FLIGHT TEST MEASUREMENT OF VERTICAL AND HORIZONTAL TAIL LOADS DURING RUDDER KICK AND STEADY SIDESLIP MANEUVERS

D. W. Rhoads

Prepared by
Cornell Aeronautical Laboratory, Inc.
Buffalo, New York

United States Air Force
Air Research and Development Command
Wright Air Development Center
Wright-Patterson Air Force Base, Dayton, Ohio
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ABSTRACT

The vertical and horizontal loads sustained during rudder kick and steady sideslip maneuvers have been investigated by means of flight tests conducted on an F-50A airplane by the Flight Research Department of the Cornell Aeronautical Laboratory, Inc., Buffalo, New York. The length of time the maximum rudder deflection is held has been shown to have a critical influence on the vertical tail load. Tests show that the most critical condition is reached if the rudder angle is forced to return to zero deflection from its maximum value at the time maximum heading change (or zero yaw rate) is attained.

The dissymmetry of the horizontal tail loads due to steady sideslip is illustrated by steady sideslip tests conducted for this purpose.

PUBLICATION REVIEW

Manuscript Copy of this report has been reviewed and found satisfactory for publication.

FOR THE COMMANDING GENERAL:

JACK A. GIBBS
Colonel, USAF
Chief, Aircraft Laboratory
Engineering Division

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**SYMBOLS, DEFINITIONS AND CONVENTIONS**

**Axes**

Stability axes are used throughout this report. These mutually perpendicular axes are fixed to the airplane and, therefore, move with it during a maneuver. Their origin O lies at the center of gravity of the airplane. OX and OY lie in the plane of symmetry and OZ is perpendicular to it. These axes are fixed to the airplane by subjecting OX to the condition that it be parallel to the free stream wind vector in initial trimmed level flight.

- **X Axis**, or longitudinal axis is positive forward.
- **Y Axis**, or transverse axis is positive along the right wing.
- **Z Axis**, or normal axis is positive downward.

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<td>1. Elevator Angle</td>
<td>$\theta_e$</td>
<td>Trailing edge of elevator down.</td>
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<td>2. Rudder Angle</td>
<td>$\theta_r$</td>
<td>Trailing edge of rudder to the left as you are looking along the positive X axis.</td>
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<td>3. Total aileron angle</td>
<td>$\theta_a$</td>
<td>Trailing edge of right aileron down (left wing down).</td>
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<td>4. Normal acceleration</td>
<td>$\mathbf{a}_n$</td>
<td>Acceleration of e.g. of the airplane in a downward direction (pilot is pushed against belt).</td>
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<td>5. Right stabilizer bending moment</td>
<td>RBM</td>
<td>Moment due to load applied to a downward direction.</td>
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<tr>
<td>6. Left stabilizer bending moment</td>
<td>LBM</td>
<td>Moment due to load applied in a downward direction.</td>
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<tr>
<td>7. Right stabilizer shear</td>
<td>RS</td>
<td>Load applied in a downward direction.</td>
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<td>8. Sideslip angle</td>
<td>$\beta$</td>
<td>Displacement along the y axis toward the right (nose to the left of relative wind).</td>
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<td>9. Left stabilizer shear</td>
<td>LS</td>
<td>Load applied in a downward direction.</td>
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<td>10. Fin bending moment</td>
<td>FBM</td>
<td>Moment due to load applied to the right looking along the positive X axis.</td>
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<td>11. Fin shear</td>
<td>FS</td>
<td>Load applied to the right looking along positive X axis.</td>
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<td>12. Rate of yaw</td>
<td>$\omega$</td>
<td>Angular velocity about the Z axis (clockwise when looking along + Z axis) (Nose to the right; right wing back).</td>
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<td>13. Rate of roll</td>
<td>$\phi$</td>
<td>Angular velocity about the X axis to the right (right wing down).</td>
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AFTR-6743
INTRODUCTION

As a continuation of the dynamic stability and tail load study of the F-80A airplane, under Air Force Contract No. W33-038-ac-18517 (18L80), this report presents the results of a series of rudder kick and sideslip flight tests in accordance with Change Order Number 13 of the above contract.

The primary objective of the rudder kick portion of the program was to determine the rudder deflection time history which would produce the most critical vertical tail loads, as well as to observe the relationship between the vertical tail load and the magnitudes of sideslip and rudder deflection applied. The tests were done at an altitude of 20,000' under several geometric and aerodynamic configurations, as noted below.

The purpose of the steady sideslip tests was to obtain data on the dissymmetry of the horizontal tail loads for future analysis. These tests were run at three different Mach numbers. A flight program block diagram appears below.

I. Rudder Kick

IIa

\( T < \frac{1}{2} \text{ D.R. period} \)

\( \omega = 0.5 \text{ sec.} \)

\( \delta_{\text{max}} = 3, 4^\circ \)

IIb

\( T > \frac{1}{2} \text{ D.R. period} \)

\( \omega = 1.5 \text{ sec.} \)

\( \delta_{\text{max}} = 3, 4^\circ \)

III

\( \Delta T = \Delta T_e \) from .1 to .5 sec.

\( \delta_{\text{max}} = 3, 3.5 \text{ and } 4^\circ \)

IV

M.N. = .6

\( \delta_{\text{max}} = 4^\circ \)

V

M.N. = .7

\( \delta_{\text{max}} = 3, 4^\circ \) and 5°

VI

Empty tip tanks

\( \delta_{\text{max}} = 3, 4^\circ \) and 5°

VII

Half full tip tanks.

\( \delta_{\text{max}} = 3.5 \text{ and } 4^\circ \)

VIII

All, moved to prevent rolling.

\( \delta_{\text{max}} = 3.5 \text{ and } 4^\circ \)

AFTR-6743
II. Steady Sideslip

The branches represent changes from the basic condition as indicated by the quantities in the branch boxes. A total of 26 rudder kick and 3 steady sideslip conditions is presented.

**Theory**

The assumption that the rudder kick maneuver may be critical from a vertical tail load standpoint may be illustrated in the following manner. If the rudder input is a step or the beginning of a ramp, the quantitative vertical tail response is:

\[ N_{kr} = f(\beta, \varphi, \alpha, \delta) \]

Where \( N_{kr} = f(\beta, \varphi, \alpha, \delta) \)

The rudder effectiveness contribution, \( \left( \frac{\partial N_{kr}}{\partial \delta} \right) \) is important for it tends to, in the above case, reduce the tail load as indicated by the portion of the curve below the origin. If, however, the rudder is returned to its neutral position, in effect, a "reverse" step or partial ramp is produced as indicated below.
It may be seen that depending upon the timing of the return input (the combination with the initial input has now produced a full ramp input) the rudder effectiveness portion of the vertical tail load function is now added to that produced by the initial rudder motion. If rudder deflection magnitudes are excessive, the additional increment of tail load caused by the rudder effectiveness portion due to the return motion may produce a critical tail load.

F-80A vertical tail load flight test data obtained during previous programs was used to predict maximum vertical tail load during both the rudder kick and steady sideslip maneuver, thereby insuring the safety of pilot and test vehicle.

In addition to the basic load quantities recorded, control deflections, rotational velocities, normal acceleration and bending moments are presented as time histories.
EQUIPMENT AND METHODS

Equipment

The test vehicle used for these measurements was a Lockheed F-80A-IALO fighter type aircraft. This is a low wing, single place, jet propelled airplane powered by an Allison J-33-11 engine. Dimensions and leading particulars are on pages 10 through 12. A photograph and three view drawing are shown on pages 13 and 14.

Flight test data were recorded by a photo-observer and a fourteen channel Consolidated Engineering Corporation recording oscillograph.

The following items were recorded on the oscillograph:

1. Aileron Position
2. Elevator Position
3. Rudder Position
4. Normal Acceleration
5. Fin Shear
6. Fin Bending Moment
7. Sideslip Angle
8. Rolling Velocity
9. Yawing Velocity
10. Right Stabilizer Shear
11. Right Stabilizer Bending Moment
12. Left Stabilizer Shear
13. Left Stabilizer Bending Moment

Stabilizer shear and bending moment were measured at Station 10" from the stabilizer centerline. Fin shear and bending moment were measured at water line 129" from the reference centerline. Aileron, elevator, and rudder position were measured at the point where the control surfaces attach to the control system; that is, at the elevator and rudder horns and the aileron quadrants.

