MUTUAL INTERFERENCE OF MULTIPLE BODIES IN THE FLOW FIELD OF THE F-4C AIRCRAFT IN THE TRANSONIC SPEED RANGE

A. A. Hesketh
ARO, Inc.

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This report has been reviewed and approved.

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FOR THE COMMANDER

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Deputy for Operations
A wind tunnel test was conducted to study the mutual interference of multiple bodies in the flow field of the F-4C aircraft. The test utilized 1/20-scale models of the F-4C aircraft, the MK-83 bomb (with and without fins) and the triple ejector rack (TER) to obtain aerodynamic loads on the MK-83 at and near the carriage position on the wing inboard pylon. Flow field data in the vicinity of the TER were also obtained. Test variables included aircraft angle of attack from -3 to 17 deg, freestream Mach number from 0.60 to 0.95, and aircraft configuration. Freestream aerodynamic loads data were also obtained on the MK-83 bomb model.
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### NOMENCLATURE

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AE</td>
<td>Engine exhaust choke exit area, (7.4662 \times 10^{-3} \text{ ft}^2), model scale</td>
</tr>
<tr>
<td>AI</td>
<td>Engine duct inlet area, (1.7050 \times 10^{-2} \text{ ft}^2), model scale</td>
</tr>
<tr>
<td>ALPHA</td>
<td>Aircraft model angle of attack relative to the free-stream velocity vector, deg</td>
</tr>
<tr>
<td>ALPHAS</td>
<td>Store model angle of attack, deg</td>
</tr>
<tr>
<td>APPE</td>
<td>Average measured total pressure at the engine exhaust choke exit plane, psf</td>
</tr>
<tr>
<td>APPE1</td>
<td>Calculated average total pressure at the engine exhaust choke exit plane for supersonic flow, psf</td>
</tr>
<tr>
<td>APSE</td>
<td>Average measured static pressure at the engine exhaust choke exit plane, psf</td>
</tr>
<tr>
<td>BL</td>
<td>Aircraft buttock line from plane of symmetry, in., model scale</td>
</tr>
<tr>
<td>CAT</td>
<td>Store model total axial-force coefficient, total axial force/(Q·AM)</td>
</tr>
<tr>
<td>CLL</td>
<td>Store model rolling-moment coefficient, rolling moment/Q·AM·L3M</td>
</tr>
<tr>
<td>CLM</td>
<td>Store model pitching-moment coefficient, pitching moment/Q·AM·L1M</td>
</tr>
<tr>
<td>CLN</td>
<td>Store model yawing-moment coefficient, yawing moment/Q·AM·L2M</td>
</tr>
<tr>
<td>CN</td>
<td>Store model normal-force coefficient, normal force/Q·AM</td>
</tr>
<tr>
<td>CONFIG</td>
<td>Aircraft model configuration designation</td>
</tr>
<tr>
<td>CPE</td>
<td>Difference in pressure coefficient between probe orifices 1 and 3, positive for positive EPS, ((P_{S1} - P_{S3})/QL)</td>
</tr>
<tr>
<td>CPS</td>
<td>Difference in pressure coefficient between probe orifices 2 and 4, positive for positive SIG, ((P_{S4} - P_{S2})/QL)</td>
</tr>
</tbody>
</table>
CR Capture ratio, mass flow rate divided by the theoretical inlet mass flow rate, (see page 12)

CY Store model side-force coefficient, side force/Q·AM

D Store model reference diameter, 0.70 in

DPHI Angle between the store lateral (Y₀) axis and the intersection of the Y₀-Z₀ and X₀-Y₀ planes, positive for clockwise rotation when looking upstream, deg

EPS Indicated angle (in pitch and calculated using CPE) between the projection of the local flow velocity vector onto the probe X₀-Z₀ plane and the probe X₀-axis, positive for a velocity-vector component in the negative Z₀ direction, deg

FS Aircraft fuselage station, in., model scale

IP, IY Pitch and yaw incidence angles of the store longitudinal axis at carriage with respect to the aircraft longitudinal axis, positive nose up and nose to the right, respectively, as seen by pilot, deg

L₁M Reference length for pitching-moment coefficient, 0.70 in. model scale

L₂M Reference length for yawing-moment coefficient, 0.70 in model scale

L₃M Reference length for rolling-moment coefficient, 0.70 in model scale

M Wind tunnel free-stream Mach number

MDOTN Engine duct mass flow rate, lbm/sec, (see page 12)

MNE Engine duct exit Mach number, (see page 12)

PS₁-PS₄, PP₅ Measured pressures for probe orifices 1 through 5, respectively, psf

PT Wind tunnel total pressure, psf

Q Wind tunnel free-stream dynamic pressure, psf

QL Local dynamic pressure, psf

RE Wind tunnel free-stream unit Reynolds number, millions per foot
RUN Data set identification number

SIG Indicated angle (in yaw and calculated using CPS) between the projection of the local flow velocity vector onto the probe \( X_B-Y_B \) plane and the probe \( X_B \)-axis, positive for a velocity-vector component in the positive \( Y_B \) direction, deg

TT Wind tunnel total temperature, °F

VR Velocity ratio, exhaust choke exit velocity divided by freestream velocity, (see page 12)

WL Aircraft waterline from reference horizontal plane, in., model scale

XCG Axial distance from the store nose to its center of gravity, 4.2083 ft full scale

Grid Aerodynamic Loads

XP Separation distance of the store nose with respect to the pylon-axis system origin in the \( X_P \) direction, in, model scale

YP Separation distance of the store nose with respect to the pylon-axis system origin in the \( Y_P \) direction, in, model scale

ZP Separation distance of the store nose with respect to the pylon axis system origin in the \( Z_P \) direction, in, model scale

Flow-field Probe

XP Position of the probe reference point with respect to the probe-axis system origin in the \( X_P \) direction, in, model scale

YP Position of the probe reference point with respect to the probe-axis system origin in the \( Y_P \) direction, in, model scale

ZP Position of the probe reference point with respect to the probe-axis system origin in the \( Z_P \) direction, in, model scale
STORE BODY-AXIS SYSTEM DEFINITIONS

Coordinate Directions

X_B  Parallel to the store longitudinal axis, positive direction is upstream at store release

Y_B  Perpendicular to X_B and Z_B directions, positive to the right looking upstream when the store is at zero yaw and roll angles

Z_B  Perpendicular to the X_B direction and parallel to the aircraft plane of symmetry when the store and aircraft are at zero yaw and roll angles, positive downward as seen by the pilot when the store is at zero pitch and roll angles

Origin

The store body-axis system origin is coincident with the store cg at all times. The X_B, Y_B, and Z_B coordinate axes rotate with the store in pitch, yaw, and roll so that mass moments of inertia about the three axes are not time-varying quantities.

