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14E. BUFFET DATA FROM M2391 DIAMOND WING

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INTRODUCTION

Unsteady aerodynamic loads may be described in terms of the aerodynamic excitation arising from unsteady separated flows (buffet) or the associated uncoupled structural response (buffeting). Buffeting response measurements are usually made on nominally rigid or aero-elastically tuned models, with buffeting levels determined from the narrow band response of wing root strain gauges or wing tip mounted accelerometers. In such cases the model structural dynamics are tuned to provide sufficient buffeting response.

Detailed studies have suggested that the first stage in the successful prediction of full scale "buffeting" must be the prediction of "buffet", unless a dynamically scaled structure can be employed. Early in the design stage, the structural characteristics of a configuration are generally unknown. Dynamically scaled models are also expensive to design and manufacture and are therefore not considered a practical solution. The use of traditional construction "flexible" models to measure "buffet" can lead to serious difficulties in the interpretation of aerodynamic data with the measured buffet excitation comprising components due to the unsteady flow field and components due to model vibration. Furthermore, the combination of a conventional wind tunnel model on a typical steel wind tunnel support structure frequently results in combined model and support natural frequencies in the region of aerodynamic interest for buffet measurement.

A buffet test technique was therefore developed at DERA Bedford to enable "pure" unsteady aerodynamic data to be acquired free from model and support structure interference. The technique centres around the use of low mass, high stiffness models with structural frequencies above the frequency range of aerodynamic interest and a new low natural frequency model support system referred to as the Buffet Support Fixture (BSF).

The BSF is shown in Figure 1 and comprises a 2-tonne mounting block attached to two stiff lateral box beams. The box structure is in turn suspended from the tunnel floor on flexible elastomeric bearings. The combination of a large mass on low stiffness mountings provides a support structure with only low natural frequency modes of vibration. The support system natural frequencies are lower than the buffet excitation frequencies expected for half models in the 13ft x 9ft low speed tunnel and are typically less than 17Hz. The BSF natural frequency can be tuned by the addition of extra mass to the block or by modification of the elastomeric bearings. High natural frequency buffet models are provided by low mass, high stiffness models fabricated using a carbon fibre and foam core construction technique. The combined model and support system structural interference is restricted to limits outside of the domain of aerodynamic interest providing a wide frequency window within which "pure" aerodynamic data can be measured.

The first wing buffet planform to be manufactured at DERA Bedford was model M2391. This model is a 40 degree leading edge sweep, half model diamond wing with a stream-wise clipped tip as shown in figure 2. The model was constructed using a carbon fibre and foam-core construction technique. A rigid foam core (Rohacell 51) was bonded to a 50mm thick aluminium root block and numerically-controlled machined from solid to the desired profile. The assembly was slotted to support internal instrumentation and skinned with an 8 layer carbon fibre laminate, each layer 0.125mm thick. A cold cure technique was employed, with each successive layer rotated through an additional 45° to provide the required directional strength. Although the 10% t/c ratio wing section shape is not representative it was generally agreed that the large scale buffet distribution and magnitude would be dominated by the low aspect ratio of the planform.

Model M2391 has interchangeable rectangular and chined fuselages, with the rectangular fuselage providing a perpendicular wing-fuselage interface. The chined fuselage allows the buffet due to mixed vortical flows to be studied. Figure 3 shows the model mounted in the DERA Bedford 13ft x 9ft low speed wind tunnel.

LIST OF SYMBOLS AND DEFINITIONS

α	model incidence, degrees
C_L	Lift coefficient -lift force (N)/qS
C_M	Pitching moment coefficient (about 25% mean aerodynamic chord)- Pitching moment (Nm)/qSc _{mac}
c _{mac}	Mean aerodynamic chord (m)

C_p	Pressure coefficient - $(P_{loc} - P_{\infty})/q$
P_{loc}	Local static pressure (Nm^{-2})
P_{∞}	Freestream static pressure (Nm^{-2})
P_{RMS}	Root mean square pressure fluctuations (Nm^{-2})
q	Freestream dynamic pressure (Nm^{-2})

PRESENTATION OF DATA

The data are supplied in ASCII files describe in the following paragraphs:

The file COORDS.DAT contains the coordinates of the 205 transducers, as given in table 1 but to greater precision in the file. Each record of the file contains the name of the transducer (5-characters) followed by the non-dimensional coordinates x/c and y/b in format 2F9.6.

The files CPxxDEG.TXT contain the steady C_p data and unsteady data as P_{RMS}/q for each transducer position for a test at incidence xx as specified in the file name. The first line is a heading and subsequent lines each contain a transducer name (5-characters) followed by the steady pressure in format F9.5 and the unsteady pressure value in format F9.6.

The files SPxxDEG.TXT contain the spectral data for each pressure transducer versus frequency. The data has been processed using 256 spectral lines giving a frequency resolution of 1.465 Hz with a maximum frequency of 300 Hz. The first line of the file contains the transducer names (format 204A6) and each subsequent line contains a frequency value (Hz) followed by the 204 spectral values, with all values in format E12.5. A sample of the data is given in table 3, showing the first 5 transducers and first frequencies and first 8 frequencies for the test at 24° incidence from file SP24DEG.TXT.

A FORTRAN code CH14.FOR is provided which demonstrates the reading of the data. The program includes a sample main segment which calls the data input subroutine CH14SEL and then lists the number of points read. This subroutine may be employed in a user's code to extract the data to serve as a model for other data extraction codes.

CH14SEL subroutine

A description of the subroutine call and arguments follows:

```

SUBROUTINE CH14SEL (NCH, INCID, TRAN, XYTRAN, FREQ, VAL, MAXF, MAXP, NF, NP)
C
C-- This routine reads and selects tables from the data file SET1.DAT
C   which contains the data of tables 5 to 18 of R702 data set 1.
C-- Arguments are as defined below (all except NCH must be variables):
C   Input values
C     NCH      channel number to be used for reading the input file
C     INCID    Specifies the required incidence (integer, degrees)
C     MAXF     The frequency-dimension of arrays in calling segment >=204
C     MAXP     The transducer-dimension of arrays in calling segment >=205
C   Returned values
C     NF       The number of frequency values
C     NP       The number of transducers
C     TRAN     The single element array of transducer names
C     XYTRAN   The two-dimension array of transducer locations
C             XYTRAN(i,j) denotes the chordwise (i=1) and spanwise (i=2)
C             position of the j-th transducer
C     FREQ     The single dimension array of frequency values
C     VAL      The values with VAL(i,j) denoting the value for the i-th
C             frequency at the j-th transducer location
C
REAL FREQ (MAXF), VAL (MAXF, MAXP), XYTRAN (2, MAXP)
CHARACTER *5 TRAN (MAXP), BUF

```

FORMULARY

1 General Description of model

1.1 Designation	M2391
1.2 Type	Half model
1.3 Derivation	Diamond wing
1.4 Additional remarks	Interchangeable fuselages, rectangular and chined
1.5 References	1

2 Model Geometry

2.1	Planform	Diamond wing
2.2	Aspect ratio	2.27
2.3	Leading edge sweep	+40°
2.4	Trailing edge sweep	-40°
2.5	Taper ratio	0.024
2.6	Twist	None
2.7	Wing centreline chord	1.994 m
2.8	Semi-span of model	1.160 m
2.9	Area of planform	1.185 m ² gross wing area
2.10	Location of reference sections and definition of profiles	Bi-convex section with constant 10% t/c ratio except at tip as noted below. Rounded leading and trailing edge radius with constant radius 3mm.
2.11	Lofting procedure between reference sections	Linear taper
2.12	Form of wing-body junction	a) Rectangular fuselage has perpendicular wing-fuselage interface b) Chined fuselage angled intersection with wing
2.13	Form of wing tip	Freestream aligned. Increased t/c at tip over last 50mm of span to permit flat upper and lower surfaces.
2.14	Control surface details	None
2.15	Additional remarks	Detailed drawings of model available from technical contact (Section 10).
2.16	References	1

