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PROCEDURES AND REQUIREMENTS FOR TESTING IN THE LANGLEY RESEARCH CENTER UNITARY PLAN WIND TUNNEL

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ABSTRACT

Information is presented to assist those interested in conducting wind-tunnel testing within the Langley Unitary Plan Wind Tunnel. Procedures, requirements, forms and examples necessary for tunnel entry are included.

SUMMARY

Procedures and requirements necessary for entry into the Langley Unitary Plan Wind Tunnel testing is presented. Pertinent information relative to models, instrumentation, data acquisition, and required forms is also presented to assist interested researchers. Included are blank forms, with examples thereof, which are required to solicit and conduct a wind-tunnel test within the Langley Unitary Plan Wind Tunnel.

INTRODUCTION

The Langley Unitary Plan Wind Tunnel is a two test section, continuous-flow facility with a variable pressure, temperature and Mach range from Mach 1.50 to 4.63. The facility was constructed under the Unitary Plan Act of 1949 (ref. 1). Brief descriptions are presented in the facility compilations of references 2, 3, and 4 and a more detailed description is presented in reference 5.

The basic elements of the Langley Unitary Plan Wind Tunnel are a 100,000-horsepower compressor drive system, a dry air supply and evacuating system, a cooling system, and the necessary interconnecting ducting to produce the proper air flow through either of the two test sections.

The low-range test section (number 1) has a design Mach number range of from 1.50 to 2.86. The stagnation pressure can be varied up to a maximum of approximately 60 psia. The high-range test section (number 2) has a design Mach number range of from 2.30 to 4.63. Its maximum stagnation pressure is approximately 150 psia.

The drive system consists of a 20,000-horsepower liquid-rheostat-controlled wound-rotor starting motor driving through a gear box to the main drive line-up. This line-up consists of a 63,333-horsepower synchronous motor driving six large-capacity centrifugal compressors. The combined maximum overload capacity of the two motors is 100,000 horsepower for 30 minutes. The compressors can be arranged in five different configurations by valves in the interconnecting ducting in order to provide the wide range of volume flows and compression ratios required for the two test sections. Since the capacity of the drive system will supply one of the test sections at a time, they cannot be operated simultaneously. The system that supplies air to the tunnel consists of compressors, vacuum pumps, and air dryer and air storage vessels. It supplies air to the tunnel at a dewpoint of lower than -65° and at the required stagnation pressure, and provides for evacuation and recharging of the tunnel or portions thereof for purging and starting.

TEST SECTIONS

Both test sections are of the asymmetric sliding-block, closed-working section type; the working section (region in which model is mounted) is 4 feet high, 4 feet wide, and approximately 7 feet long. Each test section will permit variation of Mach number at any desired increment throughout its range with the tunnel operating. Both stagnation pressure and stagnation temperature may be controlled independently. Access to each test section is provided by two doors which form the sidewalls of the test sections. The doors are rectangular and made up of nine strips of optical plate glass, each 5-1/2 inches wide and separated from each other by 1-1/4 inches of supporting structure. This arrangement permits the attainment of a large field of view while retaining excellent optical qualities. An alternate set of solid steel doors is available for sidewall model mounts and heat transfer tests. In addition, each test section is provided with an access hatch in the region of the diffuser.

Electric power is available at 110 and 440 volts alternating current and 12 and 24 volts direct current. Other power supplies, either alternating current or direct current, can be furnished only by special arrangement.

Many methods have been used to support models and probes depending on the objective of the test. The basic mechanism is the horizontal wall-mounted strut which is capable of forward and aft travel of 36.25 in. in the streamwise direction. To this strut is attached a sting support which has traverse and sideslip motion of ±20 in. and $\pm 12^{\circ}$ respectively. Forward of the sting support is the angle-of-attack mechanism which provides pitch motion from -15° to 30°. Just upstream of the pitch mechanism is the roll mechanism which provides continuous roll motion within a 310° range. The model is mounted to the roll mechanism by means of a sting. A wide assortment of sting sizes and lengths are available to provide specific model position and load requirements. In addition to several alternate pitch mechanisms, one of which can provide up to 90° angle of attack, there are assorted angular couplings and "dog-leg" or offset stings.