PYLON-AXIS SYSTEM DEFINITIONS (GRID)

Coordinate Directions

X_P  Parallel to the store longitudinal axis at carriage, positive forward as seen by the pilot

Y_P  Perpendicular to the X_P direction and parallel to the X_P-Y_P plane, positive to the right as seen by the pilot

Z_P  Perpendicular to the X_P and Y_P directions, positive downward as seen by the pilot

FLIGHT-AXIS SYSTEM DEFINITIONS (GRID)

Coordinate Directions

X_F  Parallel to the aircraft flight path direction, positive forward as seen by the pilot

Y_F  Perpendicular to the X_F and Z_F directions, positive to the right as seen by the pilot

Z_F  Parallel to the aircraft plane of symmetry and perpendicular to the aircraft flight path direction, positive downward as seen by the pilot
Origin

The origin of the pylon-axis and flight-axis coordinate systems was defined for this test as being the location of the MK-83 store nose tip (station 0.0) at the carriage position.

PROBE BODY-AXIS SYSTEM DEFINITIONS (FLOW FIELD)

Coordinate Directions

$X_B$ Parallel to the probe longitudinal axis, positive forward as seen by the pilot

$Y_B$ Perpendicular to the $X_B$ and $Z_B$ directions, positive to the right as seen by the pilot when the probe is at zero yaw and roll angles

$Z_B$ Perpendicular to the $X_B$ direction and parallel to the aircraft plane of symmetry when the probe and aircraft are at zero yaw and roll angles, positive downward as seen by the pilot when the probe is at zero pitch and roll angles

Origin

The probe reference point is the intersection of the plane containing the four static orifices and the probe centerline. The probe body-axis system origin is coincident with the probe reference point and is fixed with respect to the probe for the duration of the grid set. The $X_B$, $Y_B$ and $Z_B$ coordinate axes rotate with the probe in pitch, yaw and roll.

PROBE-AXIS SYSTEM DEFINITIONS (FLOW FIELD)

Coordinate Directions

$X_P$ Parallel to the probe longitudinal axis at the initialization of the grid set and rotated through pitch and yaw angles of $I_P$ and $I_Y$, respectively, with respect to the aircraft longitudinal axes positive forward as seen by the pilot

$Y_P$ Perpendicular to the $X_P$ direction and parallel to the $X_P$-$Y_P$ plane, positive to the right as seen by the pilot

$Z_P$ Perpendicular to the $X_P$ and $Y_P$ directions, positive downward as seen by the pilot
FLIGHT-AXIS SYSTEM DEFINITIONS (FLOW FIELD)

Coordinate Directions

\[ \begin{align*}
X_F & \quad \text{Parallel to the aircraft flight path direction, positive forward as seen by the pilot} \\
Y_F & \quad \text{Perpendicular to the } X_F \text{ and } Z_F \text{ directions, positive to the right as seen by the pilot} \\
Z_F & \quad \text{Parallel to the aircraft plane of symmetry and perpendicular to the aircraft flight path direction, positive downward as seen by the pilot}
\end{align*} \]

Origin

The origin of the probe-axis and flight-axis coordinate systems was defined for this test as being the location of the MK-83 store nose tip (station 0.0) at the carriage position.
1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), at the request of the Air Force Flight Dynamics Laboratory (AFFDL/FGC), Wright-Patterson AFB, Ohio, for Nielsen Engineering and Research, Inc., Mountain View, California, under Program Element 62201F. The project monitor was Mr. Calvin L. Dyer (AFFDL/FGC). The results of the test were obtained by ARO, Inc., AEDC Division (a Sverdrup Corporation Company), operating contractor for AEDC, AFSC, Arnold Air Force Station, Tennessee, under ARO Project Number P41C-F0 (Test TC-623). The test was conducted from November 12 through 21, 1979, in the Aerodynamic Wind Tunnel (4T).

The objective of this test was to provide aerodynamic data for use in determining the mutual interference of multiple bodies in the flowfield of the F-4C aircraft in the transonic speed range. This information will be used to improve analytic procedures for calculating aerodynamic loads on stores. The test utilized 1/20-scale models of the F-4C aircraft, the MK-83 bomb (with and without fins), and a triple ejector rack (TER) to obtain aerodynamic loads, using the captive loads and CTS grid techniques. Also, during the captive loads phase, a total pressure rake was mounted just aft of the right hand engine exhaust choke of the F-4C aircraft model to determine the mass flow rate through the simulated engine ducting.

The purpose of this report is to document the test and to describe the test parameters. The report provides information to permit the use of the data but does not include any data analysis, which is beyond the scope of this report.

The final data from this test have been transmitted to Nielsen Engineering and Research, Inc., Mountain View, California, and the Air Force Flight Dynamics Laboratory (AFFDL/FGC). Requests for the data should be addressed to AFFDL/FGC, Wright-Patterson AFB, Ohio 45433. A copy of the final data is on file on microfilm at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

The Aerodynamic Wind Tunnel (4T) is a closed-loop, continuous flow, variable-density tunnel in which the Mach number can be varied from 0.1 to 1.3 and can be set at discrete Mach numbers of 1.6 and 2.0 by placing nozzle inserts over the permanent sonic nozzle. The
nominal range of the stagnation pressure can be varied from 400 to 3,400 psf. A test section is 4 ft square and 12.5 ft long with perforated, variable porosity (0.5- to 10-percent open) walls. It is completely enclosed in a plenum chamber from which the air can be evacuated, allowing part of the tunnel airflow to be removed through the perforated walls of the test section. A more complete description of the test facility may be found in Ref. 1.

For this test, two separate and independent support systems were used. The aircraft model was installed inverted in the test section and was supported by an offset sting attached to the main pitch sector. For captive loads testing, the store model was mounted on a balance fastened to the bottom station of the TER on the aircraft model. For grid aerodynamic loads and flow-field testing the store model or the flow-field probe was mounted on the captive trajectory support (CTS). The aircraft model was removed when obtaining free-stream data, and the CTS was moved upward (and downstream) in the tunnel during the captive load phase to minimize interference. Isometric drawings of typical captive loads, grid survey, and flow-field testing are shown in Fig. 1, along with block diagrams of the computer control loops. Schematics showing the test section details and the location of the models in the tunnel are shown in Fig. 2. Further description of the CTS rig can be found in Ref. 1.