The following items were recorded on the photo-observer by a 35mm movie camera:

1. Airspeed (Ship's system and Prandtl tube)
2. Altitude
3. Outside Air Temperature
4. Fuel Quantity Remaining
5. Run Number (Oscillograph)
6. Frame Number (Camera)
7. Bank Angle
8. Stop Watch

For details of the recording instrumentation design procedures for calibration, and an estimate of overall recording accuracy, the reader is referred to Reference (1). The development of instrumentation for the purpose of measuring total tail loads and recording the data on a single oscillograph trace is presented in Reference (2). Details of instrumentation component types and models are recorded in Reference (3).
The condition imposed whereby the rudder kick duration is approximately one-half the Dutch roll period was designed to superimpose the return portion of the vertical tail load response on the peak of the load caused by the initial disturbance, thereby illustrating the maneuver characteristics which could cause a critical load condition. Previous flight has shown that, in response to a rudder step input, maximum sideslip and, hence, vertical tail load occurs at approximately zero yaw rate, and the return portion approximates maximum heading angle. This latter quantity could be visualized by the pilot with reference to some point on the ground, and therefore is used as a criterion for the specified program of kick duration.

Rudder kick maneuvers were performed both to the right and left. No particular difference may be noted between the two directions and no effort was made to present the same number of left and right for each condition. However, of the total number of rudder kick maneuvers presented, thirteen are to the left and thirteen are to the right.

Steady sideslips were performed for a number of rudder deflection magnitudes, ranging from approximately -8 to +8 degrees, resulting in load and bending moments as a function of rudder deflection. An attempt to maintain zero rolling velocity was made by using sufficient aileron in each case to null the rolling moment due to sideslip velocity.

Examination of the flight test data obtained as a result of the execution of this flight program has indicated the following:

1. The additional increment of tail load caused by the return of the rudder to its approximate neutral position is a considerable percentage of the load caused by the initial rudder displacement.
2. Whether or not this increment occurs at the maximum load due to the initial rudder disturbance depends on the rudder "holding time".
3. If the above does occur, the total load on the vertical tail may be critical, depending on the rudder magnitude initially adopted.
4. An extension of this maneuver to a "fish-tail" maneuver, or a series of alternating positive and negative ramp inputs, indicates an even more critical condition due to the repeated alternating loads.
5. Sufficient data has been obtained during both the rudder kick and steady sideslip phases of this flight program to provide a fund of information for future analysis of this type of maneuver and to obtain a thorough check of the accuracy of any proposed method of calculation of these loads.

It is recommended that such analyses as noted above be carried out, extending to more severe rudder kick maneuvers than performed during these flight tests.
REFERENCES


DIMENSIONS AND LEADING PARTICULARS
F-80A Serial No. MM-85333

I. **Principal Dimensions**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airplane - General</td>
<td>Airplane - General</td>
</tr>
<tr>
<td>Span</td>
<td>33' 1-1/2&quot;</td>
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<tr>
<td>Length (overall)</td>
<td>31' 6&quot;</td>
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<tr>
<td>Height</td>
<td>11' 4&quot;</td>
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II. **Wings**

<table>
<thead>
<tr>
<th>Airfoil Section</th>
<th>Airfoil Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root</td>
<td>NACA 65 1 - 213 (a = 0.6)</td>
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<tr>
<td>Tip</td>
<td>NACA 65 1 - 213 (a = 0.6)</td>
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<tr>
<td>Chord at Root (at airplane)</td>
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<tr>
<td>Chord at Tip (Theoretical) (Tangent to tip)</td>
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<tr>
<td>Incidence at Root</td>
<td>1°</td>
</tr>
<tr>
<td>Incidence at Tip</td>
<td>-0.3°</td>
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<tr>
<td>Dihedral - Trailing edge in Wing Ref. Plane</td>
<td>3°.5°</td>
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<tr>
<td>Sweepback (Leading edge)</td>
<td>0°.2°</td>
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<tr>
<td>Rear beam (Straight line) at</td>
<td>62°.5° chord</td>
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<tr>
<td>Aspect Ratio</td>
<td>6.39</td>
</tr>
<tr>
<td>Taper Ratio (A)</td>
<td>0.11</td>
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<tr>
<td>Mean Aerodynamic Chord (MAC)</td>
<td>90.6&quot;</td>
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<tr>
<td>Flap and aileron hinge angle at leading edge of wing to leading edge of MAC</td>
<td>18.48&quot;</td>
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III. **Empennage**

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<th>Horizontal Stabilizer</th>
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</thead>
<tbody>
<tr>
<td>Airfoil Section</td>
<td>NACA 65 1 - (10)</td>
</tr>
<tr>
<td>Tail length (distance from C/4 of wing MAC to elevator hinges line)</td>
<td>18.46 ft.</td>
</tr>
<tr>
<td>Tail length (distance from C/4 of wing MAC to C/4 of tail MAC)</td>
<td>14.74 ft.</td>
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<tr>
<td>Span</td>
<td>15.60 ft.</td>
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<tr>
<td>Incidence to horizontal reference line</td>
<td>1°.30°</td>
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<tr>
<td>Root chord (C R)</td>
<td>4.33 ft.</td>
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<tr>
<td>Tip chord (C T)</td>
<td>1.80 ft.</td>
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<tr>
<td>Aspect ratio (AR)</td>
<td>6.66</td>
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<tr>
<td>Taper ratio (t)</td>
<td>0.388</td>
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<tr>
<td>Elevator E - ratio of elevator area to area of horizontal stabilizer (including elevator)</td>
<td>0.246</td>
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<tr>
<td>Mean geometric elevator chord: c E</td>
<td>Elevator area: B E</td>
</tr>
<tr>
<td>c E B E</td>
<td>1.73 ft. 3</td>
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</tbody>
</table>

AFTR-6743 - 10 -
Trim tab dimensions
Spring tab dimensions
Elevator hinge center line at

Vertical Stabiliser
Airfoil section
NACA 65 2 010
Height
7.92 ft.
Root chord (\(C_R\))
5.41 ft.
Tip chord (\(C_T\))
2.165 ft.
Aspect ratio (\(AR\))
1.832
Taper ratio (\(L\))
-4
Rudder chord (\(C_R\))
Rudder area (\(S_R\))

Trim Tab dimensions
chord - 3 7/16" span - 15.75"
Rudder hinge center line at
chord - 4 5/8" span - 10"
75% chord

D. Fuselage
Width (max.)
66" Height (max.)
56" Plan area
127.97 sq. ft.
Side area
135.85 sq. ft.
Distance from nose to 25% MAC
205.48"

II. Areas

A. Wing
Total wing area
237.6
Wing flap area (total)
30.2
Total aileron area aft of hinge line
17.0
(including tabs)
Left aileron trim tab area
0.4

B. Empennage
Total Horizontal tail area
43.5
Stabilizer fixed area to elevator hinge (each)
17.4
Elevator area aft of hinge line (each)
4.35
(including tabs)
Elevator trim tabs (each)
2.00
Elevator spring tabs (each)
22.5
Total vertical tail area
17.2
Fin area
5.5
Rudder including fixed tab

AFTR-673
### III. Controls Surface Travel

<table>
<thead>
<tr>
<th>Surface</th>
<th>Up</th>
<th>Down</th>
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<tbody>
<tr>
<td>Ailerons</td>
<td>20°</td>
<td>20°</td>
</tr>
<tr>
<td>Aileron trim tabs (measured at inboard end of tab)</td>
<td>20°</td>
<td>20°</td>
</tr>
<tr>
<td>Elevators (measured at junction of inboard elevator rib and elevator tab hinge)</td>
<td>30°</td>
<td>16°</td>
</tr>
<tr>
<td>Elevator trim tabs</td>
<td>15°</td>
<td>15°</td>
</tr>
<tr>
<td>Tab servo ratio</td>
<td>1:3</td>
<td></td>
</tr>
<tr>
<td>Elevator spring tabs</td>
<td>10°</td>
<td>22°</td>
</tr>
<tr>
<td>Wing flaps</td>
<td>45°</td>
<td></td>
</tr>
<tr>
<td>Dive recovery flaps</td>
<td>70°</td>
<td>30°</td>
</tr>
<tr>
<td>Rudder (measured at bottom of rudder)</td>
<td>30° rt.</td>
<td>30° lt.</td>
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</table>