WIND-TUNNEL MODELS

The actual dimensions of models to be used depend upon so many factors that each case must be considered separately. The recommended maximum dimensions of a model for each of the test sections are listed in the following table:

	Low Mach number test section	High Mach number test section
Body diameter	7 inches	12 inches
Body length	30 inches	60 inches
Wing span	20 inches	34 inches

The model dimensions are the maximum dimensions that will permit testing at a Mach number of 1.5 in the low Mach number test section and 2.3 in the high Mach number test section over an angle-of-attack range from -2° to 20° and over an angle-of-sideslip range of ±12°. The maximum angle-of-attack range at any Mach number, in either test section, is from -13° to 28°. The use of larger models will reduce the allowable range of test angles.

Preliminary estimates of the angular range for a model at other than the above Mach numbers can be made using test section dimensions and conventional theoretical calculating methods for determining the reflected wave length.

The starting loads shall be assumed to be twice the maximum loads resulting from the maximum starting steady-state dynamic pressures. The maximum starting steady-state dynamic pressures correspond to a stagnation pressure of 5 psia and are 309 psi in the low Mach number test section and 184 psi in the high Mach number test section.

The models designed for inlet investigation shall duplicate the full-scale configuration for sufficient distance to assure inlet and boundary-layer flows corresponding to the full-scale configuration. All canard surfaces and other appurtenances to the forebody shall be included. Ducts through the fuselage or nacelles shall be simulated to the extent that air can flow through them with the design mass-flow ratio. Mass flow shall be controlled by choking a nozzle in the model. In scaling down the model any boundary-layer bleeds shall be modified to correct for the difference in Reynolds number. Provision shall be made for the installation of dynamic pressure pickups on the model at locations such that indication of incipient flow instability (buzz) can be obtained.

INSTRUMENTATION

Strain-gage balances used in the Langley Unitary Plan Wind Tunnel will generally be sting supported. The selection of a balance will be made at the time of the initial conference preparatory to the tests. Normally the balance will be furnished by the Langley Unitary Plan Wind Tunnel. These balances will satisfy the requirements of most airplane and missile configurations. Other balances with maximum normal forces up to 2,000 pounds and different distributions of force and moment ranges can be made available in most cases if necessary. The pitch center of the balance should be placed as closely as possible to the center-of-gravity location for the full-scale aircraft.

All calibration fixtures and supplementary equipment necessary for a complete calibration of the balance in the model and a determination of the alignment of the model and the balance will be furnished by the user. The user will also furnish all calibration fixtures and equipment for calibration and positioning of all control surfaces and all surfaces to be investigated.

DATA ACQUISITION

The data acquisition room is located between the two test sections in the Langley Unitary Plan Wind Tunnel Facility. This room contains two MODCOMP 32/85 computer systems with associated peripherals (terminals, printers, disks, magnetic tapes, etc.) networked together. Each computer system is part of a data acquisition system which includes D/A converters, analog and digital patchboards, control consoles, etc.

The computer equipment records raw data during the wind-tunnel tests and provides real-time engineering units computations which are printed, plotted, and stored as each data point is recorded. This allows the test engineer to validate data as it is being recorded and to be certain that his test objectives are being met. At the end of the test, the raw data are edited and recomputed as final data.

The experimental data files are stored both on disk and on magnetic tape point by point as each data point is being recorded (typically, 60 frames of data for each test point). Also, each channel scanned is listed on a lineprinter with setup information. A typical test consists of several hundred data points and generates 10,000 to 100,000 records.

