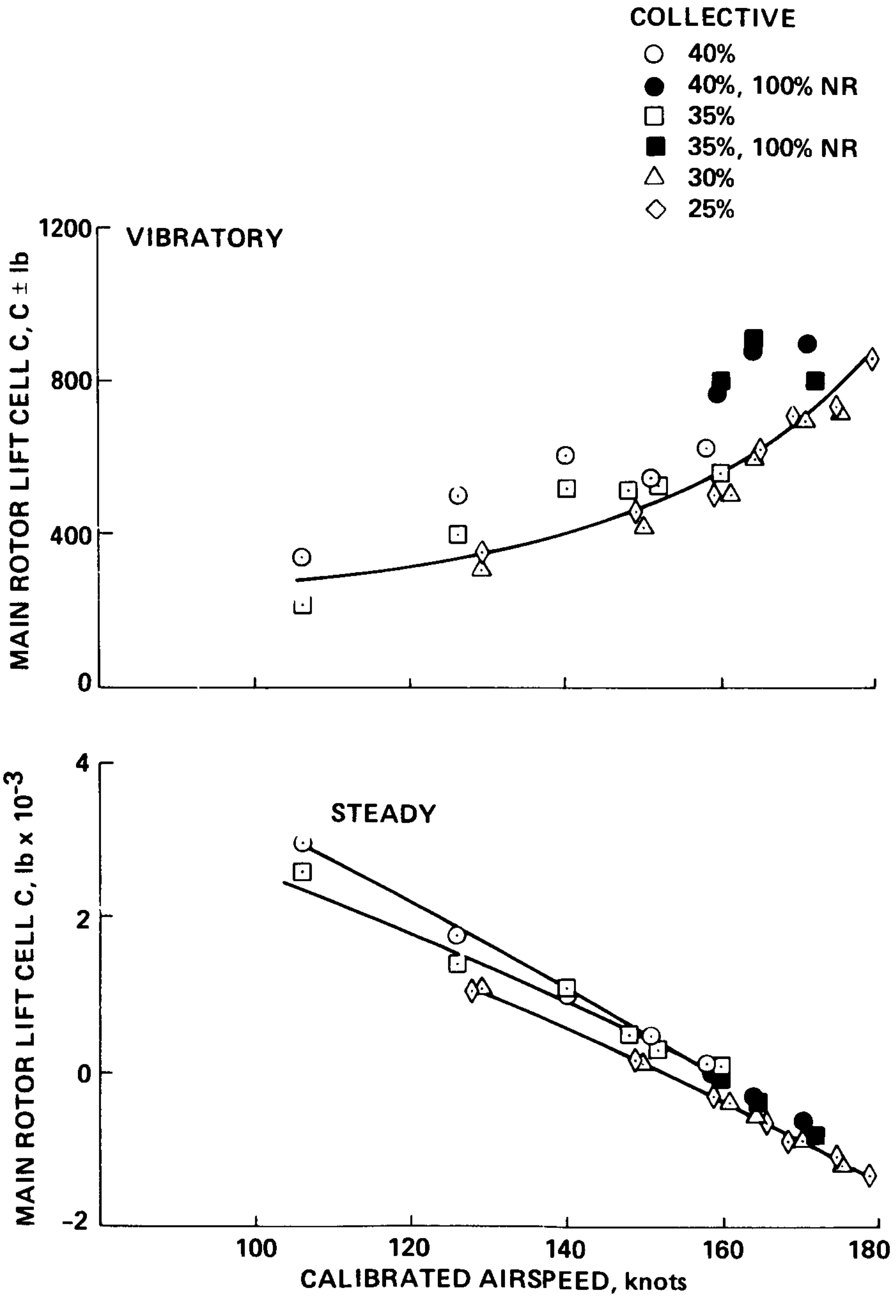


Figure 113.- Effect of collective on left aft vertical load cell versus calibrated airspeed: 10° wing angle.

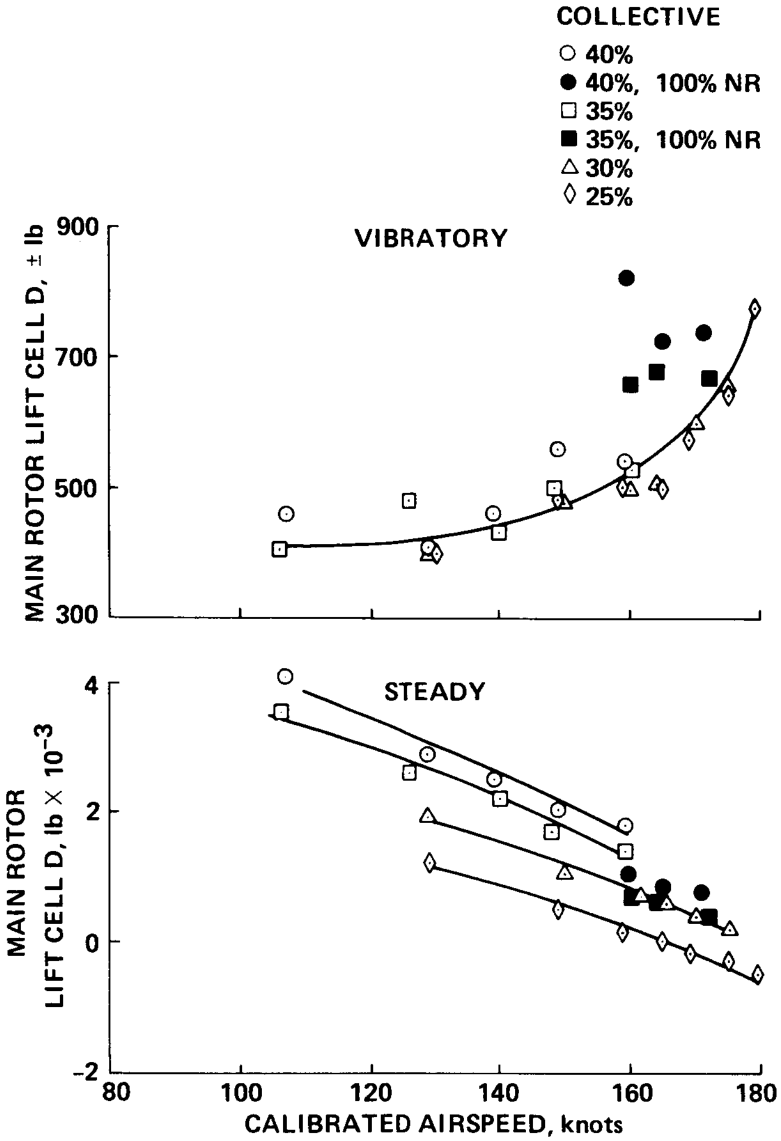


Figure 114.- Effect of collective on right aft vertical load cell versus calibrated airspeed: 10° wing angle.

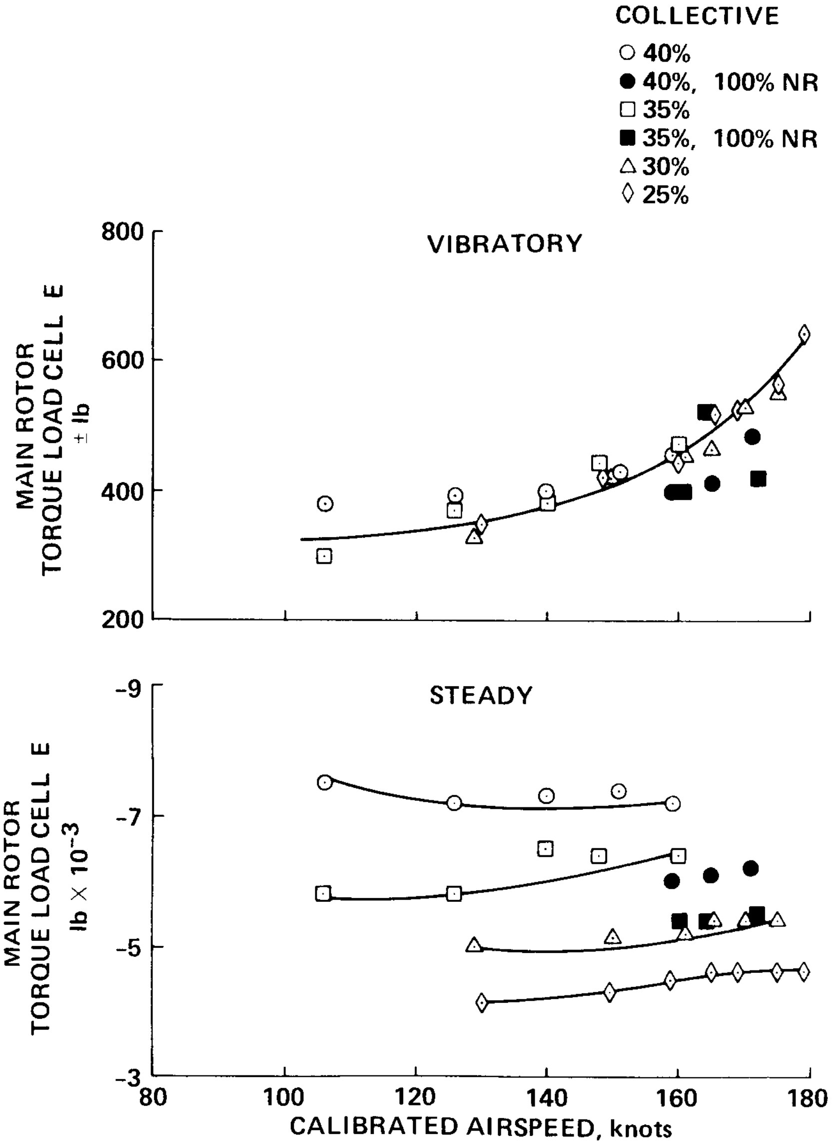


Figure 115.- Effect of collective on forward lateral load cell versus calibrated airspeed: 10° wing angle.

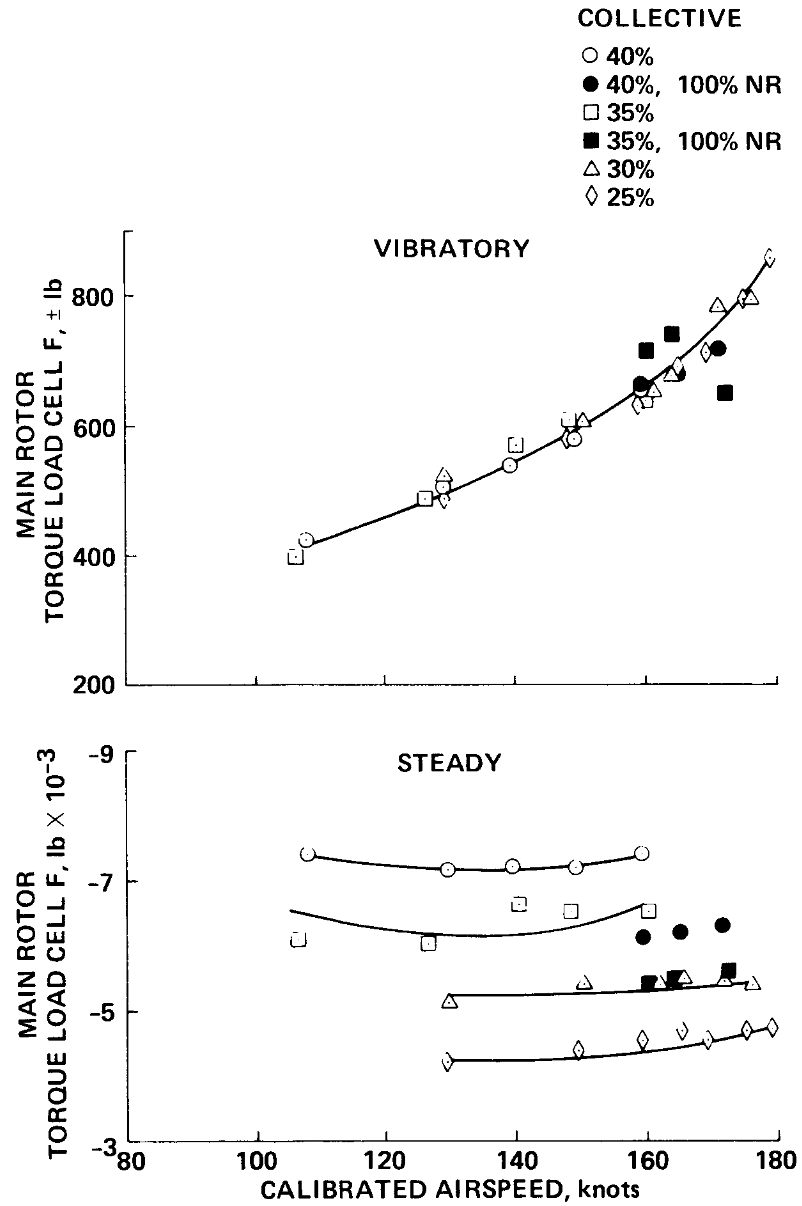


Figure 116.- Effect of collective on aft lateral load cell versus calibrated airspeed: 10° wing angle.

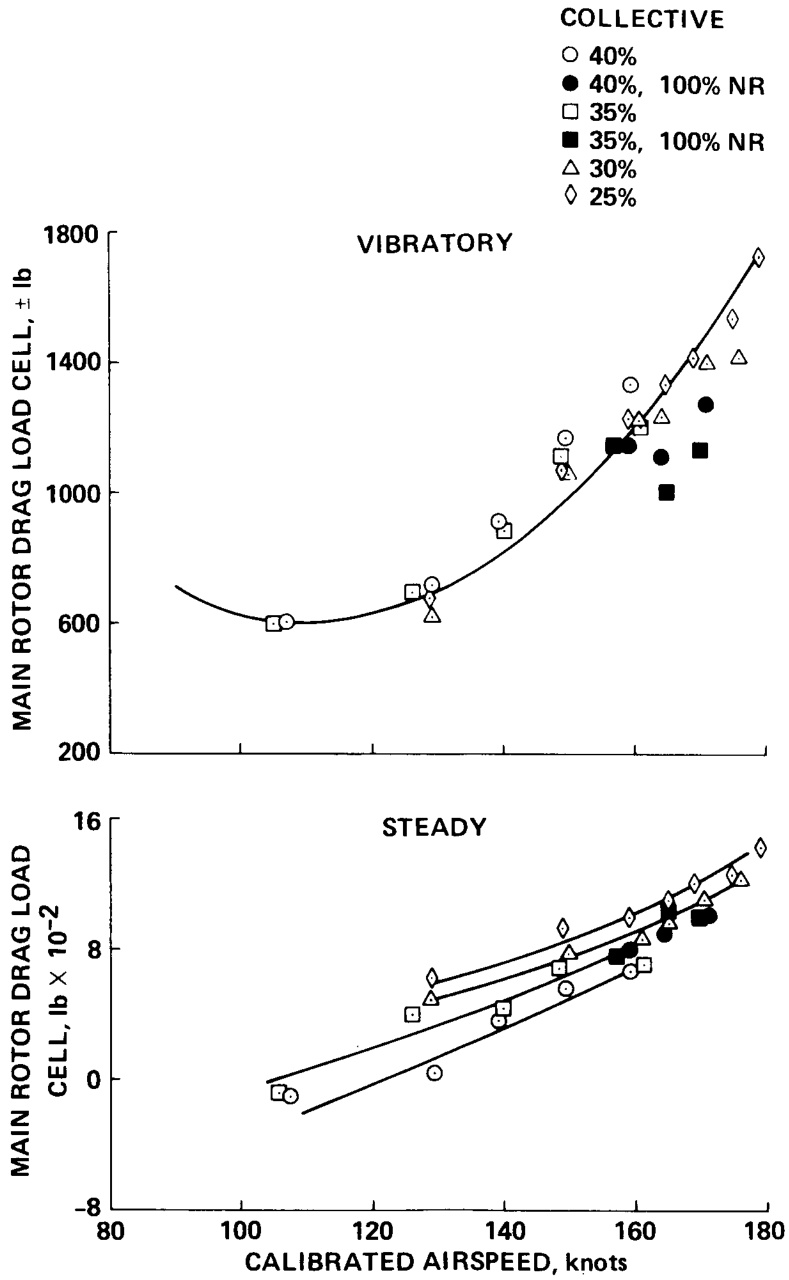


Figure 117.- Effect of collective on drag load cell versus calibrated airspeed: 10° wing angle.

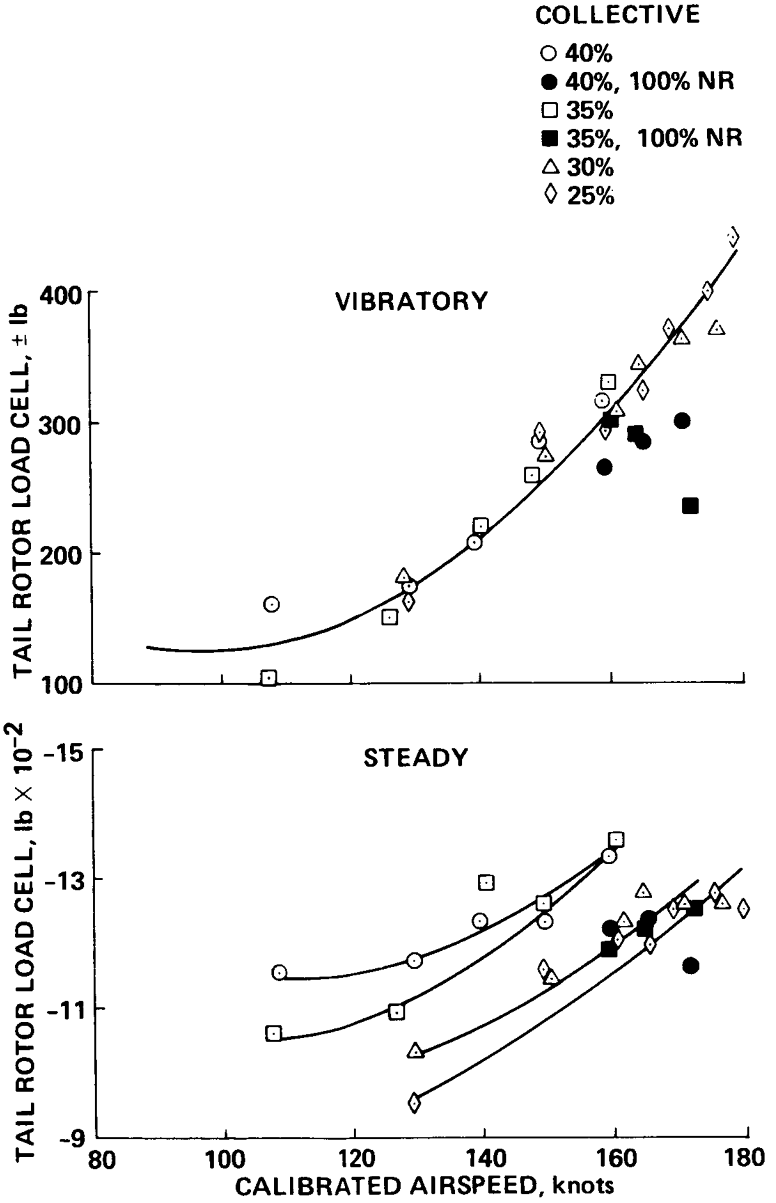


Figure 118.- Effect of collective on tail-rotor thrust load cell versus calibrated airspeed: 10° wing angle.

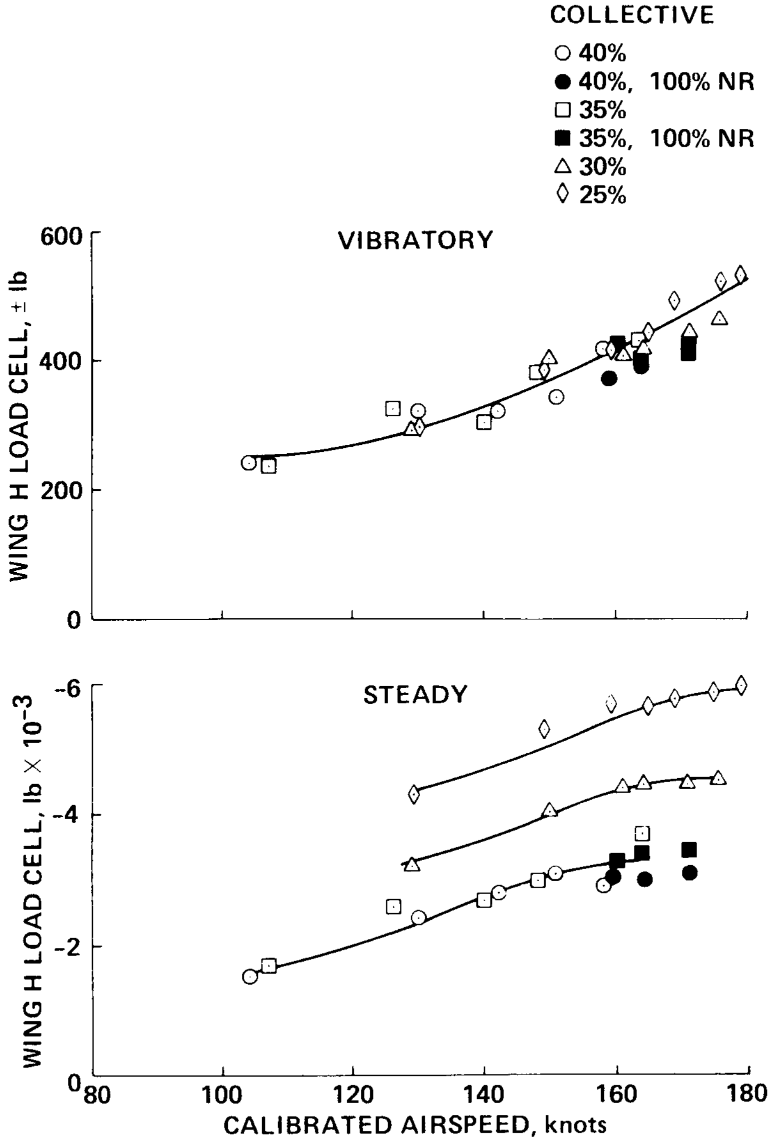


Figure 119.- Effect of collective on left actuator wing load cell versus calibrated airspeed: 10° wing angle.

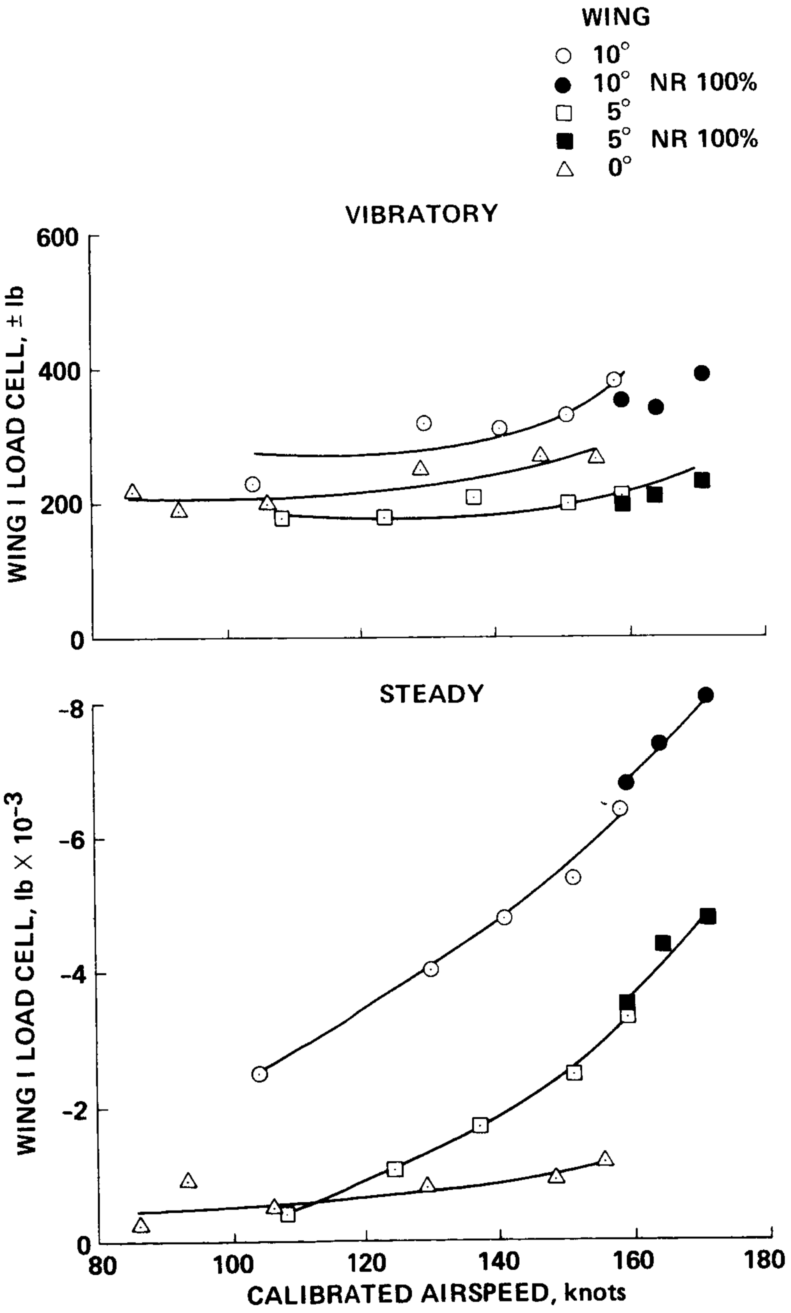


Figure 120.- Effect of wing incidence on right actuator wing load cell versus calibrated airspeed: 40% collective.

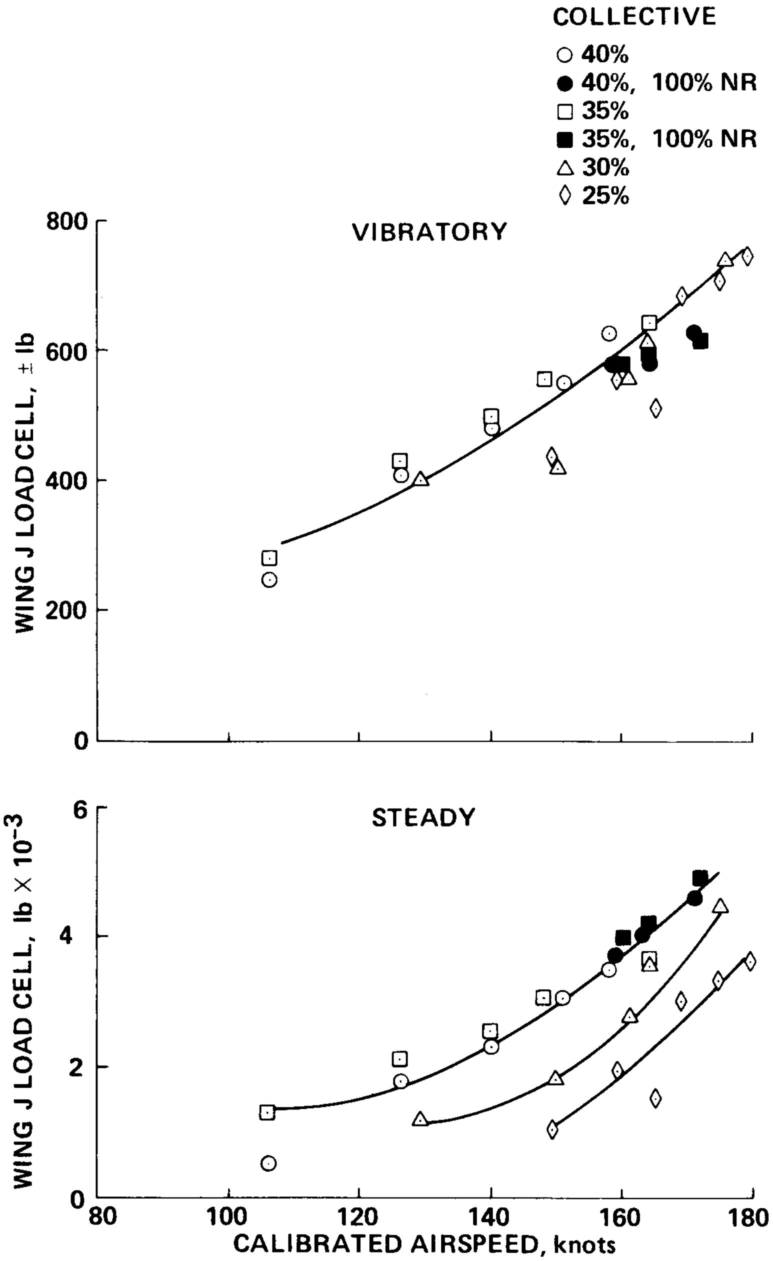


Figure 121.- Effect of collective on left lift biaxial load cell versus calibrated airspeed: 10° wing angle.

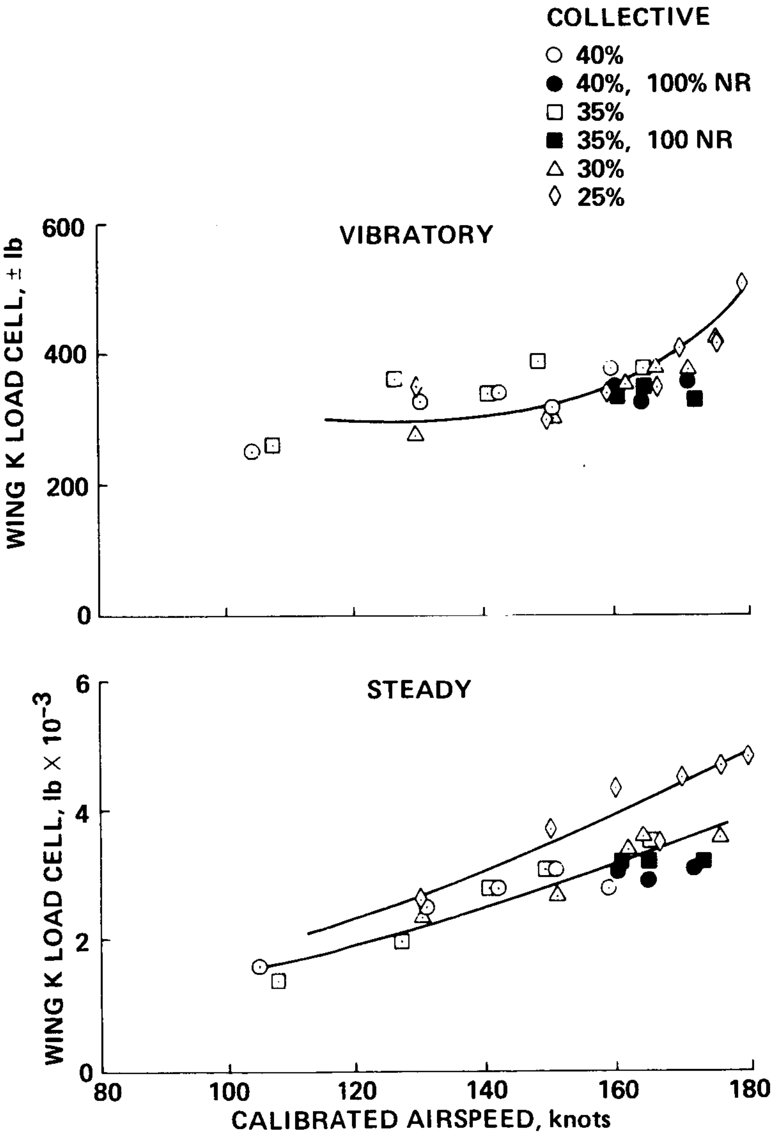


Figure 122.- Effect of collective on right lift biaxial load cell versus calibrated airspeed: 10° wing angle.

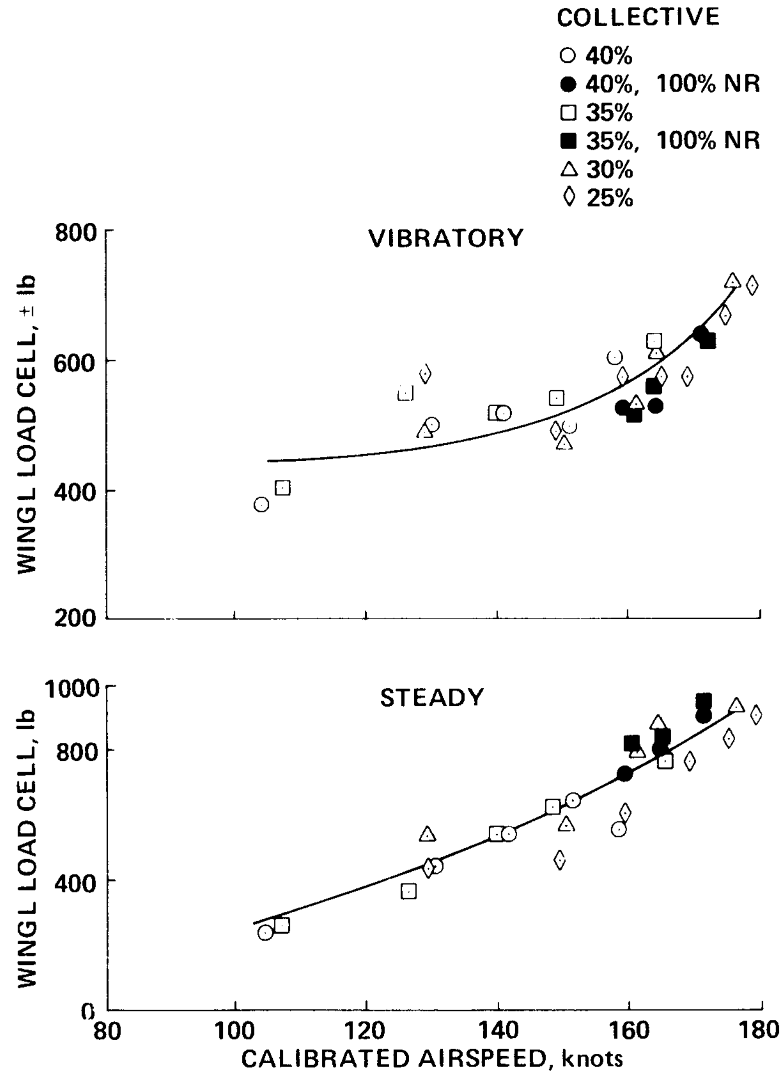


Figure 123.- Effect of collective on left drag biaxial load cell versus calibrated airspeed: 10° wing angle.

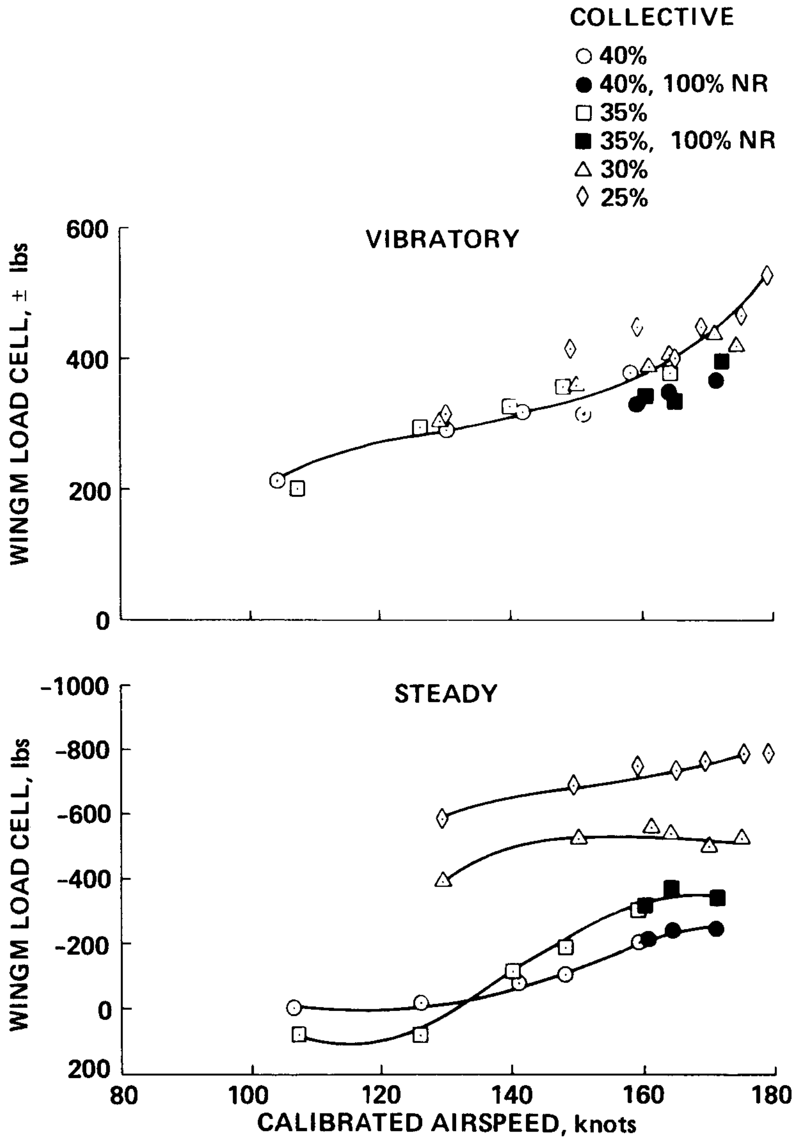


Figure 124.- Effect of collective on right wing drag biaxial load cell versus calibrated airspeed: 10° wing angle.