2.2 TEST ARTICLES

The basic details of the 1/20-scale F-4C model are presented in Fig. 3. The model is geometrically similar to the full-scale aircraft except that the tail section was removed to minimize interference with the CTS movement. The F-4 model has flow-through engine inlets and interchangeable nose sections. All testing was accomplished with the F-4C nose configuration. Details and dimensions of the F-4C pylons are given in Fig. 4. The triple ejector rack (TER) model was made with ventilation passages and sway braces to more closely simulate the full scale version. Details and dimensions of the TER model are given in Fig. 5. A total pressure rake, containing 13 total pressure orifices, was mounted just aft of the right hand engine exhaust choke of the F-4C aircraft model. The interior surface of the exhaust choke contained six static pressure orifices. Details and dimensions of the total pressure rake and exhaust choke are given in Fig. 6. Details and dimensions of the MK-83 bomb models are given in Fig. 7. The afterbody of the MK-83 bomb model was modified to allow for sting mounting on the CTS. The modified and the actual afterbody were tested during the captive loads phase. The MK-83 model was also tested with and without tail fins during the captive loads and grid survey phases.
The pressure probe which was used to obtain the flow-field measurements consisted of a single cone-cylinder with a 40-deg included angle tip. There were four equally spaced static pressure orifices on the surface of the cone and a total pressure orifice at the apex of the cone. Details of the probe are shown in Fig. 8.

Tunnel installation of typical test configurations is shown in Fig. 9.

2.3 INSTRUMENTATION

A six-component, internal strain-gage balance was used to measure the aerodynamic forces and moments acting on the MK-83 bomb model. For the captive loads testing, the balance was supported by a bracket attached to the TER. A sketch of the store, balance, and TER assembly is shown in Fig. 10. For grid survey testing the balance was sting mounted to the CTS.

All pressures were measured using ±15-psid transducers. Translational and angular positions of the store or pressure probe were obtained from the CTS analog outputs. The aircraft model angle of attack was set using an internal gravimetric angular position indicator. The TER contained a mechanical touch wire to provide accurate setting of the store or pressure probe at the reference position for each survey. The system was also electrically connected to automatically stop the CTS movement if the probe or CTS contacted the model, sting support, or test section walls.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS

Data were obtained at Mach numbers from 0.60 to 0.95 at a constant Reynolds number of 3.5 million per foot. The aircraft model angle of attack was varied from -3 to 17 deg during the captive loads testing and from 1 to 17 deg during the grid aerodynamic loads and flow-field survey testing. The nominal wind tunnel test conditions are presented in Table 1. Tunnel conditions were held constant at the desired settings while data for each captive aerodynamic loads sweep, grid aerodynamic loads survey, and flow-field survey were obtained.

3.2 DATA ACQUISITION AND REDUCTION

3.2.1 Captive Aerodynamic Loads Data

The carriage aerodynamic loads data were obtained at aircraft model angles of attack from -3 to 17 deg at 0 deg sideslip angle. The CTS was moved upward (and downstream) in the test
section to minimize its influence on the aircraft flow field. All pitch polars were run automatically utilizing online computer facilities to calculate the control commands to set the aircraft model attitude. The force and moment data for the store were reduced to coefficient form in the body axis system and the moment data were referenced to the MK-83 center-of-gravity location (XCG). Exit Mach number, mass flow rate, captive area ratio, and a velocity ratio for the right hand engine duct were calculated from the following equations using the measured total pressures from the total pressure rake, the static pressure located in the exhaust choke, and the tunnel freestream conditions.

\[
MNE = \sqrt[\frac{2}{7}]{\frac{5[(APPE/APSE)^{2/7}-1]}{1}} \quad (1)
\]

\[
MDOTN = \frac{APPE \cdot MNE \cdot AE \cdot [1+0.2(MNE)^2]^{-3} \cdot [0.8843/(TT+459.6)]^{1/2}}{(2)}
\]

\[
CR = \frac{MDOTN}{\{PT \cdot M \cdot AI \cdot [1+0.2(MNE)^2]^{-3} \cdot [0.8843/(TT+459.6)]^{1/2}\}} \quad (3)
\]

\[
VR = \frac{(MNE/M) \cdot [(1+0.2(M)^2)/(1+0.2(MNE)^2)]^{1/2}}{(4)}
\]

If the static-to-total pressure ratio \((APSE/APPE)\) was less than 0.5283, indicating that the exit flow was supersonic, the exit Mach number \((MNE)\) was determined by iteration of the Rayleigh-Pitot Formula (Eq. 5 below). The total pressure upstream of the rake shock wave was then calculated by Eq. 6, and this value was used instead of the measured total pressure value \((APPE)\) in Eq. 2.

\[
\frac{(APPE/APSE)}{(6/5) \cdot MNE^2} = \frac{[6/(7 \cdot (MNE)^2-1)]^{5/2}}{(5)}
\]

\[
APPE1 = \frac{APSE \cdot [1+0.2(MNE)^2]}{7/2} \quad (6)
\]

The rake and choke pressures were processed through an automatic pressure settling routine and were recorded and tabulated only after a prescribed convergence criterion (pressure change less than 2 psf/sec) was met.

3.2.2 Grid Aerodynamic Loads Data

To obtain store aerodynamic loads data, test conditions were first established in the tunnel. Operational control of the model support systems was then switched to the digital computer. For free-stream data, the computer would initially position the store at \(ALPHAS = 0\) through commands to the CTS (see block diagram, Fig. 1). For data in the aircraft flow field, the computer would position the aircraft model at the desired angle of attack and then position the store at a known location and orientation with respect to the
aircraft model. After initial-point data were recorded, the digital computer then positioned the store at preselected orientations and positions programmed into the computer. At each set position, the wind tunnel operating conditions and the store model forces and moments were measured and recorded. The model aerodynamic loads were then reduced to coefficient form and tabulated by the digital computer. The aerodynamic moments were reduced about the XCG location of the store. Grid aerodynamic loads in the aircraft flow field were measured along vertical traverses as shown in Table 2. Freestream aerodynamic loads data were measured at store angles of attack from -4 to 16 deg. The Mach number was varied from 0.60 to 0.95.