ORGANIZATION

The NASA Langley Unitary Plan Wind Tunnel (UPWT) is located in building 1251 at Langley Research Center (LaRC). THe facility is managed by the Applied Aerodynamics Group (AAG) of the Supersonic/Hypersonic Aerodynamics Branch (SHAB), High-Speed Aerodynamics Division (HSAD). Additional support is supplied by the Data Systems Group (DSG) of the SHAB/HSAD and the Operational Support Division (OSD).

Tunnel operations require the active involvement of seven (7) technicians and three (3) engineers. Technician support is provided by OSD of LaRC. Two of the three engineers are provided by HSAD for the supervision and coordination of activities within the UPWT test sections and the Data Acquisition Room (DAR). In addition, an engineer is to be designated by the sponsoring agency or organization (NASA, Department of Defense, or Contractor) as project engineer for the test that is to be conducted. The titles and general responsibilities of the assigned engineers are as follows:

Project Engineer - Responsible for the solicitation, definition and support of the research test project. Provided by the sponsoring organization or agency.

Test Engineer - Responsible for directing and coordinating the activities in both the UPWT test sections and the DAR to ensure safe, reliable and efficient operation. Provided by AAG/SHAB/HSAD.

Data Systems Analyst - Responsible for DAR computer programing for "on-line" data acquisition, data reduction and preliminary data analysis. Provided by DSG/SHAB/HSAD.

PROCEDURES AND REQUIREMENTS

Prior to entry into either test section of the UPWT, for the purpose of conducting experimental wind-tunnel testing, certain procedures and requirements are to be followed and met. The purpose of this publication is to complement the information contained in reference 4 and to provide information relative to present requirements. Included are instructions and necessary forms, with examples thereof, that are to be prepared by the Project Engineer and delivered to the Test Engineer prior to tunnel entry date. Additional information and assistance, if needed, can be obtained from either the Test Engineer or the OSD Lead Technician. Specific duties and responsibilities of the Project Engineer are as follows:

1. Six (6) months prior to the desired tunnel entry date.
   a. Solicitation of tunnel test time is to be requested from the Facility Manager. This requires the completion and submittal of a "Unitary Plan Wind Tunnel Schedule Sheet" (enclosure 1). A copy of this form, along with "Guideline Information for UPWT Schedule Sheet" (enclosure 2), is included at the rear of this publication. A preliminary test review meeting will be scheduled and held to establish test suitability, length and priority. The Project Engineer should determine at this time the availability, number, capacity and type of instrumentation that will be required to conduct the requested test program.

2. Three months prior to the desired tunnel entry date.
   a. Provide stress-analysis reports and/or other data to the Facility Manager. The selection and use of all model components, support hardware, instrumentation, etc. for all the test parameters requested must fully meet all safety requirements of both UPWT and those published in LaRC "Wind-Tunnel Model Systems Criteria", L.H.B. 1710.15.

3. One month prior to the desired tunnel entry date.
   a. The model and a complete set of drawings shall be delivered to the UPWT.
   b. Ensure that all required instrumentation, special hardware, and model components are delivered to the UPWT. Both, the UPWT Test Engineer and the OSD Lead Technician, are to be informed of any prior shop fabrication needed for test entry, i.e., pressure tube extensions, leak checks and identification, special wiring, cables, fittings, etc.

4. Two weeks prior to the desired tunnel entry date.

   a. Provide four (4) completed copies of the "Unitary Plan Wind Tunnel Project Installation Check Sheet" (enclosure 3a). This form is to be filled out in its entirety. See "Miscellaneous Information Relating to the UPWT Project Installation Sheet", enclosure 3b.

   b. Provide four (4) completed copies of the "Unitary Plan Wind Tunnel Operating Information" form (enclosure 4a). This form should include both, standard operating information and any optional test conditions which might become necessary because of tunnel choking, balance overload, etc. "Operating Conditions" for the majority of wind tunnel tests in the UPWT are as follows:

	Test Section I	Test Section II
Mach Range	1.50 to 2.86	2.30 to 4.63
Rn/Ft	2.0×10^6	2.0×10^6
Stagnation Temp.	125°F. Mode I-IA	125°F. Mode 2-II, III
	125°F. Mode I-II	150°F. Mode 2-IV

