AEDC-TR-68-58

EXPANSION SIDE FLOW FIELD IMPACT PRESSURE SURVEYS OF A 75-DEG DELTA WING AT MACH NUMBER 10

C. J. Spurlin
ARO, Inc.

June 1968

VON KÁRMÁN GAS DYNAMICS FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE

NOTICES

EXPANSION SIDE FLOW FIELD IMPACT PRESSURE SURVEYS OF A 75-DEG DELTA WING AT MACH NUMBER 10

C. J. Spurlin
ARO, Inc.

FOREWORD

The work reported herein was done at the request of the Aerospace Research Laboratories (ARL) (AAR), Air Force Systems Command (AFSC), under Program Element 6144501F, Project 7064.

The results of tests presented were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), AFSC, Arnold Air Force Station, Tennessee, under Contract AF40(600)-1200. The tests were conducted from November 30 to December 20, 1967, under ARO Project No. VC0845, and the manuscript was submitted for publication on February 14, 1968.

This technical report has been reviewed and is approved.

Donald H. Meyer Major, USAF AF Representative, VKF Directorate of Test	Roy R. Croy, Jr. Colonel, USAF Director of Test

ABSTRACT

Impact pressure surveys were obtained in the leeward flow field of a 75-deg sharp leading-edge delta wing. Tests were conducted at a Mach number of 10.13, Reynolds number (based on model length) of 0.43×10^6, angles of attack of 15 and 19 deg, and zero sideslip angle. Abrupt pressure changes were observed in the flow field between the model surface and bow shock. Representative results are presented for $\alpha = 15$ deg.

CONTENTS

ILLUSTRATIONS

TABLE

NOMENCLATURE

M_∞ Free-stream Mach number

p_o Tunnel stilling chamber pressure, psia

p_o' Total pressure downstream of a normal shock in free-stream flow, psia

p_t	Probe pressure, psia
$Re_{\infty,\ell}$	Free-stream Reynolds number based on model length (7.00 in.)
T_o	Tunnel stilling chamber temperature, °R
x	Model surface distance measured downstream from model nose, in.
y	Vertical distance measured upward from model surface (see Fig. 2), in.
z	Lateral distance measured from the model centerline (see Fig. 2), in.
α	Model angle of attack (positive-instrumented surface leeward), deg
δ	Angle between normal to model surface and plane of probe tip movement (see Fig. 2), deg

SECTION I
INTRODUCTION

The objective of the tests was to obtain impact pressure surveys of the expansion side flow field of a 75-deg sharp leading-edge delta wing. The data were obtained for ARL to supplement an investigation of the delta wing expansion side flow field. Results of previous surface pressure and flow field survey tests (Ref. 1) showed the need for additional surveys to define more precisely a region of abrupt pressure change in the flow field between the model centerline and leading edge. This change was most apparent when the flow field was surveyed laterally with the probe at a fixed height from the model surface.

Tests were conducted in the von Kármán Gas Dynamics Facility (VKF) 50-in. hypersonic tunnel (Gas Dynamic Wind Tunnel, Hypersonic (C)) at a Mach number of 10.13, Reynolds number (based on model length) of 0.43×10^6, angles of attack of 15 and 19 deg, and zero sideslip angle.

SECTION II
APPARATUS

2.1 MODEL

A photograph and details of the model furnished by ARL are shown in Figs. 1 and 2, respectively. For previous surface pressure tests, the model was instrumented with twenty 0.062-in.-diam pressure orifices and had four thermocouples embedded in the upper surface to monitor model temperature. For the present tests, the pressure orifices were sealed. The leading-edge thickness was approximately 0.001 in.

2.2 WIND TUNNEL

Tunnel C is a continuous, closed-circuit, variable density wind tunnel with an axisymmetric contoured nozzle and a 50-in.-diam test section. The tunnel operates at a nominal Mach number of 10 or 12 at stagnation conditions from 200 to 2000 psia at 1900°R and 600 to 2000 psia at 2400°R, respectively. The model may be injected into the tunnel for a test run and then retracted for model cooling or model changes without interrupting the tunnel flow. A description of the tunnel may be found in Ref. 2.