3.2.3 Flow-field Survey Data

During the test, flow-field probe data were obtained in the following manner. After tunnel conditions and aircraft model angle of attack were set, operational control of the CTS was switched to the digital computer. The computer then positioned the probe at a known location and orientation with respect to the aircraft model through commands to the CTS. After initial point data were recorded, the probe was automatically positioned at preselected positions and orientations programmed into the computer. The probe pressures were processed through an automatic pressure settling routine and were recorded and tabulated only after a prescribed convergence criterion (pressure change less than 2 psf/sec) was met. Flow-field survey data in the aircraft flow field were measured along XP traverses at constant YP and ZP values as shown in Table 3.

3.3 CORRECTIONS

Balance, sting, and support deflections caused by the aerodynamic loads on the store models during the captive and grid aerodynamic loads testing were accounted for in the data reduction program to calculate the true store-model angles and positions. Corrections were also made for model weight tares to calculate the net aerodynamic forces on the store model.

3.4 UNCERTAINTY/PRECISION OF MEASUREMENTS

Uncertainties in the basic tunnel parameters, PT, TT and M, were estimated from repeat calibrations of the instrumentation and from repeatability and uniformity of the test section flow during tunnel calibration. These uncertainties were then used to estimate the uncertainties in other free-stream properties, using the Taylor series method of error propagation (Ref. 2). The balance uncertainties, based on a 95-percent confidence level, were combined with the uncertainties in the tunnel parameters, assuming a Taylor series
error propagation, to estimate the precision of the aerodynamic coefficients. The maximum estimated uncertainties are given in Table 4. The uncertainties in the flow field data were calculated considering probable inaccuracies in the pressure measurements and tunnel conditions. These estimated uncertainties are also shown in Table 4.

The estimated uncertainties in store model and pressure probe positioning from the ability of the CTS to set on a specified value were ±0.050 in model scale in X, Y, and Z, ±0.15 deg in pitch and yaw, and ±1.0 deg in roll settings. Estimated uncertainty in aircraft model angle of attack is ±0.15 deg. The Mach number was held constant within ±0.005 of the quoted Mach number with an estimated uncertainty of ±0.003.

Examples of data repeatability are shown in the plots of Fig. 11.

4.0 DATA PRESENTATION

The data package consists of tabulated summary data, microfilm of the summary data, model installation photographs, and computer-generated plots of the flow field data.

A test run number summary is presented in Table 5 correlating the model configurations and the test conditions with the test data run number. Configuration identifications are shown in Table 6.

Data tabulation formats for the captive aerodynamic loads phase and nomenclature for these data are presented in Tables 7 and 8, respectively. The data tabulation format for the grid aerodynamic loads phase and nomenclature for these data are presented in Tables 9 and 10, respectively. The data tabulation format for the flow-field survey phase and nomenclature are presented in Tables 11 and 12, respectively. Online plotting capability was also available through an interactive graphics system, and some examples are shown in Figure 12.

REFERENCES


b. Grid Phase

Figure 1. Continued
c. Flow-Field Phase

Figure 1. Concluded
Figure 2. Schematic of the Test Installation
Figure 3. F-4C Aircraft Model
Figure 4. F-4C Pylon Models
Figure 5. Modified Triple Ejector Rack Model
Drill # 43 (0.089 Diam) thru
Tap # 4-40 UNC-2B thru
3 Holes Located at Ass'y
One Tube to be Vertical
at Ass'y within 10'

50°-0' Ref.

90°

10°-0' Ref.

Drill # 54 (0.055 Diam) Thru
6 holes 0.005 Diam
0.050" O.D., 0.0075" Wall X
2.5' LG. 304 SST. tubing
6 Req'd.
Silver Solder to Choke
6 Places

Note. All Diam's to be Concentric Within 0.003 T.I.R.

0.250 Const. Inside Diam
- 0.100 BSC. Typ.

0.170 Diam

0.730 Typ.

0.005 Constant
0.010

Edge Thickness

X Size

PC0053807
### Table 1: STA and DIAM

<table>
<thead>
<tr>
<th>STA</th>
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<tr>
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</tr>
</tbody>
</table>

---

![Diagram of airframe with dimensions and notes](image)

**FWD 14-IN. SUSPENSION POINT**

**0.050**

**0.700D**

**0.100D**

**0.125R**

**BASIC CONFIGURATION**

**BASE MODIFICATION FOR STING MOUNTED STORE**

**DIMENSIONS IN INCHES**

---

**b. Unfinned**

*Figure 7. Concluded*
Figure 8. Details of Flow-Field Probe
a. Captive Loads Phase

Figure 9. Typical Tunnel Installation Photograph
Figure 11. Example of Data Repeatability

a. CN vs ZP/D
Figure 11. Continued
Figure 11. Continued

d. CLN vs ZP/D
f. CAT vs ZP/D

Figure 11. Concluded
CN vs ALPHAS, Freestream

Figure 12. Typical On Line Plots
1 RUN 173, CONFIG 63, M=0.95
2 RUN 112, CONFIG 64, M=0.95

C. CN vs ALPHAS, Captive Loads

Figure 12. Continued
1 RUN 173, CONFIG 63, M=0.95
2 RUN 112, CONFIG 64, M=0.95

d. CLM vs ALPHAS, Captive Loads
Figure 12. Continued
e. CN vs ZP/D, Grid Phase
Figure 12. Continued
f. CLM vs ZP/D, Grid Phase

Figure 12. Continued
TC623 AFFDL/NWC TRANSONIC FLOW STORE TEST II
RUN = 713, 714, 715

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<tr>
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<th>YP</th>
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g. VX vs XP, Flow-Field Phase
Figure 12. Continued.
h. VY vs XP, Flow-Field Phase

Figure 12. Continued
i. VZ vs XP, Flow-Field Phase
Figure 12. Continued
II TC623 AFFDL/NYC TRANSONIC FLOW STORE TEST II
RUN = 713, 714, 715
RUN SYMBOL CONFIG MACH ALPHA VP ZP
713 1 65 0.95 5.0 0.00 0.00
714 2 65 0.95 5.0 0.00 0.35
715 3 65 0.95 5.0 0.00 0.70

j. EPS vs XP, Flow-Field Phase
Figure 12. Continued
II TC623 AFFDL/WUC TRANSONIC FLOW STORE TEST II

RUN - 713, 714, 715

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k. SIG vs XP, Flow-Field Phase
Figure 12. Continued
1. ML vs XP, Flow-Field Phase