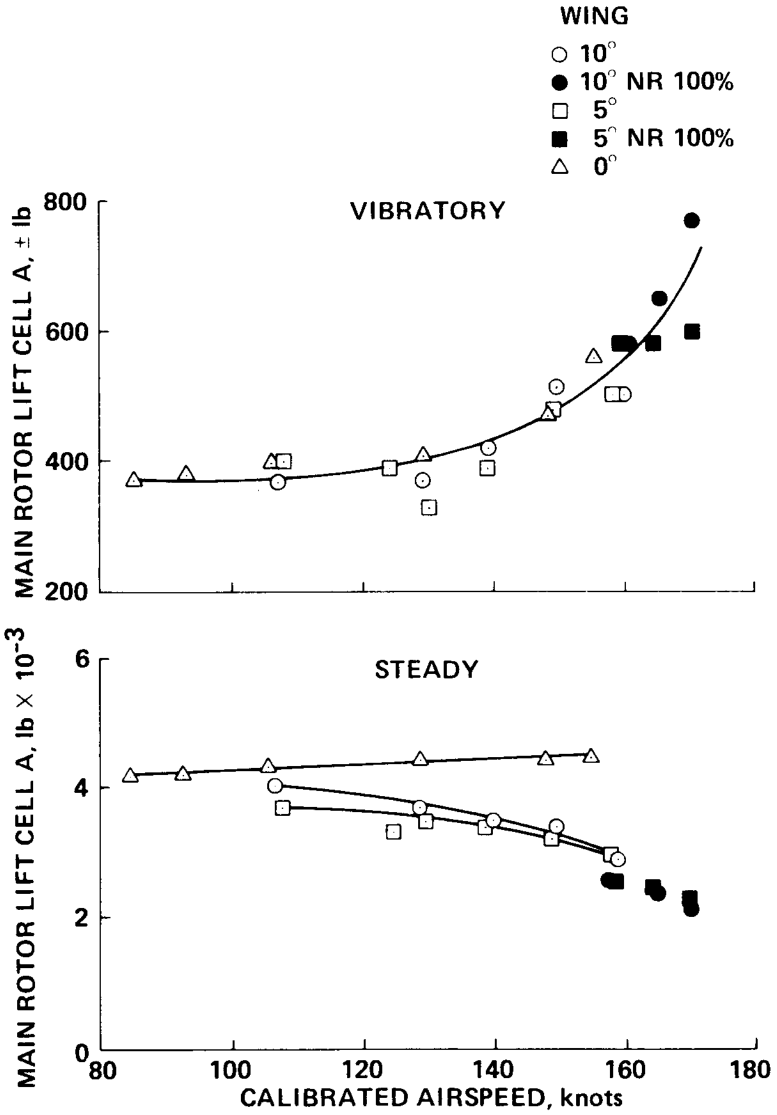


Figure 125.- Effect of wing incidence on left forward vertical load cell versus calibrated airspeed: 40% collective.

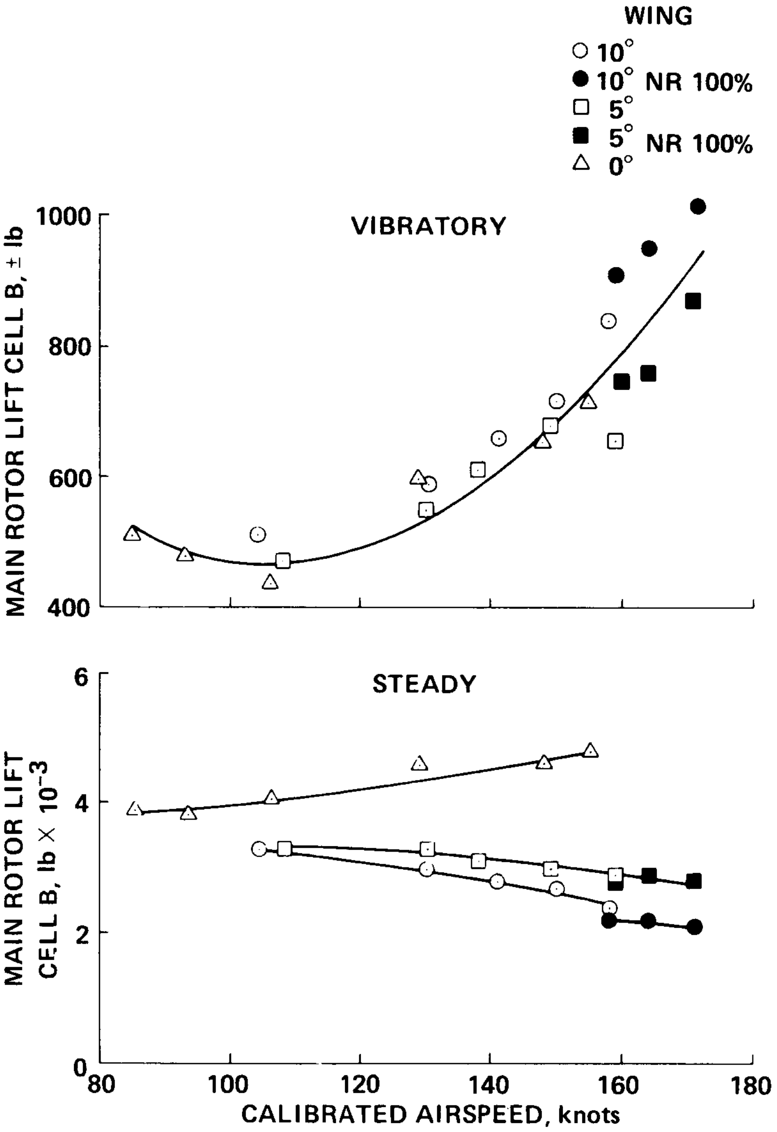


Figure 126.- Effect of wing incidence on right forward vertical load cell versus calibrated airspeed: 40% collective.

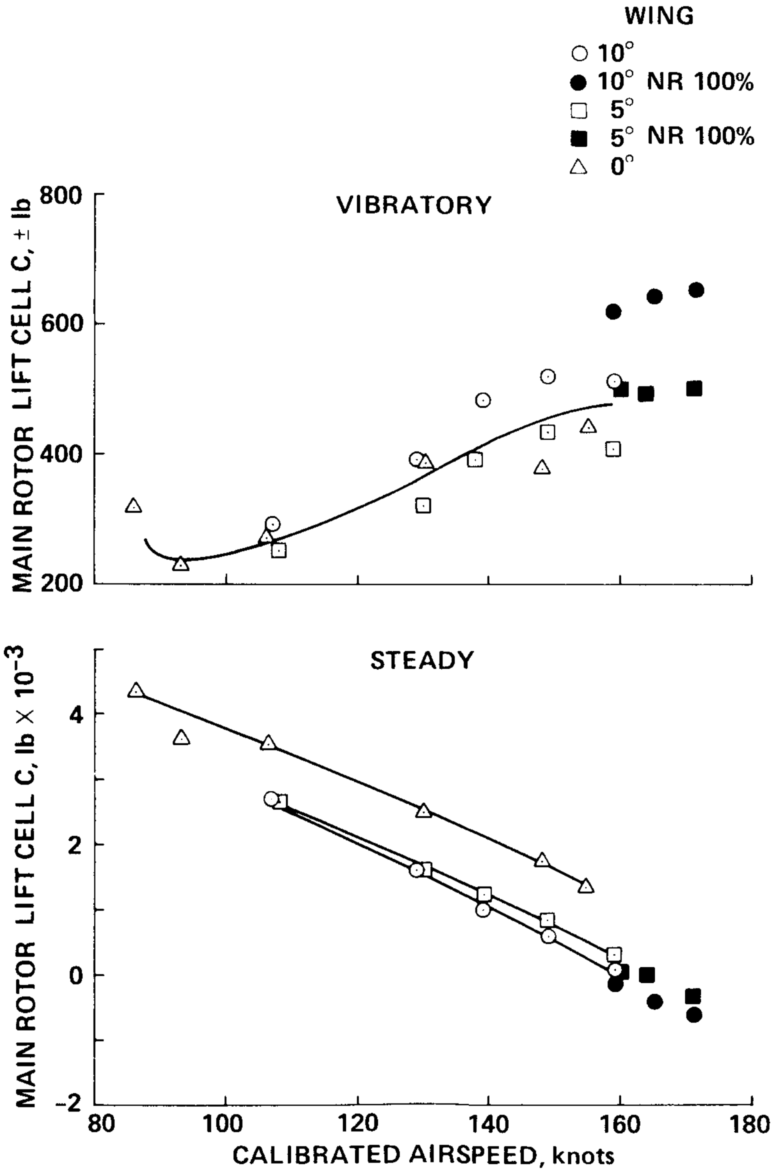


Figure 127.- Effect of wing incidence on left aft vertical load cell versus calibrated airspeed: 40% collective.

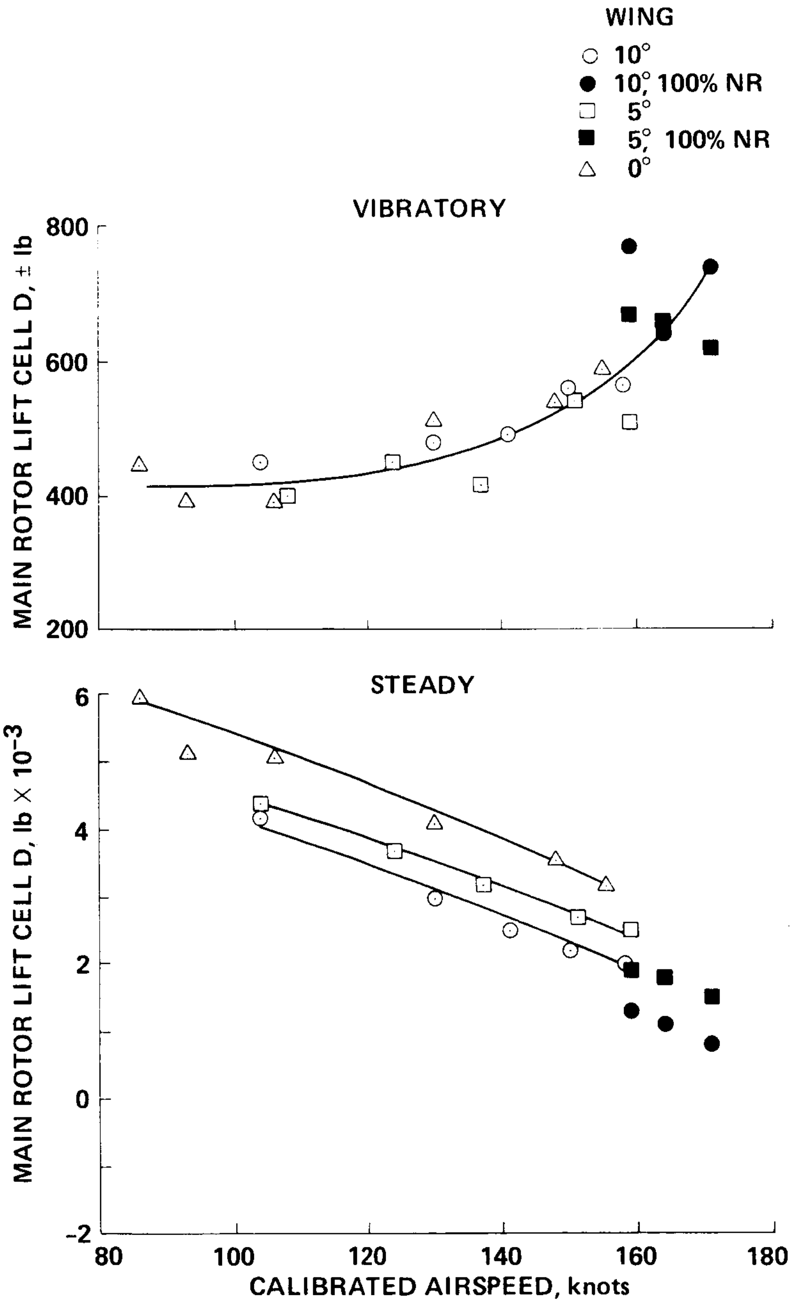


Figure 128.- Effect of wing incidence on right aft vertical load cell versus calibrated airspeed; 40% collective.

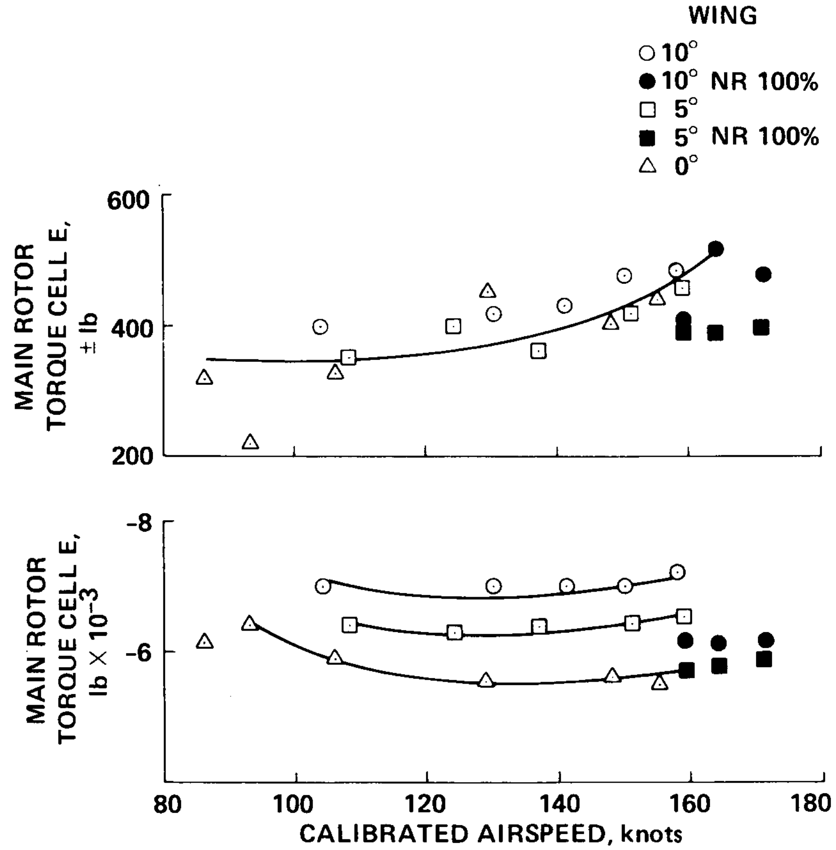


Figure 129.- Effect of wing incidence on forward lateral load cell versus calibrated airspeed: 40% collective.

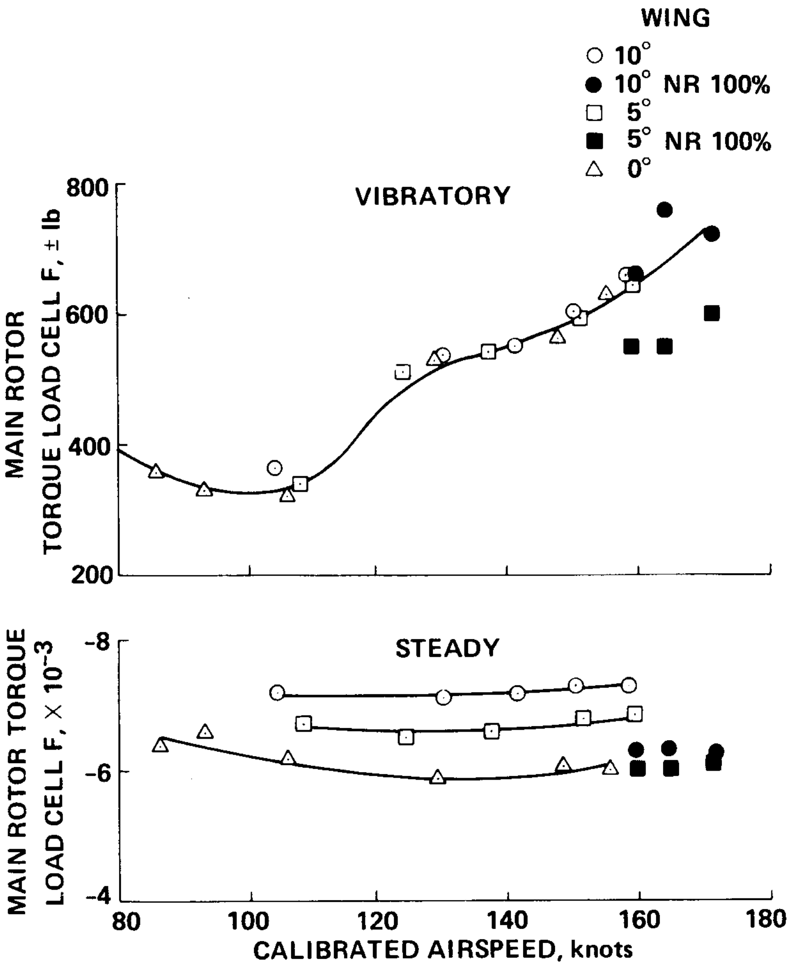


Figure 130.- Effect of wing incidence on aft lateral load cell versus calibrated airspeed: 40% collective.

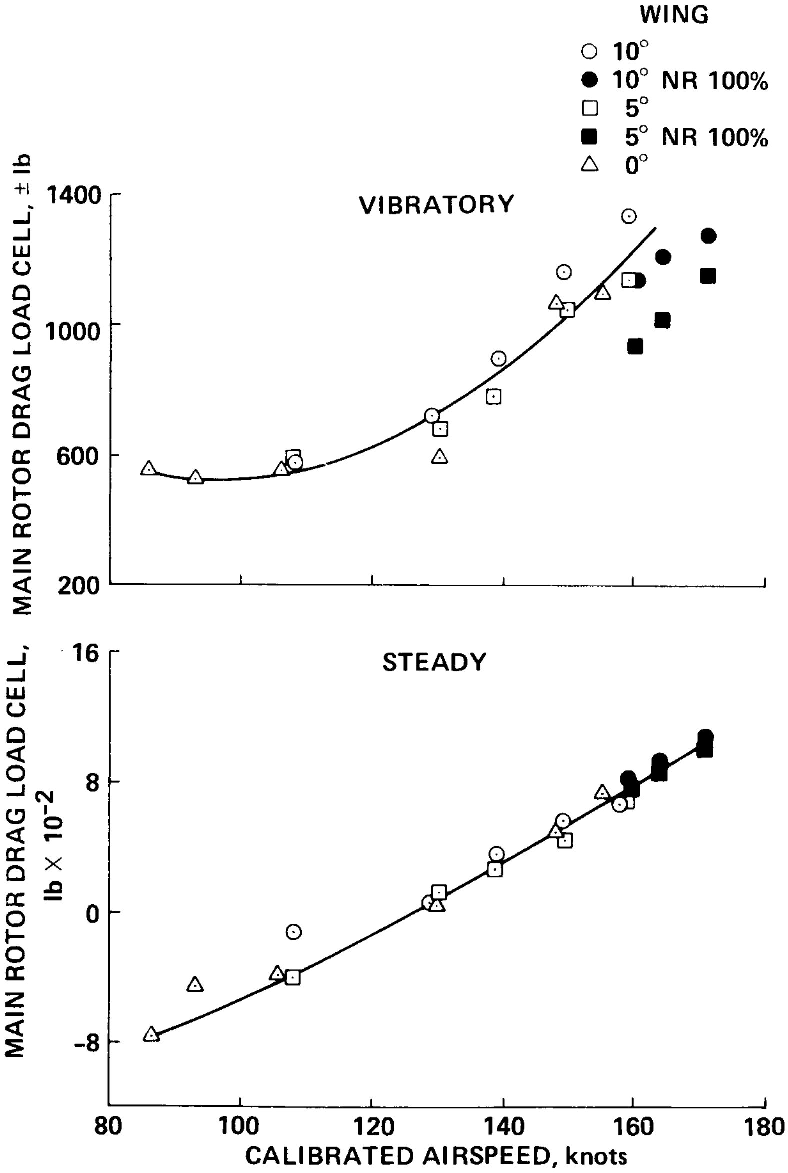


Figure 131.- Effect of wing incidence on drag load cell versus calibrated airspeed: 40% collective.

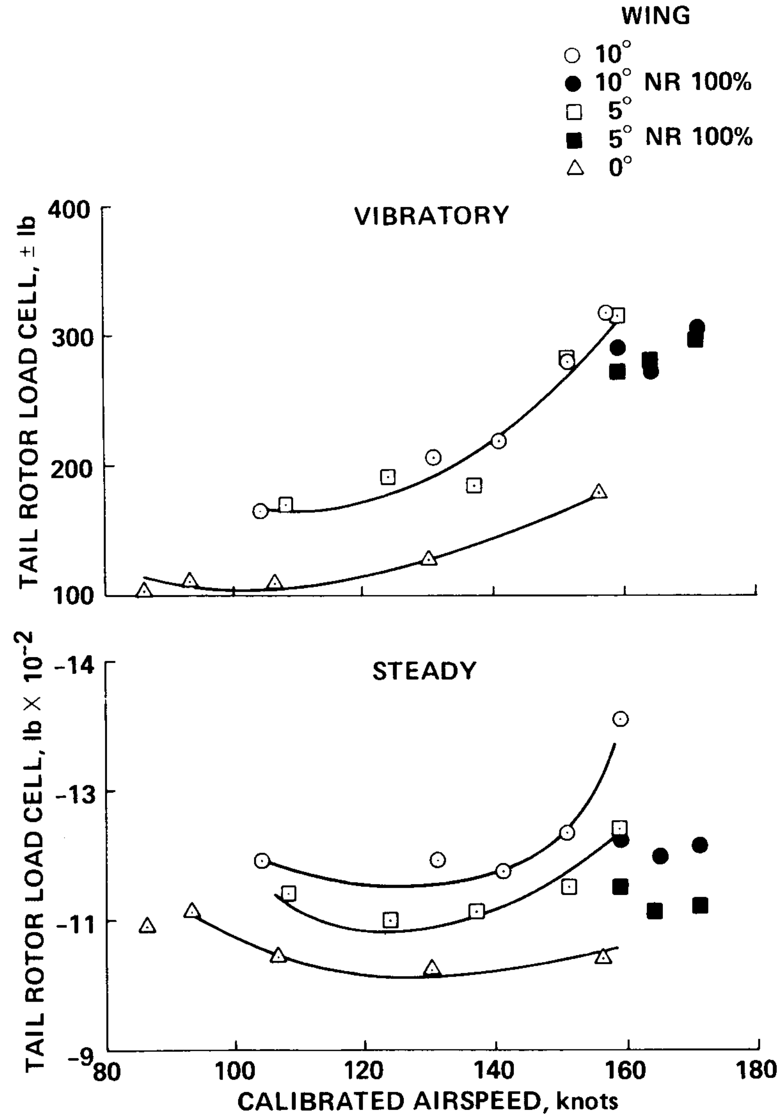


Figure 132.- Effect of wing incidence on tail-rotor thrust load cell versus calibrated airspeed: 40% collective.

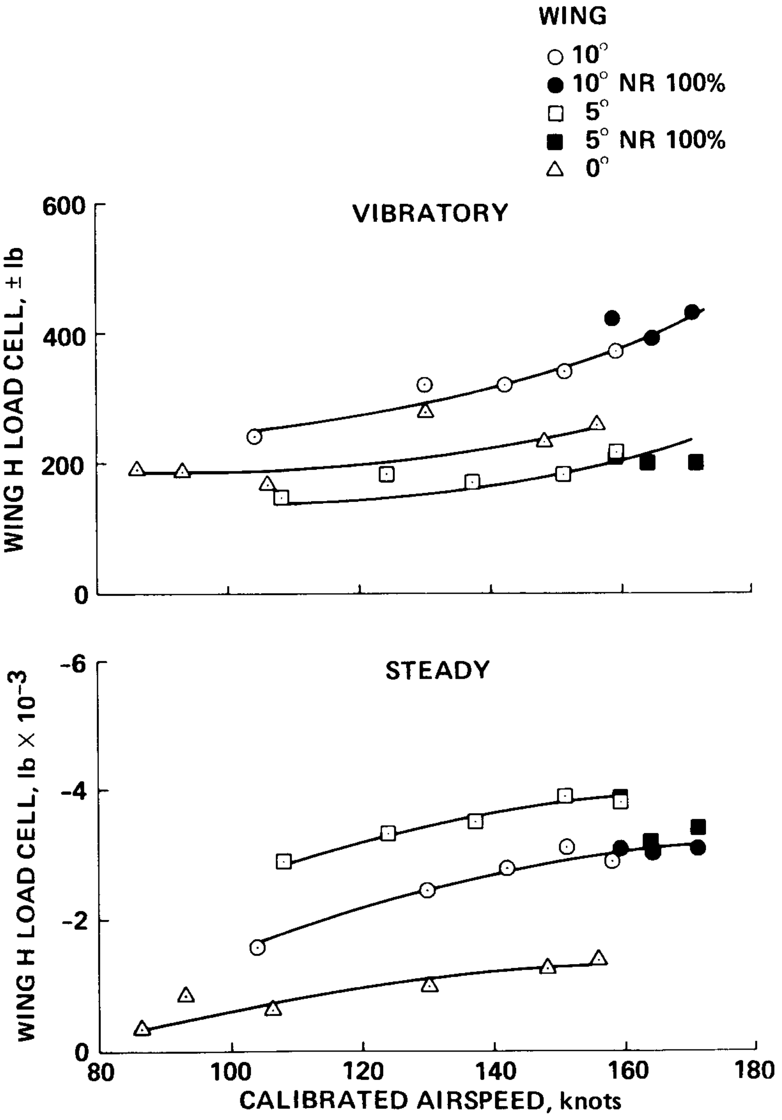


Figure 133.- Effect of wing incidence on left actuator wing load cell versus calibrated airspeed: 40% collective.

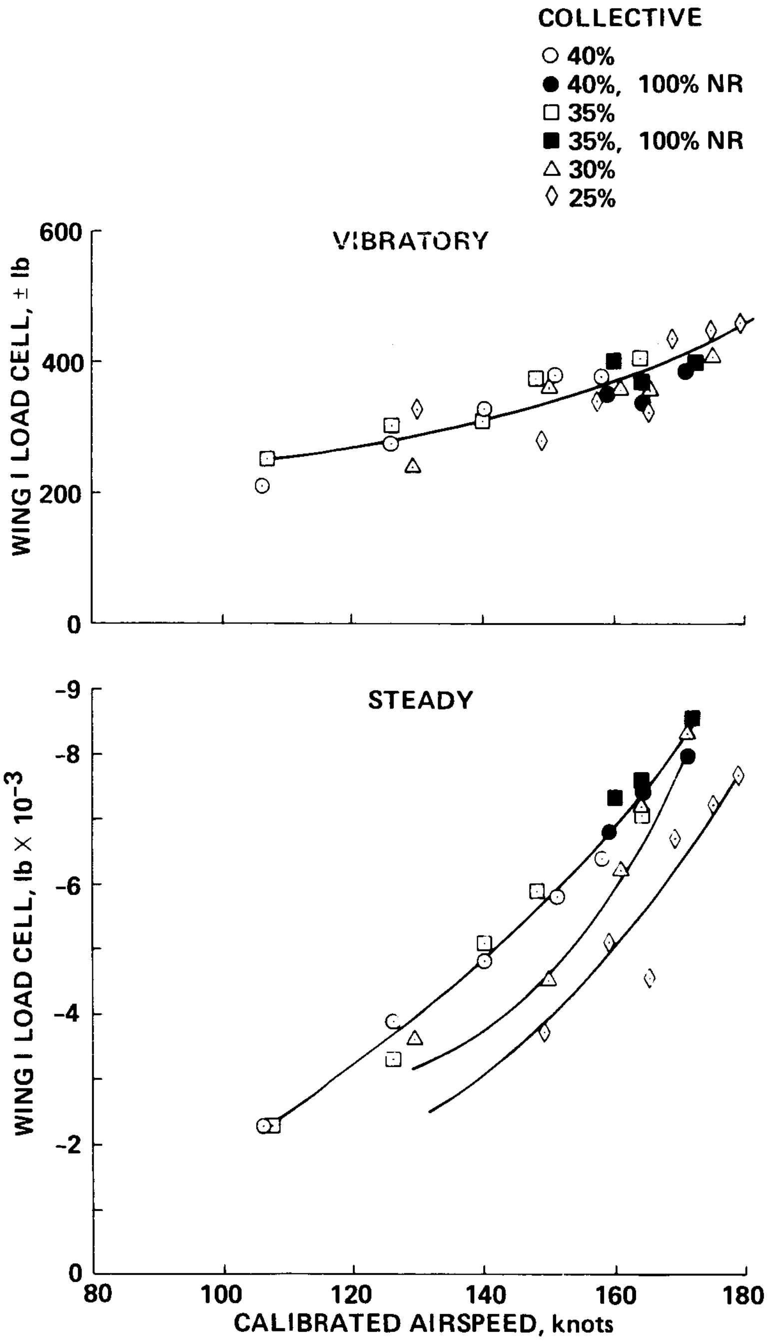


Figure 134.- Effect of collective on right actuator wing load cell versus calibrated airspeed: 10° wing angle.

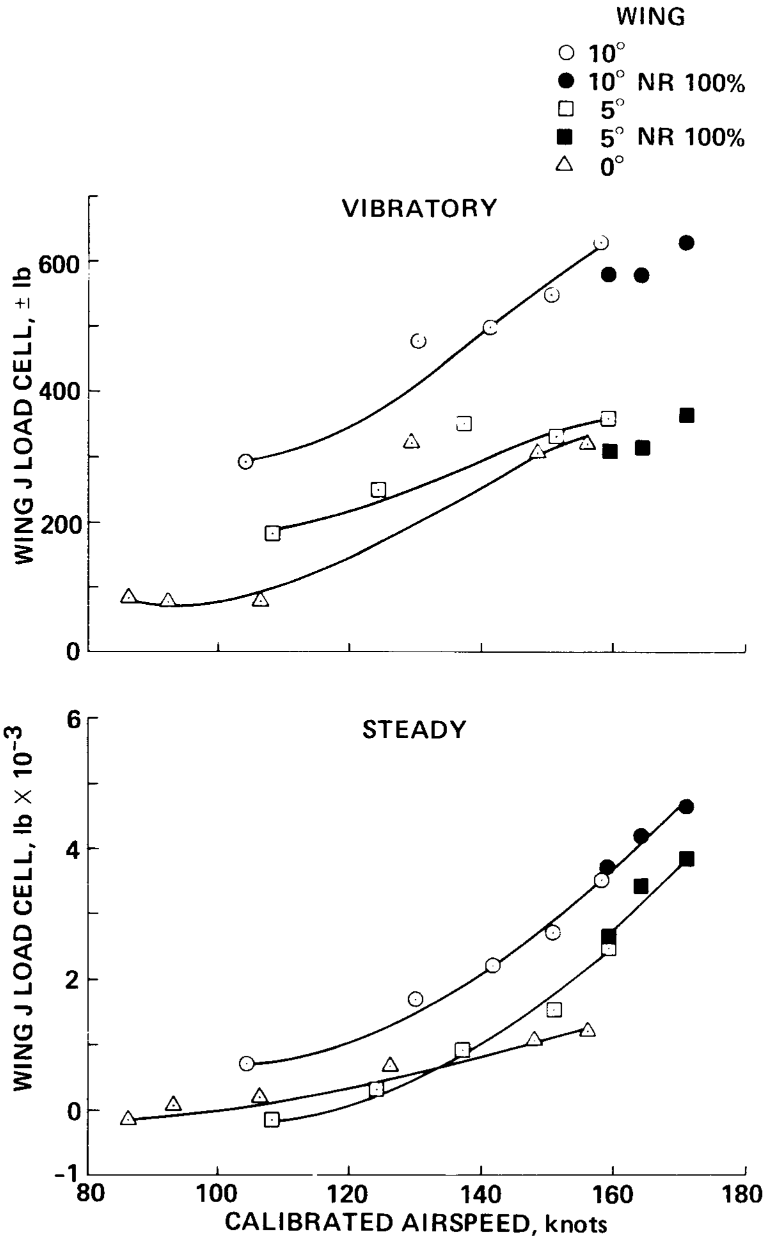


Figure 135.- Effect of wing incidence on left lift biaxial load cell versus calibrated airspeed: 40% collective.

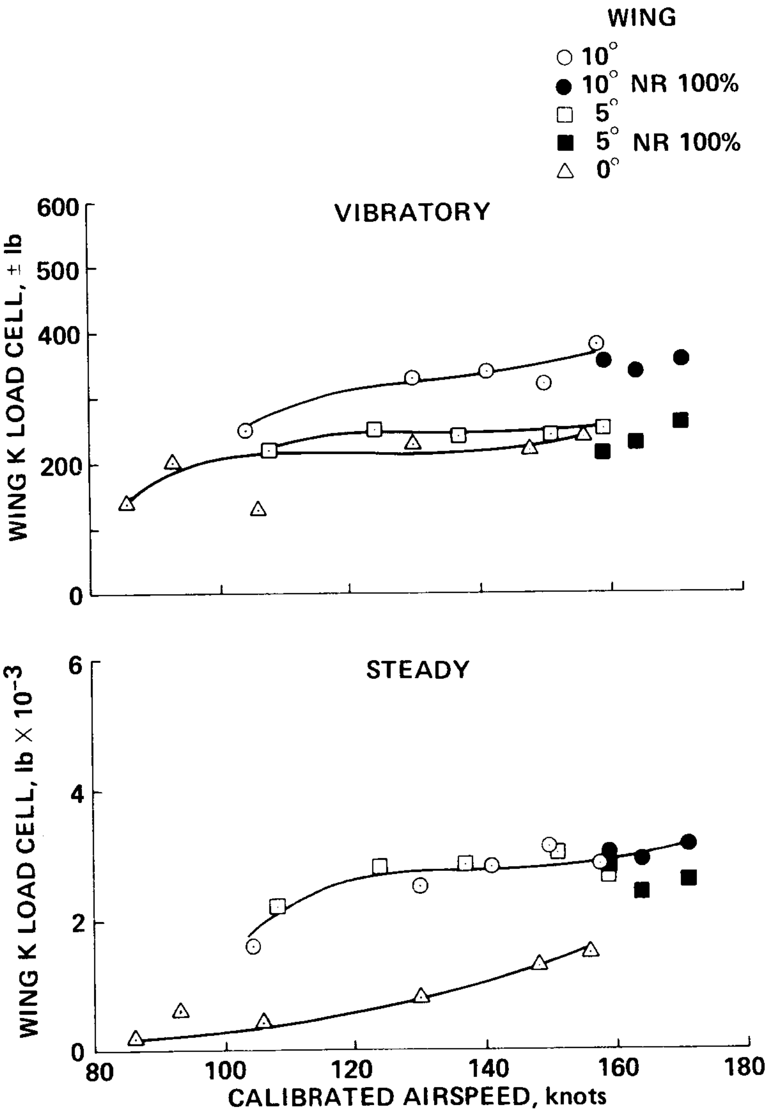


Figure 136.- Effect of wing incidence on right lift biaxial load cell versus calibrated airspeed: 40% collective.

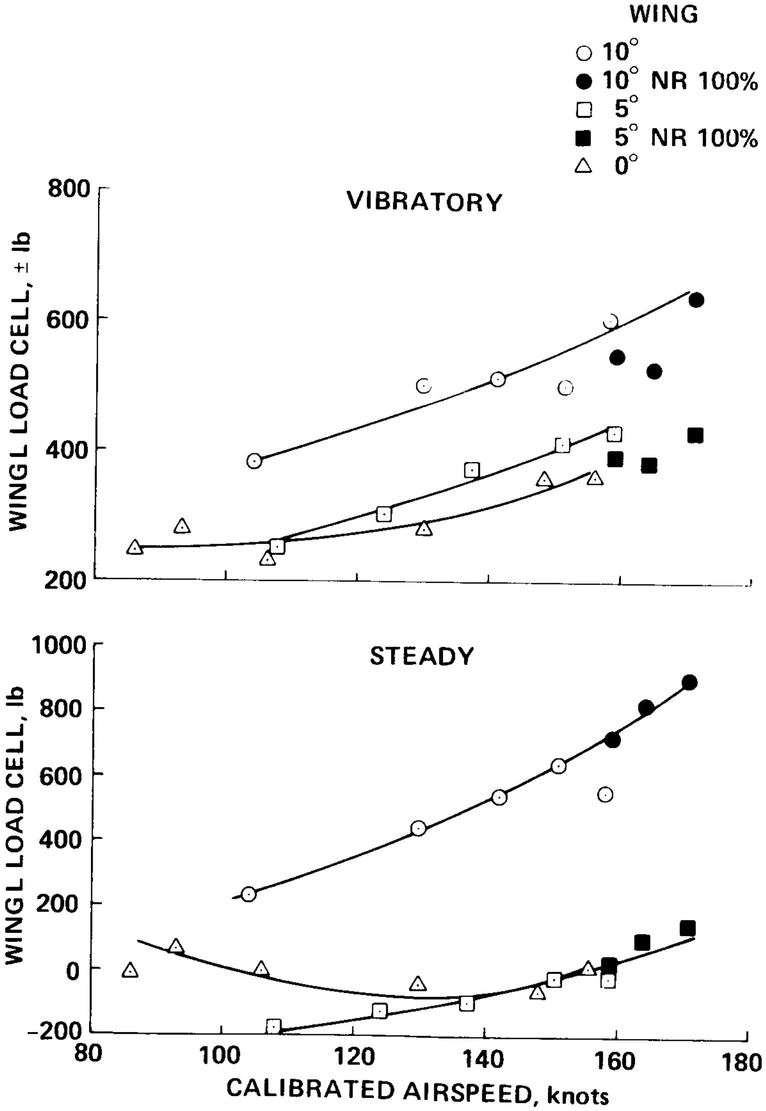


Figure 137.- Effect of wing incidence on left wing drag biaxial load cell versus calibrated airspeed: 40% collective.