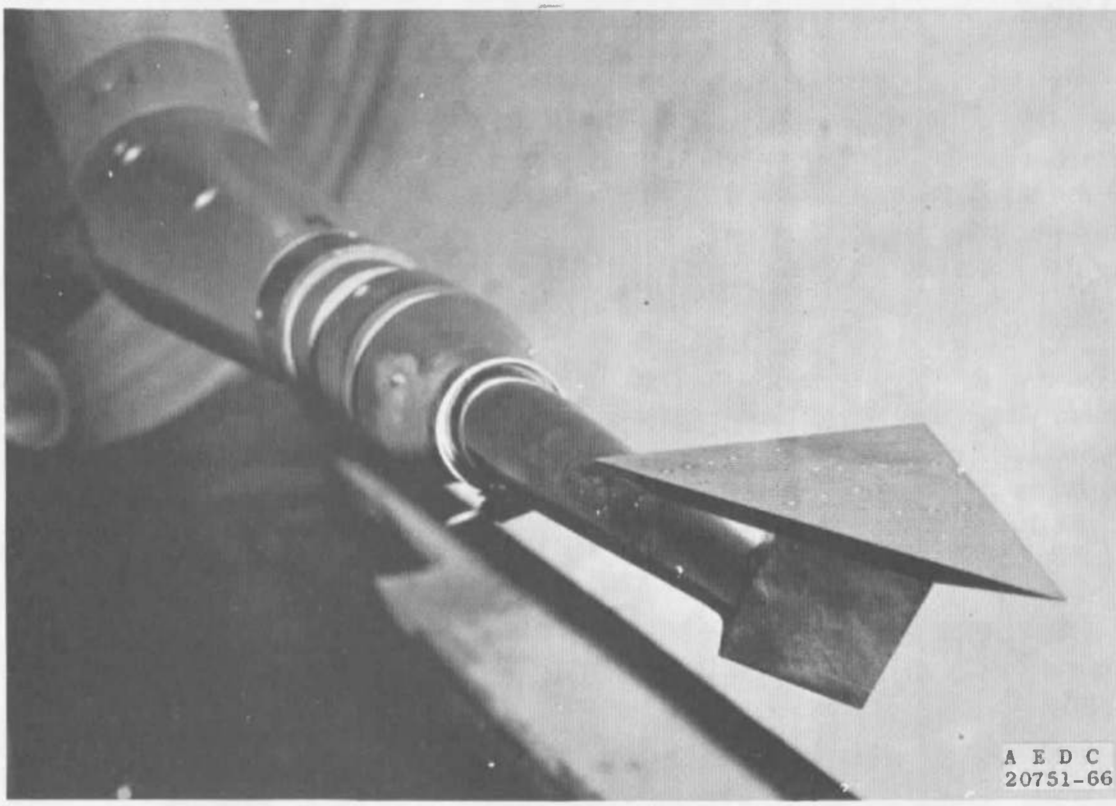
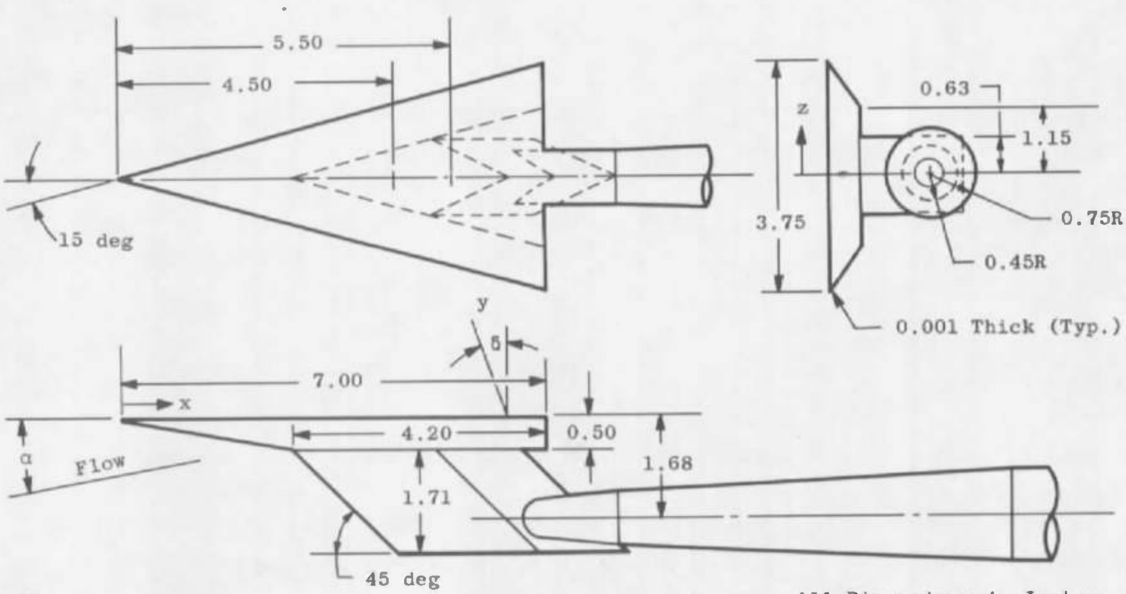