### IV. Fuel Tanks Capacities

<table>
<thead>
<tr>
<th>Tank Location</th>
<th>U.S. Gals.</th>
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<tbody>
<tr>
<td>Fuselage (1)</td>
<td>207</td>
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<tr>
<td>Wing - Inboard forward (2)</td>
<td>60</td>
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<tr>
<td>Inboard aft (2)</td>
<td>70</td>
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<tr>
<td>Outboard intermediate (2)</td>
<td>22</td>
</tr>
<tr>
<td>Outboard (2)</td>
<td>8</td>
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<tr>
<td>Leading edge (2)</td>
<td>58</td>
</tr>
<tr>
<td>Tip (droppable) (2)</td>
<td>330</td>
</tr>
<tr>
<td>Total internal fuel capacity</td>
<td>425</td>
</tr>
</tbody>
</table>
FIG. 2 BASIC DIMENSIONS OF F-80A AIRPLANE
The moments of inertia and gross weight of the airplane during these flight tests were approximately the same as for similar geometric configurations of Reference (3). For the tip tank off flights (e.g. at 30% MAC):  

\[ I_x \approx 7060 \text{ slug ft.}^2 \]
\[ I_z \approx 18000 \text{ slug ft.}^2 \]
\[ \text{Gross Weight} \approx 10,500 \text{ lbs.} \]

For the flights with empty tip tanks (same c.g.):

\[ I_x \approx 9200 \text{ slug ft.}^2 \]
\[ I_z \approx 21500 \text{ slug ft.}^2 \]
\[ \text{Gross Weight} \approx 10,900 \text{ lbs.} \]

For the flights with half full tip tanks (same c.g.):

\[ I_x \approx 21800 \text{ slug ft.}^2 \]
\[ I_z \approx 34500 \text{ slug ft.}^2 \]
\[ \text{Gross Weight} \approx 11,500 \text{ lbs.} \]
FLIGHT CONDITIONS

I. Rudder Kicks

Condition I
Alt. = 20,000 ft.
M.N. = .6
C.G. = 30% MAC
Clean Configuration

\[ \Delta \tau = \frac{1}{2} \text{Dutch roll period} \approx 1 \text{ sec.} \]

\[ \delta_{h_{\text{max}}} \text{ ranges from 2 to 5 degrees} \]

Condition IIa
Same as Condition I except \( \tau < \frac{1}{2} \) Dutch roll period \( \approx \) .5 sec.
\[ \delta_{h_{\text{max}}} \approx 3 \text{ and 4 degrees} \]

Condition IIb
Same as Condition I except \( \tau > \frac{1}{2} \) Dutch roll period \( \approx \) 1.5 sec.
\[ \delta_{h_{\text{max}}} \approx 3 \text{ and 4 degrees} \]

Condition III
Same as Condition I except \( \Delta \tau = \frac{1}{2} \) is varied from .1 sec.

\[ \text{to .5 sec.} \quad \delta_{h_{\text{max}}} \approx 3, 3.5 \text{ and 4 degrees} \]

Condition IV
Same as Condition I except that M.N. = .4
\[ \delta_{h_{\text{max}}} \approx 4 \text{ degrees} \]

Condition V
Same as Condition I except that M.N. = .7
\[ \delta_{h_{\text{max}}} \approx 2, 3, \text{ and 4 degrees} \]

Condition VI
Same as Condition I except empty tip tanks.
\[ \delta_{h_{\text{max}}} \approx 3, 3.5 \text{ and 4.5 degrees.} \]

Condition VII
Same as Condition I except half full tip tanks.
\[ \delta_{h_{\text{max}}} \approx 3.5 \text{ and 4 degrees.} \]

Condition VIII
Same as Condition I except ailerons are manually moved to prevent rolling.
\[ \delta_{h_{\text{max}}} \approx 3, 4 \text{ and 5 degrees.} \]

II. Steady Sideslip

Condition IX - Altitude = 20,000 ft.
M.N. = .4
C.G. = 30%
Clean Configuration

Condition X - Same as Condition IX except M.N. = .6

Condition XI - Same as Condition IX except M.N. = .7
# FLIGHT LOG

**F-80A RUDDER KICK FLIGHT TEST PROGRAM**  
F-80A #44-8533

<table>
<thead>
<tr>
<th>FLT NO.</th>
<th>DATE</th>
<th>PURPOSE</th>
<th>DATA REQUESTED</th>
<th>DATA OBTAINED</th>
<th>COMMENTS</th>
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<tbody>
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<td>33</td>
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<td>Mach 4</td>
<td>Cond. Mach 4.5</td>
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<td>34</td>
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<td>Cond. I, IIa, III, IV, V</td>
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<td>Cond. Mach 4.5</td>
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<td>Cond. Mach 4.5</td>
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<td>Cond. Mach 4.5</td>
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* Direction
## FLIGHT LOG

F-80A RUDDER KICK FLIGHT TEST PROGRAM
F-80A #44-85333

<table>
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<th>COND.</th>
<th>MACH</th>
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<th>ΔT2</th>
<th>ΔT3</th>
<th>ΔT4</th>
<th>ΔT5</th>
<th>ΔT6</th>
<th>ΔT7</th>
<th>ΔT8</th>
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<th>COMMENTS</th>
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<tbody>
<tr>
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<td>IV .39</td>
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<td>9207</td>
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<td>9211</td>
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* Direction
<table>
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<tr>
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<th>DATE</th>
<th>PURPOSE</th>
<th>MACH</th>
<th>$\alpha_0$</th>
<th>$\alpha_a$</th>
<th>$T$</th>
<th>$\Delta \alpha$</th>
<th>$\Delta \alpha_2$</th>
<th>TIP TANKS</th>
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<td>Right Stabilizer Shear</td>
<td>7/11/51</td>
<td>303#/in.</td>
<td>32-34</td>
</tr>
<tr>
<td></td>
<td>7/14/51</td>
<td>312#/in.</td>
<td>35-38</td>
</tr>
<tr>
<td>Left Stabilizer Shear</td>
<td>7/11/51</td>
<td>338#/in.</td>
<td>32-34</td>
</tr>
<tr>
<td></td>
<td>7/14/51</td>
<td>351#/in.</td>
<td>35-36</td>
</tr>
<tr>
<td>Right Stabilizer Bending Moment</td>
<td>7/11/51</td>
<td>14,350 in.#/in.</td>
<td>32-34</td>
</tr>
<tr>
<td></td>
<td>7/24/51</td>
<td>13,500 in.#/in.</td>
<td>35-38</td>
</tr>
<tr>
<td>Left Stabilizer Bending Moment</td>
<td>7/11/51</td>
<td>13,700 in.#/in.</td>
<td>32-34</td>
</tr>
<tr>
<td></td>
<td>7/24/51</td>
<td>12,500 in.#/in.</td>
<td>35-38</td>
</tr>
</tbody>
</table>
F-80A SIGN CONVENTION
ARROWS SHOW POSITIVE QUANTITIES

REAR VIEW

TRAILING EDGE OF LEFT AILERON UP

TOP VIEW

TRAILING EDGE OF RIGHT AILERON DOWN

SIDE VIEW

Figure 3
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 59
RUDDER $\delta_r$ 3.9°
KICK DURATION $T_1$ 1.9 sec.
TIME TO APPLY $\Delta T_1$ 2.5 sec.
TIME TO RETURN $\Delta T_2$ 2 sec.
AILERON LOCKED CONDITION

FLIGHT 34
RUN 9208
TIP TANKS OFF
ALTITUDE 27,324 FT
O.A.T. -13°C
$V_0$ 503.2 KNOT

---

Figure 4

---

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δr 9.9%
KICK DURATION τ1 1.3 SEC.
TIME TO APPLY Δτ1 2.5 SEC.
TIME TO RETURN Δτb 2.5 SEC.
AILERON LOCKED

FLIGHT 34
RUN 9208
TIP TANKS OFF
ALTITUDE 20,192 FT.
O.A.T. -130 °C
V0 503.2 MPH

CONDITION I

β
DEG.