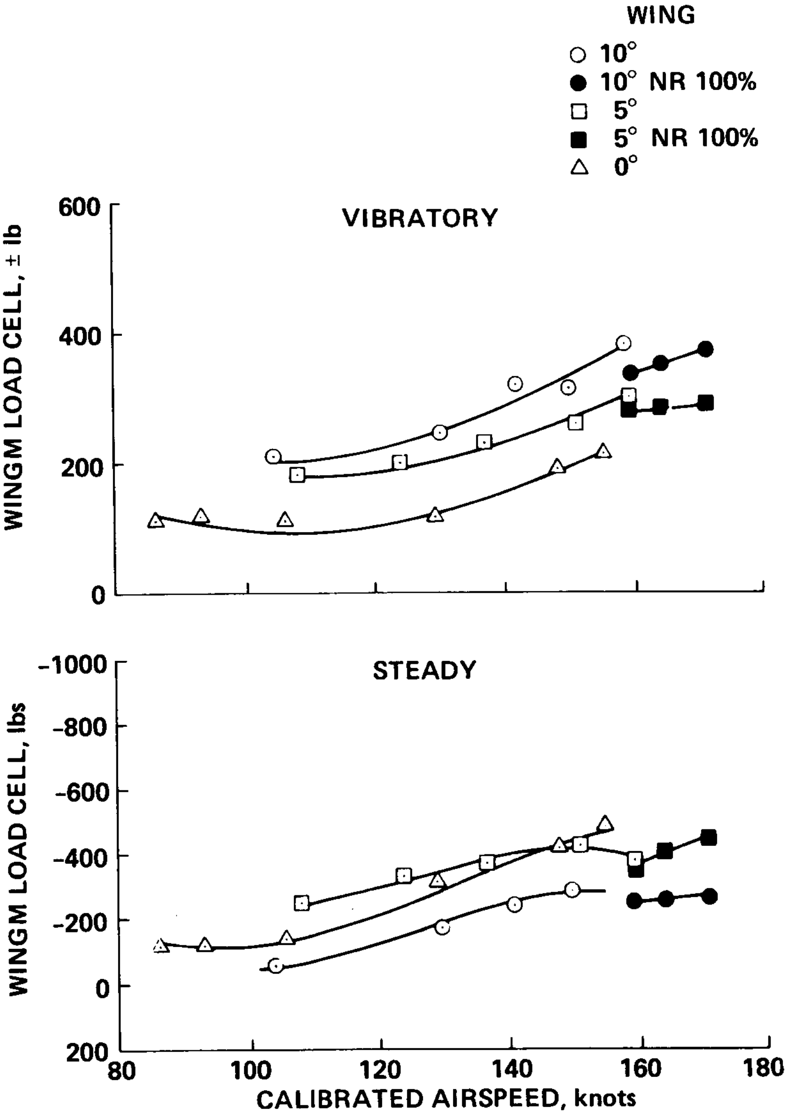


Figure 138.- Effect of wing incidence on right wing drag biaxial load cell versus calibrated airspeed: 40% collective.

7. CONTROL-SURFACE LOADS AND PYLON TEMPERATURE

The effects of main-rotor collective and wing incidence on the fixed-wing control rods are plotted versus calibrated airspeed in figures 139-150. The collective setting has little effect on most of the control rods; neither aileron is affected. The vibratory and steady loads are only influenced by forward speed. The same effect is true for both left and right elevator control rods. The endurance limit of ±190 lb is reached by the left elevator control rod at 180 knots. The difference between left and right elevator loads is attributed to asymmetrical flow over the empennage. Although the collective setting affects the stabilator actuator-rod and rudder control-rod steady loads, the vibratory loads show no change. The lower stabilator loads owing to lower collective settings are attributed to changes in aircraft pitch attitudes. The changes in the rudder control-rod steady loads are caused by collective-rudder coupling.

The effect of wing incidence on the fixed-wing control loads is quite different from the effect of collective setting. The steady loads of the left and right aileron control rods decrease with decreasing wing incidence, but the vibratory loads have no correlation. The wing incidence affects the vibratory and steady loads of both the left and right elevator control rods. Lower wing incidence leads to lower vibratory and steady loads. The stabilator actuator control rod is affected by wing incidence in the same manner as the elevator control rods. The decrease in load corresponding to lower wing incidence is attributed to the change in aircraft pitch attitudes. The rudder control rod is unaffected by wing incidence.

The TF-34 engine pylons are subject to heat impingement from the T-58 engines. The temperatures were monitored to enable the calculation of the reduced pylon strength. All temperatures over 300°F and their duration are plotted in figure 151. The analysis indicates a life of 1400 flight hours at the present rate of exposure.

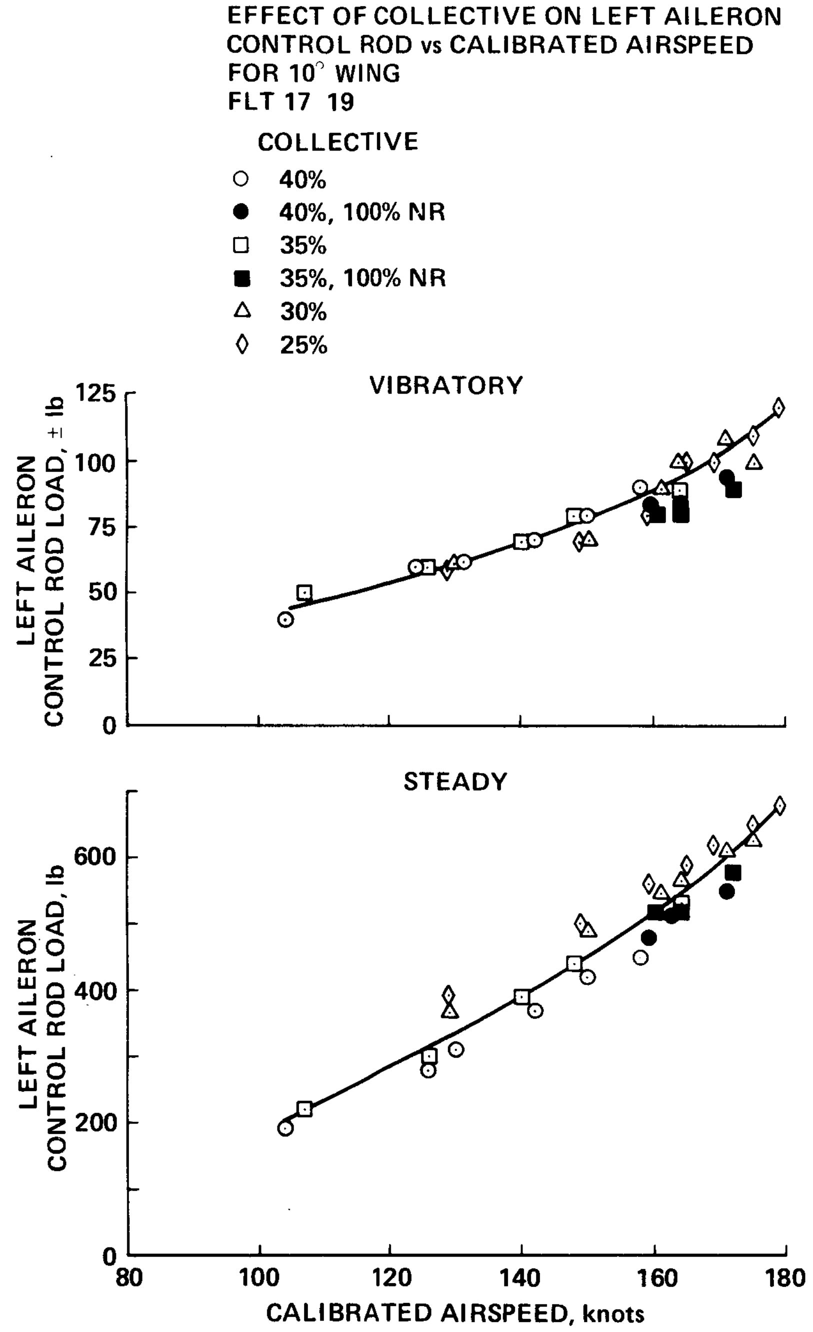


Figure 139.- Effect of collective on left aileron control rod versus calibrated airspeed: 10° wing angle.

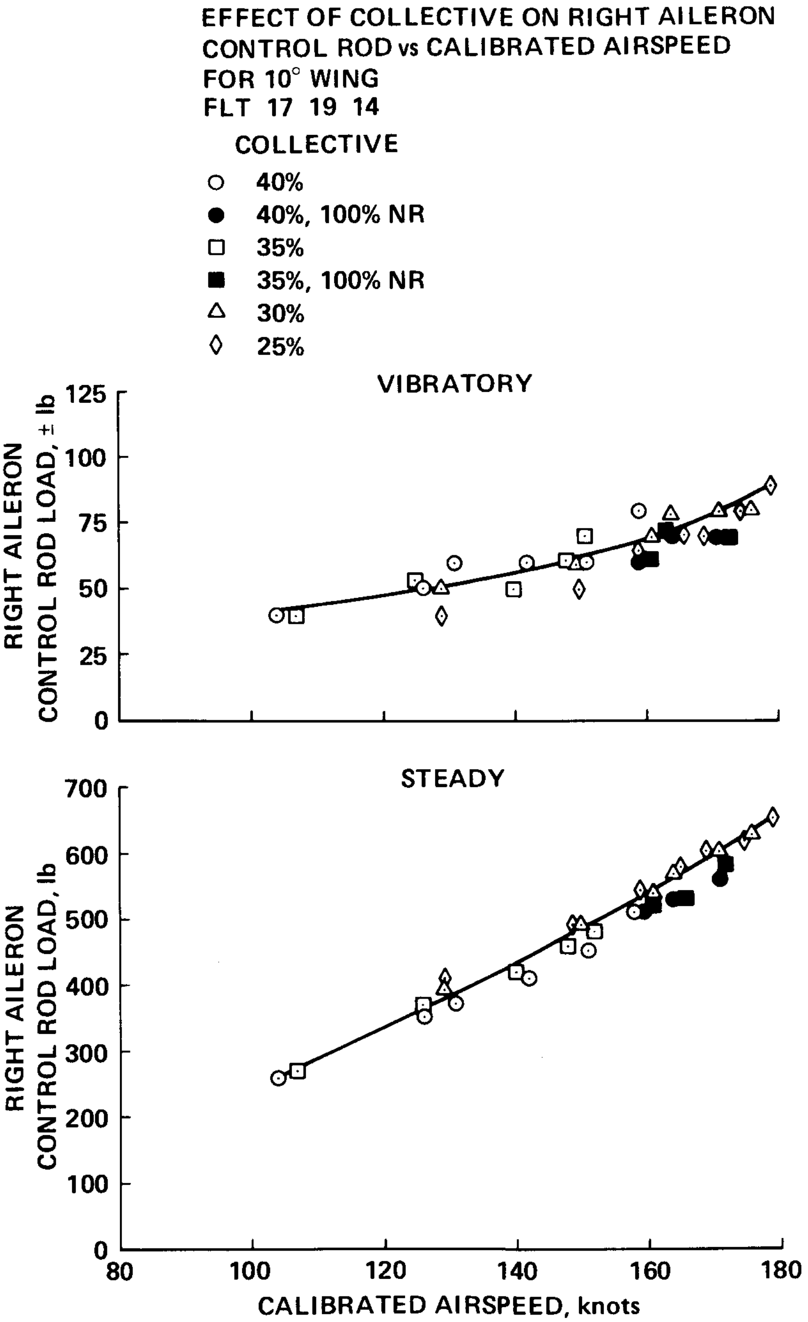


Figure 140.- Effect of collective on right aileron control rod versus calibrated airspeed: 10° wing angle.

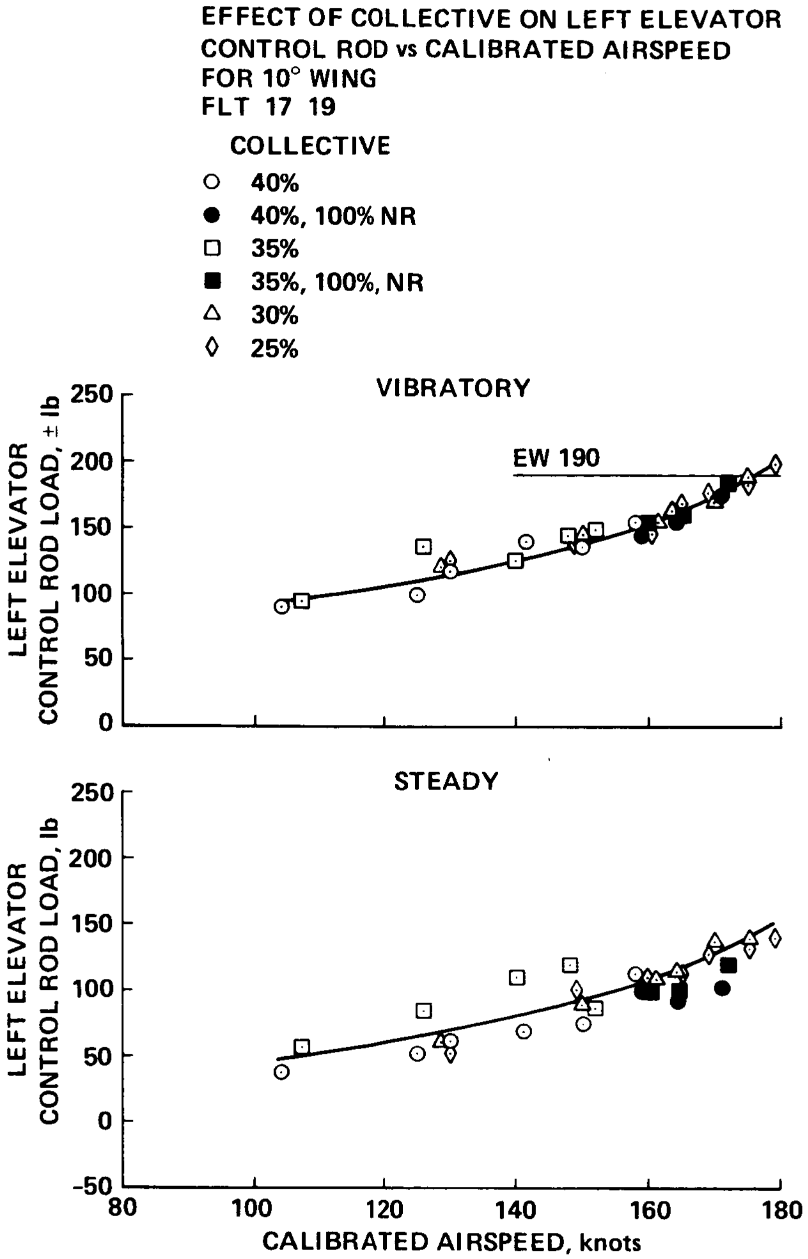


Figure 141.- Effect of collective on left elevator control rod versus calibrated airspeed: 10° wing angle.

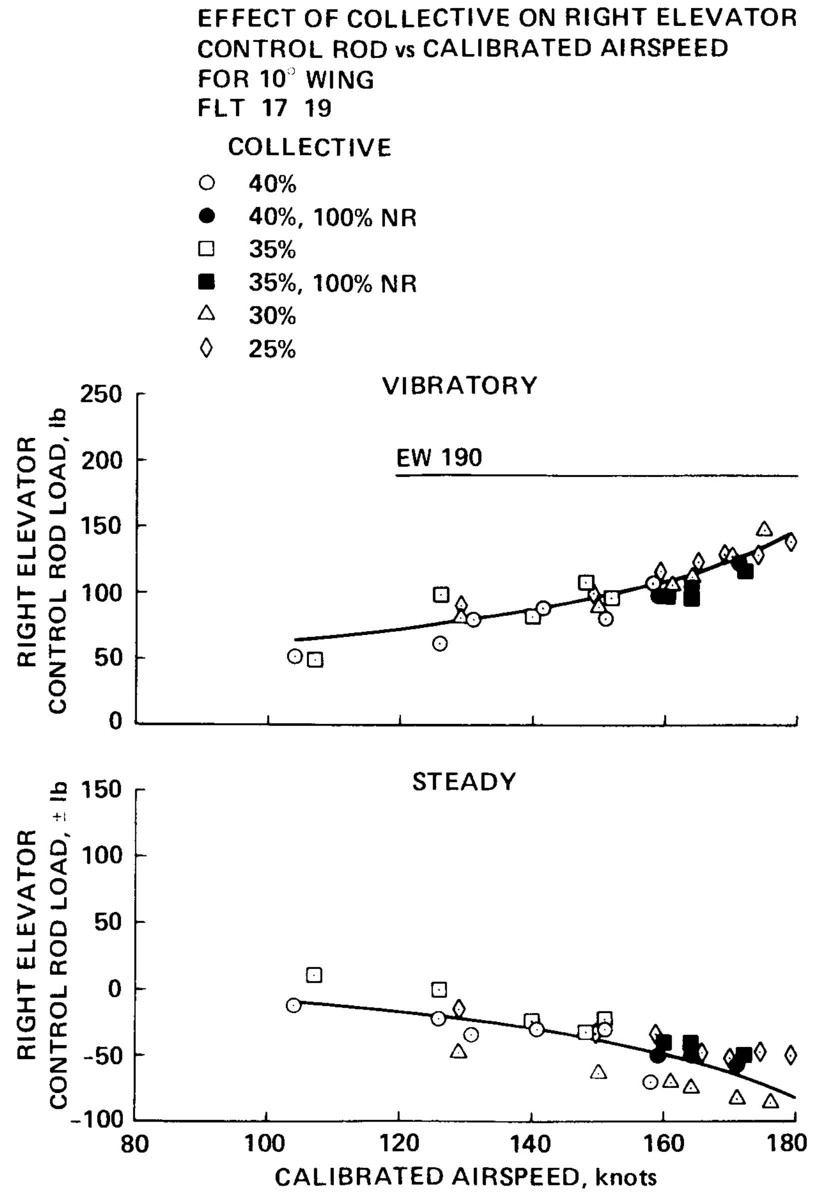


Figure 142.- Effect of collective on right elevator control rod versus calibrated airspeed: 10° wing angle.

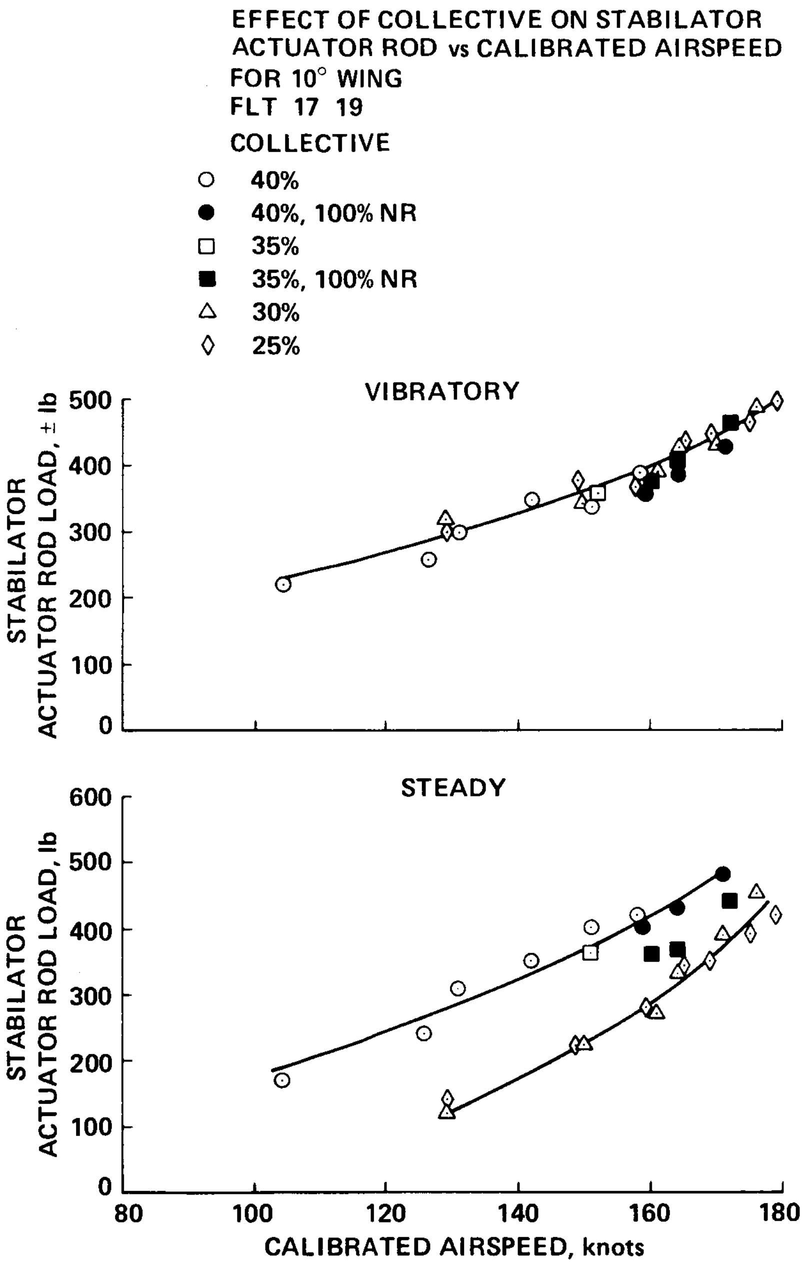


Figure 143.- Effect of collective on stabilator actuator rod versus calibrated airspeed: 10° wing angle.

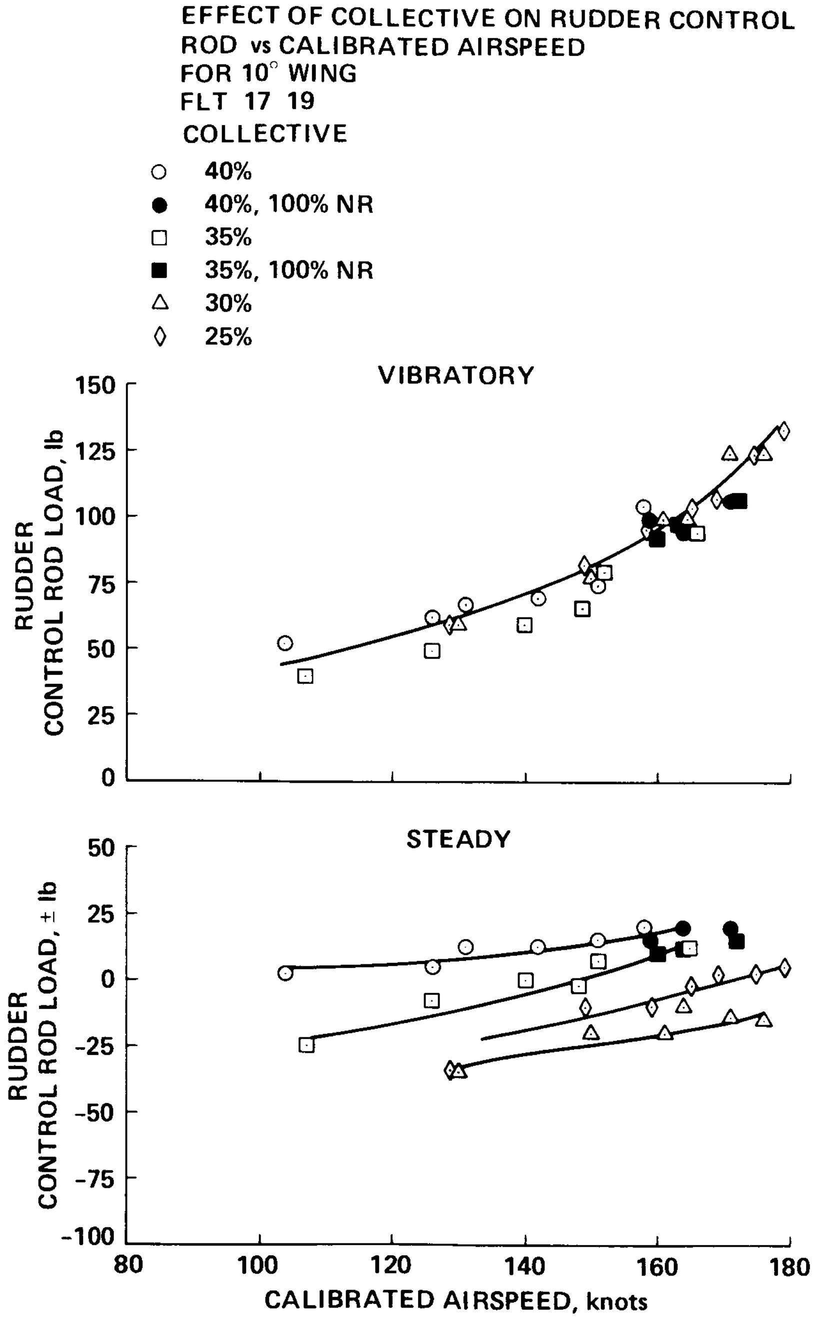


Figure 144.- Effect of collective on rudder control rod versus calibrated airspeed: 10° wing angle.

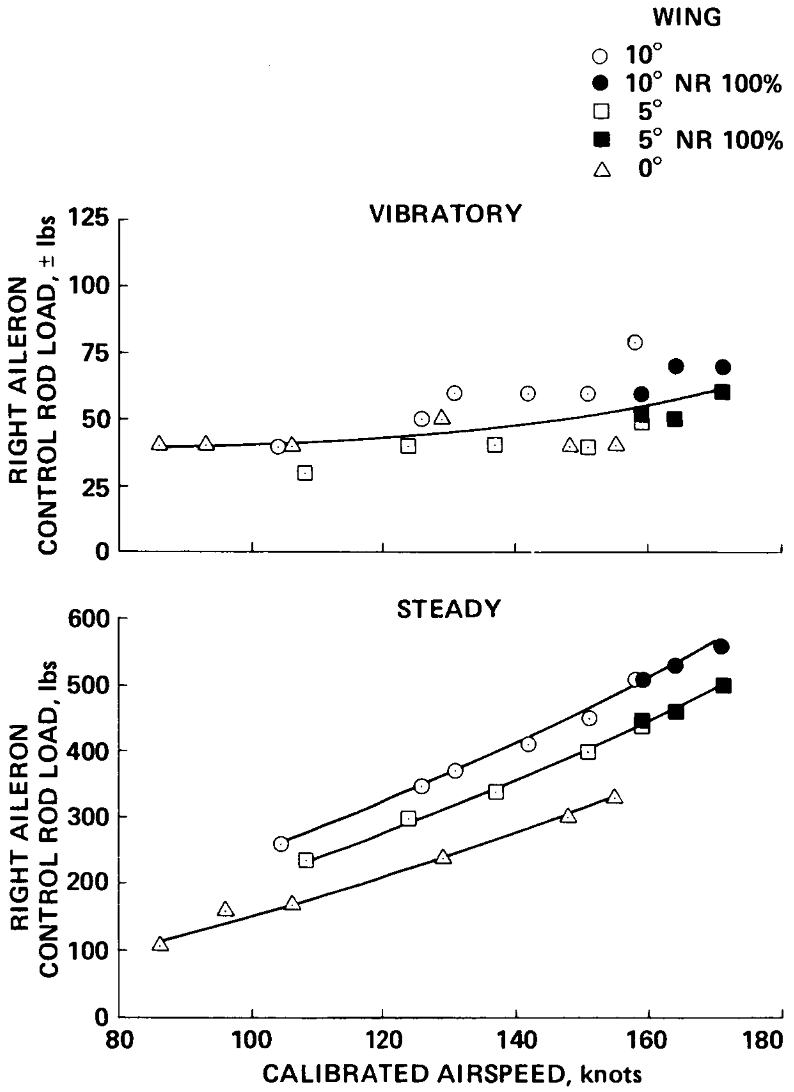


Figure 145.- Effect of wing incidence on right aileron control rod versus calibrated airspeed: 40% collective.

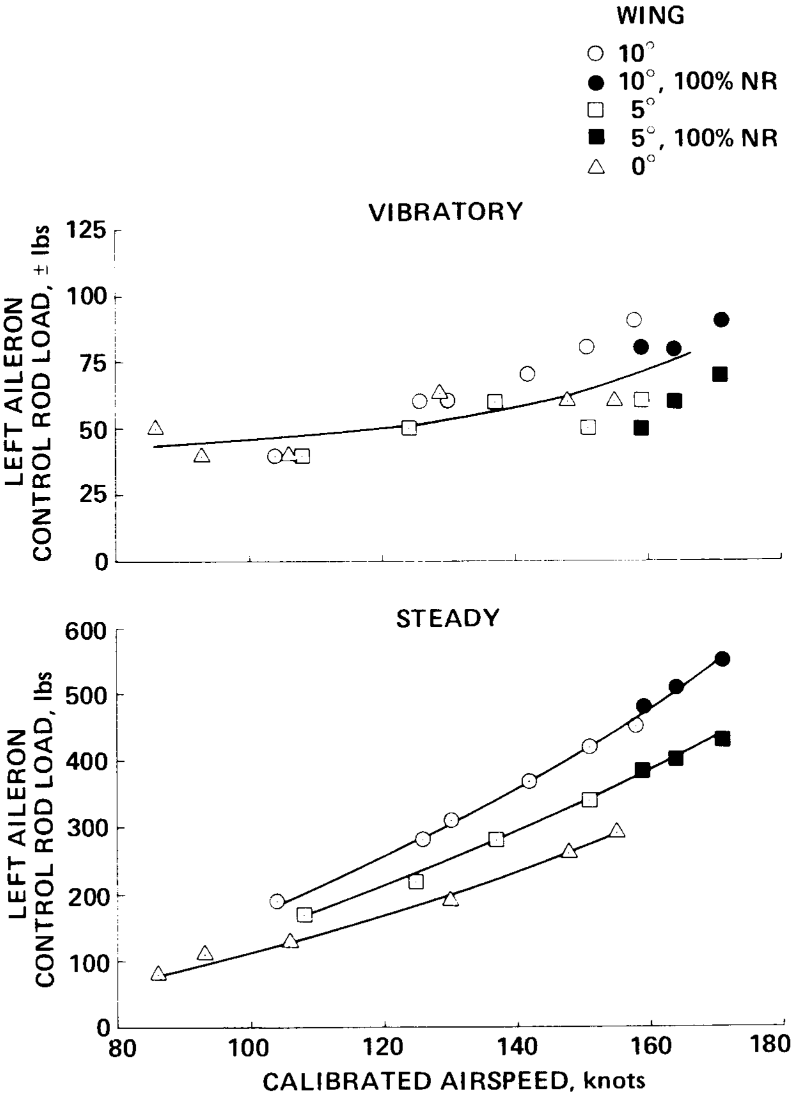


Figure 146.- Effect of wing incidence on left aileron control rod versus calibrated airspeed: 40% collective.

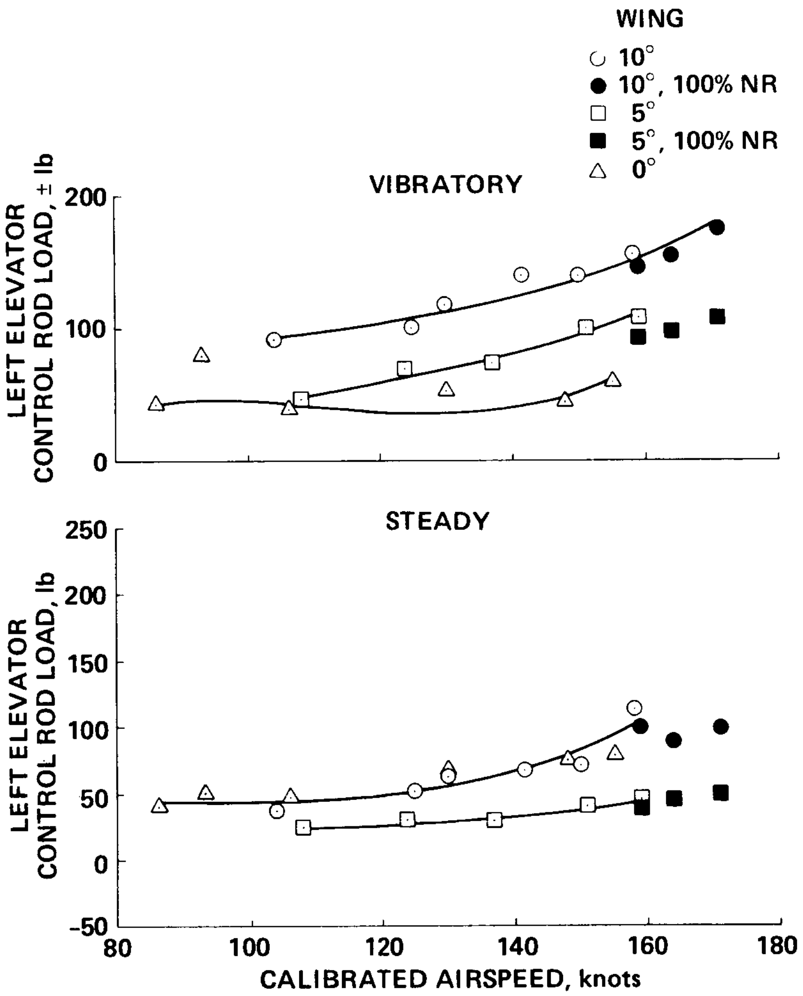


Figure 147.- Effect of wing incidence on left elevator control rod versus calibrated airspeed: 40% collective.

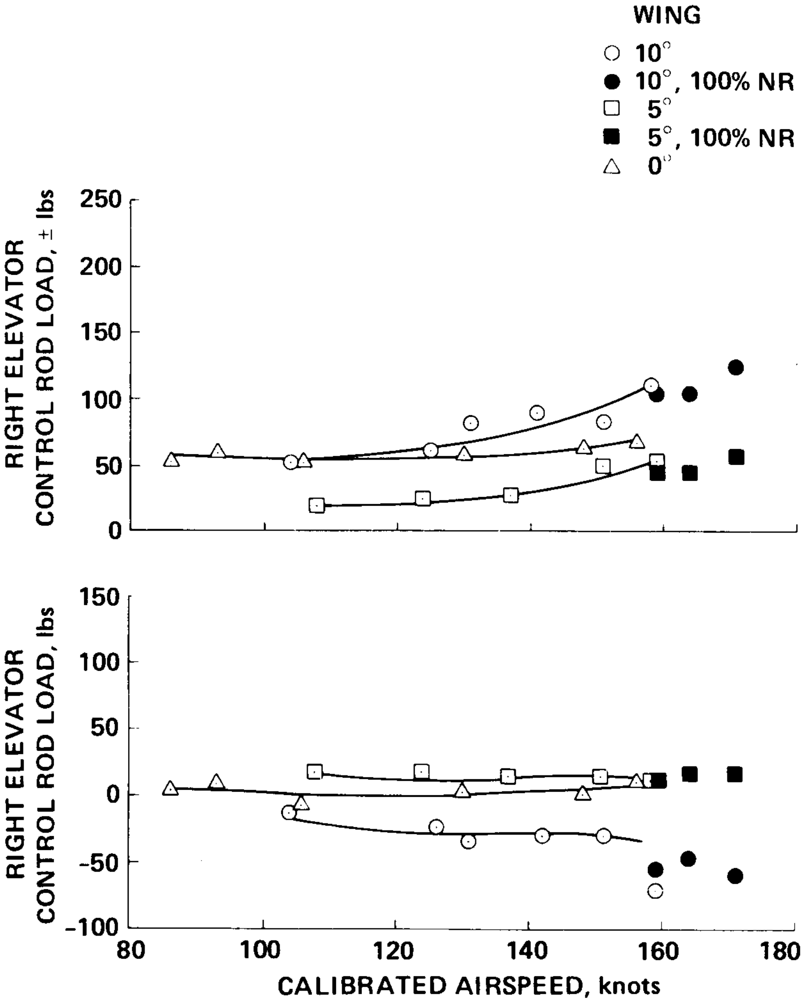


Figure 148.- Effect of wing incidence on right elevator control rod versus calibrated airspeed: 40% collective.