Fig. 1 Model Photograph



Note:

δ = 4.5 deg at α = 15 deg
δ = 8.5 deg at α = 19 deg

All Dimensions in Inches

Fig. 2 Model Details

2.3 INSTRUMENTATION

Probe pressures were measured with a 15-psid transducer referenced to a near vacuum and recorded with an analog plotter in the form of a continuous trace of pressure versus probe lateral position (z). The probe was constructed from a 0.040-in.-O.D., 0.005-in.-thick wall tube and was flattened at the forward end to 0.029 in. wide and 0.042 in. high to improve the definition of the lateral pressure gradients.

Probe pressure and lateral position linearity checks were made before and after the tests to ensure the integrity of the recording equipment. Known pressures were applied with a deadweight tester and probe lateral position (z) was monitored with a dial indicator attached to the lateral drive. Based on the linearity checks and repeat data, the precision of the plotter trace was estimated to be ±0.01 psia and ±0.013 in.

Schlieren and vapor screen photographs were obtained at selected angles of attack. A typical schlieren photograph is shown in Fig. 3 to illustrate the relationship of the probe to the model.

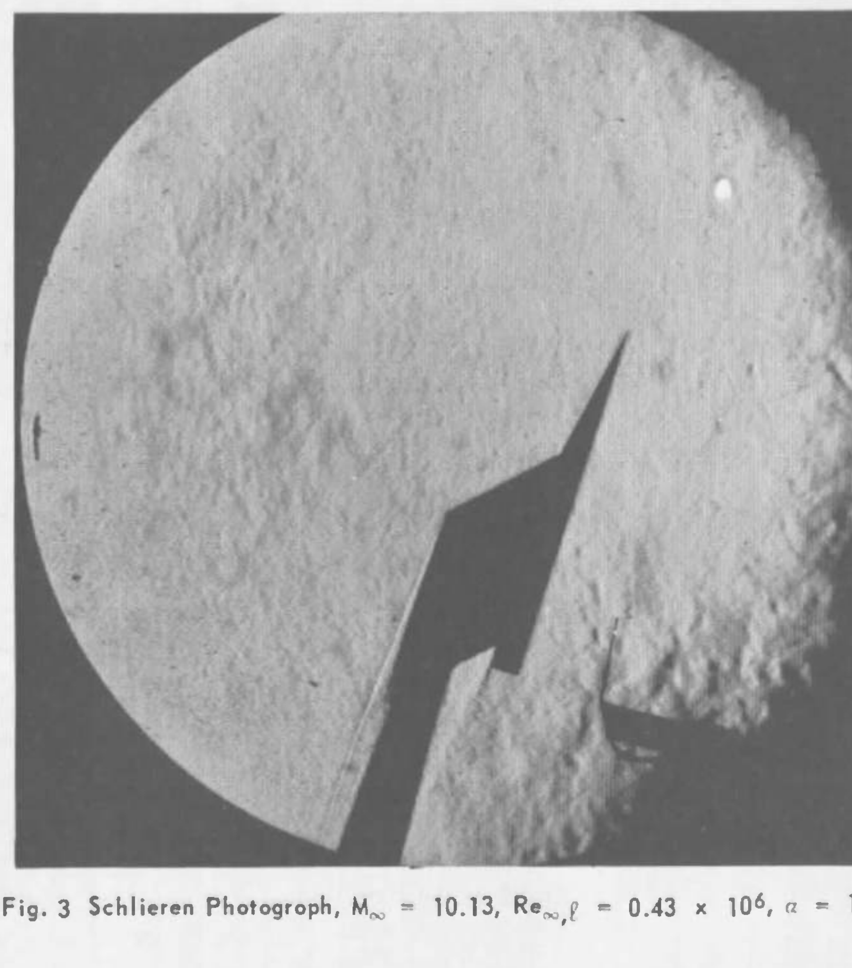


Fig. 3 Schlieren Photograph, M_∞ = 10.13, $Re_{\infty,\ell}$ = 0.43 × 10^6, α = 15 deg

SECTION III
PROCEDURE

A test summary is presented below.

TABLE I
TEST SUMMARY

Data	α, deg	x, in.	y, in.	M_∞	p_o, psia	T_o, °R	$Re_{\infty,\ell} \times 10^{-6}$	p_o', psia
Impact Pressure	15	4.50	A*	10.13	600	1835	0.43	1.66
	15	5.50	B*	↓	↓	↓	↓	↓
	19	5.50	C*	↓	↓	↓	↓	↓
Vapor Screen Photographs	5	3, 5, 7		10	600	760		
	10	3, 5, 7		↓	↓	↓		
	15	1, 3, 5, 7		↓	↓	↓		

*A lateral survey was obtained for each y listed below from z = 0 to free stream.