3 Wind Tunnel

3.1	Designation	DERA Bedford 13ft x 9ft low speed wind tunnel
3.2	Type of tunnel	Continuous atmospheric with closed return circuit
3.3	Test section dimensions	Height 9ft (2.74m), width 13ft (3.96m), length= 36ft (10.97m)
3.4	Type of roof and floor	Closed – vented at trailing edge of working section
3.5	Type of side walls	Closed – vented at trailing edge of working section
3.6	Ventilation geometry	Vents at downstream of the working section - a ring of 118 slots 260mm long, 50mm wide, ducted to chamber with one way flaps to atmosphere.
3.7	Thickness of side wall boundary layer	Approx. 0.1m
3.8	Thickness of boundary layers at roof and floor	Approx. 0.1m
3.9	Method of measuring velocity	Working section and settling chamber static pressure tappings related to tunnel speed calibration.
3.10	Flow angularity	not available
3.11	Uniformity of velocity over test section	dynamic pressure constant to within 0.05% over a 2m ² reference plane normal to the flow axis in the working section.
3.12	Sources and levels of noise or turbulence in empty tunnel	Turbulence rms levels in 2 Hz to 1 KHz bandwidth: longitudinal 0.02% of u at 15 m/s rising to 0.04% at 61 m/s; vertical and lateral components 0.02% rising to 0.1% for the same speed range.
3.13	Tunnel resonances	Not available
3.14	Additional remarks	None
3.15	References on tunnel	2

4 Model motion

- | | | |
|-----|--|--|
| 4.1 | General description | High natural frequency model mounted on Buffet Support Fixture (BSF), a large mass/low stiffness support to give low frequency mounting. |
| 4.2 | Natural frequencies and normal modes of model and support system | Model wing first bending approx. 153 Hz, wing second bending and first torsion approx. 350 Hz. Highest frequency of BSF mounting system was rigid body roll at 17 Hz |

5 Test Conditions

- | | | |
|------|---|--|
| 5.1 | Model planform area/tunnel area | 0.11 |
| 5.2 | Model span/tunnel height | 0.42 |
| 5.3 | Blockage | Function of angle of attack |
| 5.4 | Position of model in tunnel | Mounted from floor |
| 5.5 | Range of velocities | 50 m/s |
| 5.6 | Range of tunnel total pressure | 102.9kPa |
| 5.7 | Range of tunnel total temperature | Approximately 2°C to 13°C according to atmospheric conditions |
| 5.8 | Range of model steady or mean incidence | 0 to 30° |
| 5.9 | Definition of model incidence | Mean planform plane of symmetric model was used as datum for incidence |
| 5.10 | Position of transition, if free | Unknown. |
| 5.11 | Position and type of trip, if transition fixed | None |
| 5.12 | Flow instabilities during tests | Not measured |
| 5.13 | Changes to mean shape of model due to steady aerodynamic load | Not measured but considered negligible due to high model stiffness. |
| 5.14 | Additional remarks | None |
| 5.15 | References describing tests | 1 |

6 Measurements and Observations

- | | | |
|------|---|--|
| 6.1 | Steady pressures for the mean conditions | Yes |
| 6.2 | Steady pressures for small changes from the mean conditions | No |
| 6.3 | Quasi-steady pressures | No |
| 6.4 | Unsteady pressures | Yes |
| 6.5 | Steady section forces for the mean conditions by integration of pressures | No |
| 6.6 | Steady section forces for small changes from the mean conditions by integration | No |
| 6.7 | Quasi-steady section forces by integration | No |
| 6.8 | Unsteady section forces by integration | No |
| 6.9 | Measurement of actual motion at points of model | No |
| 6.10 | Observation or measurement of boundary layer properties | No |
| 6.11 | Visualisation of surface flow | Yes |
| 6.12 | Visualisation of shock wave movements | No |
| 6.13 | Additional remarks | Steady forces measured on half model balance |

7 Instrumentation

7.1	Steady pressure	
7.1.1	Position of orifices spanwise and chordwise	205 pressure tapings, located on 13 spanwise stations, see figure 2 and table 1. The data of table 1 is also presented as an electronic file.
7.1.2	Type of measuring system	Druck differential pressure transducers (± 7 kPa) mounted in each Scanivalve.
7.2	Unsteady pressure	
7.2.1	Position of orifices spanwise and chordwise	a) 16 unsteady pressure transducers , see figure 2 b) Unsteady data also extracted from the 205 static pressure tapings – see ref 1 and 3
7.2.2	Diameter of orifices	1mm
7.2.3	Type of measuring system	a) Unsteady pressure transducers b) Unsteady data extracted from Scanivalve pressure fluctuations – see ref 1 and 3
7.2.4	Type of transducers	a) Entran EPE-55 (± 2 psi) pressure transducers b) see 7.1.2
7.2.5	Principle and accuracy of calibration	a) Steady state sensitivity from applied reference and calibration pressures. Accuracy as stated by transducer manufacturer. b) Frequency domain corrections applied to data to correct for frequency response of pressure tubes. See ref. 3
7.3	Model motion	None
7.3.1	Method of measuring motion reference coordinate	N/A
7.3.2	Method of determining spatial mode of motion	N/A
7.3.3	Accuracy of measured motion	N/A
7.4	Processing of unsteady measurements	
7.4.1	Method of acquiring and processing measurements	Pressure transducer, accelerometer and Scanivalve signals recorded using an AD16V 16 bit ADC within a Concurrent Maxion 9000 series workstation. Signal quantisation and aliasing errors were reduced by amplification and filtering of the signals using Kemo VBF-35 phase matched programmable filter-amplifiers.
7.4.2	Type of analysis	Power Spectral Density spectra (PSD) obtained from pressure fluctuations after correction for the frequency response function of the pressure tubes (c.g. figure 4 and ref.3). Broad band RMS values were integrated from the PSD spectra between the limits of support and model dynamics (between 20 Hz and 150 Hz).
7.4.3	Unsteady pressure quantities obtained and accuracies achieved	Broadband RMS pressures and PSD functions. RMS repeatability indicated by RMS standard deviation of 0.8%. Good agreement has been demonstrated between data from unsteady transducers and the data processed from the steady pressure tapings at nearby locations. This is shown in figure 5 for two sample locations
7.4.4	Method of integration to obtain forces	None
7.5	Additional remarks	Steady state forces and moments were measured on the wind tunnel model balance.
7.6	References on techniques	1

8 Data presentation

8.1	Test cases for which data could be made available	50 m/s for incidence from 0° to 40°
8.2	Test cases for which data are included in	50 m/s for incidence from 0° to 28°

	this document	
8.3	Steady pressures	Values for each case
8.4	Quasi-steady or steady perturbation pressures	No
8.5	Unsteady pressures	Spectra and RMS for each pressure tapping and unsteady pressure transducer at each incidence
8.6	Steady forces or moments	Figure 6
8.7	Quasi-steady or unsteady perturbation forces	No
8.8	Unsteady forces and moments	No
8.9	Other forms in which data could be made available	Surface oil visualisations, figures 7 and 8
8.10	Reference giving other representations of data	1