   "UPWT Operating Information" for these run conditions is included as enclosure 4b. Information outside the range of enclosure 4b can be obtained from the Test Engineer or the UPWT DSG.

   c. Provide three (3) copies of "Unitary Plan Wind Tunnel Sting-Balance Deflection Loads" form (enclosure 5a) when sting-balance deflection constants are not available or need to be re-checked. Loads requested and limits must be indicated on the forms. In addition, balance information such as that shown in enclosures 5b, 5c, and 5d, is to be provided so that proper hook-up, a system span-check, and an axial force "dead-load" check can be made at the time of installation. This information can be obtained from either the UPWT DSG or the Instrument-Research Branch Balance Engineer. For safety reasons, requested loads should be limited to 450-500 pounds. For ease of computations, use the same applied loads for both Normal Force and Pitch Moment and the same for Side Force and Yawing Moment. Moment output can be selected by choice of moment arm. The Test Engineer will compute the deflection constants after the sting-balance loading. However, it is the responsibility of the Project Engineer to ensure that the results are reasonable and accurate.

d. Provide four (4) completed copies of the Electronic Scan Pressure System or Scanner-Valve Pressure Tube Hook-Up form (enclosure 6a and 6b).

Selection of type and number of pressure measuring devices must be coordinated with the AAG and DSG. The Project Engineer is responsible for determining the availability as well as the installation of all needed equipment. This is to be accomplished through contact with the Flow-Instrument Section of Wyle Laboratory, telephone 865-0000. It is routine practice, when possible, to identify and leak check all pressure connections through the data aquisition system before run start-up.

e. Provide two (2) copies of a "Test Run Schedule" (enclosure 7a and 7b). This schedule requires the approval of the Facility Manager. No major additions or large changes are permitted without prior approval of either the Test Engineer or the Facility Manager. Small changes, such as added data points during a run, shifting of configuration order, extra schliern pictures, etc., which would enhance or clarify the test data, are permitted. Request for additional data during a given run must be made prior to the beginning of a new run number.

f. Provide two (2) copies of the "Data Reduction Information" (enclosure 8) to the DSG.

5. During the test period.

a. Provide a "master" copy of each "Run Sheet" (enclosure 9a, 9b, and 9c) that will be needed during the test. This is to be done prior to start-up.

b. It will be the responsibility of the Project Engineer, or his designee, to be present during model installation, model changes, and while running. He is to assist and offer input to both the Test Engineer and the OSD Lead Technician to ensure that installation is as requested and that model configuration is correct. Failure to carry out this responsibility may result in not running, or job removal from the test section.

c. After tunnel start-up the Project Engineer, or his designee, is to be present in the DAR to observe, assist and moniter the data taking process. Any questions or discussion not related to the operation of the Model-Support Console should be directed to the Test Engineer. The primary duty of the Console Operator is the accurate and safe operation of the Model-Support System. Hold questions or discussion with the operator to a minimum while the tunnel is in operation. The Project engineer is to establish a "Balance Zero Log" (enclosure 10) and list balance "no-load readings" before, during, and after each batch of data as it is taken (a "batch" number is assigned, in numerical order, to each configuration change or configuration roll postion except in instances where control surfaces are remotely controlled while running). This not only facilitates easier data processing after the test is completed but gives a close check on any balance perculiarities or problems as they may occur, i.e., open balance component, fouling, temperature "zero" shifts, etc.

6. A blank copy of the various forms referenced in this document are contained in enclosure 11.

REFERENCES

1. Roland, Alex: Model Research, NASA SP-4103 Vol. II, pp.: 400, 1985.

2. Schaefer, William, T., Jr.: Characteristics of major Active Wind Tunnels at the Langley Research Center. NASA TMX-1130, 1965.

3. Aeronautical Facilities Catalogue, Vol. 1, Wind Tunnels, NASA RP-1132, January 1985.

4. Manual for Users of the Unitary Plan Wind Tunnel Facilities of the National Advisory Committee for Aeronautics. NACA 1956.