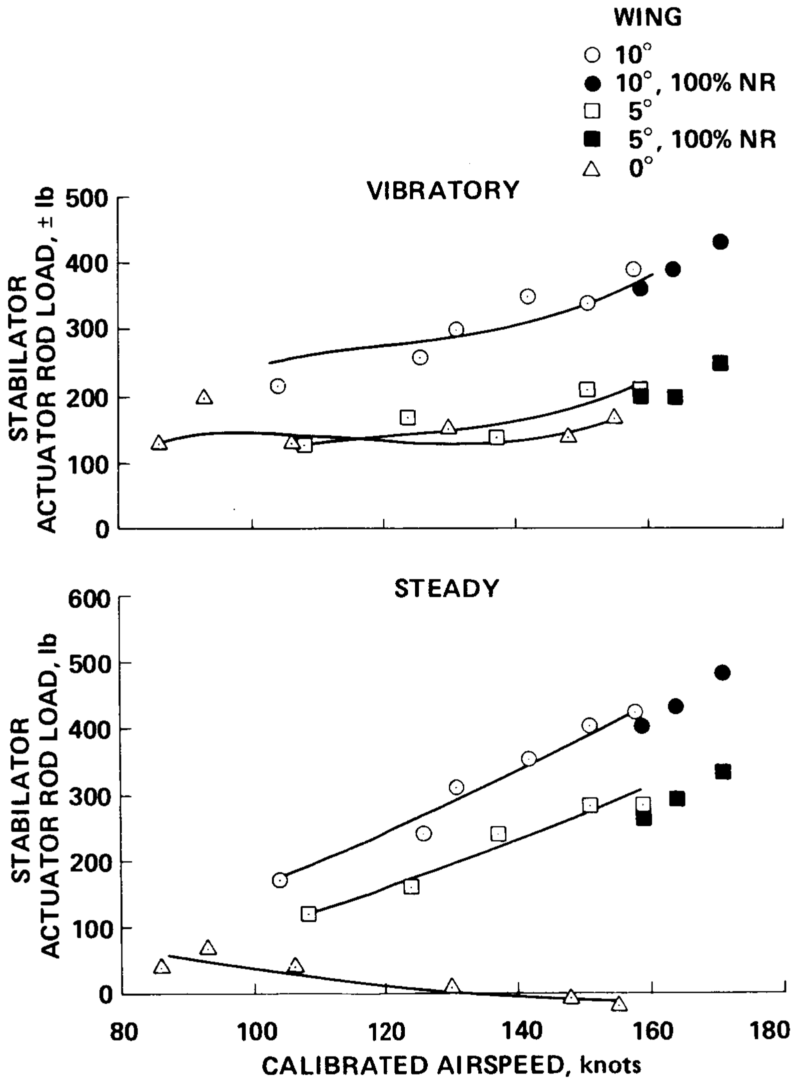


Figure 149.- Effect of wing incidence on stabilator actuator rod versus calibrated airspeed: 40% collective.

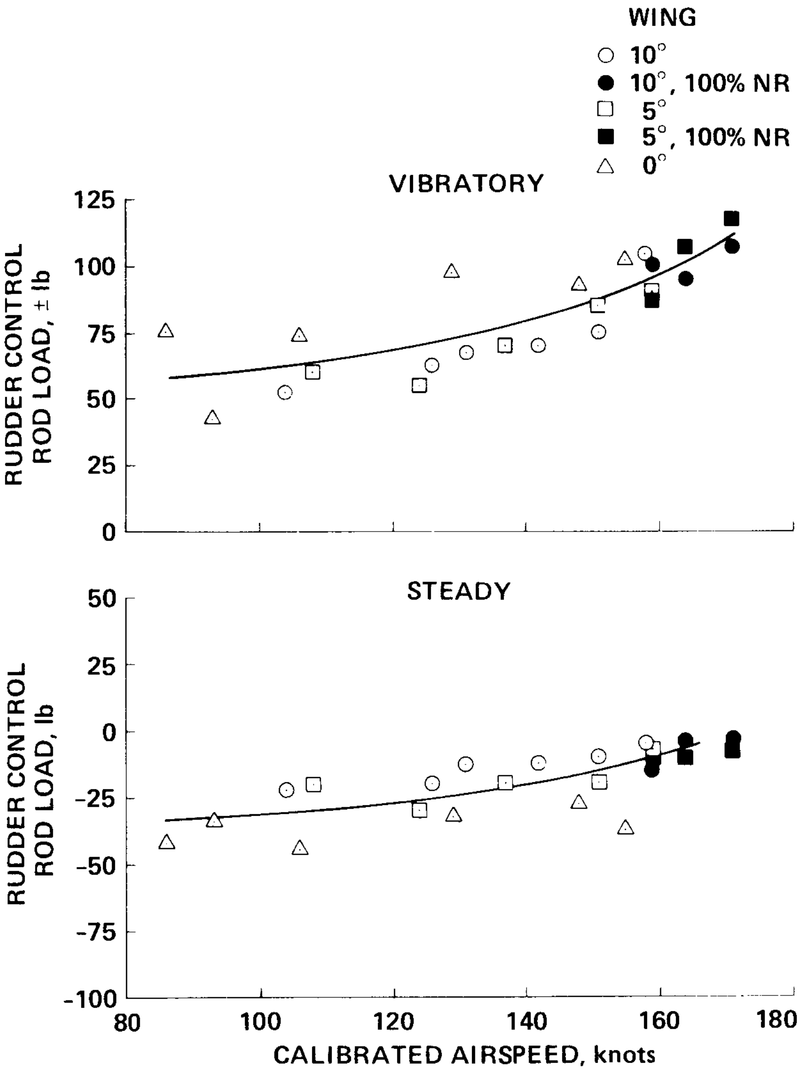


Figure 150.- Effect of wing incidence on rudder control rod versus calibrated airspeed: 40% collective.

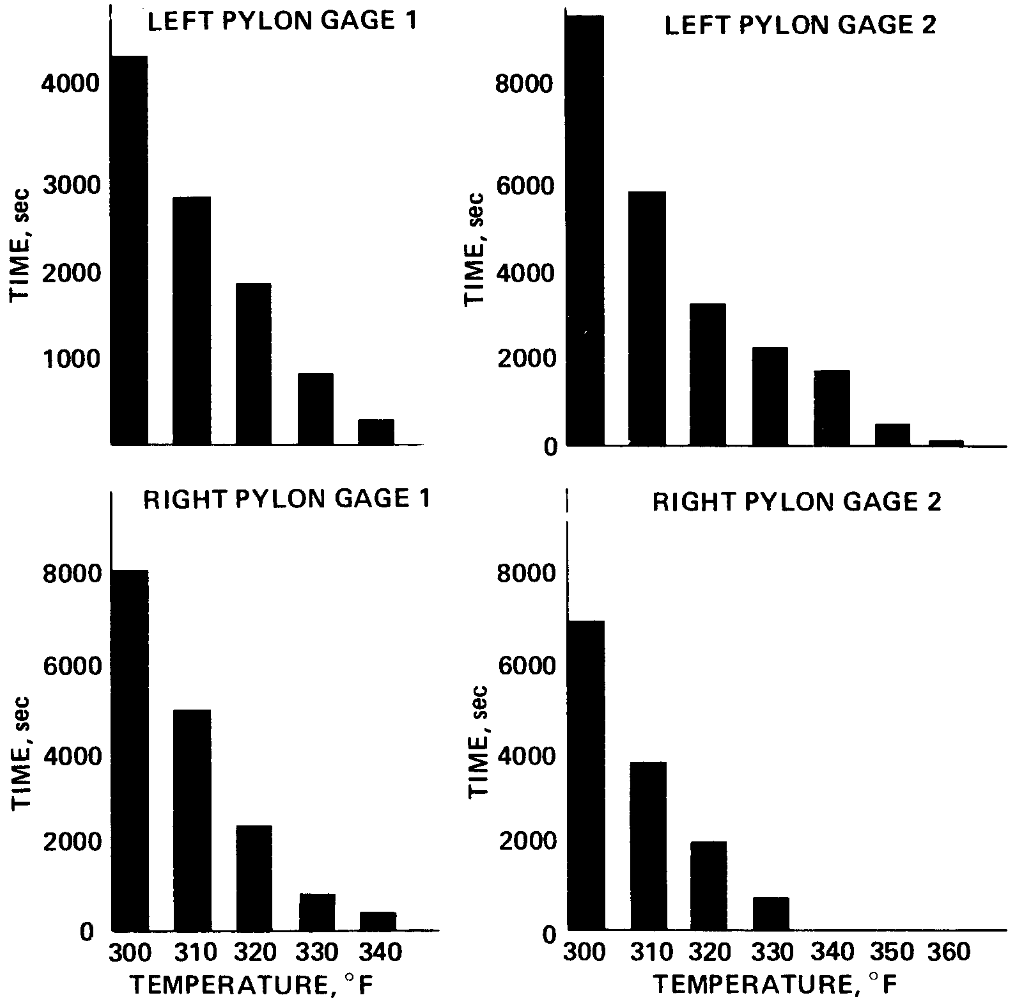


Figure 151.- TF-34 pylon temperatures: total time above temperature (rotor turning).

8. PERFORMANCE DATA

The performance plots (figs. 152-166) are compilations of data taken during the second-phase testing of the RSRA in the compound configuration. These flights were for envelope expansion and pilot training instead of performance testing. As a result, there is much data scatter for many flight conditions. Two plots are shown for most data. In each pair of figures, the first is a best-fit plot, and the second shows the data points from which the best-fit plot fairing was made. Data scatter can be attributed to the following: deviation in main-rotor speed from the nominal value of 104%; aircraft gross weight and center of gravity variations; and atmospheric effects (e.g., altitude and temperature). Where reasonable trends are apparent, lines have been added to the plots to facilitate labeling and to emphasize the general trends. Sideslip and main-rotor sweeps were performed during phase-two testing and have been included in the plots presented here. The plots of TF-34 thrust are obtained from the TF-34 fan-speed line, equation (1), and an assumption of a 4000-ft standard day:

$$T = \left[0.001085\left(\frac{N'_F}{\sqrt{\theta_T}}\right)^4 + 0.1476\left(\frac{N'_F}{\sqrt{\theta_T}}\right)^2 + \frac{N'_F}{5\sqrt{\theta_T}}\left(5M^2 - 7.25M\right) + 0.08102\right]10^3\,\delta_{amb} \tag{1}$$

where

N'_F	0.0785 N_f
θ_T	temperature ratio (°R)
δ_{amb}	density ratio
M	Mach number
N_f	percent fan speed

A test of the speed brakes was performed during phase two. The results are presented here. Four test points were obtained: 0°, 30°, 60°, and 0° extension. The two zero points do not give much confidence in this data set. If the first zero point is not used, a realistic curve emerges. The drag of the speed-brake is obtained from TF-34 thrust and rotor loads data. TF-34 thrust is obtained from equation (1) (as mentioned above), and the rotor load is obtained from load-cell data and from the appropriate calibration matrix.

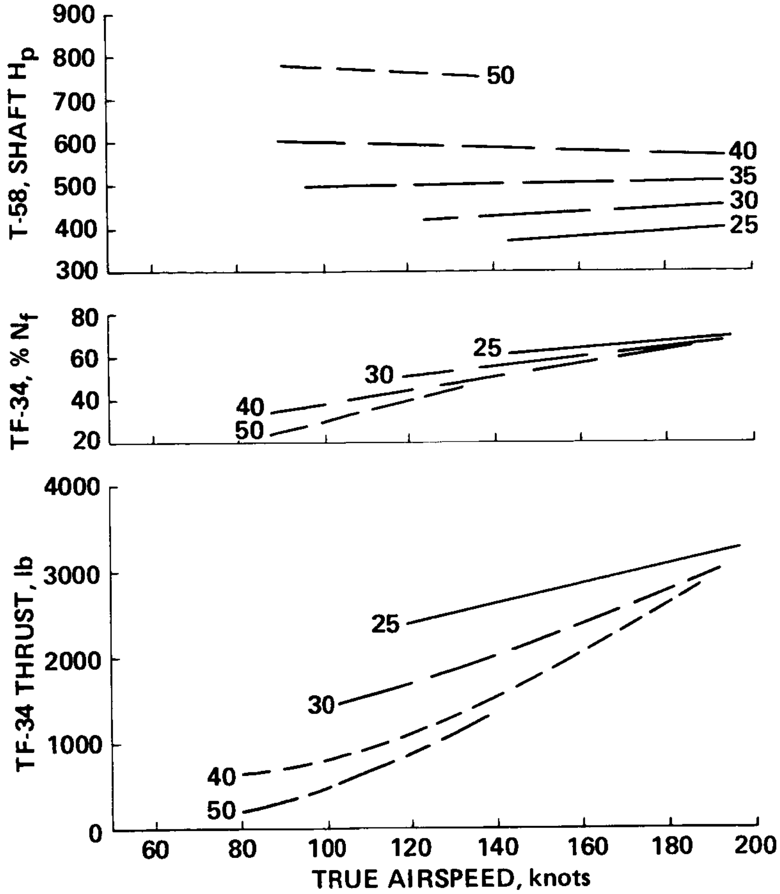


Figure 152.- Engine performance: wing incidence 10°, rotor speed 104% (best-fit curves and data points).

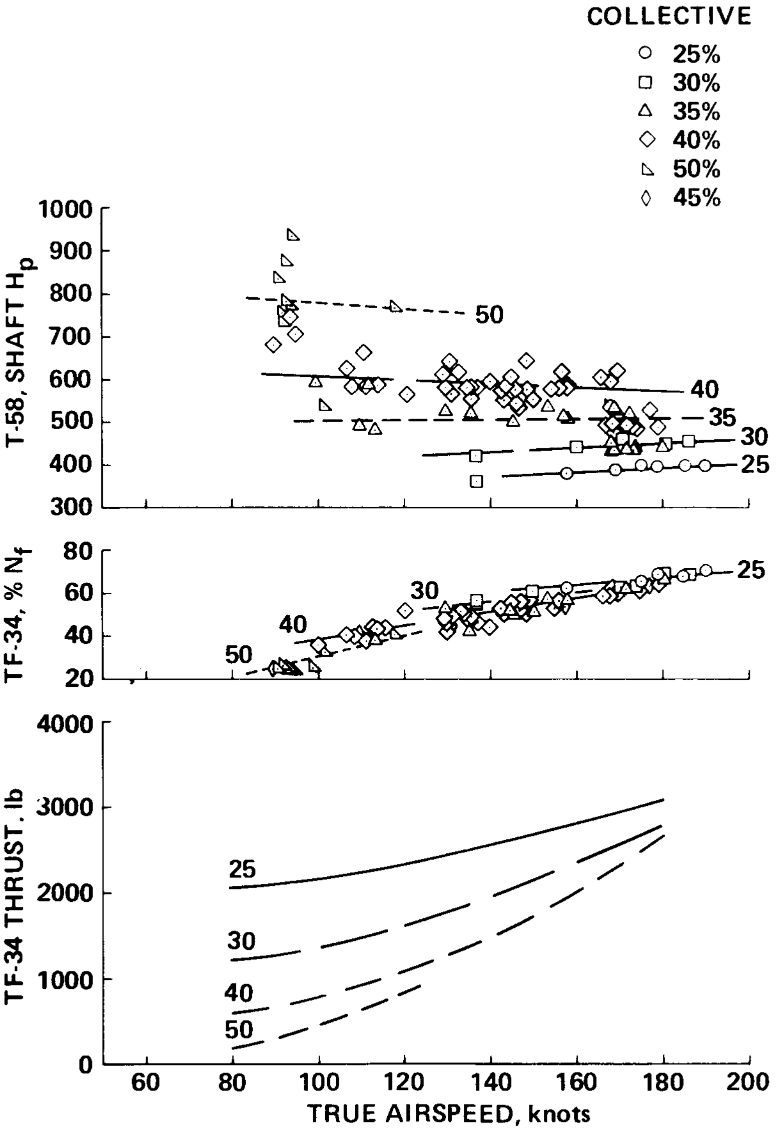


Figure 153.- Rotor torques: wing incidence 10°, rotor speed 104% (best-fit curves and data points).

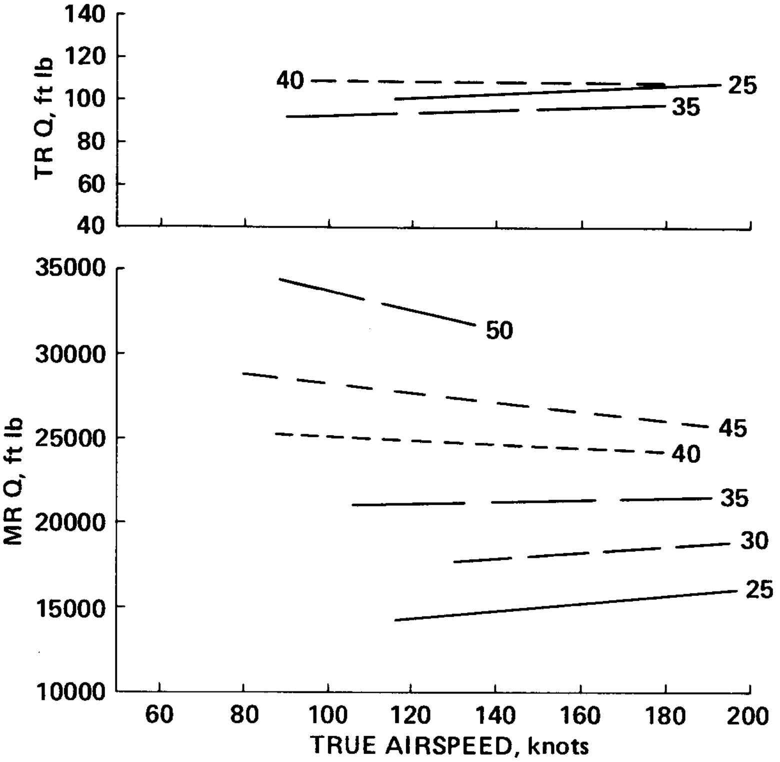


Figure 154.- Engine performance: wing incidence 7.5°, rotor speed 104% (best-fit curves and data points).

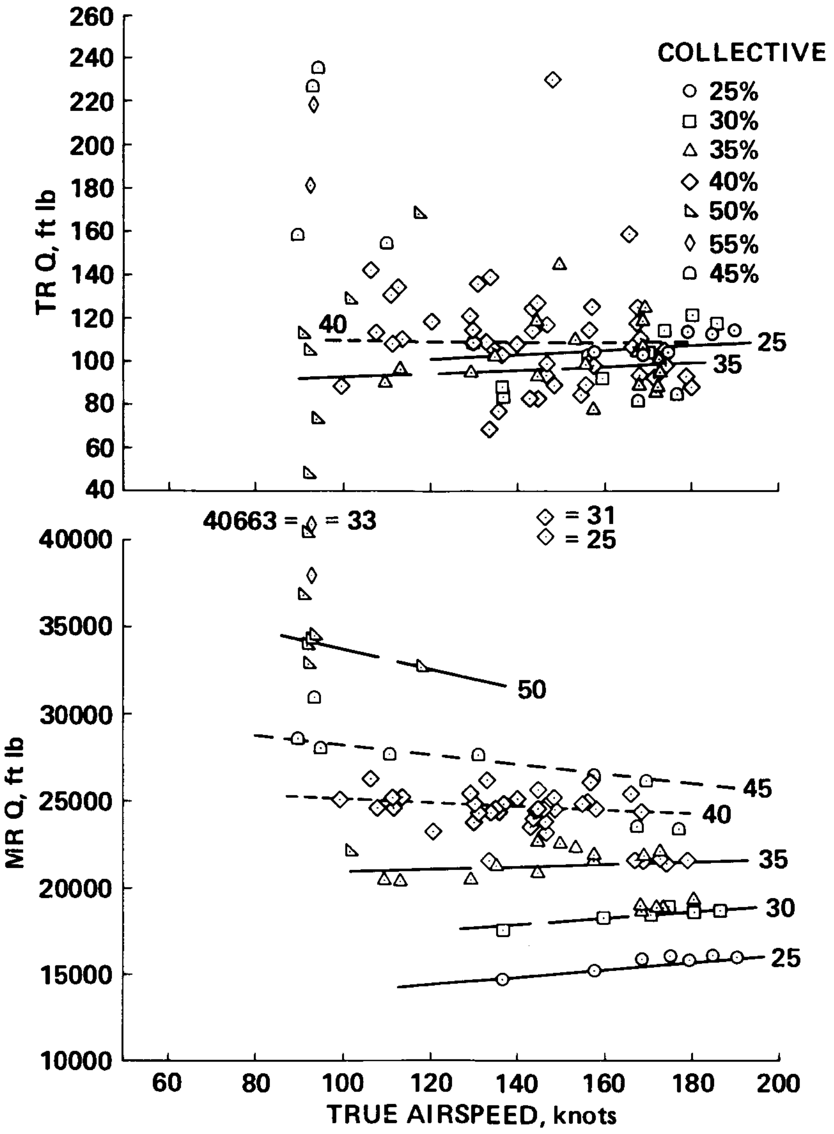


Figure 155.- Rotor torque: wing incidence 7.5°, rotor speed 104% (best-fit curves and data points).

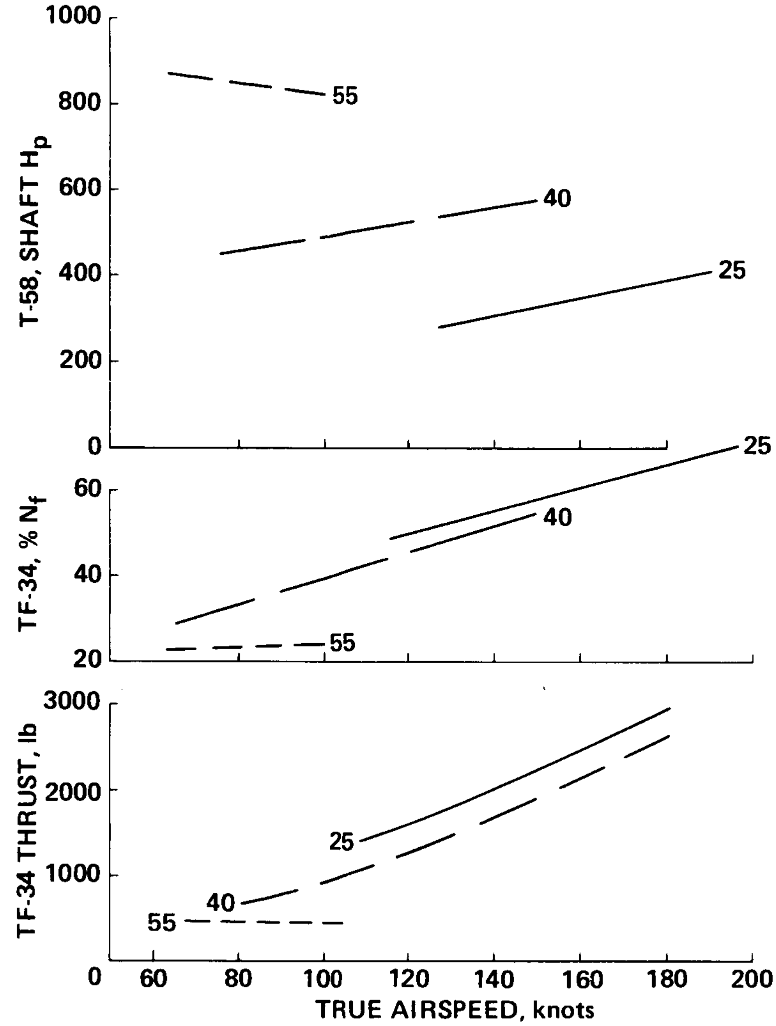


Figure 156.- Rotor torque: wing incidence 5°, rotor speed 104% (best-fit curves and data points).

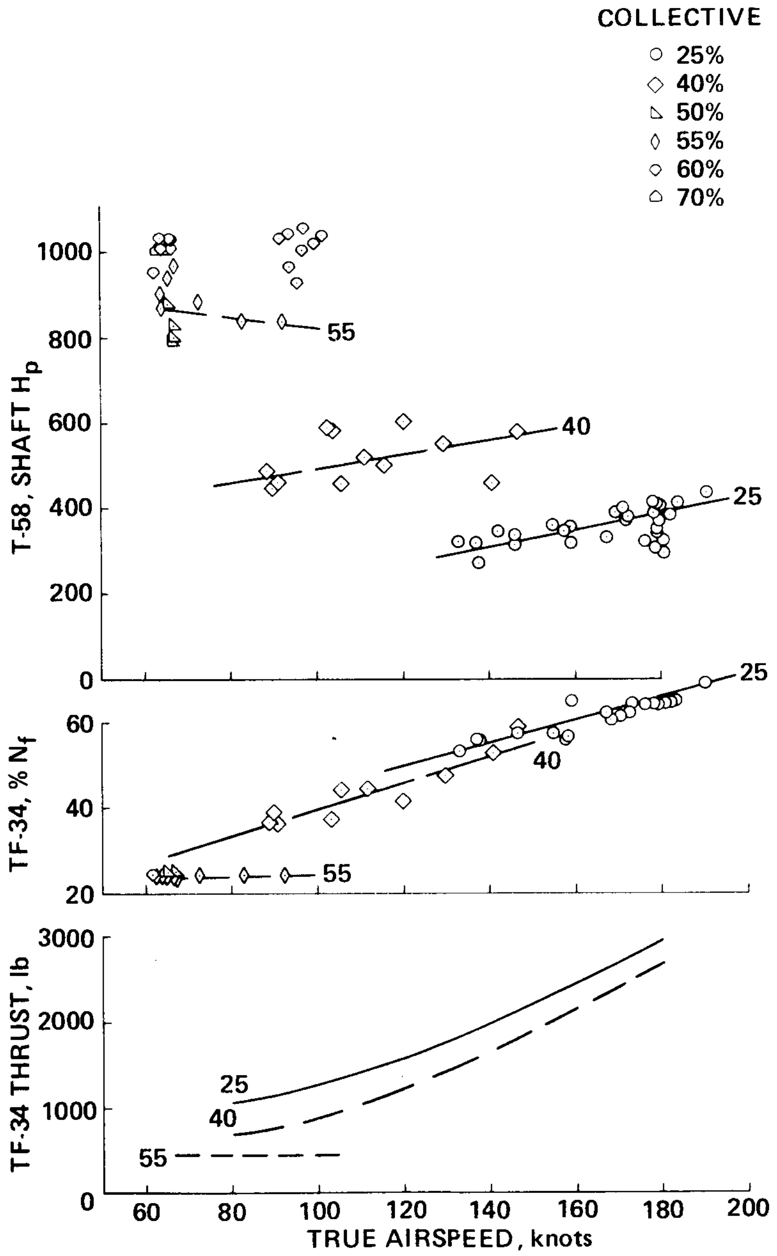


Figure 157.- Engine performance: wing incidence 5°, rotor speed 104% (best-fit curves and data points).

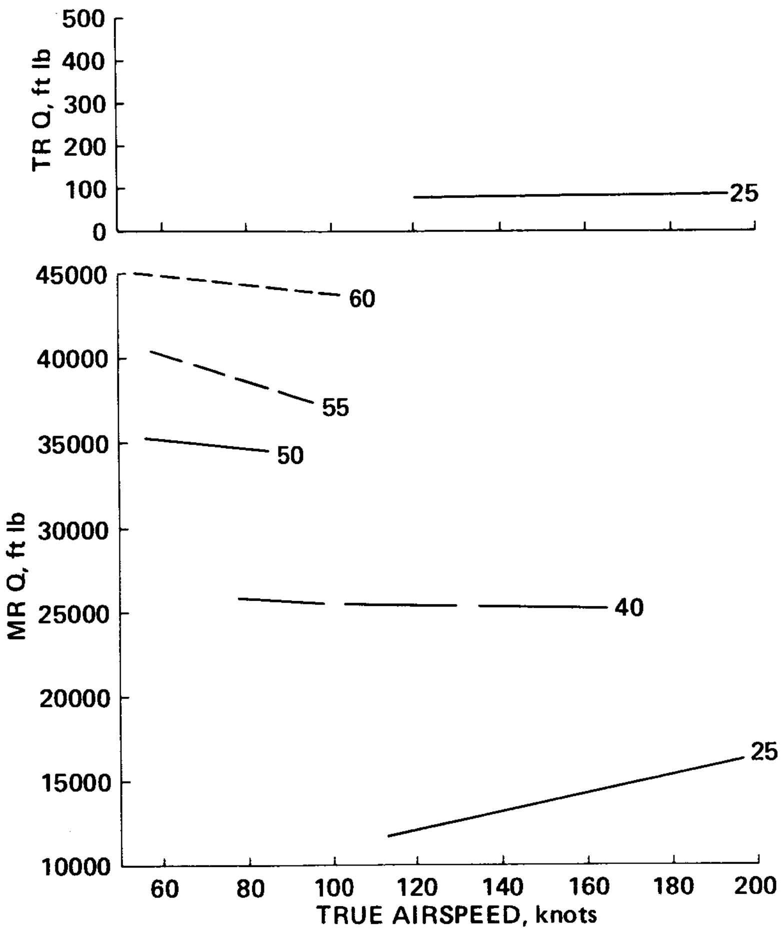


Figure 158.- Engine performance: wing incidence 0°, rotor speed 104%.

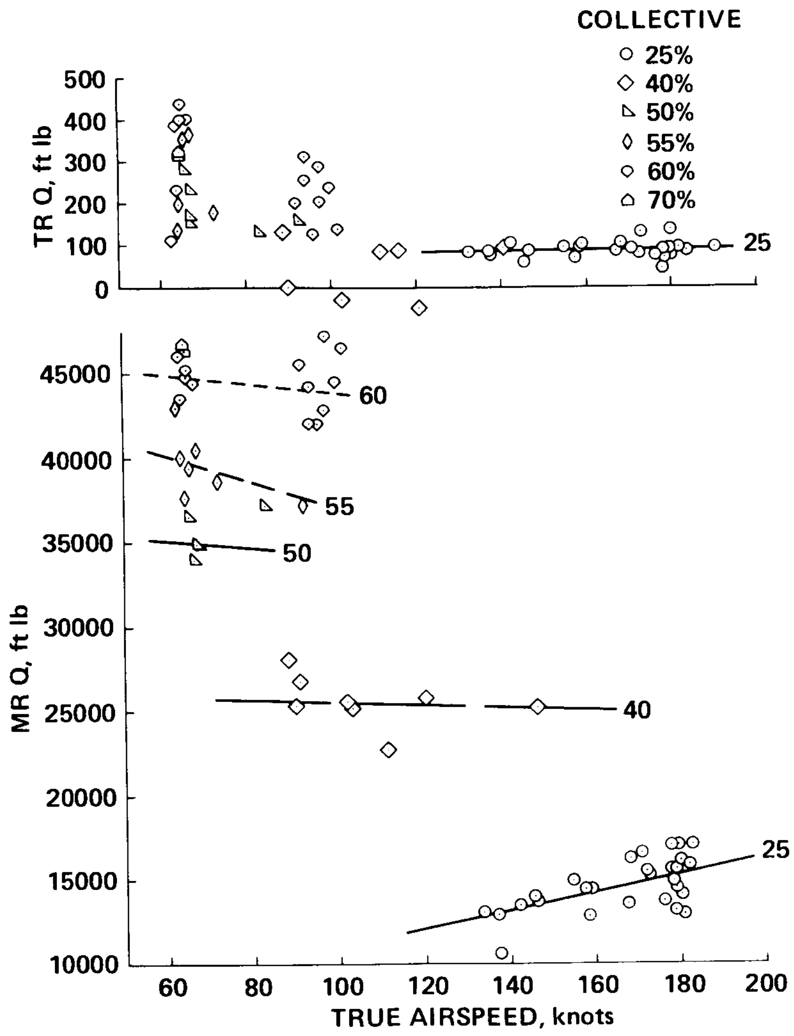


Figure 159.- Rotor torque: wing incidence 0°, rotor speed 104%.

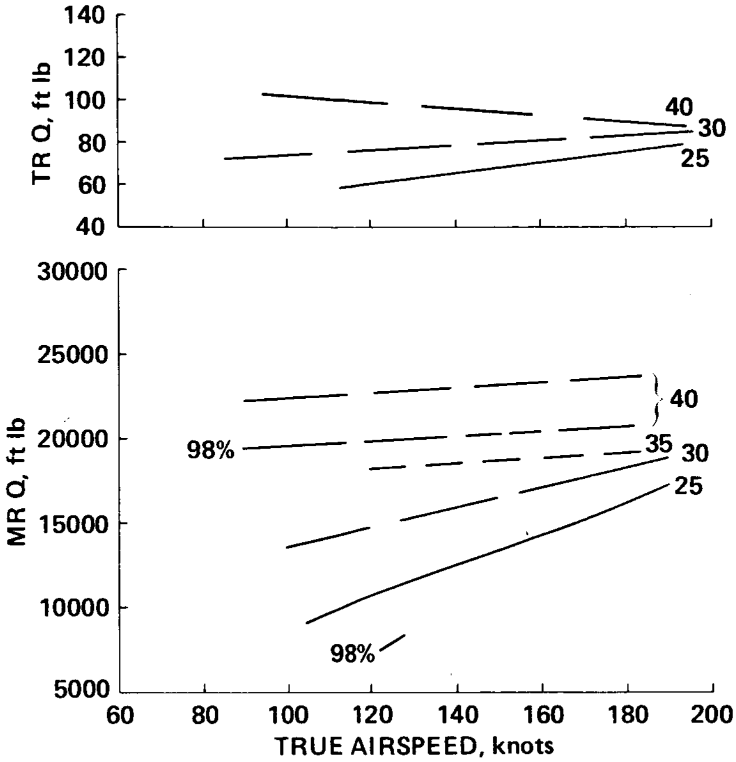


Figure 160.- Speed brake test results: 2600 ft, 140 knots, wing incidence 5°.

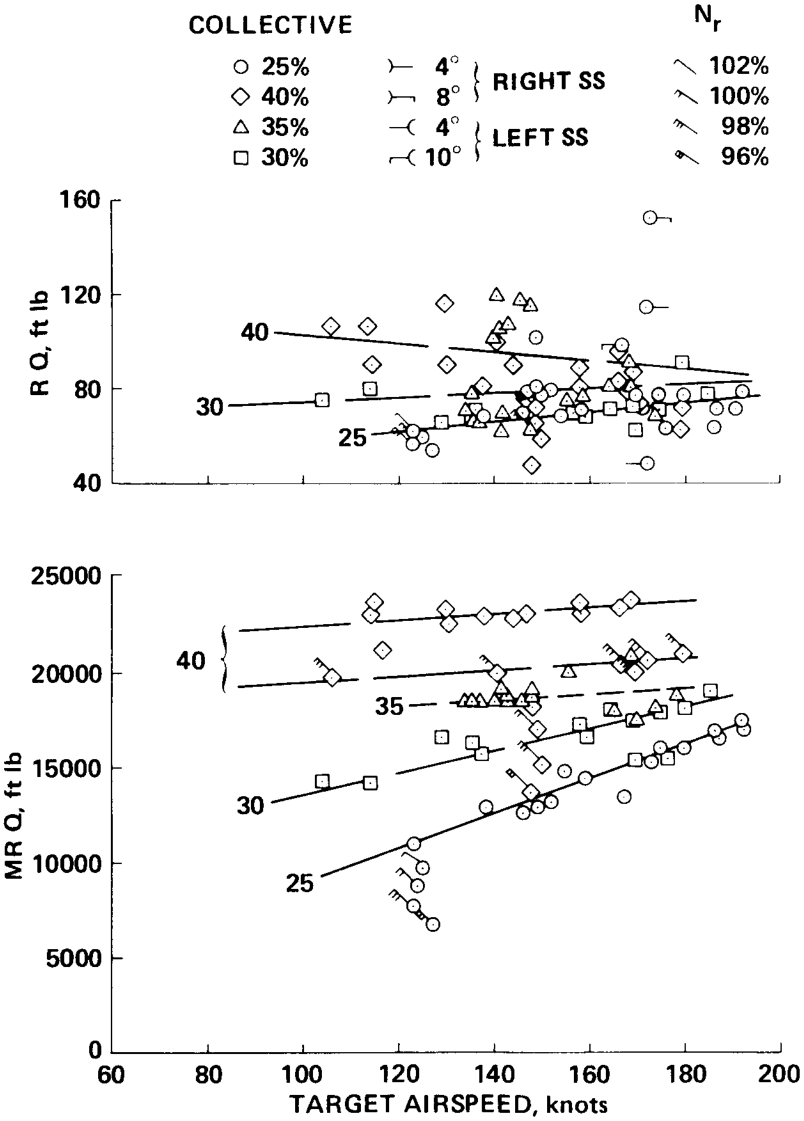


Figure 161.- Main and tail rotor torques versus airspeed.

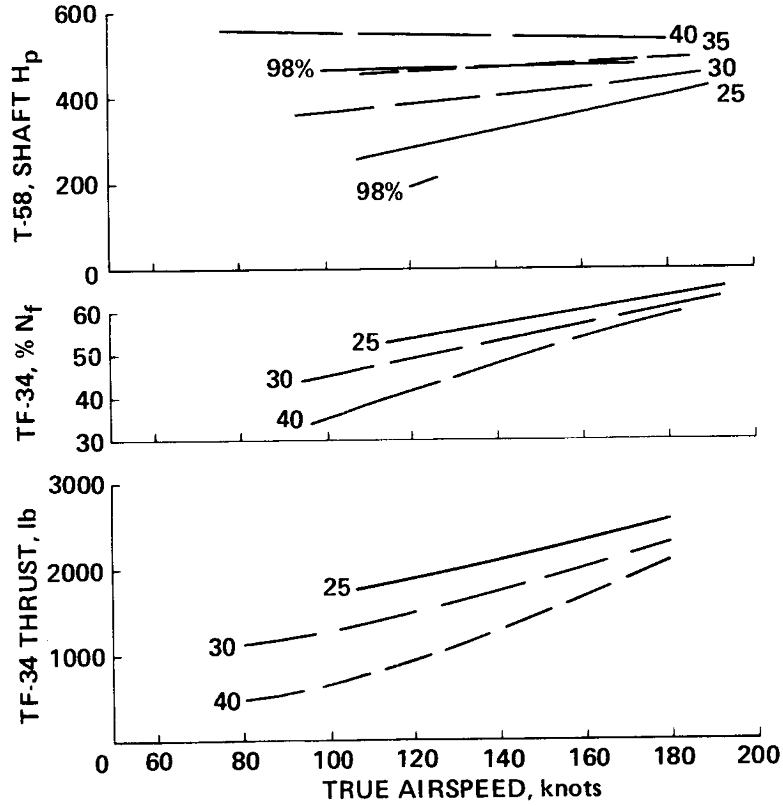


Figure 162.- Faired engine performance curves versus airspeed.