9 Comments on data

9.1	Accuracy	
9.1.1	Mach number	$\pm 0.1\%$ of set speed
9.1.2	Steady incidence	± 0.01 degrees
9.1.3	Reduced frequency	N/A
9.1.4	Steady pressure coefficients	N/A
9.1.5	Steady pressure derivatives	N/A
9.1.6	Unsteady pressure coefficients	$\pm 1.0\%$ - see 7.4.3
9.2	Sensitivity to small changes of parameter	N/A
9.3	Non-linearities	N/A
9.4	Influence of tunnel total pressure	Not examined
9.5	Effects on data of uncertainty, or variation, in mode of model motion	N/A
9.6	Wall interference corrections	Longitudinal change in freestream static pressure applied to measured pressures as an increment in local static pressure coefficient. Steady forces processed with model solid and separated wake blockage.
9.7	Other relevant tests on same model	None
9.8	Relevant tests on other models of nominally the same shapes	See ref 4
9.9	Any remarks relevant to comparison between experiment and theory	None
9.10	Additional remarks	None
9.11	References on discussion of data	1

10 Personal contact for further information

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11 List of references

- 1 R Lynn, J Gibb, A Shires. 'Buffet tests on a 40 degree diamond wing – Model M2391', DERA/MSS4/TR98309/1.0, August 1998.
- 2 M H Hunter. 'A guide to the DERA 13ft x 9ft Low Speed Wind Tunnel facility', DERA/AS/HWA/TR97636/1.0, June 1998.
- 3 R J Lynn. 'Dynamic calibration of tube-transducer systems for unsteady pressure measurements', DERA/AS/HWA/TR98022/1.0, January 1998.
- 4 M Woods, N J Wood. 'Unsteady aerodynamic phenomenon on novel wing planforms', ICAS 96, Vol.2, 11.2, 1996.

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Table 1. Pressure tapping nomenclature and absolute co-ordinates

tapping	(x/c)	(y/b)	tapping	(x/c)	(y/b)	tapping	(x/c)	(y/b)
S0101	0.010	0.087	S0303	0.054	0.230	S0417	0.474	0.301
S0102	0.036	0.087	S0304	0.074	0.230	S0418	0.531	0.301
S0103	0.053	0.087	S0305	0.092	0.230	S0419	0.588	0.301
S0104	0.074	0.087	S0306	0.120	0.230	S0420	0.647	0.301
S0105	0.097	0.087	S0307	0.146	0.230	S0421	0.707	0.301
S0106	0.121	0.087	S0308	0.179	0.230	S0422	0.768	0.301
S0107	0.149	0.087	S0309	0.221	0.230	S0423	0.832	0.301
S0108	0.184	0.087	S0310	0.248	0.230	S0424	0.896	0.301
S0109	0.251	0.087	S0311	0.297	0.230	S0501	0.010	0.373
S0110	0.347	0.087	S0312	0.341	0.230	S0502	0.037	0.373
S0111	0.429	0.087	S0313	0.381	0.230	S0503	0.060	0.373
S0112	0.531	0.087	S0314	0.426	0.230	S0504	0.080	0.373
S0113	0.647	0.087	S0315	0.476	0.230	S0505	0.099	0.373
S0114	0.768	0.087	S0316	0.531	0.230	S0506	0.123	0.373
S0115	0.896	0.087	S0317	0.588	0.230	S0507	0.152	0.373
S0201	0.010	0.159	S0318	0.647	0.230	S0508	0.184	0.373
S0202	0.033	0.159	S0319	0.768	0.230	S0509	0.223	0.373
S0203	0.053	0.159	S0320	0.896	0.230	S0510	0.254	0.373
S0204	0.069	0.159	S0401	0.010	0.301	S0511	0.306	0.373
S0205	0.090	0.159	S0402	0.036	0.301	S0512	0.338	0.373
S0206	0.123	0.159	S0403	0.055	0.301	S0513	0.369	0.373
S0207	0.151	0.159	S0404	0.082	0.301	S0514	0.425	0.372
S0208	0.180	0.159	S0405	0.100	0.301	S0515	0.479	0.373
S0209	0.218	0.159	S0406	0.116	0.301	S0516	0.531	0.373
S0210	0.288	0.159	S0407	0.132	0.301	S0517	0.588	0.373
S0211	0.335	0.159	S0408	0.154	0.301	S0518	0.647	0.373
S0212	0.378	0.159	S0409	0.184	0.301	S0519	0.707	0.373
S0213	0.432	0.159	S0410	0.213	0.301	S0520	0.768	0.373
S0214	0.531	0.159	S0411	0.249	0.301	S0521	0.832	0.373
S0215	0.647	0.159	S0412	0.278	0.301	S0522	0.896	0.373
S0216	0.768	0.159	S0413	0.304	0.301	S0601	0.010	0.444
S0217	0.896	0.159	S0414	0.339	0.301	S0602	0.036	0.444
S0302	0.036	0.230	S0416	0.432	0.301	S0604	0.085	0.444
S0301	0.010	0.230	S0415	0.389	0.301	S0603	0.059	0.444

Table 1 (continued) Pressure tapping nomenclature and absolute co-ordinates

tapping	(x/c)	(y/b)	tapping	(x/c)	(y/b)	tapping	(x/c)	(y/b)
S0605	0.102	0.444	S0718	0.769	0.515	S1007	0.437	0.729
S0606	0.125	0.444	S0719	0.832	0.515	S1008	0.532	0.729
S0607	0.148	0.444	S0720	0.897	0.515	S1009	0.647	0.729
S0608	0.190	0.444	S0801	0.010	0.587	S1010	0.769	0.729
S0609	0.223	0.444	S0802	0.040	0.587	S1011	0.897	0.729
S0610	0.259	0.444	S0803	0.060	0.587	S1101	0.035	0.800
S0611	0.302	0.444	S0804	0.094	0.587	S1102	0.086	0.800
S0612	0.338	0.444	S0805	0.134	0.587	S1103	0.125	0.800
S0613	0.386	0.444	S0806	0.183	0.587	S1104	0.208	0.800
S0614	0.438	0.444	S0807	0.260	0.586	S1105	0.243	0.800
S0615	0.482	0.444	S0808	0.350	0.587	S1106	0.342	0.800
S0616	0.531	0.444	S0809	0.439	0.587	S1107	0.418	0.800
S0617	0.588	0.444	S0810	0.531	0.587	S1108	0.532	0.800
S0618	0.647	0.444	S0811	0.647	0.587	S1109	0.648	0.800
S0619	0.707	0.444	S0812	0.707	0.587	S1110	0.769	0.800
S0620	0.769	0.444	S0813	0.769	0.587	S1111	0.897	0.800
S0621	0.832	0.444	S0814	0.832	0.587	S1201	0.075	0.872
S0622	0.896	0.444	S0815	0.896	0.587	S1202	0.126	0.872
S0701	0.012	0.515	S0901	0.017	0.658	S1203	0.186	0.872
S0702	0.036	0.515	S0902	0.064	0.658	S1204	0.270	0.872
S0703	0.053	0.515	S0903	0.124	0.658	S1205	0.327	0.872
S0704	0.076	0.515	S0904	0.194	0.658	S1206	0.434	0.872
S0705	0.102	0.515	S0905	0.245	0.658	S1207	0.533	0.872
S0706	0.119	0.515	S0906	0.341	0.658	S1208	0.649	0.872
Sf0707	0.185	0.515	S0907	0.427	0.658	S1209	0.769	0.872
S0708	0.252	0.515	S0908	0.532	0.658	S1210	0.897	0.872
S0709	0.293	0.515	S0909	0.647	0.658	S1301	0.182	0.943
S0710	0.333	0.515	S0910	0.769	0.658	S1302	0.280	0.943
S0711	0.385	0.515	S0911	0.897	0.658	S1303	0.377	0.943
S0712	0.429	0.515	S1001	0.037	0.729	S1304	0.533	0.943
S0713	0.479	0.515	S1002	0.075	0.729	S1305	0.649	0.943
S0714	0.531	0.515	S1003	0.124	0.729	S1306	0.771	0.943
S0715	0.588	0.515	S1004	0.184	0.729	S1307	0.896	0.943
S0716	0.647	0.515	S1005	0.278	0.729			
S0717	0.707	0.515	S1006	0.335	0.729			