5. Jackson, Charlie M., Jr.; Corlett, William A., and Monta, William J.: Description and Calibration of the Langley Unitary Plan Wind Tunnel, NASA TP 1905, November 1981.

Date 6/86

UNITARY PLAN WIND TUNNEL SCHEDULE SHEET

Title SUPER FLYER II

Project Engineer(s) JONES, SMITH

RTOP XXX XX XXX

Data System Analyst(s) SNOW

Job Order R XXXXX

Sponsor HSAD

Model Available Date 1/87

Desired Schedule Date 1/87

T.S. # 1 Mach Nos. 1.5, 2.0, 2.5 Reynolds No(s). 2×10^6/FT.

Pitch Range −4° TO 20° Yaw Range ± 8° Roll Range 0° TO 180°

Schlieren ✓ Vapor Screen ✓ Oil Flow ✓

Overall Model Dimensions L = 36", b = 20"

Estimated Model Loads N.F. = 500 #, A.F. = 30 #

Number of Test Configurations 10

Est. Occupancy Time 2 WKS

Est. Run Time per Config. 4 HRS

Est. Total Run Time 40 HRS

Est. Time per Model Change 2 HRS

Est. Total Power KWH 1.04×10^6

Test Objective TO EVALUATE A SUPERSONIC WING DESIGN METHOD

Instrumentation Required FORCE BALANCE, PRESSURE TRANDUCERS

Data Reduction Requirements FORCES, MOMENTS AND SURFACE PRESSURES

Remarks

Enclosure 1

GUIDELINE INFORMATION FOR UPWT SCHEDULE SHEET

Test Section(T.S.)	Mode of Compression	Mach Range
1	1-I	1.47 to 2.16
1	1-II	2.36 to 2.86
2	2-II	2.29 to 2.96
2	2-III	3.00 to 3.71
2	2-IV	3.82 to 4.63

Estimated Procedure Time and Power Requirement

T.S. Model Installation - Force Test	16 hours
T.S. Model Installation - Pressure Test	24 hours
Tunnel start-up or shut-down	45 minutes
Change of Mach number (within Mode of Compression)	10 minutes
Change in Mode of Compression - T.S. 1	25 Minutes
Change in Mode of Compression - T.S. 2	10 minutes
Time per data point - Force test	2 minutes
Time per data point - Pressure test	4-6 minutes
Average total power per hour of run time	26,000 KW

Enclosure 2.

UNITARY PLAN WIND TUNNEL PROJECT INSTALLATION CHECK SHEET

Project No. 1546 J.O. RXXXXX

Test Section 1 Date 12/86

Model SUPER FLYER II

Classification UNC

Project Engineers DOE

Balance:
Designation 832 D
Engineer QUINN

Data System Analysis DOE

Test Starts 1/87 Ends 1/87

Balance Parallel Wired? NO

Type Test: Force ✓ Pressure ✓
Other —

Cable: Parallel ___ Non-Parallel ✓
Non-Parallel Adapter ✓

Operating Conditions:

Axial Force: Limit 85 lb.
Dead Load 20 lb.

Compressor Modes I, I-1A

Span Check: At Balance Taper ✓
10 ft. from Taper —

Mach Nos. 1.5, 2.0, & 2.5

Power Range 20 to 28 MW

Sting:
Furnished by NASA No. 350-8A
Deflections: NF ✓, PM ✓, SF ✓, YM ✓

Pitch Range −4° to 20° deg.

Yaw Range ±8° deg.

Adapters:
Model-to-Balance WITH MODEL
Balance-to-Sting NONE
Sting-to-Knuckle 8-3-A

Roll Range 0° to 180° deg.

Minimum Dew Point -10 deg.F. (Std.)