R & L.
STAB.
SHEAR
LOS.

-1,000

-20,000

R & L.
STAB.
BM
W. - LOS.

20,000

-20,000

Figure 5

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.59
RUDDER $\delta_r$ 8.5°
KICK DURATION $T_1$ 1.5 SEC.
TIME TO APPLY $\Delta T_1$ 1.5 SEC.
TIME TO RETURN $\Delta T_2$ 1.5 SEC.
AILERON LOCKED

CONDITION I

\[ \Delta n_g \]

\[ \delta_a \]

\[ \delta_e \]

Figure 6

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER $\delta_r$ 4.8%
KICK DURATION $T_1$ .12 SEC
TIME TO APPLY $\Delta T_1$ .2 SEC
TIME TO RETURN $\Delta T_2$ .15 SEC
AILERON LOCKED

CONDITION I

FLIGHT 34
RUN 9.15
TIP TANKS OFF
ALTITUDE 20,035 FT
O.A.T. -30°C
Vn 295.5 MPH

Figure 7
- 29 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER δ_r 4.8°
KICK DURATION T_1 1.8 SEC
TIME TO APPLY ΔT_1 .2 SEC
TIME TO RETURN ΔT_2 .1 SEC
AILERON LOCKED

FLIGHT 34
RUN 9215
TIP TANKS OFF
ALTITUDE 20,035 FT
O.A.T. -180°C
V_o 298.5 MPH

CONDITION I

β

DEG.

R & L STAB. SHEAR

LOS.

-1,000

R - SHEAR
L - SHEAR

20,000

R & L STAB. BM
IN - LOS.

-20,000

0 1 2 3 4

t - SEC.

Figure 8
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER 58
RUDDER ∆R 4.8°
KICK DURATION T1 12 SEC.
TIME TO APPLY ∆T1 2 SEC.
TIME TO RETURN ∆T2 1 SEC
AILERON LOCKED

FLIGHT 34
RUN 9215
TIP TANKS OFF
ALTITUDE 20,035 FT
O.A.T. -13.0 °C
V0 278.5 MPH

CONDITION I

Figure 9

APTR-6743
- 31 -
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER 59
RUDDER $\delta_R$ 1.57
KICK DURATION $T_1$ 1.5 SEC.
TIME TO APPLY $\Delta T_1$ 2.5 SEC.
TIME TO RETURN $\Delta T_2$ 2.5 SEC.
AILERON LOCKED

CONDITION I

FLIGHT 34
RUN 9218
TIP TANKS OFF
ALTITUDE 80,010 FT.
O.A.T. -18.78
$V_o$ 305.0 MPH

Figure 10

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δr 2.5°
KICK DURATION T, 1.4 SEC
TIME TO APPLY ΔT₁ .2 SEC
TIME TO RETURN ΔT₂ .2 SEC
AILERON LOCKED

CONDITION I

β

0

deg.

1,000

R & L.

STAB.

SHEAR

LBS.

-1,000

R - SHEAR

L - SHEAR

20,000

R & L.

STAB.

BM

IN - LBS.

-20,000

t - SEC.

Figure 11

AFTR-6743
F 80 A Rudder Kick Flight Tests

MACH NUMBER: 59
RUDDER δ_r 2.5°
KICK DURATION T_k 1.4 sec.
TIME TO APPLY ΔT_1 2.5 sec
TIME TO RETURN ΔT_2 2.5 sec
AILERON LOCKED

FLIGHT 34
RUN 9218
TIP TANKS OFF
ALTITUDE 29,018 ft
O.A.T. -12.7°C
V_e 302.9 MPH

CONDITION I

Figure 12

AFTR-6743
- 35 -
F-80A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.60
RUDDER $\delta_r$ 3.0°R
KICK DURATION $T_1$ 1.25 SEC.
TIME TO APPLY $\Delta T_1$ 0.2 SEC.
TIME TO RETURN $\Delta T_2$ 0.2 SEC.
AILERON LOCKED

FLIGHT 33
RUN 9/40
TIP TANKS OFF
ALTITUDE 20,200 FT
O.A.T. -17.4°C
$V_0$ 307.1 MPH

CONDITION I

Figure 13
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.6
RUDDER S 3.0°R
KICK DURATION T1 1.25 sec
TIME TO APPLY AT1 2.5 sec
TIME TO RETURN AT2 2.5 sec
AILERON LOCKED

CONDITION I

FLIGHT 33
RUN 3140
TIP TANKS OFF
ALTITUDE 20,200 ft
O.A.T. - 17.4°C
V0 307.1 MPH

Figure 1a
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .6
RUDDER $\delta_r$ 3.0°
KICK DURATION $T_1$ 5.25 SEC.
TIME TO APPLY $\Delta T_1$ 2 SEC.
TIME TO RETURN $\Delta T_2$ 2.5 SEC.
AILERON LOCKED

CONDITION I

FLIGHT 33
RUN 9140
TIP TANKS OFF
ALTITUDE 20,200 FT
O.A.T. -10.4°C
$V_o$ 307.1 MPH

Figure 15
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER . 50
RUDDER \( \delta_R \) deg
KICK DURATION \( T_1 \) sec
TIME TO APPLY \( \Delta T_1 \) sec
TIME TO RETURN \( \Delta T_2 \) sec
AILERON CONTROL

CONDITION I

\[ \delta_R \text{ DEG} \]

\[ N \text{ DEG./SEC.} \]

\[ 30,000 \]

\[ FBM \text{ IN.-LOS.} \]

\[ FS \text{ LOS.} \]

\[ t - \text{SEC.} \]

Figure 16

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .60 FLIGHT 35
RUDDER δr 2.3° RUN 9151
KICK DURATION T1 12 SEC. TIP TANKS OFF
TIME TO APPLY ΔT1 2.5 SEC. ALTITUDE 20,110 FT
TIME TO RETURN ΔT2 2 SEC. O.A.T. -17.4°C
AILERON LOCKED V0 306.4 MPH

Figure 17
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 60
RUDDER $\delta_R$ 2.5° R
KICK DURATION $T_1$ 12 SEC.
TIME TO APPLY $\Delta T_1$ 2 SEC.
TIME TO RETURN $\Delta T_2$ 2 SEC.
AILERON LOCKED

CONDITION I

Flight 33
Run 9151
Tip tanks off
Altitude 29110 ft
O.A.T. -174 °C
$V_0$ 306.4 MPH

Figure 18
AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .56
RUDDER $\delta_r$ 4.2°
KICK DURATION $T_1$ .8 sec
TIME TO APPLY $\Delta T_1$ .2 sec
TIME TO RETURN $\Delta T_2$ .2 sec
AILERON LOCKED
CONDITION II-2

FLIGHT 34
RUN 9213
TIP TANKS OFF
ALTITUDE 20,000 FT
O.A.T. -12.7°F
$V_e$ 298.7 MPH

---

$\delta_r$
DEG.

A
DEG./SEC.

30,000

FBM
IN.-LBS.
FS
LBS.

--- FBM
----- FS

---

$t$ - SEC.

Figure 19

APTR-6743

- 45 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER δR 4.2°
KICK DURATION T1  .8 SEC
TIME TO APPLY ΔT1  2.5 SEC
TIME TO RETURN ΔT2  2.5 SEC
AILERON LOCKED

FLIGHT 34
RUN 9213
TIP TANKS OFF
ALTITUDE 20,144 FT
O.A.T. -27°C
V₀ 298.7 MPH

Figure 20

AFTR-6713
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER \( \delta_n \) 0.2\%
KICK DURATION \( T_1 \) 8 SEC.
TIME TO APPLY \( \Delta T_1 \) 2 SEC.
TIME TO RETURN \( \Delta T_2 \) 2 SEC.
AILERON LOCKED

FLIGHT 34
RUN 9213
TIP TANKS OFF
ALTITUDE 20,100 FT
O.A.T. -12.7 \(^{\circ}\)C
\( V_0 \) 298.7 MPH

CONDITION II-a

![Graphs showing \( \Delta n_g \), \( p \), \( \delta_a \), and \( \delta_e \) vs. time](image)

Figure 21

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .579
RUDDER $\delta_R$ 30° R
KICK DURATION $T_1$ .15 SEC
TIME TO APPLY $\Delta T_1$ 1 SEC
TIME TO RETURN $\Delta T_2$ 2 SEC
AILERON LOCKED
CONDITION E-a

---

Figure 22

APTR-6743
- 49 -
F 80 A RUDDER KICK FLIGHT TESTS

Flight 33
Run 9144
Tip tanks off
Altitude 29,500 ft.
O.A.T. -16.3 °C
Vφ 303.9 M.P.H.