Figure 12. Concluded
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Table 2. Grid Aerodynamic Loads Survey Locations

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Table 3. Flow Field Survey Locations

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Table 4. Data Uncertainties

a. Aerodynamic Coefficient Uncertainties

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b. Flow Field Angle Uncertainties

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## TABLE 5. CAPTIVE LOADS RUN NUMBER SUMMARY

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*A: ALPHA = -3, -1, 1, 3, 5, 7, 9, 11, 13, 15, 17
TABLE 5. CONTINUED

b. GRID RUN NUMBER SUMMARY

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B: ZP/D = 0, 0.1, 0.2, 0.3, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 2.0, 2.4, 2.8, 3.2, 3.6, 4.0, 4.4, 4.8, 5.2, 5.6, 6.0
TABLE 5. CONTINUED

c. FREESTREAM RUN NUMBER SUMMARY

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*A: ALPHAS = -4, -2, 0, 2, 4, 6, 8, 10, 12, 14, 16
TABLE 5. Continued

d. FLOWFIELD RUN NUMBER SUMMARY

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* XP SCHEDULES

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### TABLE 5. CONTINUED

e. FLOWFIELD RUN NUMBER SUMMARY

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NOTE: On the Tabulated Summary Data under the heading "STORE", the following Nomenclature was used for all the configurations tested:

- MK-83 F - MK-83 store metric model with fins
- MK-83 UF - MK-83 store metric model without fins
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○ DENOTES DUMMY STORE
● DENOTES STING MOUNTED STORE
CLEAN DENOTES PYLON REMOVED
EMPTY DENOTES NO STORE ON PYLON

TABLE 6. CONTINUED
### Table 6. Continued

#### Looking Upstream

**Left Wing**

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**Denotations:**
- ○ DENOTES DUMMY STORE
- ▼ - DENOTES TER
- ● DENOTES STING MOUNTED STORE
- CLEAN DENOTES PYLON REMOVED
- EMPTY DENOTES NO STORE ON PYLON

62
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- O DENOTES DUMMY STORE
- ▼ - DENOTES TER
- ▪ DENOTES STING MOUNTED STORE
- CLEAN DENOTES PYLON REMOVED
- EMPTY DENOTES NO STORE ON PYLON
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○ DEPENDS DUMMY STORE
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CLEAN DENOTES PYLON REMOVED
EMPTY DENOTES NO STORE ON PYLON

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○ DENOTES DUMMY STORE  
□ - DENOTES TER  
DENOTES STING MOUNTED STORE  
CLEAN DENOTES PYLON REMOVED  
EMPTY DENOTES NO STORE ON PYLON
<table>
<thead>
<tr>
<th>CONFIG NO.</th>
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<th>INB'D</th>
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<td>CLEAN</td>
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<tr>
<td>62</td>
<td>Mk-83 CTS</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Mk-83 captive loads</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>Mk-83 captive loads</td>
<td>OFF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- ○ DENOTES DUMMY STORE
- △ - DENOTES TER
- ● DENOTES STING MOUNTED STORE
- CLEAN DENOTES PYLON REMOVED
- EMPTY DENOTES NO STORE ON PYLON
### Table 6. Continued

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- ○ DENOTES DUMMY STORE
- ▽ - DENOTES TER
- ● DENOTES STING MOUNTED STORE
- CLEAN DENOTES PYLON REMOVED
- EMPTY DENOTES NO STORE ON PYLON

67
<table>
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<td></td>
</tr>
</tbody>
</table>

- **O** denotes dummy store
- **DENOTES** sting mounted store
- **CLEAN** denotes pylon removed
- **EMPTY** denotes no store on pylon
- **DENOTES** TER
### TABLE 7. Captive Aerodynamic Loads Data Tabulation Format

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<thead>
<tr>
<th>RUN</th>
<th>PF</th>
<th>ST</th>
<th>O</th>
<th>P</th>
<th>T</th>
<th>V</th>
<th>PE</th>
<th>TOP</th>
<th>EN</th>
<th>CONSET ZEROS SET</th>
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<td>-1.165</td>
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**DATE** 5-DEC-79  
**PROJECT NO** P41C-PO  
**AGC, INC.**  
**AERO DIVISION**  
***UNCLASSIFIED***  
**AEROSPACE CORPORATION COMPANY**  
**PROPULSION WIND TUNNEL**  
**ARNOLO AIR FORCE STATION, TENNESSEE**

**TEST TC-623 SUMMARY 2**  
**AFFDL/WHC TRANSSONIC FLOW STORE TEST**  
**TRANSSONIC 4T**

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<th>SM</th>
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**E/C CONFIG STORE**  
**F-10C 53**  
**KX-63 P**

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</table>

**TABLE 7a**  
**CONCLUDED**

---

**UNCLASSIFIED**
### Table 8. Nomenclature for Captive Aerodynamic Loads
Tabulated Summary Data

**PAGE HEADING (COMMON TO ALL SUMMARIES)**

- **DATE**: Calendar time at which the data were printed
- **PROJECT**: Alpha-numeric notation for referencing a specific test project
- **TEST**: Alpha-numeric notation for referencing a specific test program in a specific test unit

**LINE 1**

- **RUN**: Sequential indexing number for referencing data. A constant throughout specified (or all) points of a survey.
- **M**: Wind tunnel free-stream Mach number
- **PT**: Wind tunnel free-stream total pressure, psf
- **TT**: Wind tunnel free-stream total temperature, °F
- **Q**: Wind tunnel free-stream dynamic pressure, psf
- **P**: Wind tunnel free-stream static pressure, psfa
- **T**: Wind tunnel free-stream static temperature, °R
- **V**: Wind tunnel free-stream velocity, ft/sec
- **RE**: Wind tunnel free-stream unit Reynolds number, millions per foot
- **TDP**: Hygrometer dew point temperature, °F
- **SH**: Wind tunnel specific humidity, lbm H₂O per lbm air
- **CON SET**: Constant set used in data reduction
- **ZERO SET**: Run/point number of the air off set of instrument readings used in data reduction
Table 8. Continued

<table>
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<th>LINE 2</th>
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<td>Aircraft designation</td>
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<tr>
<td>CONFIG</td>
<td>Aircraft store loading designation</td>
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<tr>
<td>STORE</td>
<td>Store model designation</td>
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**COLUMNAR HEADINGS**