A: 0.125, 0.250, 0.500, 0.625, 0.750, 1.000, 1.125, 1.250, 1.312, 1.375, 1.562, 1.625, 1.687, 1.750, 1.812, 1.875

B: 0.250, 0.500, 0.625, 0.750, 0.875, 1.000, 1.250, 1.500, 1.562, 1.625, 1.687, 1.750, 1.812, 1.875, 1.937, 2.000, 2.125, 2.250, 2.312

C: 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 0.875, 1.000, 1.125, 1.250, 1.500, 1.750, 2.000, 2.250, 2.500, 2.750

A remotely controlled probe drive system was used to position the impact pressure probe in the x, y, and z directions. Because of limitations in the probe drive system and to eliminate the necessity of stopping the wind tunnel to make probe support geometry changes, the following compromises in probe positioning were made. The probe tip was inclined 15 deg to the free-stream flow and was therefore parallel to the model surface at α = 15 deg and inclined 4 deg into the model surface at α = 19 deg. Probe movement in the y-direction was in a plane inclined 79.5 deg to the horizon resulting in traverse angles (δ) (see Fig. 2) relative to a normal to the model surface.

Probe surveys were made by setting the x and y positions and then traversing in the z-direction from the model centerline plane (z = 0) to the free-stream flow. Surveys were made in both directions (i.e., centerline out and from free stream in) with no measurable differences caused by probe interference with the flow field.

SECTION IV
RESULTS AND DISCUSSION

A composite plot of probe pressure versus lateral position at several y-distances above the model surface for α = 15 deg and x = 5.50 in. is presented in Fig. 4. This is a reduced copy of the analog plotter traces with portions of the curves omitted for clarity. Of particular interest is that part of the curves near z ≈ 0.5 in. which shows an abrupt pressure change. The bow shock location is indicated by the sharp peaks.