Table 2. Sample of the pressure data contained on file CP04DEG.TXT (4^o incidence case)

Tapping Cp	Prms/q	S0417	-0.39411	0.002200	S0718	-0.28663	0.002120	
S0101	-0.37640	0.023467	S0418	-0.39039	0.002308	S0719	-0.22732	0.002231
S0102	-0.28155	0.002484	S0419	-0.36670	0.002203	S0720	-0.15643	0.002586
S0103	-0.28481	0.002203	S0420	-0.35108	0.002062	S0801	-0.88729	0.020439
S0104	-0.28982	0.002091	S0421	-0.31729	0.002115	S0802	-0.77675	0.020439
S0105	-0.29281	0.002144	S0422	-0.26925	0.002267	S0803	-0.60834	0.029906
S0106	-0.30844	0.001996	S0423	-0.19946	0.002375	S0804	-0.43388	0.021484
S0107	-0.31755	0.002199	S0424	-0.13202	0.002312	S0805	-0.42281	0.010071
S0108	-0.34170	0.002024	S0501	-0.79374	0.022483	S0806	-0.43863	0.006713
S0109	-0.35270	0.002112	S0502	-0.65215	0.034271	S0807	-0.45491	0.005028
S0110	-0.35830	0.002114	S0503	-0.37757	0.027267	S0808	-0.46396	0.003342
S0111	-0.35752	0.002333	S0504	-0.33910	0.015499	S0809	-0.46194	0.002734
S0112	-0.34437	0.002141	S0505	-0.33597	0.010158	S0810	-0.44000	0.002853
S0113	-0.29906	0.002916	S0506	-0.30577	0.007574	S0811	-0.38024	0.002541
S0114	-0.23422	0.003456	S0507	-0.32575	0.005536	S0812	-0.33871	0.002427
S0115	-0.10474	0.003520	S0508	-0.34483	0.004293	S0813	-0.29366	0.002509
S0201	-0.87056	0.025597	S0509	-0.34079	0.003774	S0814	-0.23383	0.002483
S0202	-0.29125	0.015539	S0510	-0.37360	0.003189	S0815	-0.16535	0.003741
S0203	-0.28305	0.005993	S0511	-0.38493	0.003231	S0901	-0.94601	0.021361
S0204	-0.29880	0.003571	S0512	-0.38388	0.003716	S0902	-0.68757	0.044259
S0205	-0.31469	0.002751	S0513	-0.41891	0.002550	S0903	-0.41819	0.016281
S0206	-0.32718	0.002511	S0514	-0.41429	0.002530	S0904	-0.45621	0.008037
S0207	-0.33356	0.002437	S0515	-0.40901	0.002329	S0905	-0.47769	0.005517
S0208	-0.34307	0.002363	S0516	-0.39938	0.002348	S0906	-0.48433	0.003565
S0209	-0.35147	0.002418	S0517	-0.39163	0.002118	S0907	-0.46148	0.003261
S0210	-0.36885	0.002345	S0518	-0.35947	0.002062	S0908	-0.44827	0.002641
S0211	-0.36995	0.002143	S0519	-0.32881	0.002250	S0909	-0.39951	0.002472
S0212	-0.37711	0.002298	S0520	-0.26502	0.002143	S0910	-0.30713	0.002349
S0213	-0.37581	0.002357	S0521	-0.21222	0.002198	S0911	-0.17726	0.002768
S0214	-0.36195	0.002496	S0522	-0.13716	0.002596	S1001	-1.07328	0.028864
S0215	-0.32725	0.002135	S0601	-0.82069	0.022663	S1002	-0.65176	0.051230
S0216	-0.24705	0.002331	S0602	-0.82603	0.026817	S1003	-0.46337	0.017044
S0217	-0.11529	0.002394	S0603	-0.44775	0.043792	S1004	-0.48199	0.010793
S0301	-0.86001	0.035587	S0604	-0.31788	0.016914	S1005	-0.48720	0.006489
S0302	-0.31338	0.038050	S0605	-0.34014	0.010818	S1006	-0.49755	0.005017
S0303	-0.27934	0.010804	S0606	-0.35381	0.006754	S1007	-0.47867	0.003765
S0304	-0.30551	0.005938	S0607	-0.32627	0.005527	S1008	-0.45120	0.003446
S0305	-0.30668	0.004459	S0608	-0.35361	0.003715	S1009	-0.40224	0.002763
S0306	-0.32744	0.003329	S0609	-0.37021	0.003248	S1010	-0.31820	0.002555
S0307	-0.34131	0.002923	S0610	-0.38096	0.003305	S1011	-0.19386	0.002865
S0308	-0.35602	0.002720	S0611	-0.42262	0.002554	S1101	-1.05257	0.031377
S0309	-0.37132	0.002517	S0612	-0.44182	0.002436	S1102	-0.80579	0.048765
S0310	-0.38056	0.002213	S0613	-0.43876	0.002319	S1103	-0.55145	0.029608
S0311	-0.38981	0.002191	S0614	-0.42496	0.002434	S1104	-0.50360	0.011432
S0312	-0.38844	0.002713	S0615	-0.41383	0.002324	S1105	-0.51258	0.009152
S0313	-0.39196	0.002233	S0616	-0.40400	0.002642	S1106	-0.51545	0.005814
S0314	-0.39209	0.002373	S0617	-0.40244	0.002048	S1107	-0.50965	0.004757
S0315	-0.38707	0.002198	S0618	-0.37210	0.002047	S1108	-0.46955	0.003723
S0316	-0.37542	0.002247	S0619	-0.33949	0.002034	S1109	-0.42945	0.003250
S0317	-0.35342	0.002314	S0620	-0.27550	0.002081	S1110	-0.34248	0.002939
S0318	-0.33988	0.002098	S0621	-0.21808	0.002226	S1111	-0.21313	0.004897
S0319	-0.26144	0.002151	S0622	-0.14810	0.002331	S1201	-0.85734	0.022554
S0320	-0.12675	0.002499	S0701	-0.81464	0.021984	S1202	-0.77239	0.022466
S0401	-0.84810	0.024064	S0702	-0.83573	0.021538	S1203	-0.68711	0.025096
S0402	-0.52046	0.052762	S0703	-0.69668	0.042468	S1204	-0.56772	0.014972
S0403	-0.27022	0.020923	S0704	-0.42027	0.033537	S1205	-0.53888	0.011371
S0404	-0.30420	0.008472	S0705	-0.36605	0.014286	S1206	-0.51278	0.007208
S0405	-0.32133	0.005961	S0706	-0.37399	0.010536	S1207	-0.49455	0.005736
S0406	-0.34268	0.004220	S0707	-0.41031	0.005538	S1208	-0.44325	0.004686
S0407	-0.34020	0.003850	S0708	-0.44202	0.003965	S1209	-0.36852	0.004213
S0408	-0.35101	0.003413	S0709	-0.44358	0.003469	S1210	-0.25675	0.004392
S0409	-0.37041	0.002779	S0710	-0.44338	0.003180	S1301	-0.82037	0.030708
S0410	-0.33858	0.003149	S0711	-0.44286	0.002975	S1302	-0.61694	0.012421
S0411	-0.33584	0.002886	S0712	-0.44182	0.002819	S1303	-0.56961	0.007469
S0412	-0.40452	0.002208	S0713	-0.42678	0.002833	S1304	-0.49149	0.005062
S0413	-0.39287	0.002355	S0714	-0.42067	0.002856	S1305	-0.45784	0.004208
S0414	-0.40335	0.002127	S0715	-0.40387	0.002455	S1306	-0.44579	0.003354
S0415	-0.41344	0.002184	S0716	-0.36676	0.002642	S1307	-0.37757	0.003019
S0416	-0.40348	0.002403	S0717	-0.33643	0.002385			