Mach number .59
Rudder 3° R
Kick duration T1 .75 sec.
Time to apply ΔT1 .2 sec.
Time to return ΔT2 .2 sec.
Aileron locked

Condition II-a

Figure 23
F80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_R$ 3.0° R
KICK DURATION $T_1$ .75 SEC.
TIME TO APPLY $\Delta T_1$ 2.5 SEC.
TIME TO RETURN $\Delta T_2$ 2.8 SEC.
AILERON LOCKED

FLIGHT 33
RUN 9144
TIP TANKS OFF
ALTITUDE 20,500 FT.
O.A.T. -18.3 °C
$V_0$ 303.9 MPH

CONDITION II-a.

$\Delta n_y$

$\theta$

$\rho$

deg./sec.

$\delta_e$

deg.

$\delta_d$

deg.

$T$ - SEC.

Figure 2h

APTR-6743

- 51 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .56
RUDDER $\delta_r$ 4.3%
KICK DURATION $T_1$ 1.9 SEC.
TIME TO APPLY $\Delta T_1$ 2 SEC.
TIME TO RETURN $\Delta T_2$ 2.8 SEC.
AILERON LOCKED

FLIGHT 34
RUN 9210
TIP TANKS OFF
ALTITUDE 20,058 FT.
O.A.T. -12.5°C
$V_o$ 239.8 MPH

CONDITION II-b

Figure 25
- 53 -
F 80 A Rudders Kick Flight Tests

Mach Number .56
Rudder $\delta_R$ 4 degrees
Kick Duration $T_1$ 1.9 Sec.
Time to apply $\triangle t_1$ 2 Sec.
Time to return $\triangle t_2$ 2 Sec.
Aileron Locked

Figure 26
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER . 82
RUDDER δ_r 4.3°
KICK DURATION T_1 19 SEC
TIME TO APPLY δT_1 1.2 SEC
TIME TO RETURN δT_2 3.3 SEC
AILERON LOCKED

CONDITION II-b

FLIGHT 34
RUN 9210
TIP TANKS OFF
ALTITUDE 20,068FT
O.A.T. -12.5°C
V_0 299.8 MPH

Figure 27

AFTR-6743  -  55 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .57
RUDDER $\delta_r$ 9.2\%
KICK DURATION $T_1$ 1.75 SEC
TIME TO APPLY $\Delta T_1$ 2.5 SEC
TIME TO RETURN $\Delta T_2$ 2 SEC
AILERON LOCKED

CONDITION II-b

FLIGHT 33
RUN 9143
TIP TANKS OFF
ALTITUDE 20,530 FT
O.A.T. -18.4 °C
$V_0$ 504.2 MPH

---

Figure 28
F-80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER \( S_R \) 3.2°
KICK DURATION \( T_k \) 1.75 SEC.
TIME TO APPLY \( \Delta T_1 \) .2 SEC.
TIME TO RETURN \( \Delta T_2 \) .2 SEC
AILERON LOCKED

FLIGHT 33
RUN 9143
TIP TANKS OFF
ALTITUDE 20,530 FT
O.A.T. -18.4°F
\( V_f \) 301.2 MPH

Figure 29
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER \( \delta_R \) 9.2° R
KICK DURATION \( T_1 \) 1.75 sec
TIME TO APPLY \( \Delta T_1 \) 2 sec
TIME TO RETURN \( \Delta T_2 \) 2 sec
AILERON LOCKED

FLIGHT 33
RUN 9143
TIP TANKS OFF
ALTITUDE 20,580 FT
O.A.T. -18.4°C
\( V_e \) 301.2 MPH

CONDITION II-b

Figure 30

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δr 4°
KICK DURATION T₁ 1.3 SEC.
TIME TO APPLY ΔT₁ .4 SEC.
TIME TO RETURN ΔT₂ 5 SEC.
AILERON LOCKED

FLIGHT 37
RUN 9684
TIP TANKS OFF
ALTITUDE 29,125 FT.
O.A.T. -11.3 °C
V0 302 MPH

CONDITION III

Figure 31
AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER \(0.59\)
RUDDER \(\delta_r\) 4°
KICK DURATION \(T_1\) 1.3 SEC.
TIME TO APPLY \(\Delta T_1\) 4 SEC.
TIME TO RETURN \(\Delta T_2\) 5 SEC.
AILERON LOCKED

CONDITION III

\[ \beta \text{ DEG.} \]

\[ R.S. \quad \text{STAB.} \quad \text{SHEAR} \quad \text{LOS.} \]

\[ \text{R.S.} \quad \text{-1,000} \quad 0 \quad \text{1,000} \]

\[ \text{R.S.} \quad \text{STAB.} \quad \text{BM} \quad \text{IN.-LOS.} \]

\[ \text{R.S.} \quad \text{-20,000} \quad 0 \quad \text{-20,000} \]

Figure 32

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.59
RUDDER δr 4°
KICK DURATION T1 1.3 SEC.
TIME TO APPLY ΔT1 .45 SEC.
TIME TO RETURN ΔT2 .5 SEC.
AILERON LOCKED

FLIGHT 37
RUN 9684
TIP TANKS OFF
ALTITUDE 20,125 FT
O.A.T. -113 °C
V0 332 MPH

CONDITION III

Figure 33

- 63 -
F 80 A RUDDER KICK FLIGHT TESTS
MACH NUMBER .59
RUDDER $\delta_n$ 3.2°
KICK DURATION $T_1$, 10 SEC.
TIME TO APPLY $\Delta t_1$, 3 SEC.
TIME TO RETURN $\Delta t_2$, .5 SEC.
AILERON LOCKED

CONDITION III

$\delta_n$
DEG.

$\lambda$
DEG./SEC.

30,000

-30,000

FBM
IN. - LBS.

FS
LBS.

0

1,000

-1,000

Figure 34
AFTR-6743
- 65 -
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER \% 3.2°
KICK DURATION T₁ 1.0 SEC.
TIME TO APPLY ΔT₁ .5 SEC.
TIME TO RETURN ΔT₂ 5 SEC.
AILERON LOCKED

---

CONDITION III

-4

\[ \beta \text{ DEG.} \]

1,000

R.L.
STAB.
SHEAR
LOS.

-1,000

20,000

R.L.
STAB.
BM
M.-LOS.

-20,000

0 1 2 3 4

t - SEC.

Figure 35

APTR-6743

- 66 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_r$ 3.2°R
KICK DURATION $T_1$ 1.0 SEC.
TIME TO APPLY $\Delta T_1$ .3 SEC.
TIME TO RETURN $\Delta T_2$ .5 SEC.
AILERON LOCKED

CONDITION III

Figure 36

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER \( \delta_R \) 5.6°
KICK DURATION \( T_1 \) 100 SEC
TIME TO APPLY \( \Delta T_1 \) .1 SEC
TIME TO RETURN \( \Delta T_2 \) .1 SEC
AILERON LOCKED

CONDITION III

FLIGHT 33
RUN 9147
TIP TANKS OFF
ALTITUDE 20,500 FT
O.A.T. -18.3 °C
\( V_e \) 302.6 MPH

\( \delta_R \) DEG

\( \alpha \) DEG/SEC

30,000

FBM

IN-LOS.
FS

LOS.

\( t \) SEC.