Transition:
Grit No. 50 Width 1/16"
Sprinkle ✓ Single Space —

Knuckle No. 3 Std. Arm ✓ Other —
Calibration ✓

Angular Coupling +5½°

Location (Perpendicular to L.E.):
Nose 1.2" Wing 0.25"
Tail ___ Other ___

Roll Coupling ✓ Number 2 Adapter —
Calibration @ 0°, 90° & 180° deg.

θ_M From: Cage-✓-Upright ✓ Invert. ✓
Model-✓-Upright ✓ Invert. —

Fouling Strip Required NO

Photography: Model 4"x5" - EACH BATCH
Schlieren AS REQUIRED
Other —

Orientation:
Roll Coupling UPRIGHT
Balance UPRIGHT
Model/Balance Adapter FWD DWL. HOLE
Model UPRIGHT

Remarks: ALINCO NACELLE PRESSURES ARE TO BE CONNECTED FOR 1ST 2 CONFIGURATIONS ONLY.

Pressure Transducers:
Type ESP AND ALINCO
Number Required 2 ESP MODULES, 6 ALINCO
Designation

ALINCO
#1 L. CHAMBER #2 R. CHAMBER
#3 L. BASE #4 R BASE
#5 INBD NAC. #6 OUTBD. NAC
#7 ___ #8 ___

Vapor Runs 2 CONFIG. Oil Flow 2 CONFIG

Mercury Lamps ✓ Laser —

Enclosure 3a

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MISCELLANEOUS INFORMATION RELATING TO UPWT PROJECT INSTALLATION CHECK SHEET

Model Transition (Grit) Selection

To ensure turbulent air flow over model surfaces a selection of grit size and location has been established for the following Mach ranges at a RN/FT = 2.0×10^6:

Test Section I

Mach number - Less than 2.87

Grit size - Number 50 carburundum (nominal)

Application - Sprinkled (sparse)

Width - 1/16 inch strip

Test Section II

Mach number - Less than 4.65

Grit size - Number 35 sand (nominal)

Application - Single spaced

Width - Single row

Grit location for all Mach numbers is 0.4 inch streamwise (See enclosure 3d for perpendicular distances) from the leading edge of all surfaces except the of the nose. Normal location for nose grit is 1.2 inch aft of the model nose measured along the surface. Grit should be sized for the Reynolds number and/or highest Mach number to be run. See enclosures 3c and 3d for transition size and surface location RN/FT = 2.0×10^6.

Theta Model (Θ_m) Measurement

The term Theta M refers to an angular difference between the model pitch reference and the reference flat located on the knuckle (angle of attack mechanism). This measurement is necessary because the measuring means for model pitch is a Kearfott angular accelerometer located on the base of the knuckle. The model pitch can be different from the knuckle pitch of several concurrent reasons including:

1. Weight of the model on the sting causing the sting to bend downward rotating the model more negative in angle of attack relative to the knuckle.

2. The center of gravity of the model can be forward or aft of the balance moment center which would increase or decrease the model angle of attack respectively.
3. An offset coupling or "dogleg" between the knuckle and the model can introduce an offset done purposefully to extend the model angle of attack range.
4. A bent sting or balance. Any sting or balance (unless designed with a bend) that is detected to be damaged, deformed or bent during theta cage (θ_C) measurements cannot be used in the UPWT without prior approval from the Facility Safety Head.

Theta M is always measured in the upright position for every configuration and in the inverted position, if an inverted run is to be made. Whenever a reference surface is not available on the model, the Theta M is computed by the Test Engineer knowing:

1. A term called Theta Cage (Θ_C).
2. The weight of the model.
3. The normal force sting deflection.
4. The distance between the model center of gravity and the balance center.
5. The pitching moment sting deflection.

These terms can be used to compute Theta M in place of a measured Theta M. Theta M can be simply pictured as the angular "droop" of a model on a long sting due to gravity.