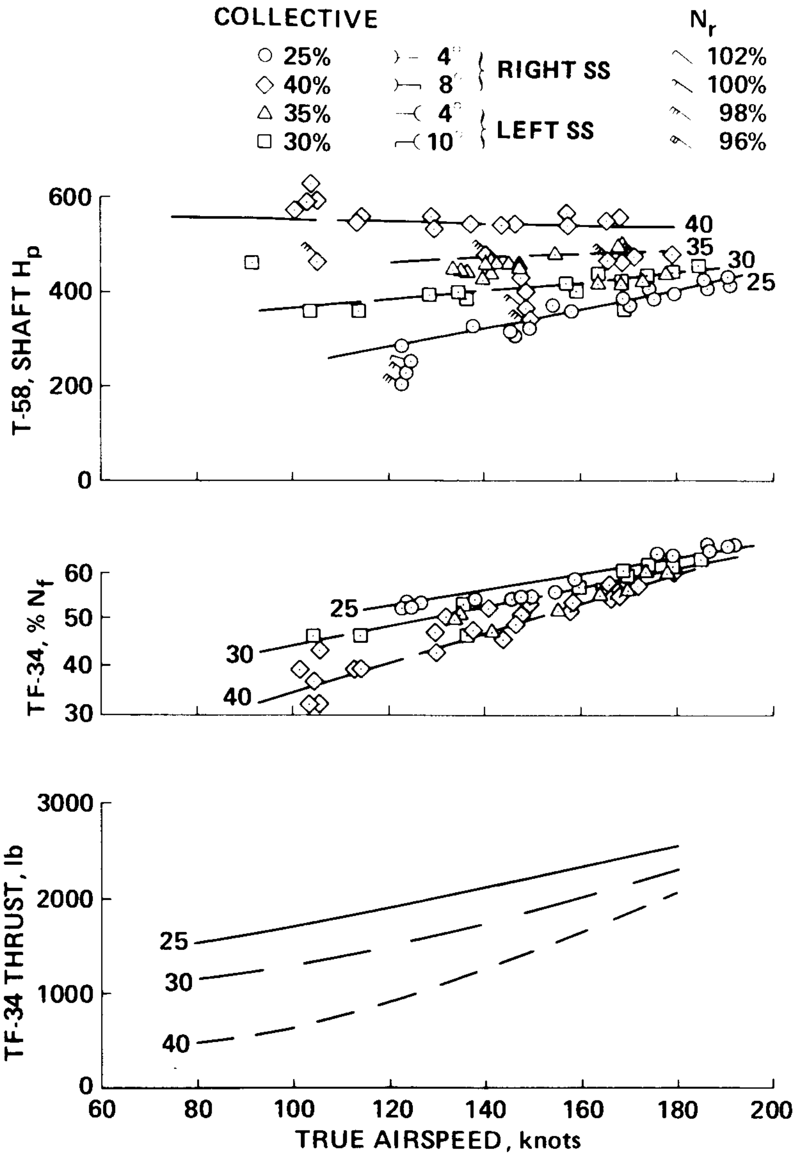


Figure 163.- Engine performance curves versus airspeed.

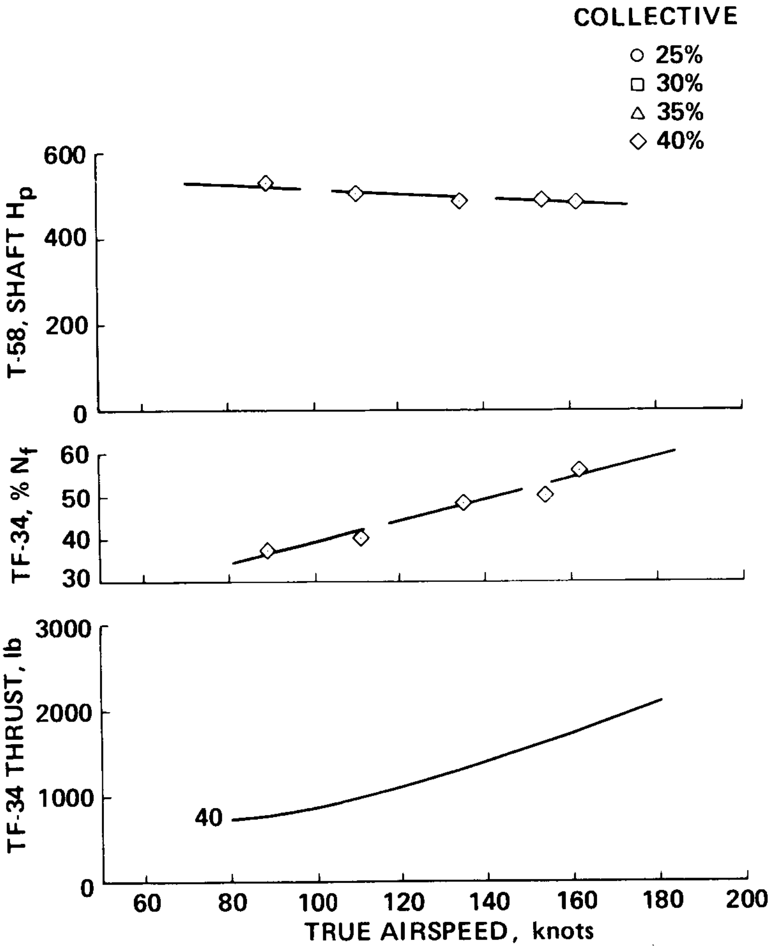


Figure 164.- Engine performance versus airspeed at 0° wing incidence.

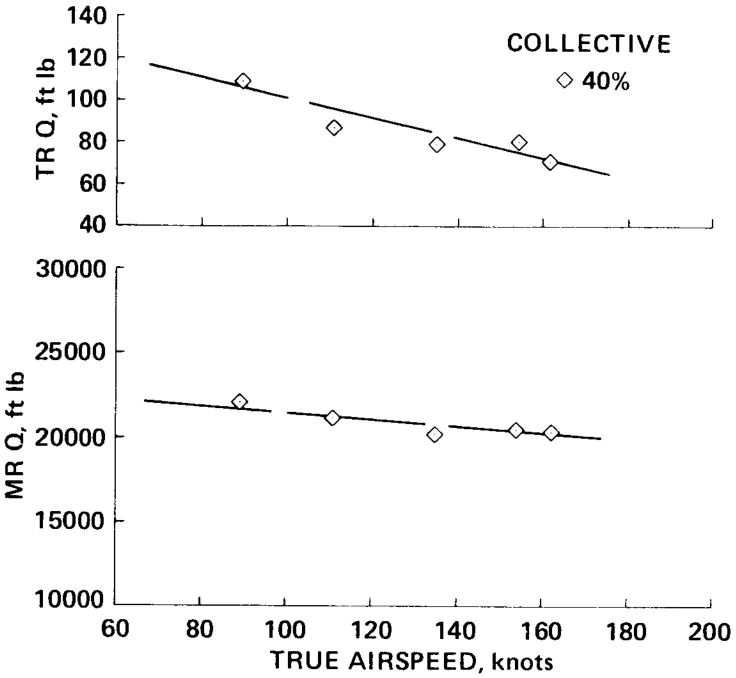
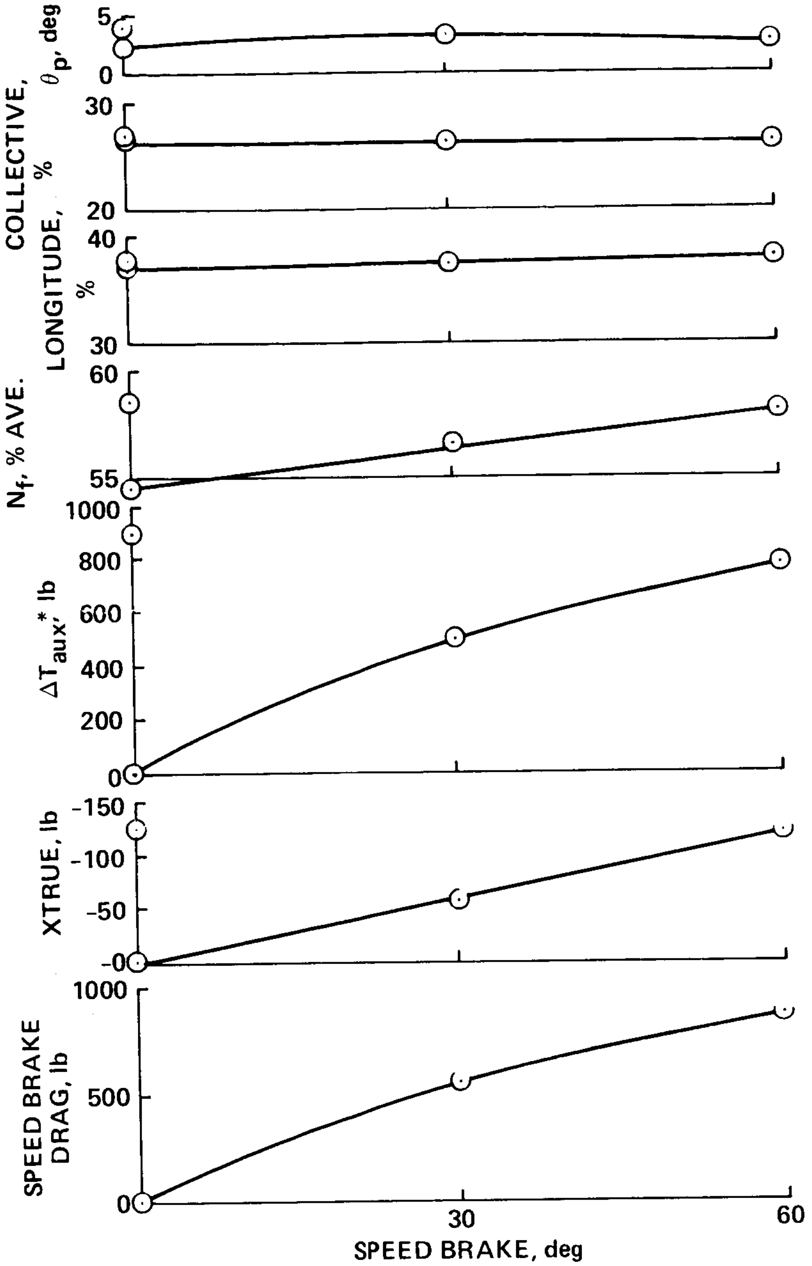


Figure 165.- Main and tail rotor torques versus airspeed at 0° wing incidence.



*NOTE: VALUES FROM T_{aux} vs. CAS PLOT

Figure 166.- Speed brake effectiveness wing incidence at 5°.

APPENDIX A

FLIGHT-TEST PLAN: HELICOPTER CONFIGURATION

SCOPE

RSRA 740 has completed balance-system calibration in the Static Calibration Facility. The aircraft is currently in preparation for flight as a compound at Ames Research Center (ARC) with the government project pilots. As part of this preparation, the aircraft will be flown in the helicopter configuration for maintenance/system checkout purposes and to acquire limited balance data. This test plan addresses those helicopter flights. The test consists of three or four flights as required, and is planned for late June 1981. This plan covers the initial flight segment at ARC as approved by reference 3. Additionally, a one-flight test will be conducted to evaluate the low-speed handling qualities of the helicopter, utilizing the balance-system data.

TEST OBJECTIVES

The objectives of this flight test are as follows:

1. Check out this particular aircraft and the function of associated systems, including data acquisition (PADS) and telemetry (TM)

2. Familiarize the test team with the characteristics of this particular airframe, and increase confidence

3. Obtain comparative data

4. Perform the above before testing the more complex compound configuration

5. Obtain initial balance-system flight-test data, including downwash loads on fuselage, system hysteresis evaluation, and low-speed handling qualities

TEST DESCRIPTION

The flight tests are defined in attachments AI and AII which contain

1. Test objectives
2. General information
3. Configuration
4. Instrumentation and data acquisition requirements
5. Flight-envelope restrictions
6. Flight maneuvers

AIRCRAFT CONFIGURATION

RSRA 740 will be in the helicopter configuration. The rudder, lower horizontal stabilizer, wing, and auxiliary engines with pylons will be removed. The larger helicopter, upper horizontal stabilizer will be in place. The cover for the wing and lower stabilizer cut-outs will be in place. RSRA 740 does not have the active isolation balance system (AIBS). The main-rotor bifilar vibration absorber will be operational with bushings previously used during helicopter flights. The TDY-43 computer will not be installed. SAS gains will be reset for helicopter configuration.

The emergency escape system (EES) will not be operational for this test. The operating flight envelope will be restricted (see Flight Envelope section).

The aircraft will be loaded to a gross weight of 19,800 lb or less, at 302 ±1 in. c.g. for takeoff.

Control from the left seat (evaluation pilot) will be operational through the force feel system (FFS). (Note: Use of the evaluation pilot control is not planned.)

The data acquisition system with telemetry (PADS) will be operational.

RESPONSIBILITIES AND CONTROL FUNCTIONS

Flight-Test Team Assignments

The flight-test team will be composed of ARC personnel with Sikorsky personnel supporting the tests under contract with ARC.

The test-team assignments for test responsibility and TM are as follows.

Title/responsibility	Person assigned	Description of responsibility
Test director	R. Erickson	Directs flight-test program
Structures/vibrations:		
Structures/leadman/ tail empennage	(R. Hodge)*	Coordinates and is responsible for all structures/vibrations and specific responsibility for stress/loads/vibrations at tail structures
MR/TR	(J. Van Horn)*	Responsible for stress/loads/vibrations/ temperatures on MR, TR, gear boxes, and drive train; maintain cycle counts; load-cell outputs
Airframe	R. Kufeld*	Responsible for A/F stress/loads/vibrations/ temperatures, except for above and ending at A/F engine mounts. Preflight and post-flight calibrations, maintain UPC

Title/responsibility	Person assigned	Description of responsibility
Handling qualities	(D. Leischer)*	Responsible for flight controls and rigging (except engine); flight characteristics
Power plants	S. Haff*	Responsible for engines — operation, control, vibrations, temperatures, stress

Notes: Parentheses indicate Sikorsky personnel. * Maintains Smart Book.

The test team assignments for aircraft, systems, and data support are as follows.

Title/responsibility	Person assigned	Description of responsibility
Balance system/ performance	C. Acree	Balance-system test data acquisition, output analysis, and performance data
Instrumentation	E. Brown	Responsible for A/C test instrumentation, emery sheet, A/C data tape, calibrations
	(R. Gruessner)	Assist E. Brown, FHI liaison to FOX
A/C manager	J. Brilla	Coordinates all activities on the RSRA 740
	(R. Brouillette)	Assist J. Brilla for A/C buildup and initial flights
Handling qualities (analytical)	J. Jinkerson	Responsible for stability and control predictions, analysis
SAS/FFS	R. Young	Engineering support for SAS/FFS
Data processing aide	A. Hood	Smooth flight log/tape cataloging, flight data files, EASE inputs, hand data plots, tabulations, calculations

Note: Parentheses indicate Sikorsky personnel.

Flight-Test Team Responsibility Definitions

In addition to the responsibility descriptions of the previous section, the following responsibilities are assigned and defined.

Smart Book- The designated persons shall prepare and maintain a loose-leaf file of flight-test data, ground-test data, and predicted data for measured parameters pertinent to their assigned area of responsibility. Plots of these data shall be maintained in this file, and new flight-test data, from TM or postflight processing, shall be added in an ongoing manner. Comparison of the new data to the previous or predicted shall be accomplished as soon as the new data are available. Unsafe or significant deviations or trends must be identified and reported immediately to the test director. Of particular concern are deviations noted during TM operations. Designated persons shall present the updated Smart Book, with appropriate comments, at each postflight briefing, postflight data review, and preflight briefing.

Data to make up the Smart Book will be obtained from previous tests as reported in SER-72045 (ref. 1); various analytical prediction reports, analysis concurrent with the program, and from the ongoing test program. The source of the data should be identifiable on the plots.

Test responsibility and TM team members- The team members listed under this heading are responsible for maintaining the accuracy and adequacy of the measurements within the scope of their assignments. This applies to TM, data acquisition on tape, data processing, and to orderly data records. These team members will prepare a section for the final report on test results when directed.

Test director- The test director is responsible for directing the flight-test program; approves all engineering measurement requests; prepares, with the pilots, the flight cards; supervises the TM test team; and, for flight-test data, will determine the necessary corrective action when unsafe or significant deviations or trends are identified by any member of the test or supporting team.

Additional details of responsibilities are given in reference 4. The reference 4 definition of structural/dynamics responsibilities generally is applicable to handling qualities.

OPERATING LIMITATIONS

Parameter Limits

Structural and system parameter limits will be as specified in the latest revision of the Flight Test Limits (ref. 5).

Structural Fatigue Estimation

Structural integrity of RSRA components will be monitored in accordance with the following procedure. A systematic record of cumulative damage will be maintained for any structural parameter that is observed to be loaded in excess of the approved endurance limit. These records will be reviewed continuously to ensure that no component remains in the aircraft beyond its safe life. These records will be included in the structural shakedown report at the end of the program.

Structural Fatigue Cumulative Damage Accountability

Based on a projected 25-flight-hour program, when the cumulative damage on any component exceeds the following criteria, the fatigue history of the component must be reviewed, and approval for continued operation obtained before the next flight. This approval is obtained by concurrence of the following:

1. Sikorsky RSRA program manager
2. RSRA chief of development
3. RSRA 740 test director
4. FHI chief

Cumulative Fatigue Damage Accountability Criteria

Review is required when the accumulated damage reaches or exceeds the following fatigue life percentages:

1. Lower horizontal stabilizer attachment:

Lug load	33.1%
Drag box	34.3%
Drag box tang	13.5%

See reference 2. These are the cumulative percentages projected at the end of a 25-hr flight program to include all previous damage.

2\.

Tail-rotor thrust cell	13.0%
Main-rotor shaft bending	10.5%
Right-aileron control rod	3.4%

See reference 1. These percentages are 25-flight-hour extrapolations of the rate at which damage was accruing during previous flights. Note: 10.9% on tail-rotor thrust occurred before a fix subsequent to which no damage has accumulated; therefore, the extrapolation uses the rate of paragraph 3, following.

3. All other components with specified fatigue lives (see ref. 5): 2.1% increase in 25 flight hours; 2.1% is a rate based on 50% damage permitted over a projected aircraft life of 600 flight hours.

Flight Field Procedures

The RSRA will operate in accordance with ARC procedures for operations of aircraft at ARC as set forth in reference 6. The RSRA will opeerate in the test areas designated by FO.

Weather

The following requirements are applicable to the RSRA flight-test program.

1. Ceiling: Sufficient to obtain ground clearance adequate for the test with at least 1000 ft vertical cloud clearance (except yardwork).

2. Visibility: Daylight — at least 3 miles with a well-defined horizon except yardwork.

3. Turbulence: No specific limit; limit at pilot's discretion.

4. Precipitation: None allowable.

5. Any special requirements as specified in each test attachment.

OPERATING PROCEDURES

The aircraft shall be operated and inspected in accordance with the latest approved revision of the Pilot's Checklist (ref. 7) and the Maintenance and Inspection Checklist (refs. 8 and 9).

Preflight and Postflight Briefings

Comprehensive preflight and postflight briefings will be conducted for each flight by the Ames flight test director. The participants at each briefing will be established by the flight test director. The test conditions will be selected from the approved Test Plan. The FHI preflight and postflight briefing checklist will be followed. Each test data point, for the applicable flight card, will be discussed in detail as to the data required, limitations, test techniques, aircraft configuration changes, and expected results. Emergency procedures will be discussed, and a notation made on the flight card of all test conditions outside the EES envelope (Note: EES will not be operable for this test plan; therefore, all flight will be restricted to the EES inoperative envelope).

All flight cards will include the planned sequence of flight-test points. The final flight card will be reviewed in detail during the preflight briefing. The instrumentation and configuration/status and aircraft configuration/changes will be documented and presented during each preflight briefing.

Parameters critical to the safety of flight or test accomplishment will be specified at the preflight briefing. These critical parameters will be of a go/no-go nature. If substitute, backup parameters are known, these parameters will be briefed. Critical parameters will be selected on the basis of experience, documented requirements, and test requirements.

At the conclusion of each test flight, a debriefing will be held. The debriefing will cover those items on the RSRA postflight briefing checklist.

Following debriefing, a flight summary report will be compiled by the test director.

Postflight Data Review

Test data will be reviewed between flights. The extent of the review will be determined by the test director. A postflight data review meeting will be conducted. The postflight data review meeting may be combined with the preflight briefing, at the discretion of the test director.

Flight Conduct

Flight-test conduct will be controlled by the ARC test director from the telemetry control room. In addition to the test director and the flight-test engineers who are monitoring the telemetry, the ground-station personnel will be in the telemetry room during all flights. The TM/Control Room area will be limited to personnel involved in the flight operation.

Telemetry will be used on an as-required basis as determined by the test director and flightcrew. The test director will always be in the telemetry station and have direct voice contact with the flightcrew. The test director shall advise the flightcrew of pertinent information available to him via telemetry. The test director will monitor selected critical parameters identified on the critical parameter list. The 10 selected parameters will be monitored on telemetry continually to verify behavior of loading relative to endurance limits/DNE levels. The current and approved Flight Test Limits, reference 5, will be used to ensure that the relationship of test values to those limits can be readily checked at all times.

During a telemetry-controlled test flight, the flightcrew and the test director equally share the responsibility for the safe conduct of the flight-test program. If either detects a potentially unsafe condition during the flight, he has the authority and responsibility to abort the flight or limit the test envelope until the problem has been resolved.

During the conduct of testing, all stations will use the assigned Ames test frequencies. The stations requiring communications include the RSRA aircraft, the chase aircraft, the tower, and the control/TM room.

A chase/rescue helicopter will accompany the aircraft on all flights outside the airfield boundary. Chase pilots and crew must attend the preflight briefings.

Photographic coverage in the chase/rescue helicopter may be used at the discretion of the RSRA pilots and test director. Any special test procedures are set forth in the test attachments.

FLIGHT ENVELOPE

The helicopter flight envelope was developed by Sikorsky Aircraft for each RSRA as reported in reference 1. The envelope developed for RSRA 740 (formerly 545) will be used for this test. A master parameter for the upper horizontal stabilizer will be monitored on telemetry for this test.

RSRA 740 helicopter envelope:

19,800 lb gross weight at takeoff
302 in. normal c.g.
104% normal operating N_R
3000-ft density altitude maximum
20-sec hover 360° turn rate
20 knots right sideward flight velocity
30 knots left sideward flight velocity
20 knots rearward flight velocity

The envelope is further defined by the rotor speed, maneuvering, and V-N diagrams excerpted from reference 1 and presented in figure A1.

With the emergency escape system (EES) inoperative, flight is restricted to hover and forward flight up to 70 knots IAS at altitudes less than 200 ft AGL over a suitable hard surface landing area.

FLIGHT-SUPPORT FACILITIES

The following support facilities are required.

1. Ames Research Center, Moffett Field, flight facility
2. (Deleted)
3. Chase/rescue helicopter for flight out of the yard
4. Fire truck on station from engine start to engine shutdown
5. Utility pace vehicle with two-way communications to tower and aircraft
6. Transit to maintain hover height
7. Data camera
8. Hand-held anemometer

DATA ACQUISITION, PROCESSING, AND TELEMETRY

Data Acquisition

Measurement data will be recorded on board by the RSRA PADS on two tapes. The PADS recording capacity is 120 FM and 104 PCM measurements. The parameters to be recorded are listed in table A1.

Data Processing

Data will be processed as required by the Playback Schedule, issued 1 day before the flight, and the tape log (Emery sheet). The FM data will be filtered as required by the Emery sheet before digitizing. Most FM data will require peak and hold processing as specified by the Emery sheet, i.e., i/T, 1/M, 5/M. PCM sampling rate is determined by the PADS setup and is 80/sec.

Oscillogram and PCM strip charts will be required immediately after each flight (1 day) to check recorded data quality and to analyze waveform.

The EASE program will be used to process digitized data to provide DA (data analysis) task tabulations of data within 2 working days following the flight. The DA layout will be specified by the test director about 1 week in advance of the test. The EASE program will also be used to provide cycle-count tabulations of parameters with vibratory concern levels. These concern levels will also be provided 1 week before the test.

It is not planned that postflight frequency or harmonic data analysis will be required.

Telemetry (TM)

Up to 10 FM parameters and the PCM will be telemetered for real-time monitoring. The TM setup and parameters to be monitored on oscillogram or Brush recorder output will be specified by the test director 10.5 days before the test. Frequency analysis of TM data may be required to troubleshoot vibration problems. The Hewlett-Packard 5423A analyzer with plotter will be required in standby condition to be switched upon request to any parameter on TM.

The aircraft PADS TM shall be switchable to any FM track. Table 2 is a list of the telemetered FM parameters required for this test.

Preflight and Postflight Data Sequence

	Action required	When and hours[a]	By whom
1.	Flight request to FO	1 week before	Test director
2.	Data review (previous flight)	Prior to or at briefing	Test director, Smart Book engineers, pilots
3.	Playback schedule and TM setup to data processing (DP)	-48	Test director
4.	Emery sheet to DP	-24	Instrument engineer
5.	Test card review	-24	Test director
6.	PADS preflight and test tape (before rollout)	-24	Instrument engineer and technician
7.	Tape to A/C, instruments setup for flight	-3 1/4	Instrument engineer and technician
8.	Briefing	-2 3/4	Test director, pilots, TM team, A/C managers, instrument engineers, support crews
9.	Man TM	-1 3/4	Test directors, TM team
10.	Send A/C calibrations to TM and tape	-1 3/4	A/F flight-test engineer
11.	Pilots to A/C	-3/4	Pilots
12.	Conduct flight	0	Pilots, TM team, test director, support crews
13.	Debrief	+1/2	Same as (7)
14.	Tape to DP	+1	Instrument engineer
15.	Flight log to DP	+1	Data aide

	Action required	When and hours	By whom
16.	Pick up stripouts	+24	Data aide
17.	Scan stripouts and initial crab sheets	+32	Flight-test engineers (Smart Book assigned)
18.	Pick up DA output	+48	Data aide
19.	Review DA and crab sheets	+54	Flight-test engineers (Smart Book assigned)
20.	Update Smart Book	+72	Flight-test engineers (Smart Book assigned)

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[a] Minus signs designate hours before flight, plus signs designate hours after flight completion.

TABLE A1.- PADS INSTRUMENTATION LIST

FM

Parameters	Mnemonic	Helicopter	Compound
MR pitch	MRPITCH	X	X
MR flap	MRFLAP	X	X
MR lag	MRLAG	X	X
MR shaft bending	MRSBLI	X	X
MR damper moment	MRDMPOI	X	X
MR blade rear station 6	MRBR6	X	X
MR push rod	PRLREDUP	X	X
MR blade rear station 7	MRBR7	X	X
MR rotating scissors	MRROTSC	X	X
MR stationary scissors	MRSTASC	X	X
MR right lateral stationary star	MRRLSS	X	X
MR contractor	MR ψ <	X	X
Left landing gear lateral vibration	LTLGLT	X	X
Right landing gear lateral vibration	LTLGRT	X	X
Longitudinal vibration, left wing tip	LOWGTLT		X
Vertical vibration, tail-rotor gearbox	VTGB	X	X
Lateral vibration, tail-rotor gearbox	LTGB	X	X
Vertical cockpit load factor	VCPLF	X	X
Lateral cockpit load factor	LCPLF	X	X
Lower stabilizer lug stress	TPYLN200		X
Lower stabilizer lug stress	TPYLN201		X
Lower stabilizer lug stress	TPYLN202		X
Left-aileron control rod load	LAICR		X
Right-aileron control rod load	LAICR		X
TR blade normal bending	TRNBR	X	X
TR Contactor	TR ψ <	X	X
TR pitch beam bending	TRPBEAM5	X	X
TR spindle edgewise bending	TRSPED1	X	X
TR stationary control load	TRSTCONT	X	X
Lower stabilizer lug stress	TPYLN203		X
Lower stabilizer lug stress	TPYLN204		X
Lower stabilizer lug stress	TPYLN205		X
Lower stabilizer drag box stress	DBOX15		X
TR blade stress	TRP2	X	X
Balance torque cell, forward	MRGBQCE	X	X
Balance torque cell, aft	MRGBQCF	X	X
Left redundant link load	LRLL	X	X
RT redundant link load	RLLL	X	X
TR balance thrust cell	TRTHRN	X	X
MR balance lift cell, left forward	MRLIFTA	X	X
MR balance lift cell, right forward	MRLIFTB	X	X
MR balance lift cell, left aft	MRLIFTC	X	X
MR balance lift cell, right aft	MRLIFTD	X	X
MR balance drag cell	MRDRAG	X	X
Wing, left biaxial lift cell	WINGJ		X

TABLE A1.- CONTINUED.

PCM

Parameters	Mnemonic	Helicopter	Compound
Airspeed	VIPBOOM	X	X
Wing incidence	IW		X
Longitudinal mixer input position	LGMIXIP	X	X
Lateral mixer input position	LATMIXIP	X	X
Collective mixer input position	COLMIXIP	X	X
Lateral stick position	LATSTKP	X	X
Longitudinal stick position	LGSTKP	X	X
Collective stick position	COLLSTKP	X	X
Pedal position	PEDP	X	X
Pitch acceleration	PITCHACC	X	X
Roll acceleration	ROLLACC	X	X
Yaw acceleration	YAWACC	X	X
Load factor	LOADFACT	X	X
Angle of attack	ATTACK		X
Sideslip	SIDESLIP	X	X
No. 1 TF-34 fuel flow	NO1AUXWF		X
No. 2 TF-34 fuel flow	NO2AUXWF		X
Lateral stick force (SP)	LATFORCE	X	X
Longitudinal stick force	LGFORCE	X	X
Pedal force (net)	PEDFORCN	X	X
Lateral load factor	LATCG	X	X
No. 1 TF-34 speed lever	NO1AUXSL		X
Right lateral servo output position	RTLATSVOP	X	X
Left lateral servo output position	LLATSVOP	X	X
Longitudinal servo output position	LGSRVOP	X	X
Rate of climb	ROCBOOM	X	X
No. 2 TF-34 speed lever	NO2AUXSL		X
No. 1 T-58 gas generator speed	NO1NGPCT	X	X
No. 2 T-58 gas generator speed	NO2NGPCT	X	X
No. 1 T-58 torque	NO1QPCT	X	X
No. 2 T-58 torque	NO2QPCT	X	X
Main gear box oil inlet temperature	MGBOILIN	X	X
Main gear box oil outlet temperature	MGBOILOT	X	X
Main gear box critical temperature	MGBCRIT	X	X
No. 1 generator air inlet temperature	TN1GENA1	X	X
No. 1 T-58 free turbine	NO1NFPCT	X	X
No. 2 T-58 free turbine	NO2NFPCT	X	X
TR torque	TRQ	X	X
No. 1 TF-34 thrust cell	THRUSTLT		X
No. 2 TF-34 thrust cell	THRUSTRT		X
No. 1 hydraulic system reservoir temperature	TN1RES	X	X
No. 2 hydraulic system reservoir temperature	TN2RES	X	X
No. 3 hydraulic system reservoir temperature	TN3RES	X	X
No. 2 T-58 T5 temperature	NO2T5	X	X
No. 1 TF-34 pylon temperature	N1TEP1		X
No. 1 TF-34 pylon temperature	N1TEP2		X
No. 2 TF-34 pylon temperature	N2TEP1		X
Lower horizontal stabilizer incidence	STABPOS		X
Rudder position	RUDPOS		X

TABLE A1.- CONCLUDED.

Parameters	Mnemonic	Helicopter	Compound
Wing angle of attack	ATTACKW		X
No. 1 T-58 fuel inlet temperature	NO1FIT	X	X
No. 2 T-58 fuel inlet temperature	NO2FIT	X	X
Right aileron position	AILPOSR		X
Right flap position	FLAPPOSR		X
Wing-pitch actuator load, left	WINGH		X
Wing-pitch actuator load, right	WINGI		X
Wing-force fail light	WNGFORFL		X
No. 1 TF-34 fan speed	NO1AUXNF		X
No. 2 TF-34 fan speed	NO2AUXNF		X
Icebath, 0°C	ICEBATH	X	X
Force augmentation system servo surface temperature	SPPFASST	X	X
Altitude	HBOOM	X	X
TF-34 gas generator speed	NO1AUXNG		X
TF-34 gas generator speed	NO2AUXNG		X
Free air temperature	ITATBOOM	X	X
Longitudinal stick position, safety pilot	LGSTKPE	X	X
Lateral stick position, safety pilot	LATSTKPE	X	X
Collective stick position, safety pilot	COLSTKPE	X	X
TF-34 thrust, left	THRUSTLT		X
TF-34 thrust, right	THRUSTRT		X
Rotary trfr unit temperature	RTUFPTMP	X	X
No. 1 TF-34 T5 temperature	NO1AUXT5		X
No. 2 TF-34 T5 temperature	NO2AUXT5		X
Wing actuator cylinder temperature, right	WACTURT		X
No. 1 TF-34 fuel inlet temperature	N1TFIT		X
No. 2 TF-34 fuel inlet temperature	N2TFIT		X
TR impressed pitch	TRIMPIT	X	X
Run tone monitor	--	X	X
Drag redundant link load	DRLL	X	X

TABLE A2.- FM TELEMETRY LIST FOR HELICOPTER CONFIGURATION

Parameter	Mnemonic
1. Lateral acceleration copilot floor	LCOPF
2. MR push-rod load	PRLREDUP
3. Upper horizontal stabilizer stress	UHZSTB
4. TR pitch beam load	TRPBEAM 5
5. TR spindle edgewise bending	TRSPED1
6. MR right lateral stationary star	MRRLSS
7. Vertical acceleration, tail gear box	VTGB
8. Main-rotor blade flapping	MRFLAP
9. Main-rotor blade bottom rear, station 6	MRBR6

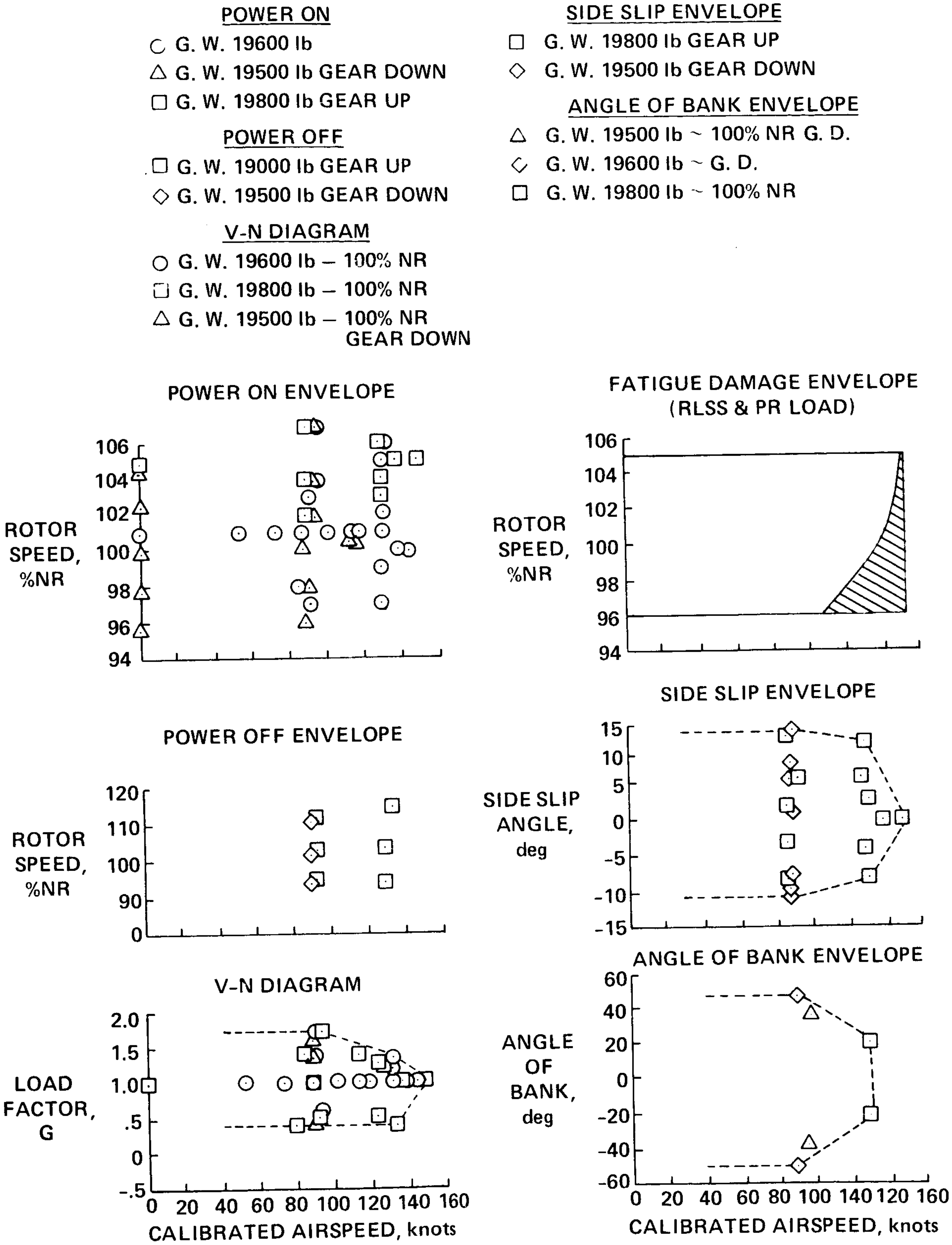

Figure A1.- Helicopter flight envelope.