Figure 37

APTR-6713

- 69 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER \( .59 \)
RUDDER \( 3.6^\circ \)
KICK DURATION \( T_1 \) 1.00 SEC.
TIME TO APPLY \( \Delta T_1 \) .1 SEC.
TIME TO RETURN \( \Delta T_2 \) .1 SEC.
AILERON LOCKED

Figure 38

- 70 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δr 36°
KICK DURATION T₁ 1.00 SEC.
TIME TO APPLY ΔT₁ .15 SEC.
TIME TO RETURN ΔT₂ .1 SEC.
AILERON LOCKED

CONDITION III

Figure 39

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER . 39
RUDDER $\delta_R$ 5°
KICK DURATION $T_1$ 1.5 SEC.
TIME TO APPLY $\Delta T_1$ 2 SEC.
TIME TO RETURN $\Delta T_2$ 2 SEC.
AILERON LOCKED

CONDITION IV

FLIGHT 34
RUN 9206
TIP TANKS OFF
ALTITUDE 20,084 FT
O.A.T. -14.0 °C
V_0 5035 MPH

Figure 40

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .39
RUDDER δR 6°
KICK DURATION T1, 1.5 SEC.
TIME TO APPLY ΔT1, 1.2 SEC.
TIME TO RETURN ΔT2, 1.2 SEC.
AILERON LOCKED

FLIGHT 34
RUN 9206
TIP TANKS ON
ALTITUDE 20,082 FT
O.A.T. -10.0 °C
V₀ 203.5 MPH

Figure 111
- 74 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .89
RUDDER δ r 5°
KICK DURATION t 1 .5 SEC.
TIME TO APPLY Δt 1 .2 SEC.
TIME TO RETURN Δt 2 .2 SEC.
AILERON LOCKED

CONDITION IV

FLIGHT 3A
RUN 9206
TIP TANKS OFF
ALTITUDE 20.084FT
O.A.T. -19.0 °C.
V 0 203.5 MPH

AFTR-6713
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .39  FLIGHT 33
RUDDER \delta_r 3.8^\circ R  RUN 9/38
KICK DURATION T_1 1.5 Sec.  TIP TANKS OFF
TIME TO APPLY \Delta T_1 .2 Sec  ALTITUDE 20,210 FT.
TIME TO RETURN \Delta T_2 2.0 Sec  O.A.T. -17.4 \degree C
AILERON LOCKED  V_s 201 MPH

CONDITION IV

\[ \delta_r \text{ DEG.} = \begin{cases} 0 & \text{for } \delta_r < 0 \\ -4 & \text{for } \delta_r > 0 \end{cases} \]

\[ \alpha \text{ DEG./SEC.} = \begin{cases} 0 & \text{for } \alpha < 0 \\ -10 & \text{for } \alpha > 0 \end{cases} \]

\[ \text{FBM: } F \text{ in.-LBS.} \]

\[ \text{FS: } LBS. \]

\[ -30,000 \quad 0 \quad 1,000 \quad 30,000 \]

\[ t \text{ SEC.} \]

Figure 43

- 77 -

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .39    FLIGHT 93
RUDDER $\delta_R$ 3.8°R    RUN 9138
KICK DURATION $t_1$ 1.5 Sec    TIP TANKS OFF
TIME TO APPLY $\Delta t_1$ .2 Sec    ALTITUDE 20,210 FT
TIME TO RETURN $\Delta t_2$ .2 Sec    O.A.T. -17.4°C
AILERON LOCKED    V_0 201 MPH

Figure 44

- CONDITION IV -

$\beta$

DEG.

1,000

R & L
STAB.
SHEAR
LBS.

-1,000

-1,000

R BM
LBM

20,000

R BM
LBM

IN.-LBS.

AFTR-6743

- 78 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .39
RUDDER $\delta_r^r 3.8^\circ$
KICK DURATION $T_1 1.5$ sec
TIME TO APPLY $\Delta T_1 .2$ sec
TIME TO RETURN $\Delta T_2 .2$ sec
AILERON LOCKED

CONDITION IV

FLIGHT 33
RUN 9138
TIP TANKS OFF
ALTITUDE 2,0210 ft
O.A.T. - 17.4°C
$V_o$ 201 MPN

Figure b5
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER $\delta_r$ 2.6%
KICK DURATION $T_1$ 1.1 SEC.
TIME TO APPLY $\Delta T_1$ .3 SEC
TIME TO RETURN $\Delta T_2$ .2 SEC
AILERON LOCKED

CONDITION V

FLIGHT 34
RUN 9220
TIP TANKS OFF
ALTITUDE 20,076 FT.
O.A.T. -13.0 °C
$V_0$ 355.4 MPH

Figure 46

AFTR-6743

- 81 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER δr 2.6°
KICK DURATION T1 1.1 SEC.
TIME TO APPLY ΔT1 1.25 SEC.
TIME TO RETURN ΔT2 2.5 SEC.
AILERON LOCKED

FLIGHT 34
RUN 9220
TIP TANKS OFF
ALTITUDE 20,070 FT.
O.A.T. -13.0 °C.
V0 355.4 MPH

CONDITION V

![Graphs showing Rudder Kick Flight Tests](image)

Figure 47

AFTR-6743
F-80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER $\delta_r$ 2.6°
KICK DURATION $T_1$ 1.1 SEC
TIME TO APPLY $\Delta T_1$ .2 SEC.
TIME TO RETURN $\Delta T_2$ .2 SEC
AILERON LOCKED

CONDITION V

$\Delta n$

$\frac{\Delta n}{n}$

$P$

DEG./SEC.

$\delta_a$

DEG.

$\delta_e$

DEG.

$t$ - SEC.

Figure 68

AFTR-6743

- 83 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER $\delta_r$ 4.0
KICK DURATION $T_1$ 1.0 SEC.
TIME TO APPLY $\Delta T_1$ .2 SEC.
TIME TO RETURN $\Delta T_2$ .2 SEC.
AILERON LOCKED

FLIGHT 35
RUN 9320
TIP TANKS OFF
ALTITUDE 20,170 FT
O.A.T. -11.4°C
$V_0$ 951.4 MPH

CONDITION V

$\delta_r$
DEG.
0
10
-10

$\lambda$
DEG./SEC.
30,000
1,000
-1,000
-30,000

FBM
IN-LBS.
FS
LBS.

Figure 49
AFTR-6743
- 85 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER δr 4.0%
KICK DURATION T1 10 SEC.
TIME TO APPLY ΔT1 .2 SEC.
TIME TO RETURN ΔT2 .25 SEC.
AILERON LOCKED

CONDITION V

ALTITUDE 29,170 FT.
O.A.T. -110 °C
V0 351.4 MPH

Figure 50

APTR-6713
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER δ\textsubscript{R} 4.0°
KICK DURATION T\textsubscript{1} 10 SEC.
TIME TO APPLY ΔT\textsubscript{1} .2 SEC
TIME TO RETURN ΔT\textsubscript{2} .2 SEC
AILERON LOCKED

FLIGHT 35
RUN 9320
TIP TANKS OFF
ALTITUDE 20,170 FT
O.A.T. -11.9 °C
V\textsubscript{0} 351.4 MPH

CONDITION V

![Graphs showing Δn, p, δ\textsubscript{a}, and δ\textsubscript{e} as functions of time (t-sec).]
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.69
RUDDER δ_r 2.3°R
KICK DURATION T_1 1.2 sec.
TIME TO APPLY ΔT_1 0.2 sec.
TIME TO RETURN ΔT_2 0.2 sec.
AILERON LOCKED

CONDITION V

Figure 52

AFTR-6743

- 89 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER \( \delta_r \) 2.3\(^{\circ}\)
KICK DURATION \( T_1 \) 1.2 SEC.
TIME TO APPLY \( \Delta T_1 \) .25 SEC.
TIME TO RETURN \( \Delta T_2 \) .25 SEC.
AILERON LOCKED

FLIGHT 33
RUN 9154
TIP TANKS OFF
ALTITUDE 20,060 FT
O.A.T. -17.5\(^{\circ}\)C
\( V_o \) 355.6 MPH

\( \beta \) DEG.

CONDITION V

R & L STAB. SHEAR

R - SHEAR
L - SHEAR

R & L STAB. BM

R - BM
L - BM

\( t \) - SEC.

Figure 53

APTR-6743
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .69
RUDDER $\delta_r$ 2.3°
KICK DURATION $T_1$ 1.8 sec.
TIME TO APPLY $\Delta T_1$ .2 sec.
TIME TO RETURN $\Delta T_2$. 2 sec.
AILERON LOCKED

FLIGHT 33
RUN 9154
TIP TANKS OFF
ALTITUDE 29,060 ft.
O.A.T. -17.9 °C
$V_o$ 355.6 MPH

CONDITION V

Figure 5a

AFTR-6743
- 91 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER: 0.69
RUDDER $\delta_r$: 3.2°
KICK DURATION $T_1$: 9 sec.
TIME TO APPLY $\Delta T_1$: 0.2 sec.
TIME TO RETURN $\Delta T_2$: 1 sec.
AILERON LOCKED

FLIGHT 35
RUN 9313
TIP TANKS OFF
ALTITUDE 20,000 ft.
O.A.T. -116°F
$V_0$: 357.7 M.P.H.