Model Pitch and Roll References

All models are required to have pitch and roll references whether or not these references are external surfaces on the model. This information is supplied by the Project Engineer and must be considered in advance of tunnel entry. Model pitch is measured with an inclinometer or a bubble level on a model surface flat aligned with the model pitch and roll planes. This surface should be at least 3 inches in length and may or may not be parallel with the model waterline. If not, then the amount of difference and the direction must be known to the nearest 0.02 degree. The measurement must be repeatable and not dependent upon where the inclinometer is located. Model angle of attack is referenced to gravity.

Model roll angle, measured in reference to gravity, can be set at 0^{o} by the use of an inclinometer or bubble level placed on the model surface flat at an angle perpendicular to the model pitch plane. Another method can be used to set model roll angle at 0^{o} when no model surface flat is available. The tunnel floor is not level in the longitudinal direction because of the assymetric sliding block. However, the tunnel floor is level in the lateral direction. A vernier height gage is used to match the distance above the tunnel floor to the furthest span locations on the model.

Pressure Transducers

When absolute or differential pressure transducers are required, the number and the connection, i.e., numbers 1 and 2 - chamber pressure, 3 and 4 - left and right base, etc., is to be noted on the "Project Installation Check Sheet" (example 3a).

The transducer data constants are kept on file in the notebooks located in the UPWT DAR. Notation should be made on the Project Installation Check Sheet if other range or type of pressure measuring instrumentation is to be installed and used during the test project.

Balance

Balance specifications and drawings can be found in the "Tunnel Operating Information Notebook" located in the DAR. Availability, calibration dates and other information pertaining to LaRC balances is available upon request from the UPWT Test Engineer.

Stings

Proper selection of a sting is necessary not only to ensure that it fully meets the requirements of the test program but also those as specified in LHB 8850.1 "Wind Tunnel Model System Criteria". Sting listing, details and other information may be found in the Tunnel Operation Information Notebook located in the UPWT DAR. Alteration, soldering, welding or other procedures that would mark or scratch the polished surface of any sting is strictly forbidden. The material composition of some stings is such that even a slight scratch could cause their failure when loaded. Any of these type stings so scratched must be removed from service, repolished and recertified, or destroyed.

Adaptors

Model, balance, sting and model support adapters used in support of UPWT test projects are stored and maintained by the UPWT OSD Support Section. Information and assistance in the choice and use of these adapters can be obtained from either the OSD Lead Technician or the Test Engineer. Any installation adaptors required should be specified by identification number or letter, if so marked. Any special adaptors that are not of UPWT origin should be identified by project or drawing number.