ATTACHMENT A1

HELICOPTER CONFIGURATION MAINTENANCE CHECKOUT: FLIGHT TEST

TEST OBJECTIVES

The specific objectives of this flight will be to

1. Perform 0.5-hr main transmission hovering run-in required after overhaul

2. Conduct maintenance flight, following lengthy downtime while disassembled in calibration fixture assembly, to check out aircraft and systems in the simpler helicopter configuration

3. Obtain balance-system data for hover and low-speed flight

4. Check out PADS, TM, and data processing system

5. Familiarize test team with this particular RSRA while in simpler helicopter configuration.

GENERAL INFORMATION

1. Only evaluation pilot and safety pilot on board aircraft

2. Aircraft-to-ground station (TM), tower, and chase/rescue communications are required

3. Chase/rescue helicopter is not required if flight is restricted to field boundaries

4. Wind velocities of 3 knots or less are desired for Functional/Research Data Flight Tests.

5. Data will be recorded for each test plan item unless specifically noted otherwise on the test card.

CONFIGURATION

1. Helicopter configuration

2. Gross weight 19,800 lb maximum at takeoff

3. Center of gravity 302 ±1 in.

4. EFCS computer OFF (not installed)

5. Bifilar installed

INSTRUMENTATION AND DATA ACQUISITION REQUIREMENTS

Real-time telemetry and on-board instrumentation data recording are required (see Data Acquisition, Processing, and Telemetry for details). FM and PCM strip-chart recording of TM data will be monitored for the flight test.

Wind velocity will be recorded using a hand-held anemometer upwind of aircraft during functional and balance-system flight tests.

FLIGHT ENVELOPE RESTRICTIONS

The aircraft will be flown within the established aircraft envelope. A 30-min fuel reserve will be maintained. The EES will not be operable. The "EES inoperative" restrictions of the flight envelope will apply.

TM will monitor, specifically, the upper horizontal stabilizer stress to assure that endurance values are not exceeded for extended periods.

FLIGHT MANEUVERS: GROUND/HOVER FUNCTIONAL FLIGHT CHECKS

Nominal sea level, gross weight 19,800 lb or less.

1. Start engines

2. Rotor engagement

3. Increase collective until light on landing gear; insure proper function of flight controls and basic airframe systems

4. Ground run, flat pitch, perform N_R sweep in 2% increments from 96 to maximum percent N_R

5. Taxi

6. On ground, perform engine acceleration/deceleration checks

7. On ground, perform damper check

8. Perform servo ground check

9. Lift to hover, SAS OFF at about 5 ft; check control response; land, lightly

10. Lift to hover, SAS OFF at about 10 ft; check larger control inputs

11. Hover, SAS OFF; perform servo checks; land

12. On ground, SAS ON; ground check all channels; lift to hover at about 10 ft; check all SAS channels ON and OFF

13. Hover, perform generator under-frequency check, N_R to 96%

14. Hover, perform engine topping checks

15. Hover, perform emergency throttle check

16. Hover, 104% N_R; perform 360° turns, left and right

17. Hover for a minimum of 30 min, items (9) through (17), followed by shutdown for MGB and a postflight and preflight inspection before continued flight.

FUNCTIONAL AND BALANCE SYSTEM DATA FLIGHT TESTS

Nominal sea level, gross weight 19,800 lb.

1. Hover, nominal 104% N_R, acquire load-cell force measurements at high gross weight from 5, 10, 20, and 40 ft and OGE. Record actual height on data camera. Repeat two more times.

2. At nominal 104% N_R, acquire load-cell force measurements at high gross weight at 10 and 20 ft and OGE; at 5, 10, and 15 knots forward speed. Record actual height and forward speed on data camera. Repeat two more times.

3. Hover, 104% N_R; perform forward acceleration to 70 knots IAS (over runway) and decelerate to hover. Repeat two more times. Perform landing gear retraction cycle during forward flight.

4. Hover, IGE; perform N_R sweep in 2% increments, from 96 to maximum percent N_R.

5. Hover, 104% N_R; establish vertical climb, then transition to vertical descent to hover. Vertical rates to be determined by pilot's judgment. Record continually with event marker at transition point and maximum obtained ROC/ROD. Repeat two more times.

6. Repeat items (1) and (2) at mid-gross-weight values.

7. Hover, 104% N_R; smoothly accelerate to about 40 knots; slowly decelerate through hover to 20 knots rearward; then accelerate back to hover. Record continually, mark zero speed and end speeds with event marker (or voice).

8. Repeat item (7), except for 20 knots left and right sideward flight.

9. Repeat items (7) and (8), in order, two more times.

Items (10)-(13) are optional, time permitting or if fuel burn-off for low gross weight required (item 14): At 104% N_R, record event when passing through zero ground speed.

10. From about 20 knots forward, decelerate to about 20 knots rearward.

11. From about 20 knots rearward, accelerate to about 20 knots forward.

12. From about 20 knots sideward, accelerate to about 20 knots left sideward.

13. From about 20 knots left sideward, accelerate to about 20 knots sideward.

14. Repeat items (1) and (2) at low gross weight.

Note that items (1), (2), (6), and (14) have fuselage vertical download as a test objective. Three repeats of each are desired. Wind speed of 3 knots or less required for hover data for these test items.

ATTACHMENT A2

HELICOPTER CONFIGURATION LOW-SPEED HANDLING-QUALITIES TEST

TEST OBJECTIVES

The specific objective of this flight test is to obtain low-speed handling-qualities data in the low-speed transition range for both forward and sideward flight using, in particular, the data from the RSRA balance system.

GENERAL INFORMATION

1. Only evaluation pilot and safety pilot on board aircraft.
2. Aircraft-to-ground station (TM), tower, and chase/rescue communications are required.
3. Chase/rescue helicopter is not required if flight is restricted to field boundaries.
4. Wind velocities must be 3 knots or less for hover data.
5. Data will be recorded for each test plan item unless specifically noted otherwise on the test card.

CONFIGURATION

1. Helicopter configuration
2. Gross weight 19,800 lb maximum at takeoff
3. Center of gravity 302 ±1 in.
4. EFCS computer OFF (not installed)
5. Bifilar installed

INSTRUMENTATION AND DATA ACQUISITION REQUIREMENTS

Real-time telemetry and on-board instrumentation data recording are required (see Data Acquisition, Processing, and Telemetry for details). FM and PCM strip-chart recording of TM data will be monitored for the flight test.

Wind velocity will be recorded using a hand-held anemometer upwind of aircraft during the test. Camera data are not required.

FLIGHT-ENVELOPE RESTRICTIONS

The aircraft will be flown within the established aircraft envelope. A 30-min fuel reserve will be maintained. The EES will not be operable. The "EES Inoperative" restrictions of the flight envelope will apply.

TM will monitor, specifically, the upper horizontal stabilizer stress to assure that endurance values are not exceeded for extended periods.

FLIGHT MANEUVERS: GROUND/HOVER FUNCTIONAL FLIGHT CHECKS

Nominal sea level, gross weight 19,800 lb or less. SAS ON, except as noted.

1. Trim level flight, 104% N_R, OGE at hover and at 5-knot increments to 60 knots forward. Pace speeds with vehicle, except airspeed may be used at higher speeds when reliable.

2. Repeat item (1). Items (1) and (2) should be conducted at about the same gross weight.

3. Trim level flight, 104% N_R, OGE at hover and at 5-knot increments to 30 knots left sideward flight, and to 20 knots right sideward flight. These tests should be conducted at about the same gross weight.

4. From trim level flight, 104% N_R, OGE at hover and 40 knots forward speed, input "sharp" pulses of approximately 10% control and 1 sec duration, in each direction for longitudinal and lateral cyclic and for collective. SAS OFF.

5. Repeat item (4) for pulses in one direction only.

APPENDIX B

FLIGHT-TEST PLAN: COMPOUND CONFIGURATION

SCOPE

RSRA 740 has completed a helicopter configuration maintenance check and vertical drag flight-test program. It is now in preparation to fly as a compound. This test plan addresses those flights planned for the first 25 flight hours as a compound at NASA Ames. RSRA 740 was approved to operate for these tests by the Airworthiness and Flight Safety Review Board on June 23, 1981 (refs. 10 and 11). This plan encompasses Phases III and IV of the Flight Project Request (FPR-2), reference 10. These phases consist of pilot familiarization, operational checkout, and baseline data acquisition. It is anticipated that the tests will be planned in three segments (inclusive to this overall plan), with the tests to be completed by June 1982.

TEST OBJECTIVES

The objectives of this flight test are as follows:

1. Perform initial flight of RSRA compound at NASA Ames

2. Familiarize and train NASA project pilots with the RSRA compound

3. Develop improved takeoff technique

4. Check out RSRA compound throughout the established envelope, acquiring flight data to complete documentation of that envelope

5. Develop and evaluate wing incidence angles combined with use of flaps and speed brake to improve flight attitudes and landing technique

6. Establish baseline RSRA compound performance with S-61 rotor system

TEST DESCRIPTION

The flight tests are defined in attachments B1 and B2 which contain

1. Test objectives

2. General information

3. Configuration/conditions

4. Instrumentation and acquisition requirements

5. Flight envelope restrictions

AIRCRAFT CONFIGURATION

RSRA 740 will be in the compound configuration with the rudder, lower horizontal stabilizer, wing, and auxiliary engines with pylons in place. The smaller, compound, upper horizontal stabilizer will be in place. The main rotor bifilar absorber will be operational with the bushings previously used with the helicopter flights. The TDY-43 computer will not be installed. SAS gains will be reset for the compound configuration.

The emergency escape system (EES) will be operational for these flight tests. The avoid envelope for this system is presented in reference 13.

The aircraft will be flown at 27,110 lb gross weight, or less, at 302 ±1 in. longitudinal center of gravity.

Control from the left seat (evaluation pilot) will be operational through the force feel system (FFS).

The data acquisition system with telemetry (PADS) will be operational.

RESPONSIBILITIES AND CONTROL FUNCTIONS

Flight-Test Team Assignments

The flight-test team will be composed of ARC personnel with Sikorsky personnel supporting the tests under contract with ARC.

The test-team assignments for test responsibility and TM are:

Title/responsibility	Person assigned	Description of responsibility
Test director	R. Erickson	Directs flight-test program
Structures/vibrations:		
Structures/tail empennage	(R. Hodge)*	Coordinates and is responsible for all structures/vibrations and specific responsibility for stress/loads/vibrations at tail structures; power plant vibrations and temperatures
MR/TR	(W. Ericson)*	Responsible for stress/loads/vibrations/temperatures on MR, TR, gear boxes, and drive train; maintain cycle counts
Airframe	R. Kufeld*	Responsible for A/F stress/loads/vibrations/temperatures, except for above and ending at A/F engine mounts. Preflight, postflight calibrations, load cells
Handling qualities	(R. Carter)*	Responsible for flight controls and rigging (except engine); flight characteristics

Title/responsibility	Person assigned	Description of responsibility
Performance	J. Cross	Responsible for power plant/airframe/rotor performance analysis
Power plants	S. Haff	Responsible for power plant operation and control

Note: Parentheses indicate Sikorsky personnel. * Maintains Smart Book.

Test team assignments for aircraft, systems, and data support:

Title/responsibility	Person assigned	Description of responsibility
Balance system	C. Acree	Balance system test data acquisition, output analysis
Instrumentation	(R. Bowolick)	Responsible to FHI for A/C test instrumentation, emery sheet, A/C data tape, calibration
A/C manager	J. Brilla	Coordinates all activities on the RSRA 740
Handling qualities (analytical)	J. Jinkerson	Responsible for stability and control predictions, analysis
SAS/FFS	R. Young	Engineering support for SAS/FFS
Data processing aide	A. Hood	Smooth flight log, tape cataloging, flight data files, EASE inputs, including UPC; hand data plots; tabulations; calculations

Note: Parentheses indicate Sikorsky personnel.

Flight-Test Team Responsibility Definitions

In addition to the responsibility descriptions of the previous section, the following responsibilities are assigned and defined.

Smart Book- The designated persons shall prepare and maintain a loose-leaf file of flight-test data, ground-test data, and predicted data for measured parameters pertinent to their assigned area of responsibility. Plots of these data shall be maintained in this file, and new flight-test data, from TM or postflight processing, shall be added in an on-going manner. Comparison of the new data to the previous or predicted shall be accomplished as soon as the new data are available. Unsafe or significant deviations or trends must be identified and reported immediately to the test director. Of particular concern are deviations noted during TM operations. Designated persons shall present the updated Smart Book, with appropriate comments, at each postflight briefing, postflight data review, and preflight briefing.

Data to make up the Smart Book will be obtained from previous tests as reported in SER-72045 (ref. 1), various analytical prediction reports, analysis concurrent with the program, and from the ongoing test program.

Test responsibility and TM team members- The team members listed under this heading are responsible for maintaining the accuracy and adequacy of the measurements within the scope of their assignments. This applies to TM, data acquisition on tape, data processing, and to orderly data records. These team members will prepare a section for the final report on test results when directed.

Test director- The test director is responsible for directing the flight-test program; approves all engineering measurement requests; prepares, with the pilots, the flight cards; supervises the TM test team; and, for flight-test data, will determine the necessary corrective action when unsafe or significant deviations or trends are identified by any member of the test or supporting team.

Additional details of responsibilities are given in reference 4. The reference 4 definition of structural/dynamics responsibilities generally is applicable to handling qualities.

OPERATING LIMITATIONS

Parameter Limits

Structural and system parameter limits will be as specified in the latest revision of the Flight Test Limits (ref. 5) and, for the lower horizontal stabilizer, SER-72051 (ref. 2). In addition, the 31 Hz tail rotor edgewise bending moment vibratory amplitude will be monitored. A limit of 40% of E_W will be observed. The 40% E_W level will be treated as an endurance level.

Structural Fatigue Estimation

Structural integrity of RSRA components will be monitored in accordance with the following procedure. A systematic record of cumulative damage will be maintained for any structural parameter that is observed to be loaded in excess of the approved endurance limit. These records will be reviewed continuously to ensure that no component remains in the aircraft beyond its safe life. These records will be included in the structural shakedown report at the end of the program.

Structural Fatigue Cumulative Damage Accountability

Based on a projected 25-flight-hour program, when the cumulative damage on any component exceeds the following criteria, the fatigue history of the component must be reviewed, and approval for continued operation obtained before the next flight. This approval is obtained by concurrence of the following:

1. Sikorsky RSRA program manager
2. RSRA chief of development
3. RSRA 740 test director
4. FHI chief

Cumulative Fatigue Damage Accountability Criteria

Review is required when the accumulated damage reaches or exceeds the following fatigue life percentages:

1. Lower horizontal stabilizer attachment:

Lug load	33.1%
Drag box	34.3%
Drag box tang	13.5%

See reference 2, revision 1. These are the cumulative percentages projected aat the end of a 25-hr flight program to include all previous damage.

2\.

Tail-rotor thrust cell	13.0%
Main-rotor shaft bending	10.5%
Right-aileron control rod	3.4%

See reference 1. These percentages are 25-flight-hour extrapolations of the rates at which damage was accruing during previous flights. Note: 10.9% on tail-rotor thrust occurred before a fix subsequent to which no damage has accumulated; therefore, the extrapolation uses the rate of paragraph 3, following.

3\. All other components with specified fatigue lives (see ref. 5): 2.1% increase in 25 flight hours; 2.1% is a rate based on 50% damage permitted over a projected aircraft life of 600 flight hours.

Braking Limitations

Repeated use of the brakes will result in overheating of the wheel and brake assemblies resulting in tire blowouts and heat damaged components. A Sikorsky Program Management Instruction, reference 14, specifies schedules for determining cooling periods and temperature limits. Tables B1 and B2 are excerpted from that document and presented herein for convenience and compliance.

Flight Field Procedures

The RSRA will operate in accordance with ARC procedures for operations of aircraft at ARC as set forth in reference 6. The RSRA will operate in the test areas designated by FO.

Weather

The following requirements are applicable to the RSRA flight-test program.

1\. Ceiling: Sufficient to obtain ground clearance adequate for the test with at least 1000 ft vertical cloud clearance.

2\. Visibility: Daylight. At least 3 miles with a well-defined horizon except yardwork.

3\. Turbulence: No specific limit; limit at pilot's discretion.

4. Precipitation: None allowable.

5. Any special requirements as specified in each test attachment.

OPERATING PROCEDURES

The aircraft shall be operated and inspected in accordance with the latest approved revision of the Pilot's Checklist (ref. 7) and the Maintenance and Inspection Checklist (refs. 8 and 9).

TF-34 Ground Operations with Rotor Blades Stopped

The following procedures will be followed to prevent TF-34 jet wash and heat damage to aircraft components when the rotor blades are stopped:

1. TF-34 power not to exceed ground idle.

2. Aircraft to be positioned so that wind (if present) comes from 15° to 30° off right side of nose.

3. Tail-rotor blades manually moved to rest against outboard stops before engine is started.

4. Crew is to note if any flapping of TR blades occurs and, if so, is to advise pilot to shut down TF-34s.

T-58 Ground Operations

The exhaust of the T-58 engines impinges upon the TF-34 pylons and can cause temperatures that reduce strength of aluminum skin and spars and deteriorates the fiberglass fairings. To minimize this heating, the following guidelines for ground operation of the T-58 engines should be followed whenever possible:

1. Minimize time on the No. 1 T-58 operating singly, either in accessory drive or rotor turning.

2. Operate the T-58 engines with the rotor turning and the load shared.

In addition, T-58 and rotor start and stop times will be recorded.

Preflight and Postflight Briefings

Comprehensive preflight and postflight briefings will be conducted for each flight by the Ames flight test director. The participants at each briefing will be established by the flight test director. The test conditions will be selected from the approved Test Plan. The FHI preflight and postflight briefing checklist will be followed. Each test data point, for the applicable flight card, will be discussed in detail as to the data required, limitations, test techniques, aircraft configuration changes, and expected results. Emergency procedures will be discussed, and a notation made on the flight card of all test conditions outside the EES envelope.

All flight cards will include the planned sequence of flight test points. The final flight card will be reviewed in detail during the preflight briefing. The instrumentation and configuration/status and aircraft configuration/changes will be documented and presented during each preflight briefing.

Parameters critical to the safety of flight or test accomplishment will be specified at the preflight briefing. These critical parameters will be of a go/no-go nature. If substitute, backup parameters are known, these parameters will be briefed. Critical parameters will be selected on the basis of experience, documented requirements, and test requirements.

At the conclusion of each test flight, a debriefing will be held. The debriefing will cover those items on the RSRA postflight briefing checklist.

Following debriefing, a flight summary report will be compiled by the test director.

Postflight Data Review

Test data will be reviewed between flights. The extent of the review will be determined by the test director. A postflight data review meeting will be conducted. The postflight data review meeting may be combined with the preflight briefing, at the discretion of the test director.

Flight Conduct

Flight-test conduct will be controlled by the ARC test director from the telemetry control room. In addition to the test director and the flight-test engineers who are monitoring the telemetry, the ground-station personnel will be in the telemetry room during all flights. The TM/control room area will be limited to personnel involved in the flight operation.

Telemetry will be used on all flights. The test director will always be in the telemetry station and have direct voice contact with the flightcrew. The test director shall advise the flightcrew of pertinent information available to him via telemetry. The test director will monitor selected parameters from the critical parameter list. The selected parameters will be monitored on telemetry continually to verify behavior of loading relative to anticipated trends. The current and approved flight test limits, reference 5, will be used to ensure that the relationship of test values to those limits can be readily checked at all times.

The flightcrew and the test director equally share the responsibility for the safe conduct of the flight-test program. If either detects a potentially unsafe condition during the flight, he has the authority and responsibility to abort the flight or limit the test envelope until the problem has been resolved.

During the conduct of testing, all stations will use the assigned Ames test frequencies. The stations requiring communications include the RSRA aircraft, the chase aircraft, the tower, and the control/TM room.

A chase/rescue helicopter will accompany the aircraft on all flights outside the airfield boundary. For flights with speeds exceeding 120 knots, a fixed-wing chase will be required in addition to the helicopter chase. Chase pilots and crew must attend the preflight briefings.

Photographic coverage in the chase/rescue aircraft may be used at the discretion of the RSRA pilots and test director. Any special test procedures are set forth in the test attachments.

FLIGHT ENVELOPE

The compound flight envelope was developed by Sikorsky Aircraft for RSRA 740 as reported in reference 1. This envelope was established for 10° wing incidence, but may be expanded to include additional wing incidence angles during this program. The expanded envelope will be based on results of flight tests to be conducted. Predictions for the expanded envelope are obtained from analysis developed for and included in reference 10, revision 2.

RSRA 740 compound envelope:

27,110 lb gross weight at takeoff
302 in. normal c.g.
104% normal operating N_R (100% at speeds >160 knots CAS)
4800-ft density altitude, maximum
57- to 181-knot CAS level flight airspeeds
7 knots maximum crosswind component for takeoff and landing

The envelope is further defined by the rotor speed, wing-flap angle, maneuvering, and V-N diagrams excerpted from reference 1 and presented in figures B1-B3. The demonstrated limits for adjustment of collective position are presented in figure B4 from data obtained from reference 1.

The envelope for safe ejection from the RSRA using the EES is presented in figures B5 and B6. The evaluation pilot's station is most critical.

FLIGHT SUPPORT FACILITIES

The following support facilities are required.

1. NASA Ames Research Center, Moffett Field, flight facility

2. Chase/rescue helicopter for flight outside the field boundary

3. Fixed-wing chase for flights on which speeds exceed 120 knots CAS. (Note: Envelope maximum speed is 181 knots)

4. Fire truck on station from engine start to engine shutdown

5. Ground operations video tape coverage

6. Airborne cinematic and still photographic coverage (when requested)

DATA ACQUISITION, PROCESSING, AND TELEMETRY

Data Acquisition

Measurement data will be recorded on board by the RSRA PADS on two tapes. The PADS recording capacity is 120 FM and 104 PCM measurements. The parameters to be recorded are listed in table B3. Note: table B3 is an initial list only and will be modified, summarily, by the test director, based on test requirements. Specifically, priority II and III parameters will be substituted for priority I tail parameters in accordance with reference 2.

Data Processing

Data will be processed as required by the Playback Schedule, issued 1 day before the flight, and the tape log (emery sheet). The FM data will be filtered as required by the emery sheet before digitizing. Most FM data will require peak and hold processing as specified by the emery sheet, that is, 1/T, 1/M, and 5/M. PCM sampling rate is determined by the PADS setup and is 80/sec.

Oscillogram and PCM strip charts will be required immediately after each flight (1 day) to check recorded data quality and to analyze waveform.

The EASE program will be used to process digitized data to provide DA (data analysis) task tabulations of data within 2 working days following the flight. The DA layout will be specified by the test director about 1 week in advance of the test. The EASE program will also be used to provide cycle count tabulations of parameters with vibratory concern levels. These concern levels will also be provided 1 week before the test.

Postflight frequency or harmonic data analysis will be required, upon request.

Telemetry (TM)

Up to 10 FM parameters and the PCM will be telemetered for real-time monitoring. The TM setup and parameters to be monitored on oscillogram and Brush recorder output will be specified by the test director. Frequency analysis of TM data may be required to troubleshoot vibration problems. The Hewlett Packard 5423A analyzer with plotter will be required in standby condition to be switched upon request to any parameter on TM. The parameter to be telemetered will be specified by the test director based on test requirements.

The aircraft PADS TM shall be switchable to any FM track.

Preflight and Postflight Data Sequence

Action required	When and hours[a]	By whom
1. Flight request to FO	Week before	Test director
2. Data review (previous flight)	Prior to or at briefing	Test director, Smart Book engineers, pilots

	Action required	When and hours	By whom
3.	Playback schedule and TM setup to data processing (DP)	-24	Test director
4.	Emery sheet to DP	-24	Instrument engineer
5.	Test card review	-24	Test director
6.	PADS preflight and test tape (before rollout)	-24	Instrument engineer and technician
7.	Tape to A/C, instrument setup for flight	-3 1/4	Instrument engineer and technician
8.	Briefing	-2 3/4 (or day before)	Test director, pilots, TM team, A/C managers, instrument engineers, support crews
9.	Man TM	-1 3/4	Test director, TM team
10.	Send A/C calibrations to TM and tape	-1 1/2	A/F flight-test engineer
11.	Pilots to A/C	-3/4	Pilots
12.	Conduct flight	0	Pilots, TM team, test director, support crews
13.	Debrief	+1/2	Same as (7)
14.	Tape to DP	+1	Instrument engineer
15.	Flight log to DP	+3	Data aide
16.	Pick up stripouts	+24	Data aide
17.	Scan stripouts and initial crab sheets	+32	Flight-test engineers (Smart Book assigned)
18.	Pick up DA output	+48	Data aide
19.	Review DA and crab sheets	+54	Flight test engineers (Smart Book assigned)
20.	Update Smart Book	+72	Flight-test engineers (Smart Book assigned)

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[a] Minus signs designate hours before flight, plus signs designate hours after flight completion.

TABLE B1.- BRAKE COOLING SCHEDULE

Brake-on velocity, knots	Change in temperature, °F
20	240
30	280
40	330
50	400
60	500
70	600
80	720
90	880
100	1080
110	1240
120	1400

TABLE B2.- COOLING TIME IN MINUTES

Brake temperature, °F	To 200°F	To 400°F	To 600°F	To 800°F	To 1000°F
200	0	0	0	0	0
250	13				
300	26				
350	38				
400	47				
450	56	6			
500	62	12			
550	68	19			
600	75	25			
650	81	31	8		
700	87	36	12		
750	93	41	16		
800	100	45	20		
850	106	49	23	5	
900	112	53	25	7	
950	118	57	28	10	
1000	125	60	30	12	
1050	131	63	32	14	1
1100	137	66	35	16	2
1150	143	70	37	18	3
1200	149	73	39	20	5
1250	-	76	41	22	6
1300	-	79	44	24	7
1350	-	82	46	26	8
Caution					
1400	-	85	48	28	9
1450	-	88	50	29	10
1500	-	91	52	31	11
1550	-	94	55	33	13
1600	-	97	57	35	14
Danger					
1650	-	100	59	37	15
1700	-	103	61	39	16
1750	-	107	64	41	17
1800	-	110	66	43	18
1850	-	113	68	45	19

Notes: Cooling times are not linear. Tables are based on a gross weight of 27,000 lb and an engine thrust of 1000 lb. "Caution" means to suspend all braking operations; allow brakes to cool a minimum of 1.5 hr. "Danger" means to avoid exposing personnel to the wheel because of danger of explosion.

TABLE B3.- PADS INSTRUMENTATION LIST

FM			
Parameters	Mnemonic	Helicopter	Compound
MR pitch	MRPITCH	X	X
MR flap	MRFLAP	X	X
MR lag	MRLAG	X	X
MR shaft bending	MRSBLI	X	X
MR damper moment	MRDMPOI	X	X
MR blade rear station 6	MRBR6	X	X
MR push rod	PRLREDUP	X	X
MR blade rear station 7	MRBR7	X	X
MR rotating scissors	MRROTSC	X	X
MR stationary scissors	MRSTASC	X	X
MR right lateral stationary load	MRRLSS	X	X
MR contactor	MR ψ <	X	X
Left landing gear lateral vibration	LTLGLT	X	X
Right landing gear lateral vibration	LTLGRT	X	X
Longitudinal vibration, left wing tip	LOWGTLT		X
Vertical vibration, tail-rotor gearbox	VTGB	X	X
Lateral vibration, tail-rotor gearbox	LTGB	X	X
Vertical cockpit load factor	VCPLF	X	X
Lateral cockpit load factor	LCPLF	X	X
Lower stabilizer lug stress	TPYLN200		X
Lower stabilizer lug stress	TPYLN201		X
Lower stabilizer lug stress	TPYLN202		X
Left-aileron control rod load	LAICR		X
Right-aileron control rod load	LAICR		X
TR blade normal bending right	TRNBR	X	X
TR contactor	TR ψ <	X	X
TR pitch beam bending	TRPBEAM5	X	X
TR spindle edgewise bending	TRSPED1	X	X
TR stationary control load	TRSTCONT	X	X
Lower stabilizer lug stress	TPYLN203		X
Lower stabilizer lug stress	TPYLN204		X
Lower stabilizer lug stress	TPYLN205		X
Lower stabilizer drag box stress	DBOX15		X
TR blade stress	TRP2	X	X
Balance torque cell, forward	MRGBQCE	X	X
Balance torque cell, aft	MRGBQCF	X	X
Left redundant link load	LRLL	X	X
Right redundant link load	RLLL	X	X
TR balance thrust cell	TRTHRN	X	X
MR balance lift cell, left forward	MRLIFTA	X	X
MR balance lift cell, right forward	MRLIFTB	X	X
MR balance lift cell, left aft	MRLIFTC	X	X
MR balance lift cell, right aft	MRLIFTD	X	X
MR balance drag cell	MRDRAG	X	X
Wing, left biaxial lift cell	WINGJ		X
Wing, left biaxial drag	WINGL		X
Wing, left forward lift	WINGH		X
Wing, right forward lift	WINGI		X

TABLE B3.- CONTINUED.

Parameters	Mnemonic	Helicopter	Compound
Wing, right biaxial lift	WINGK		X
Vertical vibration, right wing tip	VWGTPRT		X
Vertical vibration, left wing tip	VWGTPLT		X
Right biaxial drag cell	WINGM		X
Lateral vibration, left wing tip	LWGTPLT		X
Longitudinal vibration, right wing tip	LOWGTPRT		X
Vertical vibration, pilot floor	VPF	X	X
MR contactor	MR ψ	X	X
Longitudinal vibration, pilot floor	LOPF	X	X
Lateral vibration, pilot floor	LPF	X	X
Vertical vibration, copilot floor	VCOPF	X	X
Longitudinal vibration, tail pylon	LOTPYLON	X	X
Lateral vibration, tail pylon	LATTPYLON	X	X
No. 1 T-58 aft vibration, vertical	QTAV1	X	X
No. 1 T-58 aft vibration, lateral	QTAL1	X	X
Vertical vibration, tail pylon	VTTPYLON	X	X
Lower horizontal stabilizer lift, left	LHSLIFTL		X
Lower horizontal stabilizer lift, right	LHSLIFTR		X
Vertical vibration, upper stabilizer tip, right	VSTTURT		X
Vertical vibration, upper stabilizer tip, left	VSTTULT		X
Longitudinal vibration, upper stabilizer tip, left	LOSTULT		X
Longitudinal vibration, upper stabilizer tip, right	LOSTURT		X
Right lower stabilizer edge bending	RSTBEB15		X
Right lower stabilizer edge bending	RSTBEB40		X
Lower horizontal stabilizer stress	LHZSTAB40		X
Elevator control rod load, left	ELEVCRDL		X
Elevator control rod load, right	ELEVCRDR		X
Lower horizontal stabilizer actuator load	HZSTBACT		X
Rudder control rod load	RUDCROD		X
Left lower stabilizer normal bending	LSTBNB15		X
Left lower stabilizer normal bending	LSTENB40		X
Left lower stabilizer edge bending	LSTBEB15		X
Left lower stabilizer edge bending	LSTBEB40		X
Right lower stabilizer normal bending	RSTBNB15		X
Right lower stabilizer normal bending	RSTBNB40		X
No. 1 TF-34 accessory GB vertical vibration	N1AXAGVV		X
No. 2 TF-34 accessory GB vertical vibration	N2AXAGVV		X
No. 1 TF-34 Exh frame vertical vibration	N1AXEFHV		X
No. 2 TF-34 Exh frame vertical vibration	N2AXEFHV		X
Lower stabilizer drag box stress	TPYLN217		X
Lower stabilizer drag box stress	LHZSTB1		X
Lower stabilizer drag box stress	LHZSTB2		X
Lower stabilizer drag box stress	LHZSTB11		X
Lower stabilizer drag box stress	LHZSTB12		X
Lower stabilizer drag box stress	LHZSTB13		X
Lower stabilizer drag box stress	LHZSTB16		X
Lower stabilizer drag box stress	LHZSTB17		X
Lower stabilizer drag box stress	LHZSTB21		X
Lower stabilizer drag box stress	LHZSTB22		X
Lower stabilizer drag box stress	LHZSTB36		X

TABLE B3.- CONTINUED.

Parameters	Mnemonic	Helicopter	Compound
Lower stabilizer drag box stress	LHZSTB37		X
Vertical lug load, right lower stabilizer	FDVLTR		X
Longitudinal lug load, right lower stabilizer	FVLR		X
Upper stabilizer stress	UHZSTB1	X	X
Upper stabilizer stress	UHZSTB2	X	X
Upper stabilizer stress	UHZSTB3		X
Upper stabilizer stress	UHZSTB4		X
Upper stabilizer stress	UHZSTB5		X
Lower stabilizer drag box stress	TPYLN220		X
Lower stabilizer drag box stress	TPYLN224		X
PCM			
Heading	HEADING		X
MR speed	NR	X	X
MR torque	MRQ1	X	X
Pitch attitude	PITCHATT	X	X
Roll attitude	ROLLATT	X	X
Wing tilt, left upper cylinder pressure	WIACLTUP		X
Wing tilt, left lower cylinder pressure	WIACLTLO		X
Wing tilt, right upper cylinder pressure	WIACRTUP		X
Wing tilt, right lower cylinder pressure	WIACRTLO		X
Pitch rate	PITCHRAT	X	X
Roll rate	ROLLRAT	X	X
Long load factor	LGCG	X	X
Yaw rate	YAWRAT	X	X
Airspeed	VIPBOOM	X	X
Wing incidence	IW		X
Longitudinal mixer input position	LGMIXIP	X	X
Lateral mixer input position	LATMIXIP	X	X
Collective mixer input position	COLMIXIP	X	X
Lateral stick position	LATSTKP	X	X
Longitudinal stick position	LGSTKP	X	X
Collective stick position	COLLSTKP	X	X
Pedal position	PEDP	X	X
Pitch acceleration	PITCHACC	X	X
Roll acceleration	ROLLACC	X	X
Yaw acceleration	YAWACC	X	X
Load factor	LOADFACT	X	X
Angle of attack	ATTACK		X
Sideslip	SIDESLIP	X	X
No. 1 TF-34 fuel flow	NO1AUXWF		X
No. 2 TF-34 fuel flow	NO2AUXWF		X
Lateral stick force (SP)	LATFORCE	X	X
Longitudinal stick force	LGFORCE	X	X
Pedal force (net)	PEDFORCN	X	X
Lateral load factor	LATCG	X	X
No. 1 TF-34 speed lever	NO1AUXSL		X
Right lateral servo output position	RTLATSVOP	X	X
Left lateral servo output position	LLATSVOP	X	X

TABLE B3.- CONTINUED.

Parameters	Mnemonic	Helicopter	Compound
Longitudinal servo output position	LGSRVOP	X	X
Rate of climb	ROCBOOM	X	X
T-58 engine fuel totalizer	T58WQ	X	X
TF-34 engine fuel totalizer	TF34WQ		X
No. 2 TF-34 speed lever	NO2AUXSL		X
No. 1 T-58 gas generator speed	NO1NGPCT	X	X
No. 2 T-58 gas generator speed	NO2NGPCT	X	X
No. 1 T-58 torque	NO1QPCT	X	X
No. 2 T-58 torque	NO2QPCT	X	X
MGB oil inlet temperature	MGBOILIN	X	X
MGB oil outlet temperature	MGBOILOT	X	X
No. 1 generator air inlet temperature	TN1GENA1	X	X
No. 1 T-58 free turbine	NO1NFPCT	X	X
No. 2 T-58 free turbine	NO2NFPCT	X	X
TR torque	TRQ	X	X
No. 1 TF-34 thrust cell	THRUSTLT		X
No. 2 TF-34 thrust cell	THRUSTRT		X
No. 1 hydraulic system reservoir temperature	TN1RES	X	X
No. 2 hydraulic system reservoir temperature	TN2RES	X	X
No. 3 hydraulic system reservoir temperature	TN3RES	X	X
No. 2 T-58 T5 temperature	NO2T5	X	X
No. 1 TF-34 pylon temperature	N1TEPT1		X
No. 1 TF-34 pylon temperature	N1TEPT2		X
No. 2 TF-34 pylon temperature	N2TEPT1		X
No. 2 TF-34 pylon temperature	N2TEPT2		X
Lower horizontal stabilizer incidence	STABPOS		X
Rudder position	RUDPOS		X
Wing angle of attack	ATTACKW		X
No. 1 T-58 fuel inlet temperature	NO1FIT	X	X
No. 2 T-58 fuel inlet temperature	NO2FIT	X	X
Upper stabilizer left tip lateral acceleration	LSTBTLAT		X
Upper stabilizer roll moment	USROLLMO		X
Upper stabilizer lateral load	USLATLD		X
Upper stabilizer axial load	USAXLD		X
Right aileron position	AILPOSR		X
Right flap position	FLAPPOSR		X
Wing pitch actuator load, left	WINGH		X
Wing pitch actuator load, right	WINGI		X
Wing force fail life	WNGFORFL		X
No. 1 TF-34 fan speed	NO1AUXNF		X
No. 2 TF-34 fan speed	NO2AUXNF		X
Icebath, 0°C	ICEBATH	X	X
FAS servo surface temperature	SPPFASST	X	X
Altitude	HBOOM	X	X
TF-34 gas generator speed	NO1AUXNG		X
TF-34 gas generator speed	NO2AUXNG		X
Free air temperature	ITATBOOM	X	X
Longitudinal stick position, safety pilot	LGSTKPE	X	X
Lateral stick position, safety pilot	LATSTKPE	X	X
Collective stick position, safety pilot	COLSTKPE	X	X

TABLE B3.- CONCLUDED.