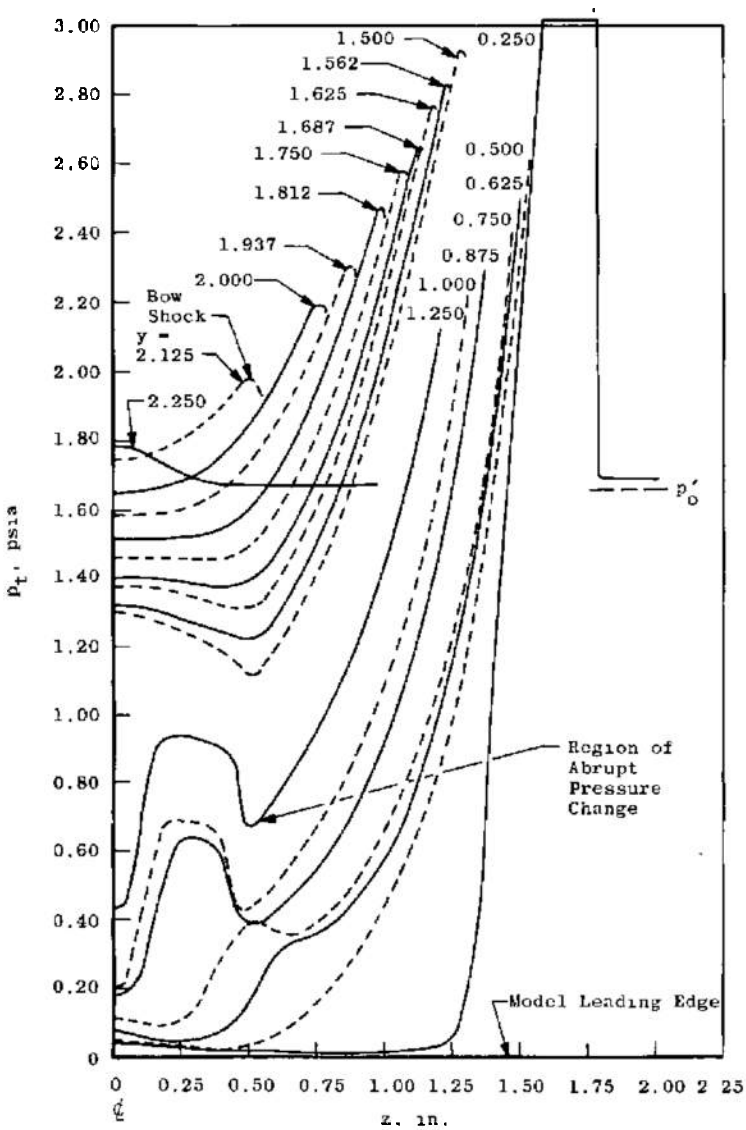


Fig. 4 Impact Probe Pressure Surveys, α = 15 deg, x = 5.50 in.

Figure 5 was made by plotting selected points from Fig. 4 to show a cross section of the flow field for α = 15 deg and x = 5.50 in. The region of abrupt pressure change is shown as a straight line extending from y ≈ 0.8 in. to y ≈ 1.6 in. at z ≈ 0.5 in. The curve representing the bow shock is incomplete for y less than 1.5 in. because the peaks of the pressure traces in Fig. 4 were off scale and could not be extrapolated accurately.