Table 3. Sample data from spectrum file SP24DEG.TXTTest at incidence 24^o sample values shown for the first 5 transducers and first 8 frequencies

Freq. (Hz)	S0101	S0102	S0103	S0104	S0105
1.46500E+00	4.07630E-05	4.27847E-05	5.71330E-05	3.45853E-05	3.15013E-05
2.93000E+00	4.53870E-05	4.73784E-05	6.22269E-05	5.23849E-05	3.04545E-05
4.39500E+00	4.39129E-05	3.14200E-05	4.84005E-05	4.90865E-05	2.49529E-05
5.85900E+00	4.29258E-05	2.27708E-05	3.53050E-05	2.95438E-05	2.44439E-05
7.32400E+00	2.92946E-05	2.14469E-05	2.46458E-05	2.15162E-05	1.49071E-05
8.78900E+00	1.93204E-05	2.00130E-05	1.81076E-05	1.34836E-05	9.41825E-06
1.02540E+01	1.62893E-05	1.18886E-05	1.53177E-05	1.08384E-05	8.76493E-06
1.17190E+01	1.74268E-05	1.52507E-05	1.57682E-05	9.42644E-06	7.28511E-06

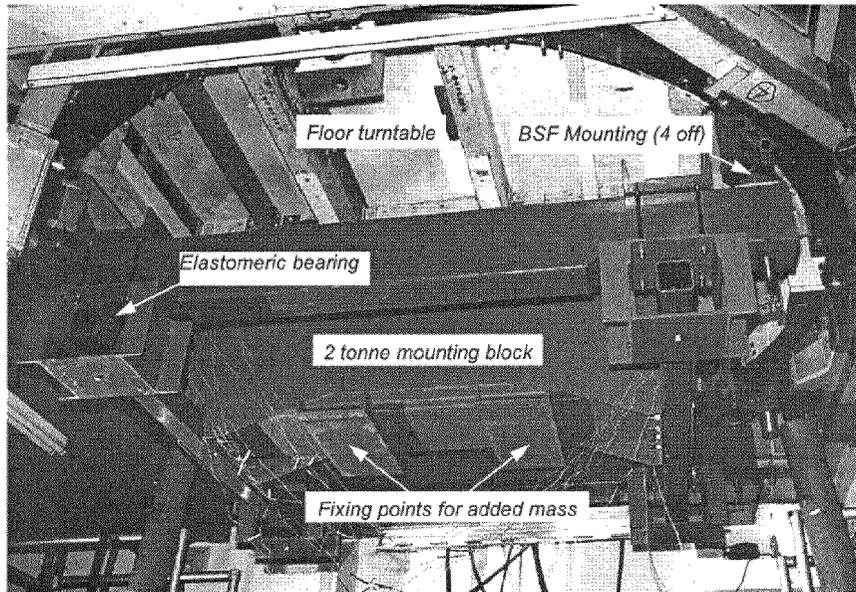


Figure 1

Buffet Support Fixture (BSF) mounted beneath the 13ft x 9ft Low Speed tunnel turntable

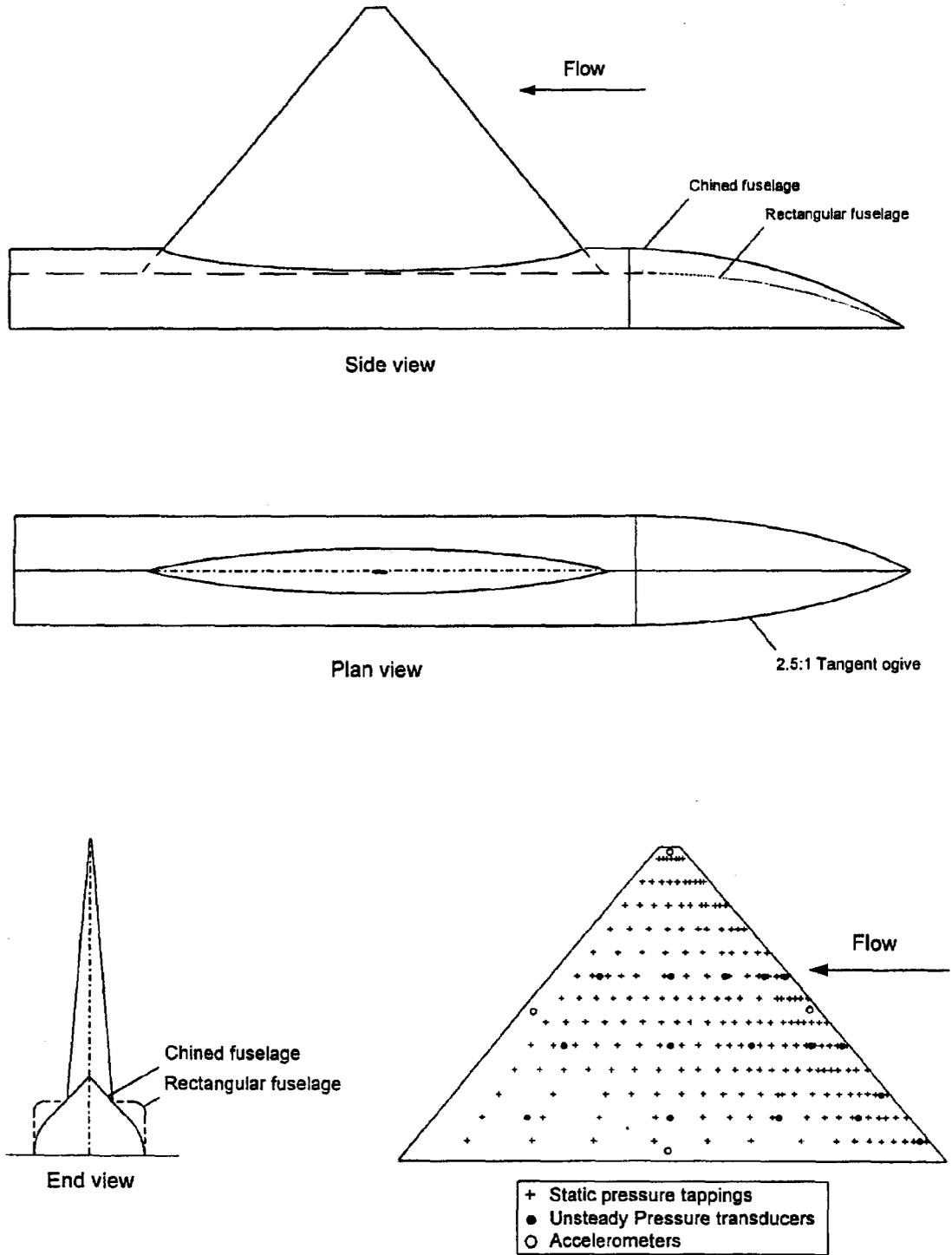


Figure 2
General arrangement of diamond wing half-model - M2391.