Parameters	Mnemonic	Helicopter	Compound
TF-34 thrust, left	THRUSTLT		X
TF-34 thrust, right	THRUSTRT		X
Rotary trfr unit temperature	RTUFPTMP	X	X
No. 1 TF-34 T5 temperature	NO1AUXT5		X
No. 2 TF-34 T5 temperature	NO2AUXT5		X
Wing actuating cylinder temperature, right	WACTURT		X
No. 1 TF-34 fuel inlet temperature	N1TFIT		X
No. 2 TF-34 fuel inlet temperature	N2TFIT		X
TR impressed pitch	TRIMPIT	X	X
Run tone monitor	--	X	X
Drag redundant link load	DRLL	X	X
Left lateral redundant link load	LRLL	X	X
Right lateral redundant link load	RLLL	X	X

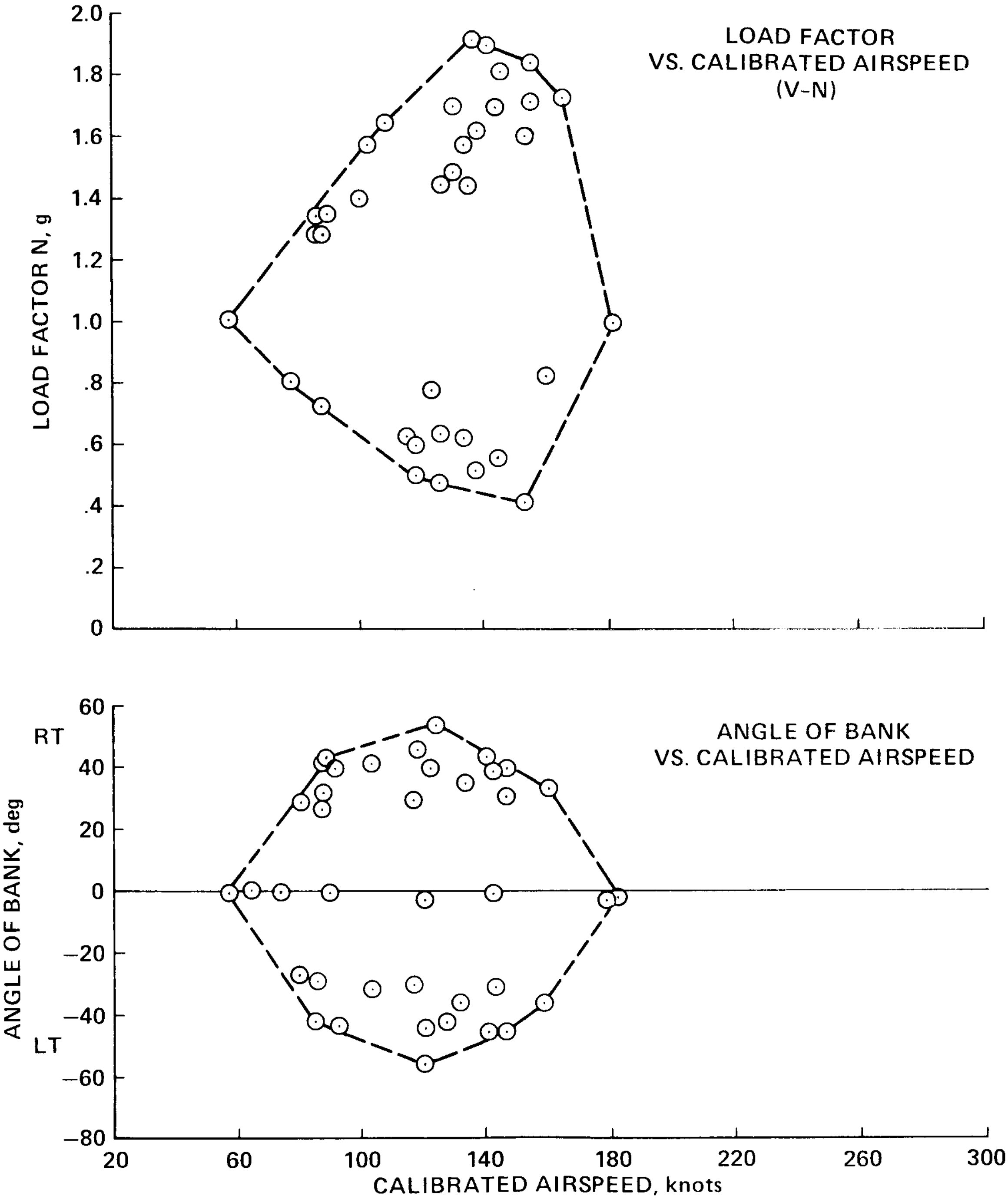

Figure B1.- Flight envelope: load factor and angle of attack versus calibrated airspeed.

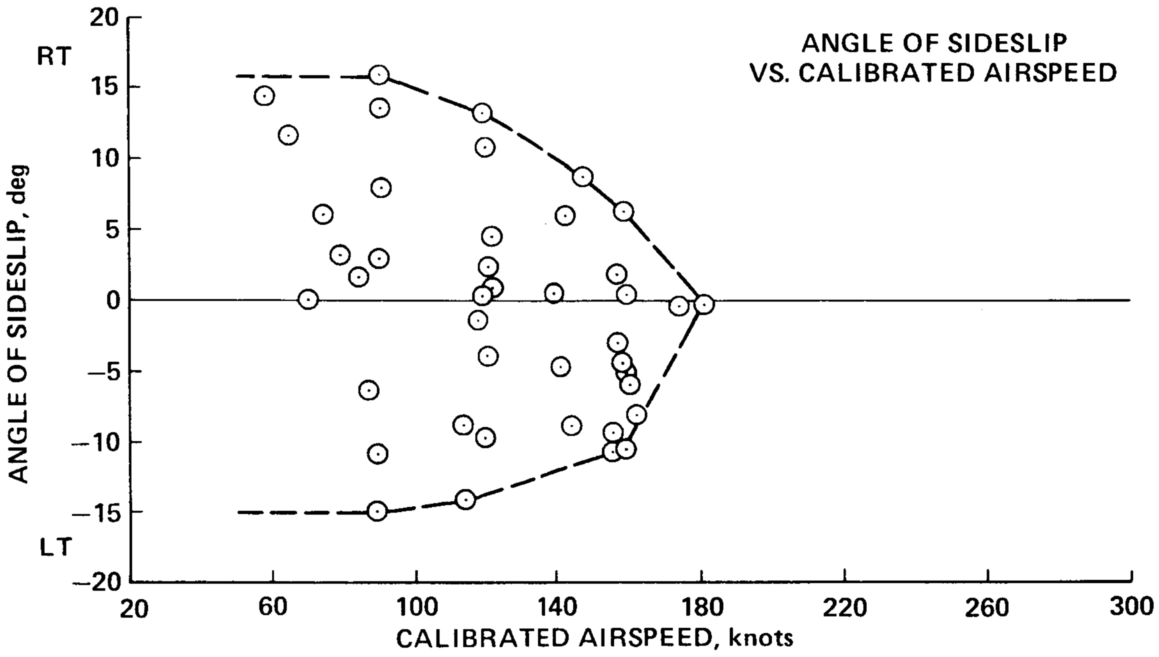

Figure B2.- Flight envelope: angle of sideslip versus calibrated airspeed.

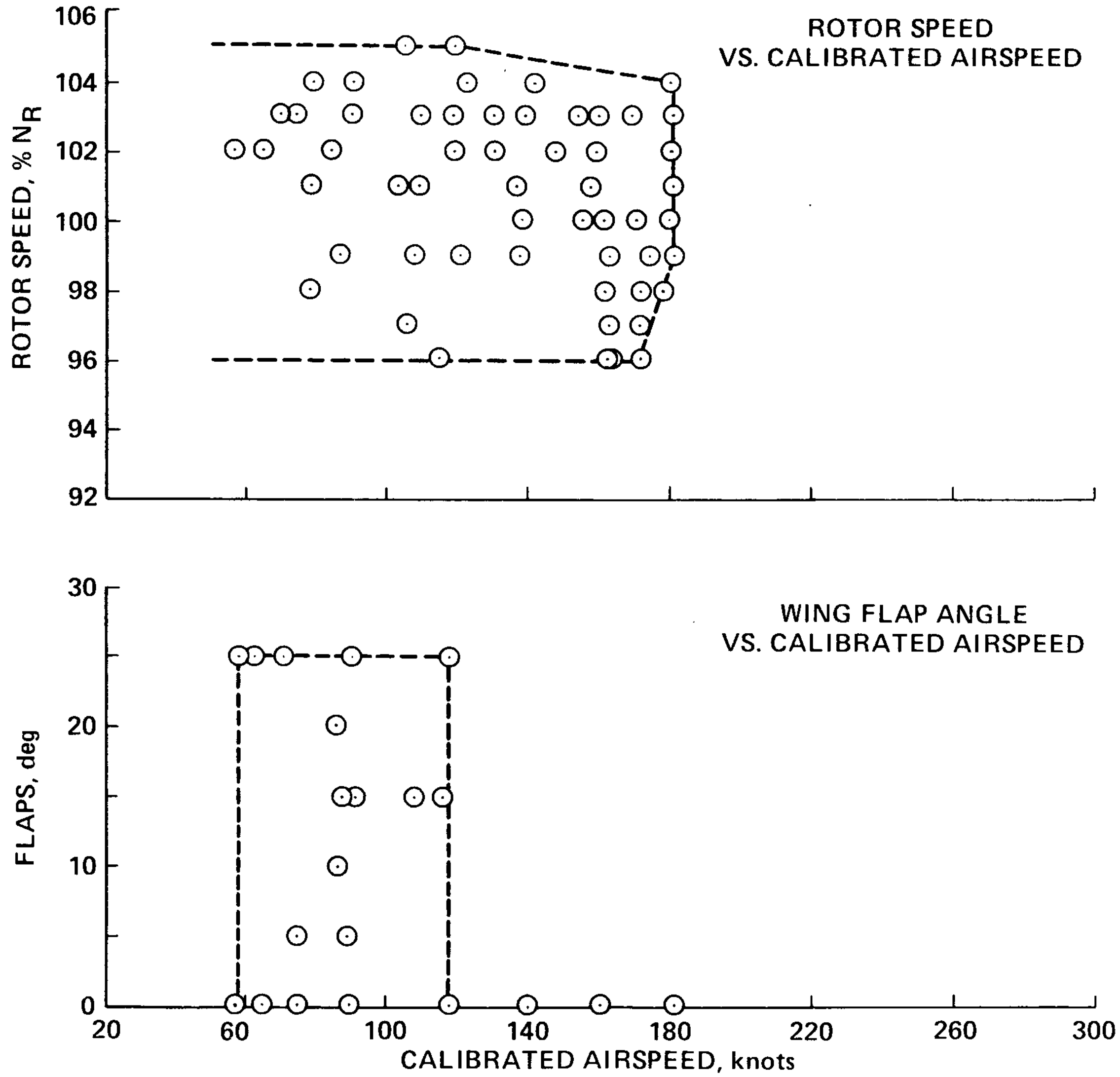

Figure B3.- Flight envelope: rotor speed and wing-flap angle versus calibrated airspeed.

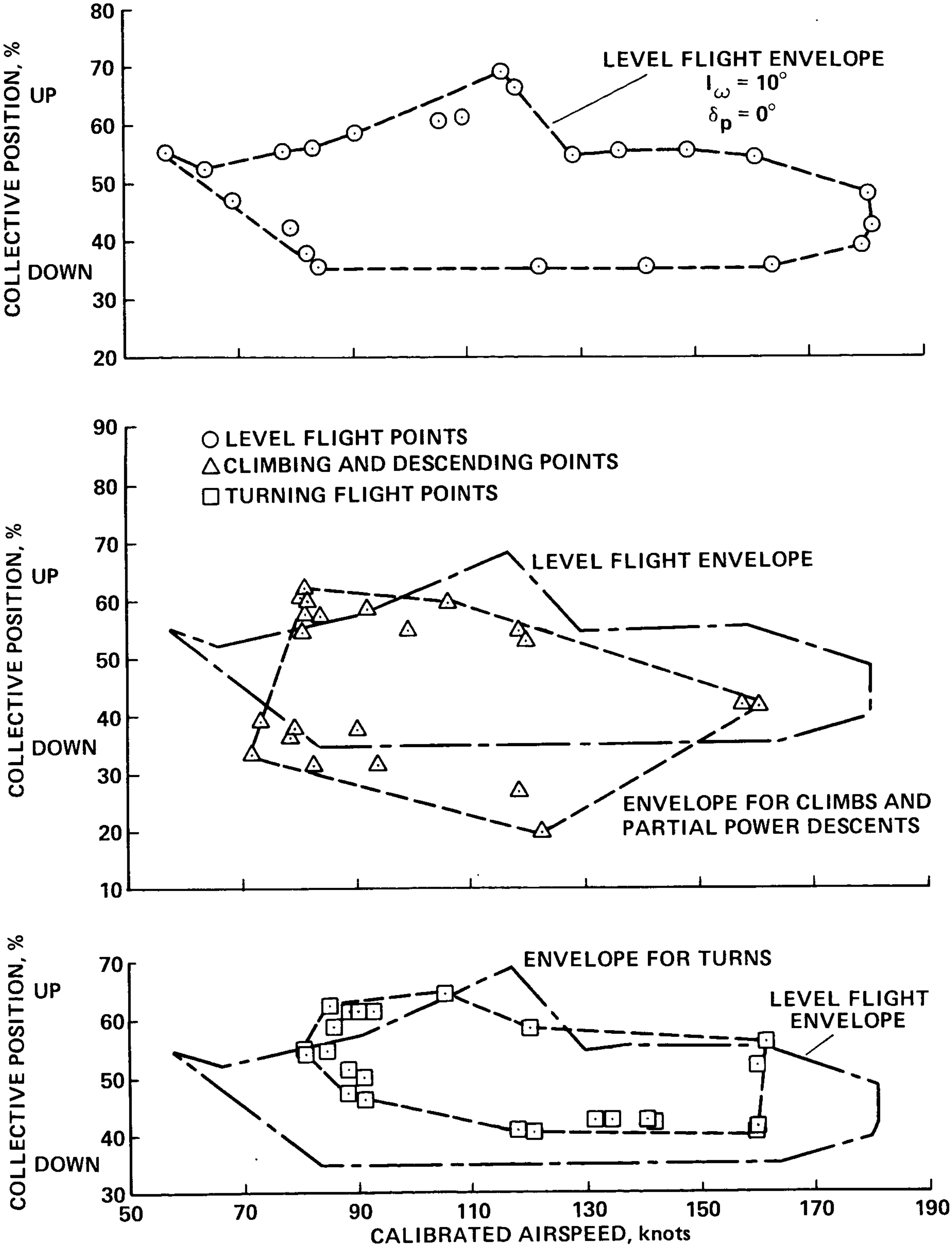

Figure B4.- Collective position versus calibrated airspeed.

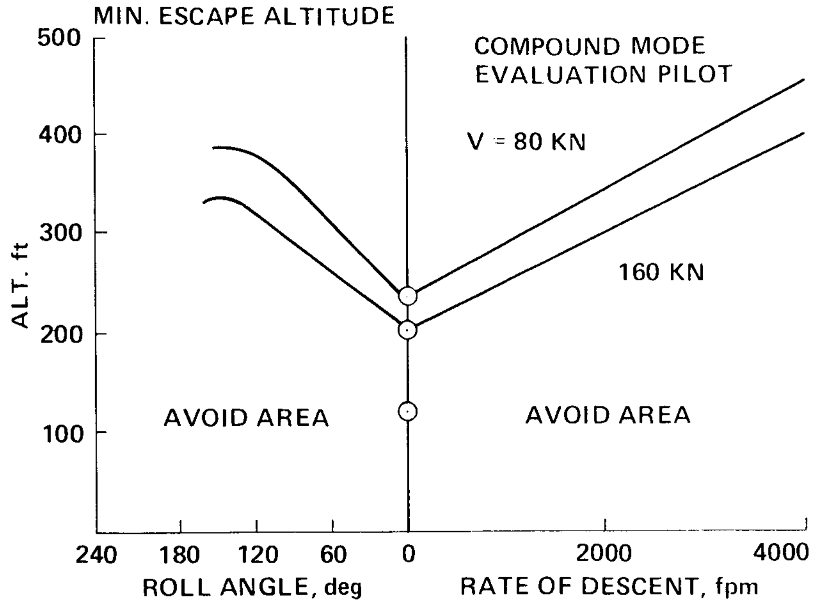

Figure B5.- Flight envelope: emergency escape system.

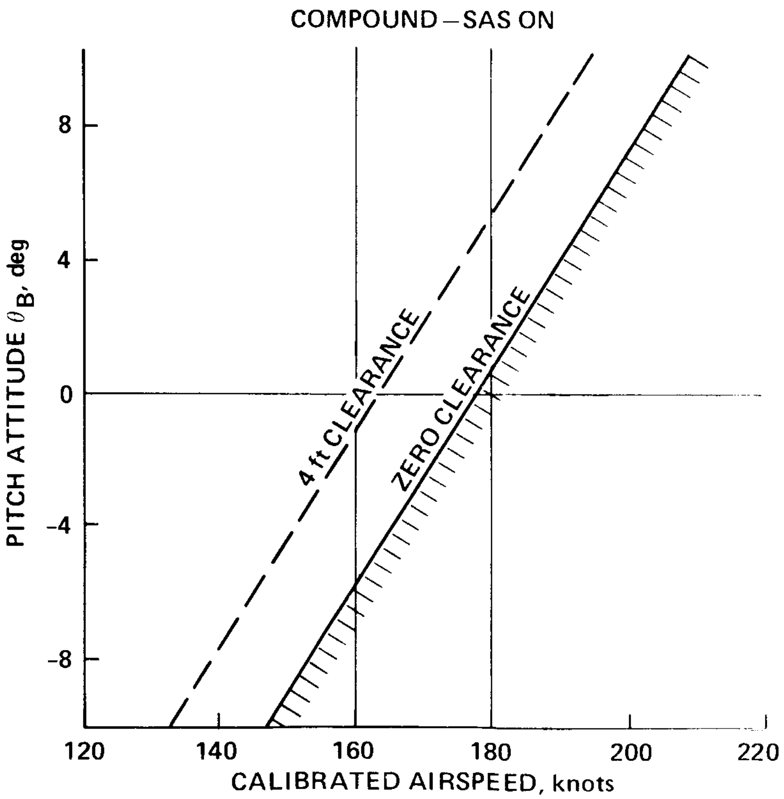

Figure B6.- Emergency escape system: trim pitch attitude with speed for deployment bag clearance.

ATTACHMENT B1

COMPOUND FAMILIARIZATION: FLIGHT TEST

TEST OBJECTIVES

The specific objectives of this flight will be to

1. Perform initial flight of the RSRA compound at NASA Ames

2. Familiarize and train the NASA project pilot in the RSRA compound

3. Develop and evaluate a new takeoff technique that may reduce lower horizontal stabilizer lug loads on takeoff

4. Check out a second project pilot in the RSRA compound

5. Develop and evaluate new wing incidence angles combined with use of flaps and speed brake to improve flight attitudes and landing technique

GENERAL INFORMATION

1. Estimated start date: 10-13-81
   Estimated flight hours: 6
   Estimated taxi test hours: 7
   Estimated test duration: 3 months

2. Safety pilot and evaluation pilot are the only crew aboard the aircraft

3. Aircraft-to-ground communications to telemetry, tower, and chase/rescue/ photo aircraft are required

4. Chase/rescue helicopter is required for all flights outside the field boundaries

5. Fixed-wing or high-speed helicopter photo/chase is required for all flights outside the field boundaries, for speeds above 120 knots

6. It is intended that the primary RSRA compound pilot conduct the tests of plans A and B, followed by the checkout of the second RSRA compound pilot

7. Brake cooling will be required following each taxi/landing deceleration in accordance with guidelines of PMI P72-M-780

8. Actual training program will depend on pilot confidence and flight frequency

CONFIGURATION/CONDITIONS

1. Compound configuration
2. Gross weight 27,110 lb maximum at takeoff (or less)
3. Center of gravity 302 ±1 in.
4. EFCS computer not installed
5. All SAS ON; compound gains
6. N_R 104% for all speeds to 150 knots IAS, except as noted
7. CPUs 100/100 (FW/RW) for all axes
8. Bifilar installed
9. Stabilator +1° (T.E. up) at 50% longitudinal stick
10. Speed brake 0° (closed) to full open, manual
11. Wing incidence +10° to 0° (current stop installed at +5°)
12. Landing gear up above 80 knots IAS (normally)
13. EES will be operable for all flights (does not include taxi)
14. The lower horizontal stabilizer may be removed from the aircraft for items 1 through 9 of plan A. This is to provide repeated pilot familiarization taxi tests without damage to the stabilator lug fittings.

INSTRUMENTATION AND DATA ACQUISITION REQUIREMENTS

Real-time telemetry and on-board instrumentation data recording is required (see Data Acquisition, Processing, and Telemetry for details). FM and PCM strip-chart recording of TM data will be monitored for the flight test.

FLIGHT ENVELOPE RESTRICTIONS

The aircraft will be flown within the established aircraft envelope except that the speed brake may be manually (i.e., cockpit control) extended and the wing incidence may be varied from 10° to 0° throughout the envelope. These changes shall be approached using buildup, envelope expansion methodology. Flight maneuvers outside the EES safe-escape envelope will be noted on the flight card. No compound flight will be conducted without an operable EES.

TM will monitor, specifically, the lower horizontal stabilizer lug load to assure that endurance values are not exceeded for extended periods.

PLANS

Plan A: Taxi and Takeoff Development

Item	Entry condition[a]		Flap position, deg	TF-34[b] N_F	Collective
1	FP	Rotor engage to 104%	0	0	FP*
2	FP	Start left TF-34	0	GI	FP
3	FP	Start right TF-34 (if desired)	0	GI	FP
4	FP	Start taxi	0	AR	FP
5	Taxi	Left taxi turn	0	AR	FP
6	Taxi	Right taxi turn	0	AR	FP
7	Taxi	Brake to stop	0	AR	FP
8	FP	N_R sweep, 96 to 106% N_R	0	GI	FP
9	Taxi	Taxi at 30, 40, 50 knots IAS (tail locked and unlocked)	0	AR	FP
10	Taxi	Accelerate using TF-34 thrust and low collective to 70 knots IAS (or less) and decelerate to stop. Use Sikorsky technique,[c] steps 1-3. Cool brakes. Repeat, as necessary. When possible, shut down No. 2 TF-34 for return taxi and decelerate to reduce brake heating	0	≤60%	AR
11	Taxi	Accelerate using TF-34 thrust and collective to 50, 60, and 70 knots IAS and decelerate to stop. Use proposed technique,[d] steps 1 and 2	0	≤60%	AR
12		Repeat items (1)-(11), as needed to accomplish development			

Notes: (1) Perform items (1)-(9) with the lower horizontal stabilizer removed from the aircraft. These items may be repeated with stabilizer installed. (2) For items (9)-(11), record acceleration and stop distances to acquire T.O. and abort runway requirement data. Use transit or equivalent to measure distances. (3) Utilize aerodynamic speed brake during ground run decelerations, as desired, to assist in braking and to gain initial experience in system operation.

[a] FP = flat pitch.

[b] AR = as required; GI = ground idle.

[c] Sikorsky technique: (1) establish 55%-60% fan speed on the TF-34 engines, with wheel brakes locked. (2) Establish full low collective, with forward cyclic to keep the aircraft firmly on the ground before takeoff and to minimize main-rotor shaft bending. (3) Release wheel brakes and use TF-34 thrust to accelerate to 70 knots IAS (80 knots CAS). (4) Lift off using collective. (5) Climb at 90 knots IAS

[d] Proposed technique: (1) TF-34s at ground idle, low collective. Release brakes. (2) Advance TF-34 engines to 55%-60% fan speed while RSRA accelerates down runway. Keep aircraft on ground with forward cyclic to minimize shaft bending. Use drag brake, as desired, to aid in deceleration. (3) At 70 knots IAS, lift off using collective. (4) Climb at 90 knots IAS. Note: For practice accelerations, do not increase collective for lift-off.

Plan B: Flight Familiarization and Training

Item	Entry condition		Flap position, deg	TF-34 N_F	Collective position,[a] %
1	Taxi	Take off, using technique developed in plan A	0	AR	AR
2	TO	Climb, 90 knots IAS, 104% N_R	0	55-60%	AR
3	LF 80	Trim, LF 80 knots IAS	0	GI	AR
4	LF 80	Turn left and right, 15° and 30° AOB	0	GI	AR
5	LF 80	Accelerate to 100 knots IAS using TF-34 thrust	0	AR	AR
6	LF 100	Trim LF 100 knots IAS	0	AR	AR
7	LF 100	Accelerate to 110 knots IAS using TF-34 thrust	0	AR	AR
8	LF 110	Trim LF 110 knots IAS	0	AR	AR
9	LF 110	Turn left and right, 15° and 30° AOB	0	AR	AR
10	LF 110	Decelerate to 80 knots IAS, reducing TF-34 thrust, adjust collective as necessary	0	GI	AR
11	LF 80	Descent 80 knots IAS, reducing collective	0	GI	AR
12	Descent	Landing 70 knots IAS	0	GI	AR
13	Taxi	Taxi to stop, cool brakes	0	AR	AR
14	--	Repeat items (1)-(13), as needed to accomplish familiarization and training			
15	--	Continue training, selecting items from plan A and plan B, (1)-(14), as needed, plus the following items			
16	LF 80	Trim climbs at 80 knots IAS; 750 and 1500 ft/min, using TF-34	0	AR	AR
17	LF 80	Trim descents at 80 knots IAS; 500 and 1000 ft/min using collective	0	AR	AR
18	LF 110	Trim climbs at 110 knots IAS; 750 and 1500 ft/min using TF-34	0	AR	AR
19	LF 110	Trim descents at 110 knots IAS; 750 and 1500 ft/min, using collective	0	AR	AR
20	LF 110	Perform N_R sweep in 2% increments from 96% to 105% N_R	0	AR	AR
21	LF 110	Accelerate to 130 knots IAS, using TF-34 thrust	0	AR	AR
22	LF 130	Trim LF 130 knots IAS	0	AR	40
23	LF 130	Turn left and right at 15° and 30° AOB	0	AR	40
24	LF 130	Accelerate to 150 knots IAS, using TF-34 thrust	0	AR	AR
25	LF 150	Trim LF 150 knots IAS	0	AR	AR
26	LF 150	Turn left and right at 20° AOB	0	AR	40

Item	Entry condition		Flap position, deg	TF-34 N_F	Collective position,[a] %
27	--	Conduct climbs and descents at speeds 60-150 knots IAS, within envelope limits, using TF-34 and collective	0 (110-150 knots IAS) 0-25 (60-110 knots IAS)	AR	AR
28	--	Conduct trim LF tests from 60 to 110 knots IAS using flaps as desired	0-25	AR	AR
29	--	Conduct turns to 30° AOB from 60 to 110 knots IAS using flaps as desired	0-25	AR	AR
30	--	Conduct touch-and-go landings	0-25	AR	AR
31	--	Landing	0-25	AR	AR
32	--	Repeat items (1)-(31), as needed, to accomplish familiarization and training			
33	--	From LF 80 knots IAS, retrim wing incidence from 10° to 7.5°. Repeat items (1)-(31), as desired, using buildup technique to redevelop envelope			
34	--	Based on results of item (33), repeat item (33) for 5° and 0° wing incidence, as desired			
35	--	Repeat selected items from plans A and B, as desired			

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[a] Collective position may be adjusted "as required" but must remain within upper limits specified in figure 4, and the lower limits (20%) specified in the analysis provided with reference 10.

ATTACHMENT B2 (Rev. 4)

OPERATIONAL CHECKOUT: FLIGHT TEST

TEST OBJECTIVES

The specific objectives of this flight test will be to:

1. Resubstantiate the current flight envelope in the range of wing incidences from 0° to 10°

2. Check out the compound aircraft and the test team in operations at or near the envelope limits

3. Document static stability for current configuration

GENERAL INFORMATION

1. Estimated start date: 3-17-82
   Estimated flight hours: 9
   Estimated test duration: 2-1/2 months

2. Safety pilot and evaluation pilot are the only crew aboard the aircraft

3. Aircraft-to-ground communications to telemetry, tower, and chase/rescue aircraft are required

4. Chase/rescue helicopter is required for all flights outside the field boundaries

5. High-speed chase is required for the purpose of maintaining visual contact for all flights outside the field boundaries at speeds above 120 knots IAS

CONFIGURATION/CONDITIONS

1. Compound configuration

2. Gross weight 27,110 lb maximum at takeoff (or less)

3. Center of gravity 302 ±1 in.

4. EFCS computer not installed

5. All SAS ON; compound gains

6. Normal operating N_R will be 104% up to 150 knots IAS; 100% above 150 knots IAS; exceptions will be as specified

7. CPUs 100/100 (FW/RW) for all axes

8. Bifilar installed

9. Stabilator +1° (T.E. up) at 50% longitudinal stick

10. Speed brake 0° (closed) to full open, manual

11. Wing incidence +10° to 0° (down stop installed at 0°)

12. Landing gear up above 80 knots IAS (normally)

13. EES will be operable for all flights

INSTRUMENTATION AND DATA ACQUISITION REQUIREMENTS

Real-time telemetry and on-board instrumentation data recording are required (see Data Acquisition, Processing, and Telemetry for details). FM and PCM strip-chart recording of TM data will be monitored for the flight test.

FLIGHT ENVELOPE RESTRICTIONS

The aircraft will be flown within the established aircraft envelope except that the speed brake may be manually (i.e., cockpit control) extended and the wing incidence may be varied from 10° to 0° throughout the envelope. Flight maneuvers outside the EES safe-escape envelope will be noted on the flight card. No compound flight will be conducted without an operable EES.

TM will monitor, specifically, the lower horizontal stabilizer lug load to assure that endurance values are not exceeded for extended periods.

Collective position may be adjusted "as required" but must remain within upper limits specified in figure B4, and the lower limits (20%) specified in the analysis provided with the Flight Project Request (FPR-2), reference 10.

PLAN: OPERATIONAL CHECKOUT

Conduct the following tests. Conditions typically are endpoints and imply lesser conditions. Unless specified differently, rotor speed is 104% below 150 knots IAS, 100% above 150 knots IAS, and collective position is 40%; 104% N_R may be used above 150 knots IAS provided advancing MR blade-tip speed does not exceed Mach 0.9.

Wing incidence may be varied between 0° and 10° with 5° being the nominal setting. Wing incidence of 7.5° with full flaps is nominal for landing and 10° wing incidence with no flaps is nominal for takeoff. These values may be varied within the envelope established to suit pilot preference.

Maneuver	Conditions (indicated airspeed, knots)
Level flight	160 at 100% N_R
	50 at 104% N_R
	170 at 104% N_R
	(MR tip speed $\leq$ 0.9 Mach)
Turns	60, ±20° AOB
	80, ±45° AOB
	110, ±55° AOB
	150, ±35° AOB
	160, ±20° AOB
Sideslips	50, ±15°
	80, ±15°
	130, +10°
	130, -12°
	150, +7°
	150, -10°
	160, +3°
	160, -5°
N_R	50 at 105%
	50 at 96%
	110 at 105%
	110 at 96%
	130 at 96%
	130 at 104.5%
	160 at 104%
	160 at 96%
Collective position	106 at 70%
	150 at 55%
	160 at 40%
	60-160 at 20%
	60-160 at 40%
	160-170 at 35% (or less)
Symmetrical pull-up	65, 1.2 g
	130, 1.9 g
	160, 1.5 g
Symmetrical pushover	65, 0.74 g
	90, 0.62 g
	142, 0.42 g
	160, 0.65 g
Static stability (trim ON and OFF)	90 ±10
	110 ±10
	130 ±10
	150 ±10
Climbs and descents	150 ±500 ft/min
	160 ±500 ft/min
Wing incidence	60-160 at 0°
	60-170 at 5°
	60-170 at 10°

APPENDIX C

RSRA FLIGHT REPORTS: RSRA 740

Appendix C includes the Flight Reports of the RSRA 740 aircraft for this test phase and were written by the test director and pilots' reports included where appropriate. All tests were conducted from the Ames Research Center (Moffett Field). The test area extended through the Livermore Pass into the San Joaquin Valley.

30 June 1981 Flight 2A-1 Pilots: Hall and Merrill

CONFIGURATION: Helicopter. GROSS WEIGHT: 19,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: 0 ft. WIND: 340°/10 knots. OAT: 21°C. FLIGHT TIME: 00:30. TOTAL FLIGHT TIME: 45:00. PURPOSE OF FLIGHT: Maintenance check flight. TEST POINTS COMPLETED: Flat pitch N_R sweep; damper checks; servo checks; SAS checks; hover, 30-min "penalty" hover for overhauled transmission; control response. FLIGHT COMMENT: This was the first flight for RSRA 740 at ARC.

1 July 1981 Flight 2 Pilots: Merrill and Hall

CONFIGURATION: Helicopter; roll SAS gains reduced by half. GROSS WEIGHT: 18,700 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: 70 ft. WIND: 330°/10 knots. OAT: 21°C. FLIGHT TIME: 00:30. TOTAL FLIGHT TIME: 45:30. PURPOSE OF FLIGHT: Maintenance check flight. TEST POINTS COMPLETED: Engine topping checks; emergency throttle checks; hover turns; force feel system OFF check; new roll SAS gain evaluated (much improved); maintenance flight check complete.

10 July 1981 Flight 3 Pilots: Merrill and Tucker

CONFIGURATION: Helicopter. GROSS WEIGHT: 19,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -30 ft. WIND: Calm. OAT: 15°C. FLIGHT TIME: 02:00. TOTAL FLIGHT TIME: 47:30. PURPOSE OF FLIGHT: Vertical drag and balance system hysteresis tests. TEST POINTS COMPLETED: Approximately 40% of data tests. Heavy-weight hovers; heavy-weight slow forward flight at 10 ft; midweight hovers; midweight slow forward flight at 10 ft; accelerate and decelerate to 70 knots IAS; hover N_R sweep; forward/aft speed hysteresis test.

17 July 1981 Flight 4 Pilots: Hall and Tucker

CONFIGURATION: Helicopter. GROSS WEIGHT: 19,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: 10 ft. WIND: 3 knots. OAT: 14°C. FLIGHT TIME: 2:20. TOTAL FLIGHT TIME: 49:50. PURPOSE OF FLIGHT: Vertical drag and balance system hysteresis. TEST POINTS COMPLETED: Test program 40% complete (including scope increase). Vertical climb tests; landing gear retraction checks completed; hover hysteresis checks completed. NOTE: Lost all camera data. Vertical drag tests were not acceptable.

21 July 1981 Flight 5 Pilots: Hall and Merrill

CONFIGURATION: Helicopter. GROSS WEIGHT: 19,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -10 ft. WIND: 5 knots. OAT: 14°C. FLIGHT TIME: 02:05. TOTAL FLIGHT TIME: 51:55. PURPOSE OF FLIGHT: Vertical drag tests. TEST POINTS COMPLETED: Test program 70% complete (including scope increase). Completed were: heavy-weight forward speed vertical drag tests; midweight forward speed vertical drag tests; light-weight forward speed vertical drag tests; SAS gain evaluation (new settings).

24 July 1981 Flight 6 Pilots: Merrill and Hall

CONFIGURATION: Helicopter. GROSS WEIGHT: 17,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: 50 ft. WIND: 5 knots. OAT: 16°C. FLIGHT TIME: 00:10. TOTAL FLIGHT TIME: 52:05. TAKEOFF TIME: 0655. PURPOSE OF FLIGHT: Vertical drag test. TEST POINTS COMPLETED: None. Aborted due to fuel smell in cockpit.

28 July 1981 Flight 7 Pilots: Hall and Tucker

CONFIGURATION: Helicopter. GROSS WEIGHT: 17,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: 0 ft. WIND: 2 knots. OAT: 16°C. FLIGHT TIME: 00:30. TOTAL FLIGHT TIME: 52:35. TAKEOFF TIME: 0634. PURPOSE OF FLIGHT: Vertical drag test at light weight. TEST POINTS COMPLETED: All OGE light-weight hover points; 10- and 15-knot forward speed points. NOTES: Very easy to exceed TR endurance limits on hover maneuvers at 19,800 lb. Pilots recommend a TR pitchbeam load indicator in cockpit, particularly for the helicopter configuration.

28 July 1981 Flight 8 Pilots: Hall and Tucker

CONFIGURATION: Helicopter. GROSS WEIGHT: 19,800 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -30 ft. WIND: 4 knots. OAT: 16°C. FLIGHT TIME: 01:05. TOTAL FLIGHT TIME: 53:40. TAKEOFF TIME: 0800. PURPOSE OF FLIGHT: Low-speed handling qualities. TEST POINTS COMPLETED: Level flight trims to 60 knots; left and right sideward flight trims; 0- and 40-knot pulses.