**SUMMARY PAGE 1**

<table>
<thead>
<tr>
<th>PN</th>
<th>Sequential indexing number for referencing data obtained during one run. Indexes each time a new set of data inputs is obtained.</th>
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<tbody>
<tr>
<td>ALPHAS, BETAS</td>
<td>Store model angle of attack and sideslip angle, respectively, deg.</td>
</tr>
<tr>
<td>CN</td>
<td>Normal-force coefficient</td>
</tr>
<tr>
<td>CY</td>
<td>Side-force coefficient</td>
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<td>CAT</td>
<td>Total axial-force coefficient</td>
</tr>
<tr>
<td>CLM</td>
<td>Pitching-moment coefficient</td>
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<tr>
<td>CLN</td>
<td>Yawing-moment coefficient</td>
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<tr>
<td>CLL</td>
<td>Rolling-moment coefficient</td>
</tr>
<tr>
<td>NCP</td>
<td>Normal force center-of-pressure location, CLM/CN</td>
</tr>
<tr>
<td>YCP</td>
<td>Side force center-of-pressure location, CLN/CY</td>
</tr>
<tr>
<td>ALPHA, BETA</td>
<td>Aircraft-model angle of attack and sideslip angle, respectively, deg</td>
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</tbody>
</table>

**SUMMARY PAGE 2**

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<td>Aircraft-model angle of attack and sideslip angle, respectively, deg</td>
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<tr>
<td>APSE</td>
<td>Average measured static pressure at the engine exhaust choke exit plane, psfa</td>
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72
Table 8. Concluded

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<th>Acronym</th>
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<tr>
<td>APPE</td>
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<tr>
<td>APPE1</td>
<td>Calculated average total pressure at the engine exhaust choke exit plane, psfa</td>
</tr>
<tr>
<td>MNE</td>
<td>Duct exit Mach number</td>
</tr>
<tr>
<td>MDOTN</td>
<td>Engine duct mass flow rate, lbm/sec.</td>
</tr>
<tr>
<td>CR</td>
<td>Capture ratio, engine duct mass flow rate divided by the theoretical inlet mass flow rate</td>
</tr>
<tr>
<td>VR</td>
<td>Velocity ratio duct exit velocity divided by freestream velocity</td>
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### TABLE 9: Grid Aerodynamic Loads

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<th>DESCRIPTION</th>
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<td>ARM-58, PROJ-40, PSIC-FD</td>
<td>AERODYNAMIC RESEARCH DIVISION</td>
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<th>P</th>
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### SUMMARY 2

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### BODY AXIS COEFFICIENTS

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<th>CM</th>
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<th>CLW</th>
<th>CLL</th>
<th>CAT</th>
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<th>RUN</th>
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</table>

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The table above presents data collected during a series of aerodynamic tests conducted using a specific configuration labeled 'F74C'. The data includes various parameters such as angle of attack (ALPHA), beta, IP, IV, and configuration settings among others. The intent is to analyze and compare aerodynamic coefficients across different conditions, as indicated by the columns labeled CM, CLM, CY, CLW, and CLL. The summary at the bottom reflects the coefficients' impact across different runs, possibly highlighting trends or significant changes in aerodynamic behavior.
### Table 10. Nomenclature for Grid Aerodynamic Loads
Tabulated Summary Data

#### PAGE HEADING (COMMON TO ALL SUMMARIES)

#### COMPANY HEADING

**DATE**
Calendar time at which the data were printed

**PROJECT**
Alpha-numeric notation for referencing a specific test project

**LINE 1**

**RUN**
Sequential indexing number for referencing data. A constant throughout specified (or all) points of a survey.

**SURVEY**
Configuration indexing number used to correlate data with the test log. Survey may be used to identify all or portion of a grid set.