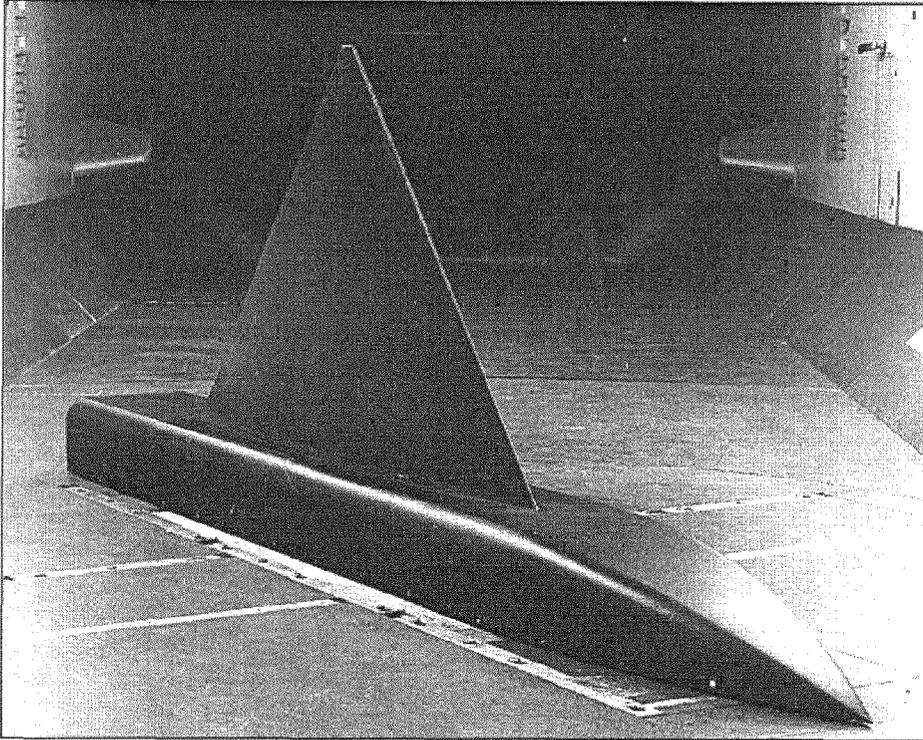


Figure 3

M2391 with chined fuselage installed in the DERA 13ft x 9ft low speed wind tunnel

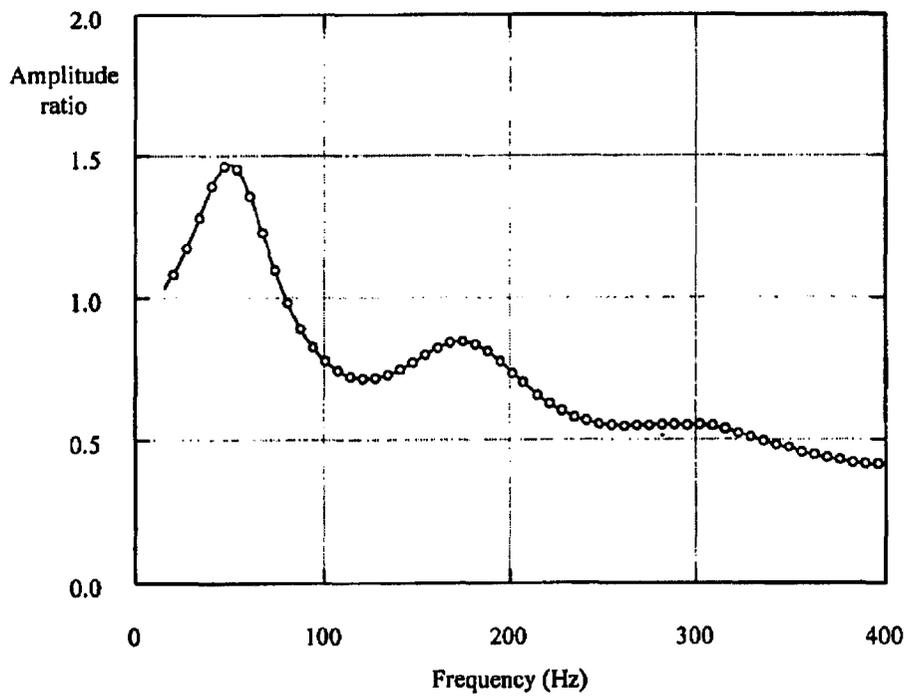
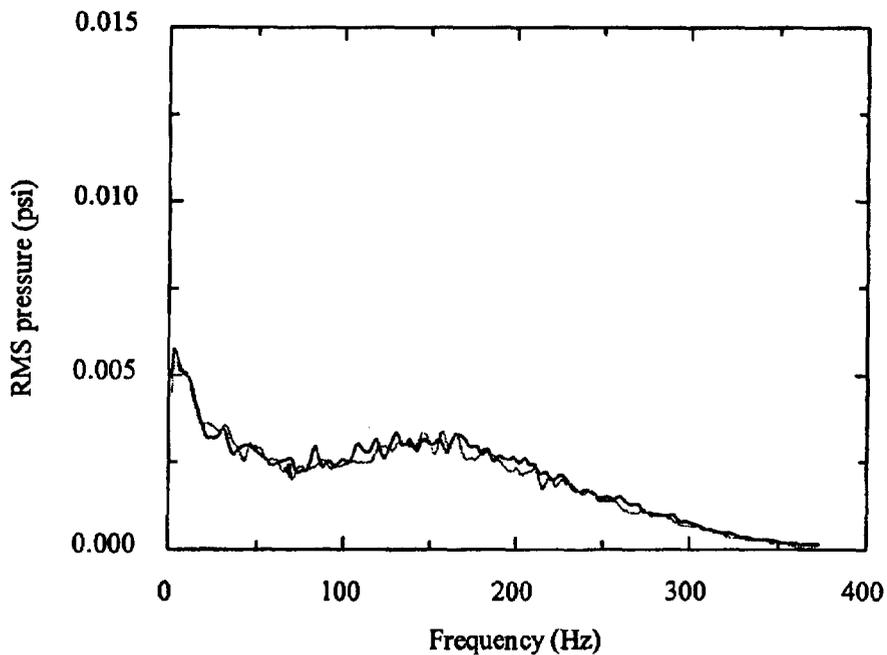
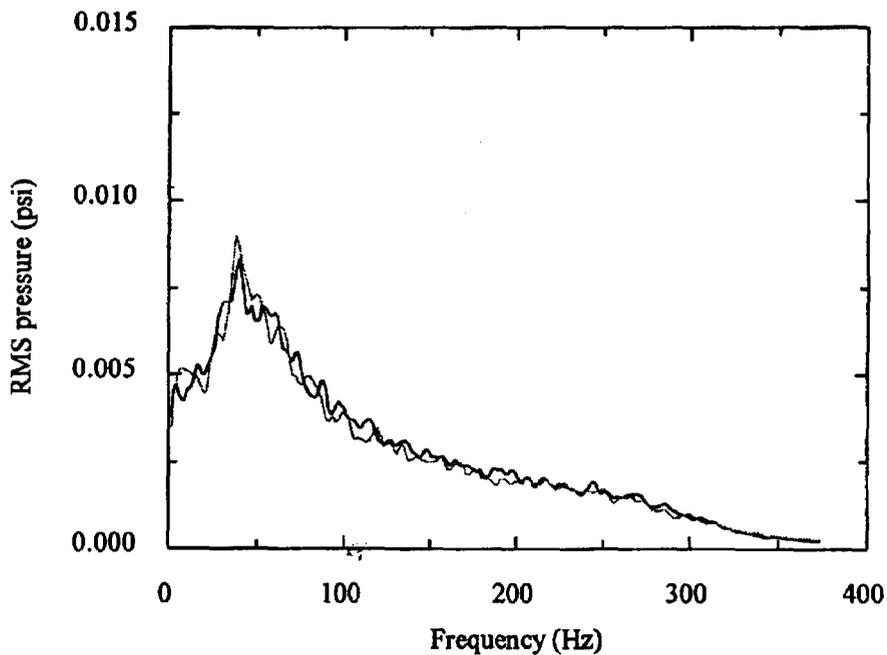