5 Nov. 1981 Flight 1 PILOTS: Hall and Merrill

CONFIGURATION: Compound RSRA without lower horizontal stabilizer. GROSS WEIGHT: 27,021 lb. CENTER OF GRAVITY: 301.2 in. GROUND PRESSURE ALTITUDE: -60 ft. WIND: Calm. OAT: 17°C. FLIGHT TIME: 0. TOTAL FLIGHT TIME: 53:40. OTHER: 01:26 taxi test. PURPOSE OF FLIGHT: Taxi tests with TF-34 thrust. TEST POINTS COMPLETED: Completed six high-speed taxi tests successfully. Pilot Hall commented positively on the ability to control TF-34 thrust during acceleration run, as well as on the ease of directional control. He commented that previous simulator training was realistic and helped considerably in doing these tests — to the point that he desired no further taxi test in this configuration. The brake overheating problem, reported from previous Sikorsky testing, was not encountered. A new technique, which was to shut down the right TF-34 during deceleration and to coast until speed reduced to 35-40 knots before brake application, was used. No excessive heating occurred (temperatures were monitored after each run).

5 Nov. 1981 Flight 2 Pilots: Merrill and Hall

CONFIGURATION: Compound RSRA without lower horizontal stabilizer. GROSS WEIGHT: 27,021 lb. CENTER OF GRAVITY: 301.2 in. GROUND PRESSURE ALTITUDE: -40 ft. WIND: 320°/5 knots. OAT: 17°C. FLIGHT TIME: 0. TOTAL FLIGHT TIME: 53:40. OTHER: 00:43 taxi test. PURPOSE OF FLIGHT: Taxi tests with TF-34 thrust. TEST POINTS COMPLETED: Backup RSRA pilot, R. Merrill, completed four high-speed taxi runs. He was pleased with the aircraft behavior on these tests. The right TF-34 was not shut down during deceleration on these runs and it was noted that after the final run the temperatures were increasing to concern levels. Both pilots recommended termination of these tests and proceeding to install the stabilator prior to final taxi tests and takeoff.

19 Nov. 1981 Flight 3 Pilots: Hall and Tucker

CONFIGURATION: Compound (with lower horizontal stabilizer). GROSS WEIGHT: 27,115 lb. CENTER OF GRAVITY: 302.5 in. GROUND PRESSURE ALTITUDE: -160 ft. WIND: Calm. OAT: 9°C. FLIGHT TIME: 0. TOTAL FLIGHT TIME: 53:40. OTHER: 01:40 taxi test. PURPOSE OF FLIGHT: Develop takeoff roll technique in full configuration. TEST POINTS COMPLETED: Seven accelerations to takeoff aborts were performed satisfactorily. Technique of bringing up TF-34 thrust during roll did not cause excessive low horizontal stabilator lug loads. All runs had lug loads at or below endurance. Bringing in collective during roll did not cause lug loads to increase. Pushing nose down with longitudinal cyclic to raise tail also caused no problems. No problems were encountered with lug loads, brake heating, main-rotor shaft bending, directional control, or TF-34 throttle control. Pilot stated he was ready to proceed to first flight.

25 Nov. 1981 Flight 2B-4 Pilots: Hall and Merrill

CONFIGURATION: Full compound, 10° wing incidence. GROSS WEIGHT: 27,215 lb. CENTER OF GRAVITY: 302.5 in. GROUND PRESSURE ALTITUDE: -160 ft. WIND: 300°/ 10 knots. OAT: 14°C. FLIGHT TIME: 00:45. TOTAL FLIGHT TIME: 54:25. PURPOSE OF FLIGHT: Pilot familiarization, first flight of compound at Ames. TEST POINTS COMPLETED: Performed takeoff, level flight to 120 knots CAS with turns, climbs, and descents, practiced approaches and go-arounds, and final landing. Pilots liked an approach speed of 90 knots IAS with 35% collective. Pilots noted the sensitivity of wing angle of attack to collective inputs (decrease collective, increase wing AOA). Aircraft was easily controllable. Initial practice takeoff roll incurred increased MR shaft bending loads due to use of aft cyclic to slow ground roll. This had not happened when done previously. Lower horizontal stabilizer loads were as anticipated with minimal exceeding of endurance levels. The flight was successful.

PILOT'S REPORT: The first event was a high speed taxi test up to just over 90 knots. The cyclic stick was moved too far forward on the initial acceleration and the top portion of the blade proximity wand on the engine cowl was knocked off. On the deceleration, the airplane felt like it wanted to continue along the runway without slowing down. The cyclic stick was then moved too far aft and high bending loads were incurred in the main rotor shaft. The second event was the takeoff. The following technique was used: (1) the airplane was allowed to start the takeoff roll with the TF-34s at idle, the cyclic stick near center, and the collective full down; (2) the TF-34s were accelerated to between 50% and 60% N_F; (3) the collective was slowly raised to approximately 40% collective position and simultaneously the cyclic was moved forward of center; (4) at 70 knots the collective was increased slightly and the cyclic pulled aft; and (5) a smooth takeoff occurred. The airplane accelerates on the ground quite rapidly and only a short takeoff run is required. Once airborne, I was surprised at how quickly the airplane wanted to accelerate. I increased nose attitude three different times to hold a 90-knot climb speed. Climb rate was of the order of 1500 to 1800 ft/min. We climbed out to just over 2500 ft while taking a climb record. Aircraft control was quite positive with no major handling-qualities problems noted. Several level-flight trim points were taken. It is difficult to attain stable speeds because of the poor but acceptable TF-34 throttle characteristics. There was a general tendency for me to be in a continual climb. I felt the level flight attitude was more nose low than I would have liked. Small bank angle turns require very little TF-34 throttle increase to maintain flight speed; however, large bank angles ($\cong$30°) require a noticeable throttle increase to maintain speed. The airplane also appears to have a slightly unstable spiral mode requiring aileron away from the turn to maintain a given bank angle. There was more pitch change with throttle than I had seen in the simulator. Speaking of our simulation, it was indeed a valuable training aid for this first flight. During the climbs and descents, it became quite obvious that collective was considerably more effective in controlling wing angle of attack than were increases in speed. There seemed to be a one-to-one correlation between collective and wing angle of attack. I thought it was interesting that I could not feel the lift transfer from the wing to the rotor or vice versa and certainly not as rapidly as the wing angle of attack indicated that it was happening. I decided I liked the 90-knot descent for the landing approach. Another pleasant surprise was how much smoother the airplane felt at 100 to 110 knots IAS than it did at 80 to 100 knots. The vibration levels were noticeably reduced. This could be more a consequence of the bifilar system than anything else. Several low approaches were made at Moffett. The most obvious thing was the real lack of down or rate of descent capability if you expect to keep the wing angle of attack below stall. At 90 knots, with the TF-34s at or near idle, a collective setting below 30% to 35% collective position results in only about 750 ft/min down with the wing angle of attack near 15°. Collective must be increased to reduce the wing angle of attack which in turn reduces the rate of descent. The go-around maneuver is easily accomplished by increasing thrust on the TF-34s and possibly increasing the collective slightly. The latter seeming to be less important than the former, provided sufficient collective is being held to keep the wing angle of attack from being excessively high. Typically I felt I wanted to operate the throttles just above idle. Unfortunately, the engine response at this setting is very nonlinear; a small movement in the off direction results in a rapid rundown to idle power and vice versa. It is possible that flaps and/or speed brakes would allow the engines to be operated above this range with a correspondingly better throttle response. The final landing was made from a 90-knot-IAS approach with about 35% collective position; descent and speed were modulated with the TF-34s. A smooth touchdown occurred at or near 70 knots with the tail wheel contacting the runway first, followed shortly by the main gear. (Movies indicated the main gear was approximately 2 ft off the runway when tail wheel contact occurred.) A normal roll-out was made with little or no aft cyclic, the right TF-34 shut down, and little braking required. Taxi and shutdown were normal.

RECOMMENDATIONS: I was impressed with the importance of collective position especially on wing angle of attack and recommend that the collective position indicator be moved from the center console to the pilot's instrument panel (both sides). I feel that lowering the wing angle of attack will greatly reduce the numerous excursions to high wing angle of attack that occurred. It would be neat if there was some way the pilot could tell how much lift was being carried by the wing and how much was being carried by the rotor. I recommend early movement of the flaps and speed brakes to determine if they might be of assistance in the landing phase.

CONCLUSIONS: It was a great flight due mostly to the efforts of a large number of people. I felt adequately prepared for the flight. The simulator was invaluable in developing the new takeoff and landing techniques. We must continue to update the simulator as we obtain actual flight test data. The high-speed taxi test had adequately prepared me for both the takeoff roll and stopping techniques and should be continued for any new pilot checkouts.

9 Dec. 1981 Flight 5 Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -40 ft. WIND: 180°/10 knots. OAT: 10°C. FLIGHT TIME: 00:45. TOTAL FLIGHT TIME: 55:10. PURPOSE OF FLIGHT: Pilot familiarization. TEST POINTS COMPLETED: Conducted tests at speeds from 70 to 140 knots CAS and did pattern approaches and go-arounds, all with flaps up. Pilots commented on smoothness of aircraft as speeds were increased; 140 knots CAS was particularly smooth. The pilots were comfortable with aircraft at all times. The loads and stresses were nominal. Takeoff and landing were smooth and uneventful.

22 Jan. 1982 Flight 6 Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -440 ft. WIND: Calm. OAT: 8°C. FLIGHT TIME: 00:10. TOTAL FLIGHT TIME: 56:20. OBJECTIVES: Pilot familiarization, including use of wing flaps in preparation for tests of wing incidence change. TESTS COMPLETED: Level flight tests were conducted to 160 knots CAS including turns. The wing flaps were lowered to full 25° down at speeds from 85 to 120 knots CAS. Three low approaches and go-arounds were conducted at a range of flap settings. Final landing was made with 15° flaps; 66 data test points were acquired, including a T-58 engine vibration rpm sweep. FORWARD SPEED TESTS: Forward speed tests were successfully completed from 100 to 160 knots CAS using auxiliary thrust only with fixed collective. Turns to 30° angle of bank and gentle climbs and descents were accomplished at 160 knots CAS. The redundant wing actuators developed a force unbalance during these tests, following which the forces gradually equalized. The cause for this will be reviewed before the next flight. The aircraft handled easily throughout these tests with acceptable stress loadings throughout the speed regime. WING FLAP TESTS: Comparison tests of wing flaps were made at 0°, 15°, and 25° flap angles at speeds from 85 to 120 knots CAS. The pilot reported almost no change in handling qualities. Flap angles of 15° were almost imperceptible to the pilot; 25° of flaps decreased the aircraft attitude about 2° from the no flaps condition. LOW APPROACH AND LANDING TESTS: Three practice low approach and go-around tests were performed at 0°, 15°, and 25° flap settings, respectively. As a result, a 15° flap setting was selected for final landing. This setting provided a three point attitude for touchdown at 10° wing incidence. GENERAL: A SAS roll rate and lag rate gain reduced by one-third was used on this flight. The pilot stated that these gains were much better than previous. A test of T-58 engine output shaft vibrations was performed. Preliminary results of this test indicate that shaft vibration levels, in the compound configuration, are well within tolerance and shaft indexing may not be required.

2 Feb. 1982 Flight 7 Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -220 ft. WIND: Calm. OAT: 15°. FLIGHT TIME: 01:15. TOTAL FLIGHT TIME: 57:35. OBJECTIVES: First-time operation of wing tilt system in-flight and development of landing technique with lower wing incidence, in order to increase stall margin during the descent and approach to landing. TESTS COMPLETED: Wing-tilt system successfully operated in-flight. Low-speed trim and maneuvering tested at 7.5° and 5° wing incidence. Landing completed with low (5°) wing incidence and full flaps; 41 data test points were acquired. WING TILT OPERATION: The wing was commanded from 10° to 8°, and back to 10° wing incidence in level flight at 90 knots. This was the first time the wing has ever been moved in flight. The maneuver was easily performed. Following this initial movement the pilot commanded a 7.5° and then a 5° incidence. The effect on control trim was virtually unnoticeable to the pilot; only pitch attitude was affected. Pitch attitude was more nose-up, as predicted. The pilot commented that the fuselage seemed to rotate about the wing. LOW SPEED TESTS: Tests were performed at 7.5° and 5° wing incidence at speeds from 70 knots CAS to 140 knots CAS. Tests included climbs, descents, turns, and flap operation at 15° and 25° (full). The pilot said the aircraft handled the same as with 10° incidence except for a more desirable nose-up attitude. Stress and vibration levels were virtually unchanged, including main-rotor flapping. Pitch attitude increased about 2° with the change to 5° incidence. Wing angle of attack decreased about 5°, indicating a load transfer to the main rotor. Longitudinal cyclic change was virtually unnoticeable. Good test results were obtained for partial and full flaps at 5° wing incidence. These results were comparable to earlier flap tests at 10° wing incidence. LANDING TESTS: Several approach and go-around tests were performed at 5° wing incidence with 15° and 25° flaps. Full, 25° flaps were selected for final landing. The final was smooth and easy. Attitude was about 1°-2° nose-up from a three-point touchdown attitude. The pilot considered this less desirable than previous touchdown attitudes. A 7.5° incidence, full-flap final is to be considered for the next flight to reduce the nose-up attitude. GENERAL: A very satisfactory and informative flight.

9 Feb. 1982 Flight 8 Pilots: Merrill and Hall

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -130 ft. WIND: Calm. OAT: 9°C. FLIGHT TIME: 0. TOTAL FLIGHT TIME: 57:35. OBJECTIVES: To provide flight familiarization training to qualify a second pilot for compound RSRA operation. TESTS COMPLETED: Two practice takeoff runs were completed before abort of flight. Drag brakes were tested during deceleration. DISCUSSION: Flight was aborted because of inability to start right TF-34 auxiliary thrust engine, apparently because of a relay switch malfunction. Practice takeoff runs were satisfactory and provided good initial training for the pilot. Operation of the drag brakes during deceleration from 70 knots caused no change to aircraft stress levels.

18 Feb. 1982 Flight 9 Pilots: Merrill and Hall

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -230 ft. WIND: Calm. OAT: 17°C. FLIGHT TIME: 01:00. TOTAL FLIGHT TIME: 58:35. OBJECTIVES: First flight and pilot familiarization for Lt. Col. R. Merrill. TESTS COMPLETED: Conducted level flight, turns, climbs, and descents from 70 to 130 knots CAS at 5° and 10° wing incidence. Landing at 7.5° wing incidence, full flaps; 34 data points were acquired. The takeoff and climb-out were done at 10° wing incidence, no flaps, and were smooth and uneventful. WING TILT OPERATION: The wing tilt was operated in flight without problem, first to 5°, then to 7.5° for landing. A wing-tilt-fail shutdown occurred at one time but this was due to very slow motion of the tilt handle which causes the fail logic to activate. This characteristic has been previously documented. LEVEL FLIGHT/MANEUVERS: Tests were performed at 10° and 5° wing incidence at speeds from 70 to 130 knots CAS. The landing gear was extended for these tests. The results were satisfactory and similar to previous test results. The tests included turns to 30° angle of bank and climbs and descents using both TF-34 thrust and collective control changes. The pilot appeared to be comfortable with all of these maneuvers. LANDING CONFIGURATION: The landing configuration practice was performed at 7.5° wing incidence. Climbs, descents, and turns were performed at 15° and 25° flap settings. The pilot commented about the small control and trim changes with flaps. A failure of the environmental control system cut short the flight and a final landing was made with 7.5° wing and full flaps. Lt. Col. Merrill's first landing of the compound was smooth and, very slightly, tail-wheel first. GENERAL: This was a very successful first flight for Lt. Col. Merrill. Both pilots commented that the compound RSRA is an easy aircraft to fly.

3 Mar. 1982 Flight 10 Pilots: Merrill and Hall

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -220 ft. WIND: Calm. OAT: 12°C. FLIGHT TIME: 01:05. TOTAL FLIGHT TIME: 59:40. OBJECTIVES: Second flight and pilot familiarization for Lt. Col. Merrill. TESTS COMPLETED: Conducted level flight, turns, climbs, and descents from 100 to 140 knots CAS at 5° wing incidence. Practiced three low approaches to Moffett Field at various flap settings with 7.5° wing incidence. Final landing was made at 7.5° wing, full flaps; 31 data points were acquired. The takeoff and climb-out were with 10° wing incidence, no flaps; smooth and uneventful. WING TILT OPERATION: The wing tilt was operated frequently throughout the flight and performed flawlessly. LEVEL FLIGHT/MANEUVERS: Training maneuvers were conducted at 5° wing incidence at speeds from 100 to 140 knots CAS. The landing gear was extended for these tests. Several pulse/step inputs were made at 120 knots CAS. Collective inputs caused noticeable coupling to other axes. The results of these tests were satisfactory and no load or stress problems were encountered. LANDING CONFIGURATION: Three practice approaches to Moffett Field were made at 0°, 15°, and 25° flaps with 7.5° wing incidence. The final landing was made with 25° flaps. Touchdown was slightly tail-wheel first. The landing was smooth. Following this landing, a takeoff abort distance test run was made to accurately record that distance using a transit. GENERAL: This was a successful training flight. The pilot again commented that the aircraft was easy to fly. In specific, Lt. Col. Merrill said that he flew the RSRA much as a fixed wing, using TF-34 thrust as a primary control with the collective pitch control relatively fixed.

3 Mar. 1982 Flight 11 Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -200 ft. WIND: 360°/10 knots. OAT: 16°C. FLIGHT TIME: 0. TOTAL FLIGHT TIME: 59:40. OBJECTIVES: Pilot training for W. Hall. TESTS COMPLETED: None, flight aborted. DISCUSSION: Aborted because of inability to start right TF-34 engine. Starter would drop out before engine up to speed.

19 Mar. 1982 Flight 12 Pilots: Hall and Morris

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -300 ft. WIND: Calm. OAT: 11°C. FLIGHT TIME: 01:10. TOTAL FLIGHT TIME: 60:50. OBJECTIVES: Pilot training for Major Morris and operational checkout tests. TESTS COMPLETED: Conducted level flight and turns from 70 to 140 knots CAS at 5° wing incidence. Recorded static stability at 100 and 120 knots CAS. Acquired 35 data points. PILOT TRAINING: This flight was Major Morris' first as copilot on the compound and initiates the training of a third pilot for the compound RSRA. LEVEL FLIGHT/TURNS: Turns to 45° angle of bank were completed at 120 knots CAS and at lesser angles at slower speeds, staying at or below the contractor-defined envelope. Pilot Hall enjoyed the feel of the aircraft at higher bank angles. Level flight speeds were limited to 140 knots CAS pending approval to retract the landing gear. STATIC STABILITY: Tests of static stability at initial trim speeds of 100 and 120 knots CAS were conducted separately with force feel system stick trim and with backup system trim. Control motions over a ±10-knot range were very small so that steady forces developed were almost unnoticeable to the pilot. The pilot did comment that the backup trim seemed to cause him to overcontrol somewhat. The pilot normally flies with trim OFF. LANDING CONFIGURATION: Several approaches and go-arounds were practiced and a final landing was made, all using 7.5° wing incidence and 25° (full) flaps. The landing was smooth, positive, and slightly tail-wheel first, as is becoming usual.

25 Mar. 1982   Flight 13   Pilots: Hall and Morris

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -40 ft. WIND: Calm. OAT: 17°C. FLIGHT TIME: 01:10. TOTAL FLIGHT TIME: 62:00. OBJECTIVES: Evaluation pilot training for Major Morris. TESTS COMPLETED: Conducted level flight and turns from 70 to 140 knots CAS at 5° wing incidence. Transferred control from safety pilot to evaluation pilot for extended period. Acquired 28 data points. EVALUATION PILOT (EP) CONTROL: Major Morris flew much of the flight from the left seat in EP control mode thereby gaining hands-on experience (EP control is the electronic control mode). The system functioned smoothly the entire time. This is a first time for operation in EP control for the compound RSRA at NASA Ames. GENERAL: Maneuvers performed on this flight were a repetition of earlier tests and were restricted to speeds of 140 knots CAS and less pending approval to retract the landing gear. The flight was smooth and acceptable in all respects. Previous SAS 1-2 fail light problem appears to be resolved.

7 Apr. 1982   Flight 14   Pilots: Merrill and Hall

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -200 ft. WIND: Calm. OAT: 13°C. FLIGHT TIME: 01:15. TOTAL FLIGHT TIME: 63:15. OBJECTIVES: Check operation of aircraft at speeds to 170 knots CAS. TESTS COMPLETED: Surveyed effect of wing incidence and collective position on main-rotor blade stress at speeds from 110 to 150 knots CAS. Conducted 40° angle-of-bank turns at 150 knots CAS; 45 data points were recorded. Speeds were limited to 150 knots CAS since a high-speed chase was not readily available; therefore, operational check at 170 knots CAS was not completed. MAIN ROTOR BLADE STRESS: This MR-blade stress investigation was completed from 110 to 150 knots CAS at wing incidence angles of 5° and 10°. The effect of collective was also checked for 35% and 40% positions. Test altitude was 3000 ft H_d. Results of the test are pending further test and analysis. The blade stresses did exceed endurance values at high-speed, high-loading conditions by a small margin, as expected. Tests to higher speed (170 knots CAS) are expected on the next flight. Turns to 40° AOB at 40% collective and 10° wing incidence were performed without difficulty. GENERAL: Several practice approaches and final landing were smoothly and easily accomplished. The SAS 102 tail light and cruise guide indicators were malfunctioning during the flight. These are recurring minor discrepancies.

16 Apr. 1982   Flight 15   Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -190 ft. WIND: 0°/7 knots. OAT: 14°C. FLIGHT TIME: 01:05. TOTAL FLIGHT TIME: 64:20. OBJECTIVES: Check operation of aircraft at speeds to 170 knots CAS. TESTS COMPLETED: Limited data acquired to 160 knots CAS in level flight; 25 data points recorded. MAIN-ROTOR BLADE STRESS: Data acquired were compromised because of turbulent air. Limited data were recorded since comparison of such to previous data would be inappropriate. Data were recorded incrementally from 110 to 160 knots CAS. LUG-LOAD PROCESSOR: This flight was to initiate use of the analog lug-load processor. This device, which derives lower horizontal stabilizer attachment lug load from several strain-gage sources, was removed from the aircraft just before flight, because the installation was judged unsatisfactory for flight. This processor was intended to provide on-line lug-load data for this potentially high-fatigue area. Less sophisticated methods are currently being utilized for this purpose. GENERAL: Approach and go-around practice was conducted for pilot proficiency and the landing was smooth, as usual. Rough air was encountered because flight was scheduled for 10 a.m. takeoff and was almost 2 hr late getting off. It was recommended that an earlier takeoff would be better. An 8:30 takeoff is planned for future flights.

22 Apr. 1982 Flight 16 Pilots: Merrill and Hall

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -160 ft. WIND: Calm. OAT: 18°C. FLIGHT TIME: 01:05. TOTAL FLIGHT TIME: 65:25. OBJECTIVES: Check operation of aircraft at speeds to 170 knots CAS. TESTS COMPLETED: Completed tests at 10° and 5° wing incidence at speeds from 110 to 165 knots CAS. Tested collective at 35% and 40% at the higher speeds. Completed turns at 110 knots IAS to 55° bank angle. Recorded 55 data points. LEVEL FLIGHT SPEED SWEEPS: Tests were completed to speeds of 165 knots CAS at 4000-ft density altitude for wing incidence angles of 10° and 5°. Collective was varied from 40% to 35% at speeds at and above 160 knots CAS. Speed was limited to 165 knots CAS because MR blade stresses began to exceed endurance levels. Telemetered data indicated that reduction of collective may be beneficial. Change of wing incidence, at least initially, did not appear to have an effect on blade stresses. Initial tail-rotor-blade stress data also ran higher than Sikorsky results. Analysis of on-board data must be completed for a more definitive statement of results. Ambient temperatures were higher than usual which caused the density altitude to be higher than was desired for comparison to previous data. MANEUVERS: Turns to 55° angle of bank were successfully accomplished at 120 knots CAS. Additional maneuver tests were not completed, for fuel ran low. GENERAL: This was a very good, informative flight. The air conditions were smooth. A great number of good data points were acquired on which to perform comparative analysis. The earlier takeoff time, 8:30 a.m., was strongly supported by the results.

29 Apr. 1982 Flight 17 Pilots: Hall and Merrill

CONFIGURATION: Compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -26 ft. WIND: Calm. OAT: 14°C. FLIGHT TIME: 01:05. TOTAL FLIGHT TIME: 66:30. OBJECTIVES: Check level-flight operation of aircraft at speeds to 170 knots CAS and sideslips to 140 knots CAS. TESTS COMPLETED: All objectives were accomplished; 55 data points were acquired. LEVEL FLIGHT: Level flight data were acquired at speeds from 90 to 174 knots CAS (184 knots TAS) at 3700-ft density altitude and at wing incidence angles of 5° and 10°. Collective position data were obtained at 35% and 40% for speeds of 150 knots CAS and above. No unusual vibrations or abnormal aircraft tendencies were noted. Main-rotor-blade stress exceeded endurance at 170 knots CAS. Blade-stress trends obtained on previous flights generally were confirmed. SIDESLIPS: Level-flight sideslips were performed incrementally to the limits of the established envelope, ±15° at 90 knots CAS and 10° right to 12° left at 140 knots CAS. These tests were accomplished quickly and easily with no abnormal tendencies noted by the pilot. Tail-rotor parameters were at endurance during the 10° right sideslip test at 140 knots CAS. AIRSPEED CALIBRATION: A T-28 made available by AEFA, configured to perform airspeed calibrations, was used as chase. A recheck of the existing airspeed calibration was obtained for many of the level-flight test conditions. Initial review of these data does not indicate any large error in the RSRA 740 airspeed calibration. GENERAL: This was a very successful flight which added to the data file for comparison with previous Sikorsky data acquired at Wallops Island and for analysis. Level-flight speed objectives were attained. The airspeed calibration was a bonus, thanks to AEFA.

7 July 1982 Flight 18 Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -100 ft. WIND: 20 knots. OAT: 19°C. FLIGHT TIME: 01:00. TOTAL FLIGHT TIME: 67:30. OBJECTIVES: Obtain flight data for 0° wing incidence; for 30% collective at 5° wing incidence; for collective trimmed at 80 knots with jets idle; and for auxiliary engine vibrations. TESTS COMPLETED: All objectives were attained; 51 data points were recorded. 0° WING INCIDENCE: This is the first flight to test 0° wing incidence. At 80 knots, pitch attitude was 6°-7° nose up, almost uncomfortably so. However, at higher speeds the attitude reduced to a very comfortable, slight nose-up position. Data were recorded at speeds to 158 knots CAS. Shaft bending and other parameter values were nominal with the exception of the master blade gage which reached endurance at 150 knots CAS. A lower collective trim setting may need to be used at 0° wing incidence to achieve higher airspeeds since rotor load appears to increase (as predicted) with decreased wing incidence. 30% COLLECTIVE: A speed sweep to 160 knots CAS was completed. The wing was at 5° incidence (the current work-a-day nominal) and the collective pitch was reduced to 30% versus the usual 40%. Because of rough air and loss of a primary blade monitor, the speed was limited to 160 knots CAS; 30% collective looked very good relative to blade stresses. 80-KNOT COLLECTIVE TRIM: Collective was trimmed to hold level flight at 80 knots with auxiliary jets at idle rather than at the usual 40%. The new trimmed position was 42%, causing more blade loading during forward flight. It was anticipated that this procedure might produce less blade loading. This method of collective trim will be abandoned. TF-34 ENGINE VIBRATIONS: A resonance over a narrow range of fan speed was noted previously on the left auxiliary thrust engine. It is believed to have been caused by a vibrating wire to the CCD transducer which has subsequently been rerouted. A fan speed-sweep was conducted to check the fix. Results are not yet available. GENERAL: This was the initial flight following an extended down period for a 50-hr inspection and resulting replacement of a number of load-cell bushings. The aircraft was in good shape and almost no crabs were logged.

22 July 1982 Flight 19 Pilots: Merrill and Hall

CONFIGURATION: Compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -40 ft. WIND: Calm. OAT: 18°C. FLIGHT TIME: 01:00. TOTAL FLIGHT TIME: 68:30. OBJECTIVES: Obtain flight for 5° and 10° wing incidence for 30% and 25% collective pitch settings. TESTS COMPLETED: All objectives were attained; 46 data points were completed. Level flight speeds to 192 knots TAS were achieved. DISCUSSION: This was a very successful flight during which level-flight speed sweeps were conducted at 5° and 10° wing-incidence settings with collective-pitch settings reduced from the previous 40%. Speeds to the Sikorsky established envelope of 181 knots CAS (192 knots TAS at 4000 ft H_d) were achieved at 25% collective for both 5° and 10° wing. At 30% collective, speed was limited to 175 knots CAS because of main-rotor-blade stresses. Blade stresses were least at high speed with 10° wing and 25% collective. At these same conditions, however, the pilots commented on vibration levels. This vibration was reduced at 5° wing. Preliminary results of this flight indicate that 25% collective position is an improvement over 40% or 30% collective relation to main-rotor stresses. No problems were encountered at the lower positions; however, tests were performed in level flight and gentle turns only.

22 July 1982 Flights 20A, 20B Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -40 ft. WIND: 0°/10 knots. OAT: 22°C.

FLIGHT TIME: 01:00 (20A); 00:20 (20B). TOTAL FLIGHT TIME: 69:50. OBJECTIVES: The objective of this flight was to continue operational checkout within the Sikorsky flight envelope at 5° wing incidence and 25% collective position, and to operate the drag brake. TESTS COMPLETED: Rotor speed (N_R) sweeps were conducted at 110 and 130 knots IAS; the drag brake was opened at 130 knots IAS; turns and sideslips were conducted at 150 knots IAS; and load factor push-overs and pull-ups were accomplished at 130 knots IAS. Fifty-two data points were acquired. Note that flight was in two parts. The second was a ferry return following a precautionary landing at Livermore owing to a main gear box over-temperature indication. N_R SWEEPS: At 110 knots IAS with 25% collective, 5° wing, the pilots reported "mushy control" at lower rotor speeds. Torque reduced to low values. Pilots reported the tip-path plane was up and aft, although flapping was still reported satisfactory by telemetry. Approach to wing stall was a possibility so N_R was not reduced beyond 98%. A subsequent N_R sweep was done at 130 knots IAS using 35% collective; no "mush control" was reported. DRAG BRAKE: The drag brake was opened to 30° and full at 130 knots IAS; 30° was barely noticeable to the pilots, but full manual open was noticeable. No effect on the tail rotor was observed. These trim data are to be used to correlate wind tunnel data to the full-scale RSRA. 150 KNOTS IAS TURNS AND SIDESLIPS: Turns to 35° AOB and sideslips to 7° right and 10° left were performed easily. Stresses and control were satisfactory. LOAD FACTOR MANEUVERS: Pull-ups and push-overs were performed at 130 knots IAS within the current envelope limit; 1.6 g and 0.6 g were achieved. The tests were satisfactory although full envelope limits were not reached. The tests were not continued pending a review of technique. GENERAL: Shortly after starting a level-flight speed sweep at 7.5° wing, 25° collective, a main gear box over-temperature indication was noted both on the caution panel and the cockpit gage. The flight was aborted into Livermore. After maintenance and inspection cleared the aircraft for ferry, the flight was completed to Ames late in the day. Following shutdown of the right TF-34 auxiliary thrust engine on roll-out (normal procedure), an over-temperature of the engine was noted by the pilot. His attempts to motorize the engine to cool it were unsuccessful because the engine did not motorize. A post-flight over-temperature inspection is required.

5 Aug. 1982 Flight 21 Pilots: Merrill and Hall

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -160 ft. WIND: Calm. OAT: 17°C. FLIGHT TIME: 01:00. TOTAL FLIGHT TIME: 70:50. OBJECTIVES: The objective of this flight was to continue operational check of the Sikorsky flight envelope using 7.5° wing incidence at 25% collective position. TESTS COMPLETED: All planned tests were successfully completed including maneuvers at 170 knots CAS up to 1.6-g load factor and up to 1.8-g at 140 knots CAS. Fifty data points were acquired. LEVEL-FLIGHT SPEED SWEEP: Data were recorded in level flight at 7.5° wing incidence, 25% collective, from 130 knots CAS to 180 knots CAS; 7.5° wing had been selected as a compromise setting between 10° and 5°. Ten degree wing incidence is associated with higher tail structure loads and 5° is associated with higher main-rotor-blade loads. Results at 7.5° were satisfactory, but full analysis of all data is required prior to conclusive statement. 170 KNOTS CAS MANEUVERING FLIGHT: Sikorsky envelope limit maneuvers were performed. These were slow climb and descent, turns to 20° bank angles, small sideslips, pull-ups to 1.6 g, push-overs to 0.65 g, and an N_R sweep from 104% to 96%. Nominal exceedance of blade loading was encountered at 1.6 g. Main-rotor control loads did not exceed endurance. All maneuvers were quite satisfactory. 140-150 KNOTS CAS LOAD FACTOR MANEUVERS: Pull-ups were accomplished to 1.8 g and push-overs to 0.4 g; 1.8 g was short of the 1.9-g limit, but further attempts were curtailed, for blade damage was initially seen to be at a significant rate. Reexamination of on-line data shows that endurance was only exceeded by

±1500 lb/in.^{2} which was less than the first look. Again, these were very successful maneuvers. GENERAL: Problems occurring on the previous flight were main gearbox overheating and a post-shutdown overheat of the right TF-34 engine. Neither of these problems reappeared. "De-servicing" the main gearbox oil level and tightening the fan belts on the oil cooler appear to have fixed the MGB. Maximum in-flight main-gearbox oil outlet temperature was about 30°C cooler than before with only a 5°C decrease in ambient. The TF-34 rigging adjustment corrected the post-shutdown fire problem. The inability to motor the engine, a second problem, was also fixed by repairing the abort start microswitch. Postflight procedure for shutdown of the TF-34 engine has been changed to be accomplished when the aircraft is at the chocks and in more controlled circumstances.

5 Aug. 1982 Flight 22 Pilots: Hall and Merrill

CONFIGURATION: Full compound. GROSS WEIGHT: 27,110 lb. CENTER OF GRAVITY: 302 in. GROUND PRESSURE ALTITUDE: -140 ft. WIND: 320°/10 knots. OAT: 24°C. FLIGHT TIME: 01:00. TOTAL FLIGHT TIME: 71:50. OBJECTIVES: The objective of this flight was to complete the operational checkout phase of the test program. In particular, the low-speed maneuvering of the compound was evaluated and 20% collective was tested. TESTS COMPLETED: All planned tests were successfully completed. Thirty data points were acquired. LOW-SPEED TESTS: A speed sweep from 100 knots IAS down to 50 knots IAS was accomplished; ±15° sideslips and an N_R sweep from 105% to 96% was done at this low speed. The pilot reported aircraft control to be imprecise at 50 knots IAS so that the sideslips were not well trimmed. However, they did note that control improved with reduction in N_R. General vibration levels also increased at the lower speeds. T-58 engine power at 50 knots IAS was close to or at maximum continuous rating, 86% Q. Push-overs and pull-ups to 0.74 g and 1.2 g were easily accomplished at 65 knots IAS. Turns, both left and right, were made to 45° angle of bank at 80 knots IAS. The pilot reported a "lateral shuffle" on recovery from the right turn. TF-34 power (above ground idle) was needed to make these turns. STATIC STABILITY TESTS: Static stability tests were performed at 130 and 150 knots IAS to a range of ±10 knots from trim. The 150 knots IAS set was poor due to rougher air conditions. 20% COLLECTIVE TESTS: A short speed sweep from 150 to 120 knots IAS was conducted at 20% collective. This was quite successful and plenty of engine torque was still being used by the rotor, 26% at 140 knots IAS. GENERAL: Main-rotor gearbox temperatures were well within limits. Maximum cockpit indication was 114°C at an ambient 22°C. The oil cooler output temperatures were monitored. These indicated that the oil cooler was reducing the oil temperature by 15° to 25°. This flight completes the series of tests called the "Operational Checkout" during which the previously developed Sikorsky envelope was investigated. One major difference was noted. That is the main-rotor-blade stresses, MRBR-6 and -7, were a few hundred psi higher than previous results. Prudent test methods did not allow attainment of 181 knots CAS at 40% collective position. This speed was attained at a lower collective setting. During this testing considerable new data were acquired at collective settings down to 20% position and at wing incidence angles from 10° to 0°.

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16. Abstract

This data report documents the flight-test activities of the Rotor System Research Aircraft (RSRA), NASA 740, from June 30, 1981 to August 5, 1982. Tests were conducted in both the helicopter and compound configurations. Helicopter vertical-drag test results are reported in NASA Contractor Report 166399, December 1981. Compound tests reconfirmed the Sikorsky flight envelope except that main-rotor blade-bending loads reached endurance at a speed about 10 knots lower than previously. Wing incidence changes were made from 0° to 10°.

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R. E. Erickson, et al

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Page 111: In fifth paragraph, first line, change figures to read

(figs. 119, 121-124, 134)

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Page 159: Caption for figure 152 should read

Engine performance: wing incidence 10°, rotor speed 104% (best-fit curves)

Page 160: Caption for figure 153 should read

Engine performance: wing incidence 10°, rotor speed 104% (best-fit curves and data points)

Page 161: Caption for figure 154 should read

Rotor torques: wing incidence 10°, rotor speed 104% (best-fit curves)

Page 162: Caption for figure 155 should read

Rotor torques: wing incidence 10°, rotor speed 104% (best-fit curves and data points)

Page 163: Caption for figure 156 should read

Engine performance: wing incidence 7.5°, rotor speed 104% (best-fit curves)

Page 164: Caption for figure 157 should read

Engine performance: wing incidence 7.5°, rotor speed 104%
(best-fit curves and data points)

Page 165: Caption for figure 158 should read

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Page 166: Caption for figure 159 should read

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Page 167: Caption for figure 160 should read

Rotor torques: wing incidence 5°, nominal rotor speed 104%
(best-fit curves)

Page 168: Caption for figure 161 should read

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Page 169: Caption for figure 162 should read

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