CONDITION I

$\delta_a$
\[\text{DEG.}\]

$\alpha$
\[\text{DEG./SEC.}\]

$FBM$
\[\text{IN.-LOS.}\]

$FS$
\[\text{LOS.}\]

$-30,000$
$-1,000$
$1,000$
$30,000$

$0$
$1$
$2$
$3$
$4$

$FBM$

$---- FS$

Figure 55
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.49
RUDDER $\delta_r$ 32°
KICK DURATION $t_k$ 9 SEC.
TIME TO APPLY $\Delta t_1$ 2.5 SEC.
TIME TO RETURN $\Delta t_2$ 1 SEC.
AILERON LOCKED

CONDITION IV

$\beta$ DEG.

$-4$

1,000

R & L STAB. SHEAR

0

-1,000

20,000

R & L STAB. BM

0

-20,000

0 1 2 3 4

$-4$

R SHEAR

L SHEAR

R BM

L BM

Figure 56

APTR-6743

- 94 -
F80A RUDDER KICK FLIGHT TESTS

MACH NUMBER 0.69
RUDDER \( \delta_r \) 9.2°
KICK DURATION \( t_1 \) .75 SEC.
TIME TO APPLY \( \Delta t_1 \) 2.5 SEC.
TIME TO RETURN \( \Delta t_2 \) 1.5 SEC.
AILERON LOCKED

CONDITION V

\( \Delta n_z^{\circ} \)

\( p \) deg./sec.

\( \delta_\alpha \) deg.

\( \delta_\epsilon \) deg.

Figure 57

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δ,R 46°
KICK DURATION T1 1.1 SEC.
TIME TO APPLY ΔT1 .2 SEC
TIME TO RETURN ΔT2 .2 SEC
AILERON LOCKED

FLIGHT 58
RUN 9742
TIP TANKS EMPTY
ALTITUDE 20,100 FT.
O.A.T. -11.5°C
V0 303 MPH

CONDITION VI

δ,R
DEG.
0
10
0
10
30,000
1,000
FBM
M - LBS.
FS
lbs.
-30,000
0
1
2
3
4

Figure 58
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER Δθ 4.6°
KICK DURATION T₁ 1.1 SEC.
TIME TO APPLY ΔT₁ 2 SEC.
TIME TO RETURN ΔT₂ 2 SEC
AILERON LOCKED

FLIGHT 58
RUN 9142
TIP TANKS EMPTY
ALTITUDE 20,000 FT
O.A.T. -115°C
V₀ 305 MPH

CONDITION III

β DEG.

1,000
R & L. STAB. SHEAR
0
-1,000

20,000
R & L. STAB. BM
0
-20,000

Figure 59

AFTR-6743
- 98 -
F 80 A RUDDER KICK FLIGHT TESTS:

MACH NUMBER .59
RUDDER ΔR 4.6°
KICK DURATION T1 1.1 SEC
TIME TO APPLY ΔT1 .25 SEC
TIME TO RETURN ΔT2 .25 SEC
AILERON LOCKED

FLIGHT 38
RUN 9742
TIP TANKS EMPTY
ALTITUDE 20,100 FT.
O.A.T. -11.5°C
V0 303 MPH

CONDITION VI

Figure 60

AFTR-67143
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_r$ 5.0°
KICK DURATION $T_1$ 1.1 sec.
TIME TO APPLY $\Delta T_1$ 1.2 sec.
TIME TO RETURN $\Delta T_2$ 2.2 sec.
AILERON LOCKED

CONNECTION VI

FLIGHT SS
RUN 9744
TIP TANKS EMPTY
ALTITUDE 20,170 ft.
O.A.T. -112 °C
V$_o$ 304 M.P.H.

Figure 61

AFTR-6743
- 101 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER θr 30° E
KICK DURATION T1 1.1 SEC
TIME TO APPLY ΔT1 .8 SEC
TIME TO RETURN ΔT2 .2 SEC
AILERON LOCKED

FIGURE 62

AFTR-6743
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F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER: 0.59
RUDDER $\delta_r$ 3.0° R
KICK DURATION $T_1$: 1.1 sec
TIME TO APPLY $\Delta T_1$: 2.5 sec.
TIME TO RETURN $\Delta T_2$: 0.2 sec.
AILERON LOCKED

FLIGHT 38
RUN 9744
TIP TANKS EMPTY
ALTITUDE 20,170 FT.
O.A.T. -11.2°C
$V_0$: 304 M.P.H.

CONDITION VI

\[ \Delta n_g \]

0
-1
10
5
0
-5
-10

\[ p \] 

DEG./SEC.

2
0
-2

\[ \delta_s \] 

DEG.

2
0
-2

\[ \delta_e \] 

DEG.

0
1
2
3
4

t - SEC.

Figure 63

AFTR-6743

- 103 -
MACH NUMBER .59
RUDDER \( \delta_R \) 3.4\%
KICK DURATION \( T_1 \) .85 sec
TIME TO APPLY \( \Delta T_1 \) .2 sec
TIME TO RETURN \( \Delta T_2 \) 1 sec.
AILERON LOCKED

CONDITION VI

FLIGHT 38
RUN 9747
TIP TANKS EMPTY
ALTITUDE 20,038 FT.
O.A.T. -11.6°C
\( V_e \) 304.6 MPH

Figure 64

AFTR-67\#3
- 105 -
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_{r}$ 34° E
KICK DURATION $T_1$ .8 SEC.
TIME TO APPLY $\Delta T_1$ .2 SEC.
TIME TO RETURN $\Delta T_2$ .1 SEC
AILERON LOCKED

FLIGHT 38
RUN 9747
TIP TANKS EMPTY
ALTITUDE 29,038 FT.
O.A.T. -11.6°C
$V_e$ 304.6 MPH

Figure 65
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER \delta_r 3.4°R
KICK DURATION T_1 .8 sec
TIME TO APPLY \Delta T_1 .2 sec
TIME TO RETURN \Delta T_2 .1 sec
AILERON LOCKED

CONDITION VI

Figure 66

AFTR-6743
- 107 -
F 80.A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_r$ 3.4°
KICK DURATION $T_1$ 1.5 SEC.
TIME TO APPLY $\Delta T_1$ .2 SEC
TIME TO RETURN $\Delta T_2$ .2 SEC
AILERON LOCKED

CONDITION VI

FLIGHT 38
RUN 9748
TIP TANKS EMPTY
ALTITUDE 19,967 FT.
O.A.T. -112°F
$V_0$ 903.7 MPH

Figure 67
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_r$ 3.4°<sub>R</sub>
KICK DURATION $t_1$ 1.5 SEC.
TIME TO APPLY $\Delta t_1$ .2 SEC.
TIME TO RETURN $\Delta t_2$ .2 SEC.
AILERON LOCKED

CONDITION VI

ALTIMETER 19,967 FT
O.A.T. -112° F
$V_0$ 303.7 MPH

Figure 68

APTR-6743
- 110 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_r$ 3.4° R
KICK DURATION $T_1$ 1.5 SEC.
TIME TO APPLY $\Delta T_1$ .2 SEC.
TIME TO RETURN $\Delta T_2$ .2 SEC.
AILERON LOCKED

FLIGHT 38
RUN 9748
TIP TANKS EMPTY
ALTITUDE 19,967 FT
O.A.T. -11.2°C
$V_o$ 303.7 MPH

CONDITION II

\[ \Delta n_2 \]

\[ \frac{\Delta \theta}{\theta} \]

\[ p \]

\[ \theta_a \]

\[ \delta_e \]

$\delta_e$ DEG.

$\Delta \theta$ DEG.

$\Delta n_2$ DEG.

$\theta_a$ DEG.

$T$ SEC.