Figure 4

Typical frequency response function of M2391 tube transducer installation

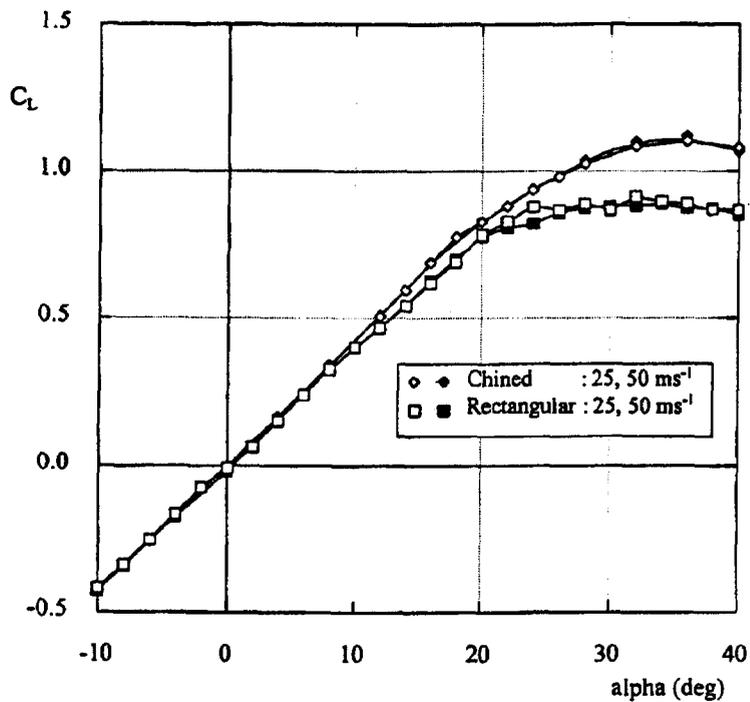


(a) Excitation at leading edge ($\alpha = 4^\circ$)

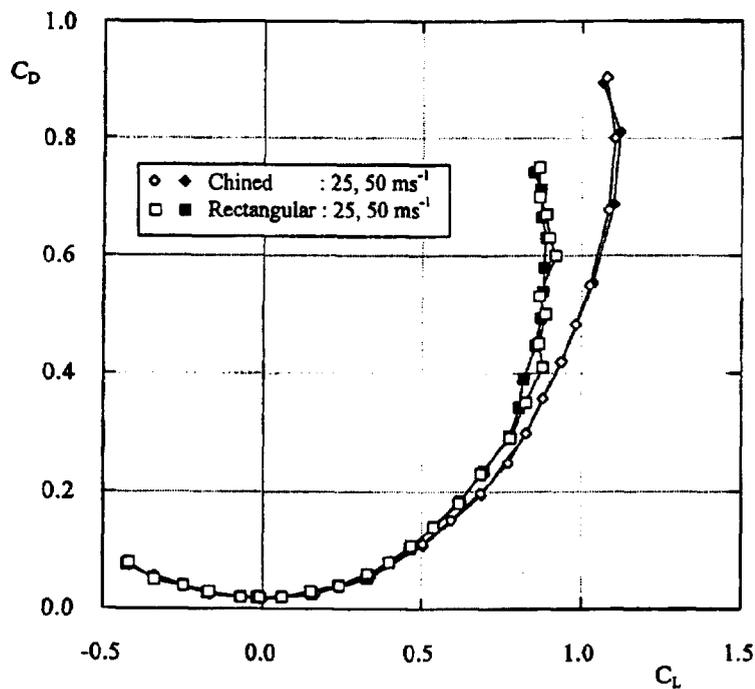


(b) Excitation near primary attachment ($\alpha = 6^\circ$)

Figure 5
Accuracy of spectral correction technique at two measurement stations



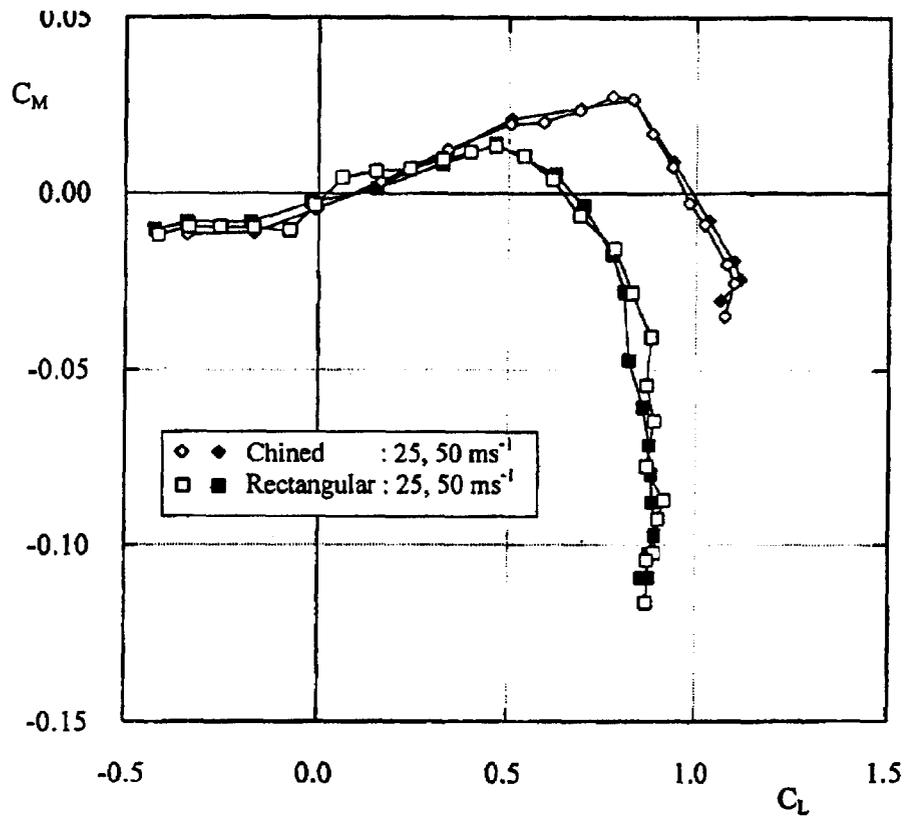
a) Variation of lift coefficient with incidence



b) C_D vs C_L polar

Figure 6

Model M2391 steady state force and moment results from half model balance



c) C_M vs C_L polar

Figure 6 (continued)

Model M2391 steady state force and moment results from half model balance.