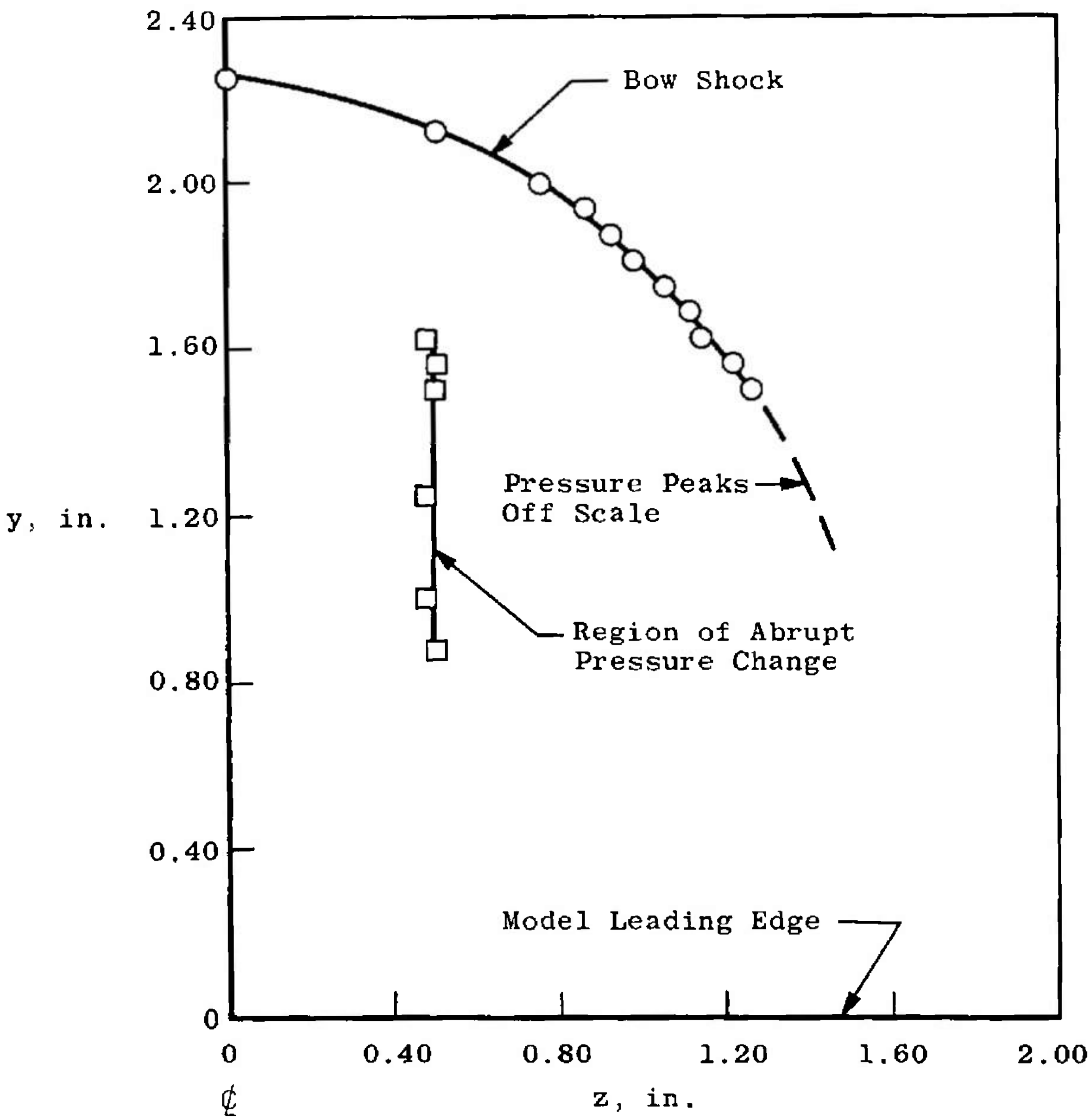


Fig. 5 Profile of Abrupt Pressure Change Region and Bow Shock, α = 15 deg, x = 5.50 in.

REFERENCES

1. Spurlin, C. J. "Expansion Side Flow Field Pressure Tests of a 75-deg Delta Wing at Mach Number 10." AEDC-TR-67-36, March 1967.

2. Test Facilities Handbook (6th Edition). "von Kármán Gas Dynamics Facility, Vol. 4." Arnold Engineering Development Center, November 1966.

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) Arnold Engineering Development Center ARO, Inc., Operating Contractor Arnold Air Force Station, Tennessee	2a REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b GROUP N/A

3 REPORT TITLE

EXPANSION SIDE FLOW FIELD IMPACT PRESSURE SURVEYS OF A 75-DEG DELTA WING AT MACH NUMBER 10

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

November 30 to December 20, 1967 - Final Report

5 AUTHOR(S) (Last name, first name, initial)

C. J. Spurlin, ARO, Inc.

6. REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
June 1968	13	2

8a CONTRACT OR GRANT NO. AF 40(600)-1200 b PROJECT NO. 7064 c. Program Element 6144501F d	9a ORIGINATOR'S REPORT NUMBER(S) AEDC-TR-68-58 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) N/A

10. AVAILABILITY/LIMITATION NOTICES

This document has been approved for public release and sale; its distribution is unlimited.

11 SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Available in DDC	Aerospace Research Laboratories (ARR), Wright-Patterson AFB, Ohio 45433

13 ABSTRACT

Impact pressure surveys were obtained in the leeward flow field of a 75-deg sharp leading-edge delta wing. Tests were conducted at a Mach number of 10.13, Reynolds number (based on model length) of 0.43×10^6, angles of attack of 15 and 19 deg, and zero sideslip angle. Abrupt pressure changes were observed in the flow field between the model surface and bow shock. Representative results are presented for α = 15 deg.

DD FORM 1 JAN 64 1473

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
hypersonic flow						
impact surveys						
pressure change						
delta wing						
high lift-to-drag ratio						