**M**
Wind tunnel free-stream Mach number

**PT**
Wind tunnel free-stream total pressure, psfa

**TT**
Wind tunnel free-stream total temperature, °F

**Q**
Wind tunnel free-stream dynamic pressure, psf

**P**
Wind tunnel free-stream static pressure, psfa

**T**
Wind tunnel free-stream static temperature, °R

**V**
Wind tunnel free-stream velocity, ft/sec

**RE**
Wind tunnel free-stream unit Reynolds number, millions per foot

**TDP**
Hygrometer dew point temperature, °F

**SH**
Wind tunnel specific humidity, lbm H₂O per lbm air

**SCALE**
Aircraft model scale factor

**DATE**
Calendar time at which data were recorded

**TIME**
Time at which data were recorded (hr/min/sec)

**CON SET**
Run/point number of constants set used in data reduction

**ZERO SET**
Run/point number of the air off set of instrument readings used in data reduction

75
Table 10. Continued

<table>
<thead>
<tr>
<th>TEST</th>
<th>Alpha-numeric notation for referencing a specific test program in a specific test unit</th>
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<tbody>
<tr>
<td>LINE 2</td>
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<tr>
<td>A/C</td>
<td>Aircraft designation</td>
</tr>
<tr>
<td>ALPHA,BETA</td>
<td>Aircraft-model angle of attack and sideslip angle, respectively, deg</td>
</tr>
<tr>
<td>IP,IY</td>
<td>Pitch and yaw incidence angles of the store longitudinal axis at carriage with respect to the aircraft longitudinal axis, positive nose up and nose to the right, respectively, as seen by pilot, deg</td>
</tr>
<tr>
<td>IR</td>
<td>Roll incidence of the store $Z_B$ axis at carriage with respect to the aircraft plane of symmetry, positive for clockwise roll looking upstream, deg</td>
</tr>
<tr>
<td>CONFIG</td>
<td>Aircraft store loading designation</td>
</tr>
<tr>
<td>WING</td>
<td>Location of store launch position</td>
</tr>
<tr>
<td>STORE</td>
<td>Store model designation</td>
</tr>
<tr>
<td>A</td>
<td>Store reference area, $\text{ft}^2$, full scale</td>
</tr>
<tr>
<td>L1,L2,L3</td>
<td>Store reference lengths for pitching-moment, yawing-moment, and rolling-moment coefficients, respectively, $\text{ft}$, full scale</td>
</tr>
<tr>
<td>XCG</td>
<td>Axial distance from the store nose to the center of gravity location, $\text{ft}$, full scale</td>
</tr>
<tr>
<td>YCG,ZCG</td>
<td>Lateral and vertical distances from the store reference (balance) axis to the center of gravity location, positive in the positive $Y_B$ and $Z_B$ directions, respectively, $\text{ft}$, full scale</td>
</tr>
<tr>
<td>PHIS</td>
<td>Roll angle of the store Number 1 fin with respect to the $-Z_B$ axis, positive clockwise looking upstream, deg</td>
</tr>
<tr>
<td>COLUMNAR HEADINGS</td>
<td>SUMMARY PAGE 2</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
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<tr>
<td>PN</td>
<td>Sequential indexing number for referencing data obtained during one run. Indexes each time a new set of data inputs is obtained.</td>
</tr>
<tr>
<td>XP,YP</td>
<td>Separation distance of the store nose with respect to the pylon-axis system origin in the X_p and Y_p directions, respectively, in, model scale</td>
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<tr>
<td>ZP/D</td>
<td>Separation distance of the store nose with respect to the pylon-axis system origin in the Z_p direction, calibres</td>
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<tr>
<td>DPSI</td>
<td>Angle between the projection of the store longitudinal axis in the X_p-Y_p plane and the X_p-axis, positive for store nose to the right as seen by the pilot, deg</td>
</tr>
<tr>
<td>DTHA</td>
<td>Angle between the store longitudinal axis and its projection in the X_p-Y_p plane, positive when the store nose is raised as seen by the pilot, deg</td>
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<tr>
<td>DPHI</td>
<td>Angle between the store lateral (Y_B) axis and the intersection of the Y_B-Z_B and X_p-Y_p planes, positive for clockwise rotation when looking upstream, deg</td>
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<tr>
<td>ALPHA, BETAS</td>
<td>Store model angle of attack and sideslip angle, respectively, deg</td>
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<tr>
<td>NCP</td>
<td>Normal force center-of-pressure location, CLM/CN</td>
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<tr>
<td>YCP</td>
<td>Side force center-of-pressure location, CLN/CY</td>
</tr>
<tr>
<td>CAT, CN, CY</td>
<td>Store measured aerodynamic axial-force, normal-force, and side-force coefficients, positive in the negative X_p, negative Z_B, and positive Y_B direction, respectively</td>
</tr>
<tr>
<td>CLL, CLM, CLN</td>
<td>Store measured aerodynamic rolling-moment, pitching-moment, and yawing-moment coefficients. The positive vectors are coincident with the positive X_B, Y_B, and Z_B axes, respectively.</td>
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<tr>
<td>Q</td>
<td>Wind tunnel free-stream dynamic pressure, psf</td>
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<tr>
<td>NDX</td>
<td>Sequential indexing number for referencing data obtained during a grid set. Indexes for each position in the set</td>
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Table 10. Continued

SUMMARY PAGE 2 (Continued)

RUN

Sequential indexing number for referencing data. A constant throughout specified (or all) points of a survey.

STORE BODY-AXIS SYSTEM DEFINITIONS

Coordinate Directions

<table>
<thead>
<tr>
<th>Coordinate</th>
<th>Description</th>
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<tbody>
<tr>
<td>X_B</td>
<td>Parallel to the store longitudinal axis, positive direction is upstream at store release</td>
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<tr>
<td>Y_B</td>
<td>Perpendicular to X_B and Z_B directions, positive to the right looking upstream when the store is at zero yaw and roll angles</td>
</tr>
<tr>
<td>Z_B</td>
<td>Perpendicular to the X_B direction and parallel to the aircraft plane of symmetry when the store and aircraft are at zero yaw and roll angles, positive downward as seen by the pilot when the store is at zero pitch and roll angles</td>
</tr>
</tbody>
</table>

Origin

The store body-axis system origin is coincident with the store cg at all time. The X_B, Y_B, and Z_B coordinate axes rotate with the store in p’tch, yaw, and roll so that mass moments of inertia about the three axes are not time-varying quantities.

PYLON-AXIS SYSTEM DEFINITIONS (GRID)

Coordinate Directions

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<thead>
<tr>
<th>Coordinate</th>
<th>Description</th>
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<tr>
<td>X_P</td>
<td>Parallel to the store longitudinal axis at carriage, positive forward as seen by the pilot</td>
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<tr>
<td>Y_P</td>
<td>Perpendicular to the X_P direction and parallel to the X_P-Y_P plane, positive to the right as seen by the pilot</td>
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<tr>
<td>Z_P</td>
<td>Perpendicular to the X_P and Y_P directions, positive downward as seen by the pilot</td>
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Table 10. Concluded

FLIGHT-AXIS SYSTEM DEFINITIONS (GRID)

Coordinate Directions

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<th>Variable</th>
<th>Definition</th>
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<td>$X_F$</td>
<td>Parallel to the aircraft flight path direction, positive forward as seen by the pilot</td>
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<tr>
<td>$Y_F$</td>
<td>Perpendicular to the $X_F$ and $Z_F$ directions, positive to the right as seen by the pilot</td>
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<tr>
<td>$Z_F$</td>
<td>Parallel to the aircraft plane of symmetry and perpendicular to the aircraft flight path direction, positive downward as seen by the pilot</td>
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Origin

The origin of the pylon-axis and flight-axis coordinate systems was defined for this test as being the location of the MK-83 store nose tip (station 0.0) at the carriage position.
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**Summary**

**Pylon Axes**

Body Axis Flow Angles and Velocities
Table 12. Nomenclature for Flow Field
Tabulated Summary Data

**PAGE HEADING (COMMON TO ALL SUMMARIES)**

**COMPANY HEADING**

<table>
<thead>
<tr>
<th>DATE</th>
<th>Calendar Time at which data were printed</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROJECT</td>
<td>Alpha-numeric notation for referencing a specific test project</td>
</tr>
</tbody>
</table>

**LINE 1**

<table>
<thead>
<tr>
<th>RUN</th>
<th>Sequential indexing number for referencing data. A constant throughout specified (or all) points of a survey.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURVEY</td>
<td>Configuration indexing number used to correlate data with the test log. Survey may be used to identify all or portion of a grid set.</td>
</tr>
</tbody>
</table>