Figure 69

APTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δR 4.4°
KICK DURATION T₁ 1.1 SEC.
TIME TO APPLY ΔΤ₁ .25 SEC.
TIME TO RETURN ΔΤ₂ .15 SEC.
AILERON LOCKED

FLIGHT 3B
RUN 9739
TIP TANKS HALF FULL
ALTITUDE 29,130 FT.
O. A. T. -11.2 °C
V₀ 303 MPH

CONDITION VII

Figure 70
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER S. 4.4%
KICK DURATION T1 .11 SEC
TIME TO APPLY AT1 .2 SEC
TIME TO RETURN AT2 .15 SEC
AILERON LOCKED

FLIGHT 38
RUN 9739
TIP TANKS HALF FULL
ALTITUDE 20,130 FT
O. A. T. -11.2 °C
V0 303 MPH

CONDITION VII

\[ \beta \]
\[ \text{deg.} \]

\[ \text{R. & L. STAB. SHEAR LOS.} \]

\[ \text{R. & L. STAB. BM} \]

\[ \text{t - SEC.} \]

Figure 71
- 11h -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δₚ 4.4°
KICK DURATION T₁ 1/1 SEC
TIME TO APPLY ΔT₁ 0.5 SEC
TIME TO RETURN ΔT₂ 1/3 SEC
AILERON LOCKED

CONDITION VII

Figure 72

AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER \( \delta_r \) 35°
KICK DURATION \( t_1 \) 1.3 SEC.
TIME TO APPLY \( \Delta t_1 \) .25 SEC.
TIME TO RETURN \( \Delta t_2 \) .15 SEC.
AILERON LOCKED

CONDITION VII

FLIGHT 58
RUN 9755
TIP TANKS HALF FULL
ALTITUDE 19,990 FT
O.A.T. -11.4° F
\( V_o \) 301.6 MPH

\( \delta_A \) DEG.

\( \lambda \) DEG. /1 SEC.

30,000

FBM
IN-LOS.

FS
LBS.

\(-30,000\)

\(-1,000\)

0

1,000

3,000

5,000

7,000

9,000

11,000

FBM

FS

0

1

2

3

4

\( t \) SEC.

Figure 73

- 117 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER \( \delta_R \) 3.5\(^\circ\)
KICK DURATION \( T_1 \) 1.3 SEC.
TIME TO APPLY \( \Delta T_1 \) .25 SEC.
TIME TO RETURN \( \Delta T_2 \) .15 SEC
AILERON LOCKED

ALTITUDE 19,990 FT.
O.A.T. -11.4\(^\circ\)C

\( \beta \) deg.

\( \Delta S \) RS

\( \Delta S \) LG

\( \Delta S \) BM

AFTR-67f3
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .58
RUDDER δr 35°L
KICK DURATION T1 1.3 SEC.
TIME TO APPLY ΔT1 .2 SEC
TIME TO RETURN ΔT2 .15 SEC
AILERON LOCKED

CONDITION VII

Figure 75

AFTR-6743
F 80A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_R$ 3.8°
KICK DURATION $T_1$ 10 SEC.
TIME TO APPLY $\Delta T_1$ .2 SEC.
TIME TO RETURN $\Delta T_2$ .1 SEC.
AILERON MOVED ANTI-ROLL
CONDITION VIII

FLIGHT 35
RUN 9311
TIP TANKS OFF
ALTITUDE 12,970 FT.
O.A.T. -12.2°C
$V_e$ 304.1 MPH

Figure 76
APTR-6743
- 121
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δ_{R} 3.8°
KICK DURATION T_{1} 10 SEC.
TIME TO APPLY ΔT_{1} 2.3 SEC.
TIME TO RETURN ΔT_{2} 1 SEC.
AILERON MOVED ANTI ROLL

CONDITION VIII

1,000
R & L.
STAB.
SHEAR

R SHEAR
L SHEAR

20,000
R & L.
STAB.
BM

R BM
L BM

AFTR-6743

Figure 77

- 122 -
F-80A Rudders Kick Flight Tests

Mach Number .59
Rudder $\delta_r$ 3.8°
Kick Duration $T_k$ 10 sec.
Time to Apply $\Delta T_1$ .2 sec.
Time to Return $\Delta T_2$ .1 sec.
Aileron Move Anti Roll
Condition VIII

FLIGHT 35
RUN 9317
Tip Tanks Off
Altitude 19,970 ft
O.A.T. -12.2 °C
$V_0$ 304.1 MPH

Figure 78
- 123 -
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER $\delta_R$ 5°
KICK DURATION $T_1$ 1.2 SEC.
TIME TO APPLY $\Delta T_1$ .2 SEC.
TIME TO RETURN $\Delta T_2$ .2 SEC.
AILERON MOVED ANTI ROLL CONDITION VIII

FLIGHT 37
RUN 9689
TIP TANKS OFF
ALTITUDE 29,195 FT.
O.A.T. -11.1 °C
$V_0$ 303 MPH

Figure 79
APTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER .59
RUDDER δr 5° L
KICK DURATION T1 1.2 SEC.
TIME TO APPLY ΔT1 .2 SEC.
TIME TO RETURN ΔT2 .2 SEC.
AILERON MOVED ANTI ROLL Vb 303 MPH

CONDITION VIII

β DEG.

R & L. STAB. SHEAR LBS.

R & L. STAB. BM IN. - LBS.

R.S. ——- RS.
L.S. ——— LS.

RBM ——— RBM
LBM ——— LBM

Figure 80
AFTR-6743
F 80 A RUDDER KICK FLIGHT TESTS

MACH NUMBER . 59
RUDDER $\delta_r$ 5°
KICK DURATION $T_1$ 1.2 SEC.
TIME TO APPLY $\Delta T_1$ 2 SEC.
TIME TO RETURN $\Delta T_2$ 2 SEC.
AILERON MOVED ANTI ROLL

CONDITION VIII

FLIGHT 37
RUN 9689
TIP TANKS OFF
ALTITUDE 20, 195 FT.
O.A.T. -11.1 °C
$V_0$ 303 MPH

Figure 81

AFTR-6743
- 127 -
F-80A STEADY SIDESLIP FLIGHT TESTS

MACH NUMBER .398
FLIGHTS 36 & 37

ALTITUDE 20225 FT.
O.A.T. -10.8°C

V₀ 204.5 MPH
TIP TANKS OFF

CONDITION IX

Figure 82
- 128 -
F-80A STEADY SIDESLIP FLIGHT TESTS

MACH NUMBER .398
FLIGHTS 36 & 37
ALTITUDE 20225 FT.
O.A.T. -10.8°C.
V_e 204.5 MPH
TIP TANKS OFF

CONDITION LK

RS & LS ~ LBS

RBM & LBM ~ IN-LBS

FBM & FS ~ LBS

AFTR-6743

Figure 83
F-80A STEADY SIDESLIP FLIGHT TESTS

MACH NUMBER .588
FLIGHTS 36,37, & 38
ALTITUDE 20105 FT.
O.A.T. -11.4°C

V_e 302.5 MPH

CONDITION X

△ TIP TANKS ON
○ TIP TANKS OFF

Figure 8h
- 130 -
F-80A STEADY SIDESLIP FLIGHT TESTS

MACH NUMBER .588
FLIGHTS 36, 37 & 38
ALTITUDE 20105 FT
Vₚ 302.5 MPH
O.A.T. -11.4°C.

CONDITION X

--- RS --- LS O TIP TANKS OFF Δ TIP TANKS ON

--- RBM --- LBM

--- FBM --- FS

Figure 55
AFTR-6713
F-80A STEADY SIDESLIP FLIGHT TESTS

MACH NUMBER .687
ALTITUDE 20075 FT.
V_c 353.5 MPH

FLIGHTS 36 & 37
O.A.T. -10.8°C
TIP TANKS OFF

CONDITION XI

Figure 86

APTR-6743
F-80A STEADY SIDESLIP FLIGHT TESTS

MACH NUMBER .687

ALTITUDE 20075 FT.

$V_e$ 353.5 MPH

FLIGHTS 36 & 37

O.A.T. -10.8 °C.

TIP TANKS OFF

CONDITION XI

--- Graphs showing RS & LS in LBS, RBM & LBM in IN-LBS, and FBM & FS in LBS vs $\beta$ DEG. ---

Figure 87

AFTR-67L3