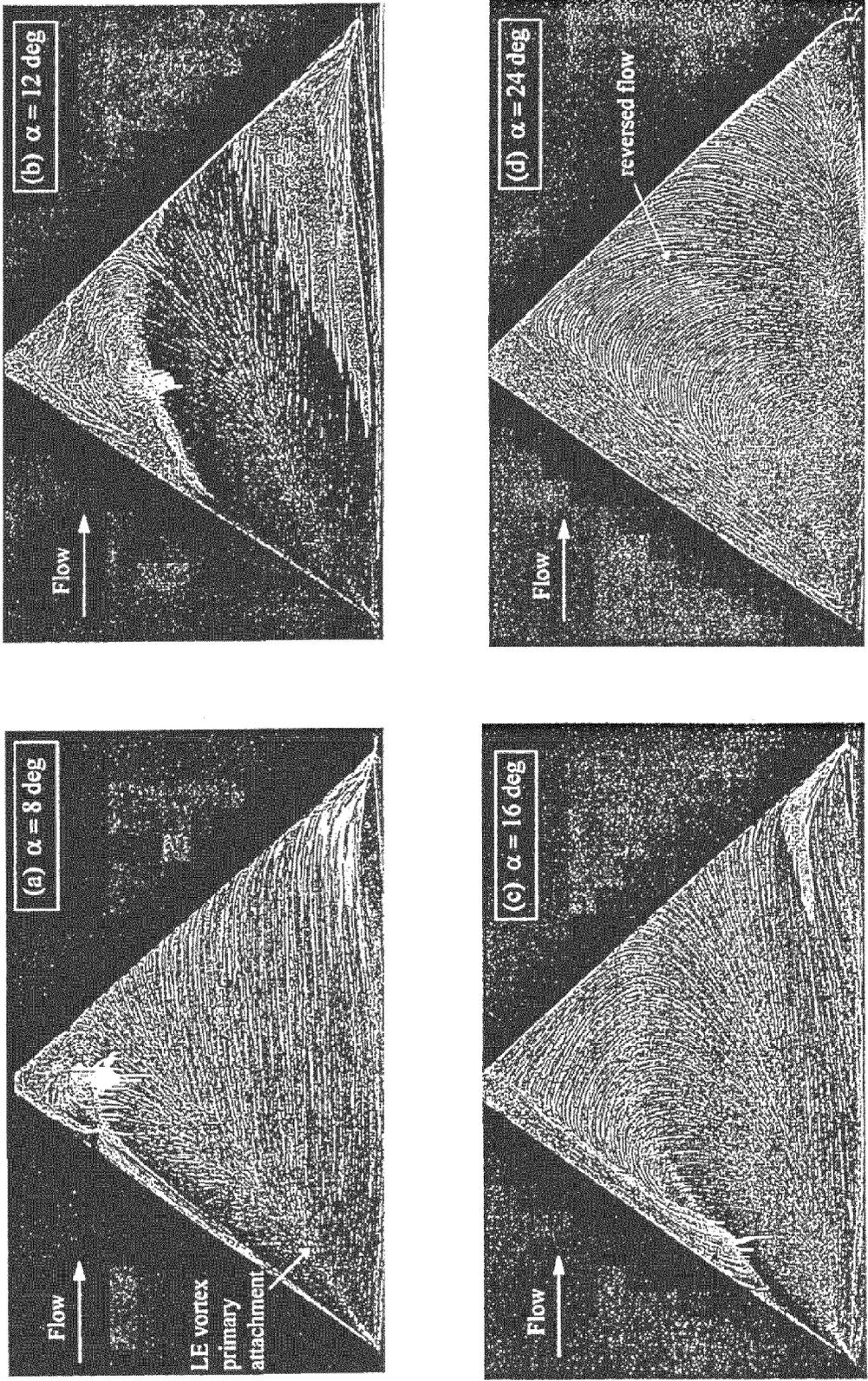


Figure 7
M2391 surface oil flow visualisation - rectangular fuselage configuration, $V = 50\text{ms}^{-1}$.

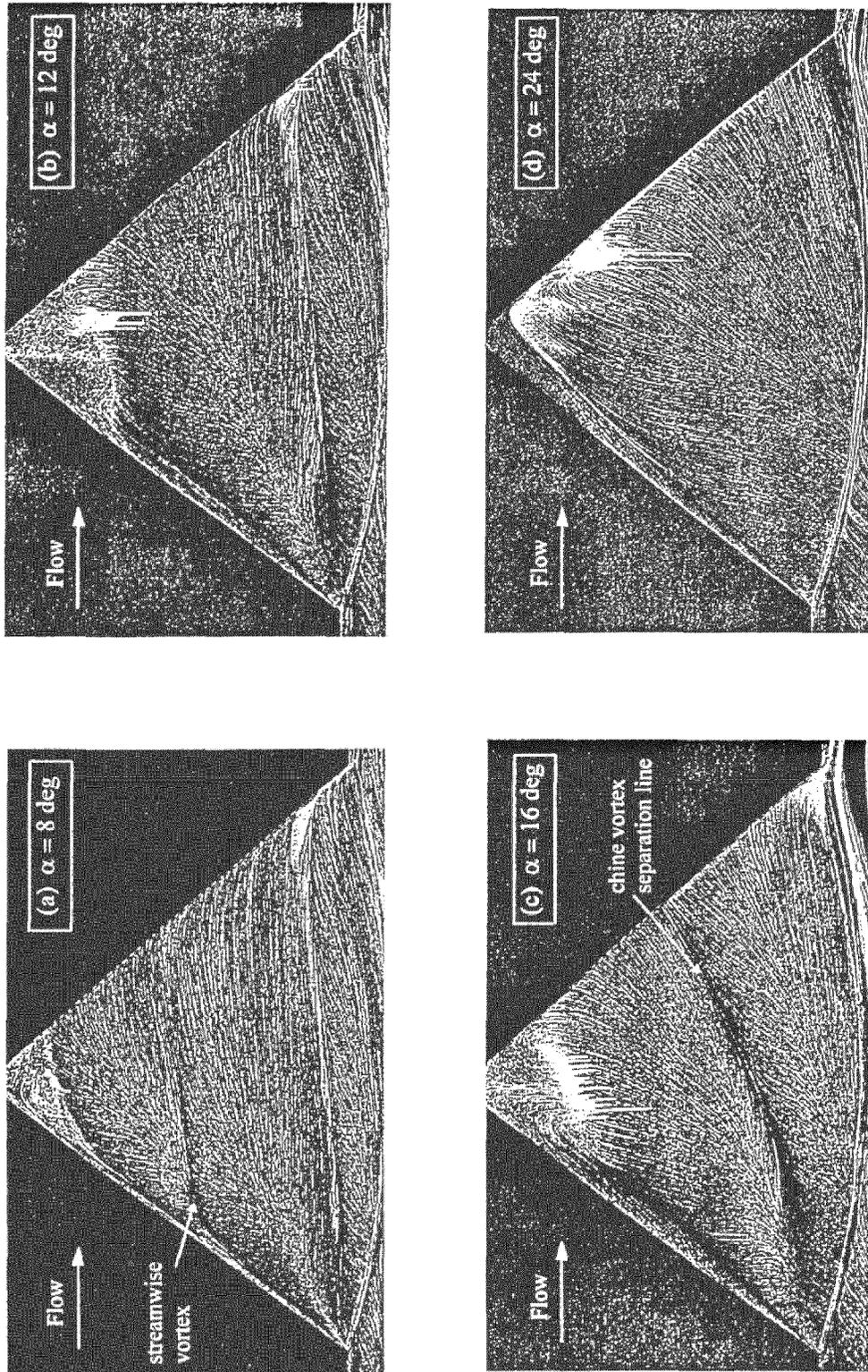


Figure 8
M2391 surface oil flow visualisation - chined fuselage configuration, $V=50 \text{ ms}^{-1}$.