<p>| M | Wind tunnel free-stream Mach number |
| PT | Wind tunnel free-stream total pressure, psfa |
| TT | Wind tunnel free-stream total temperature, °F |
| Q | Wind tunnel free-stream dynamic pressure, psf |
| P | Wind tunnel free-stream static pressure, psfa |
| T | Wind tunnel free-stream static temperature, °R |
| V | Wind tunnel free-stream velocity, ft/sec |
| RE | Wind tunnel free-stream unit Reynolds number, millions per foot |
| TDP | Hygrometer dew point temperature, °F |
| SH | Wind tunnel specific humidity, lbm H₂O per lbm air |
| SCALE | Aircraft model scale factor |
| DATE | Calendar time at which data were recorded |
| TIME | Time at which data were recorded (hr/min/sec) |
| CON SET | Run/point number of constants set used in data reduction |</p>
<table>
<thead>
<tr>
<th>LINE 1</th>
<th>(Continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZERO SET</td>
<td>Run/point number of the air off set of instrument readings used in data reduction</td>
</tr>
<tr>
<td>TEST</td>
<td>Alpha-numeric notation for referencing a specific test program in a specific test unit.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LINE 2</th>
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</thead>
<tbody>
<tr>
<td>A/C</td>
<td>Aircraft designation</td>
</tr>
<tr>
<td>ALPHA,BETA</td>
<td>Aircraft-model angle of attack and sideslip angle, respectively, deg</td>
</tr>
<tr>
<td>IP,IY</td>
<td>Pitch and yaw incidence angles of the probe longitudinal axis at the initialization of the grid set with respect to the aircraft longitudinal axis, positive tip up and tip to the right, respectively, as seen by pilot, deg</td>
</tr>
<tr>
<td>IR</td>
<td>Roll incidence of the probe ZB axis at the initialization of the grid set with respect to the aircraft plane of symmetry, positive for clockwise roll looking upstream, deg</td>
</tr>
<tr>
<td>CONFIG</td>
<td>Aircraft store loading designation</td>
</tr>
<tr>
<td>WING</td>
<td>Location of probe survey</td>
</tr>
</tbody>
</table>

**COLUMNAR HEADINGS**

<table>
<thead>
<tr>
<th>SUMMARY PAGE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PN</td>
</tr>
<tr>
<td>XP</td>
</tr>
<tr>
<td>YP</td>
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</tbody>
</table>
Table 12. Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZP</td>
<td>Position of the probe reference point with respect to the probe-axis system origin in the Zp direction, in, model scale</td>
</tr>
<tr>
<td>ALFXY</td>
<td>Indicated angle between VXY and VX, positive for positive VY, same as SIG, deg</td>
</tr>
<tr>
<td>ALFZX</td>
<td>Indicated angle between VXZ and VX, positive for positive VZ, same as EPS, deg</td>
</tr>
<tr>
<td>ALFYZ</td>
<td>Indicated angle between VYZ and -Zb-axis, positive clockwise looking upstream, deg</td>
</tr>
<tr>
<td>VX, VY, VZ</td>
<td>Velocity components parallel to the probe Xb, Yb, and Zb axes, positive in the -Xb, Yb, and -Zb directions, respectively, ft/sec</td>
</tr>
<tr>
<td>VXY, VXZ, VYZ</td>
<td>Velocity components in the probe body-axis Xb-Yb, Xb-Zb, and Yb-Zb planes, respectively, ft/sec</td>
</tr>
<tr>
<td>PTP</td>
<td>Probe measured free-stream total pressure corrected for local Mach number</td>
</tr>
<tr>
<td>QL</td>
<td>Local dynamic pressure, psf</td>
</tr>
<tr>
<td>VL</td>
<td>Local velocity, ft/sec</td>
</tr>
<tr>
<td>THAT</td>
<td>Angle between the local flow velocity vector and the negative Xb-axis, deg</td>
</tr>
<tr>
<td>ML</td>
<td>Local Mach number calculated from the ratio of the average of the four static pressures and the probe total pressure, ((PS1 + PS2 + PS3 + PS4)/4PP5))</td>
</tr>
<tr>
<td>NDX</td>
<td>Sequential indexing number for referencing data obtained during a grid set. Indexes for each position in the set</td>
</tr>
<tr>
<td>RUN</td>
<td>Sequential indexing number for referencing data. A constant throughout specified (or all) points of a survey.</td>
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</table>
Table 12. Continued

PROBE BODY-AXIS SYSTEM DEFINITIONS (FLOW FIELD)

Coordinate Directions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_B$</td>
<td>Parallel to the probe longitudinal axis, positive forward as seen by the pilot</td>
</tr>
<tr>
<td>$Y_B$</td>
<td>Perpendicular to the $X_B$ and $Z_B$ directions, positive to the right as seen by the pilot when the probe is at zero yaw and roll angles</td>
</tr>
<tr>
<td>$Z_B$</td>
<td>Perpendicular to the $X_B$ direction and parallel to the aircraft plane of symmetry when the probe and aircraft are at zero yaw and roll angles, positive downward as seen by the pilot when the probe is at zero pitch and roll angles</td>
</tr>
</tbody>
</table>

Origin

The probe reference point is the intersection of the plane containing the four static orifices and the probe centerline. The probe body-axis system origin is coincident with the probe reference point and is fixed with respect to the probe for the duration of the grid set. The $X_B$, $Y_B$ and $Z_B$ coordinate axes rotate with the probe in pitch, yaw and roll.

PROBE-AXIS SYSTEM DEFINITIONS (FLOW FIELD)

Coordinate Directions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_P$</td>
<td>Parallel to the probe longitudinal axis at the initialization of the grid set and rotated through pitch and yaw angles of $IP$ and $IY$, respectively, with respect to the aircraft longitudinal axes positive forward as seen by the pilot</td>
</tr>
<tr>
<td>$Y_P$</td>
<td>Perpendicular to the $X_P$ direction and parallel to the $X_P$-$Y_P$ plane, positive to the right as seen by the pilot</td>
</tr>
<tr>
<td>$Z_P$</td>
<td>Perpendicular to the $X_P$ and $Y_P$ directions, positive downward as seen by the pilot</td>
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</tbody>
</table>
Table 12. Concluded

**FLIGHT-AXIS SYSTEM DEFINITIONS (FLOW FIELD)**

**Coordinate Directions**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>$X_F$</td>
<td>Parallel to the aircraft flight path direction, positive forward as seen by the pilot</td>
</tr>
<tr>
<td>$Y_F$</td>
<td>Perpendicular to the $X_F$ and $Z_F$ directions, positive to the right as seen by the pilot</td>
</tr>
<tr>
<td>$Z_F$</td>
<td>Parallel to the aircraft plane of symmetry and perpendicular to the aircraft flight path direction, positive downward as seen by the pilot</td>
</tr>
</tbody>
</table>

**Origin**

The origin of the probe-axis and flight-axis coordinate systems was defined for this test as being the location of the MK-83 store nose tip (station 0.0) at the carriage position.