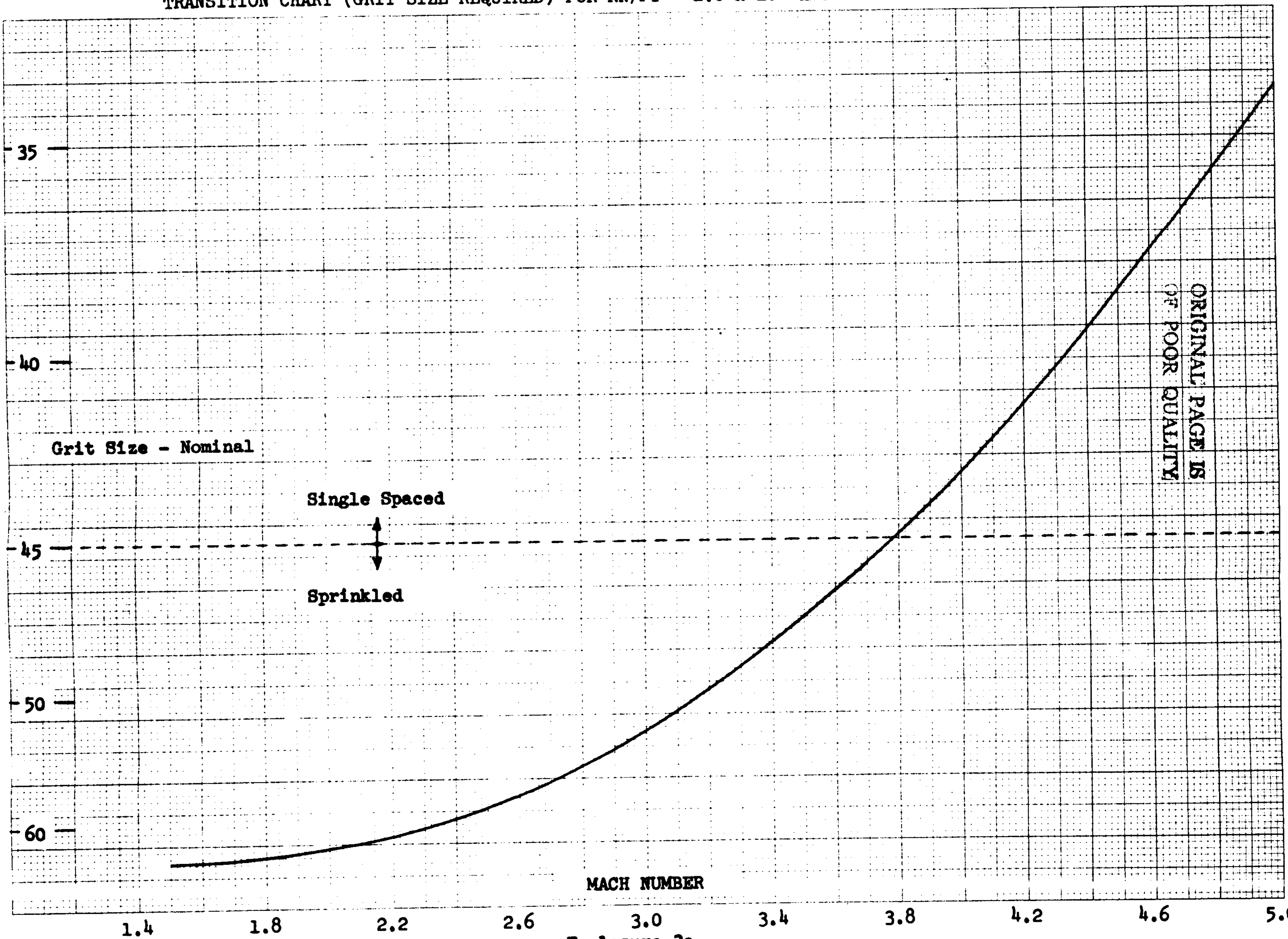
Knuckle and Roll Coupling Calibration

Whenever a roll coupling is to be used, a new roll-angle calibration is required. A balance fixture/cage surface or some other reference plane is used to obtain this calibration. A minimum of three angle readings are required and must include 0°, 90°, and 180°. All test models, unless otherwise requested, are run in a "wings-level" or "zero-roll" attitude. Roll axis misalignment if any, between model and balance is referred to as "delta phi" ($\Delta\Phi$). Model-roll angle is designated as "phi model" (Φ_m). Balance fixture/cage roll angle is designated as "phi cage" (Φ_c). Periodic calibrations are made of the Pitch and Yaw (Knuckle/Beta) angle-of-attack mechanisms and print-outs of angle in raw-counts are kept in the "Knuckle/Yaw Calibration Notebook" in the UPWT DAR. Dependent upon model and sting total length, normal obtainable pitch range is -15° to 30° and yaw range is $\pm 12^{\circ}$. Shifts of these ranges can be accomplished by the use of offset couplings or interchangeable knuckle upper-link sections.

Flow Angle

The model support system can be positioned fore and aft (upstream, downstream) within a range of 36.25 inches. Positioning of the test model within the test section is sometimes necessary in order to select a preliminary flow-angle correction from the "Flow-Angle Calibration Chart" (enclosure 3e and 3f). At the maximum upstream position the front of the knuckle assembly is located approximately 18 inches into the test section area. It can be moved downstream approximately 36.25 inches from this position.

TRANSITION CHART (GRIT SIZE REQUIRED) FOR RN/FT = 2.0×10^6 LOCATED 0.4 INCH STREAMWISE

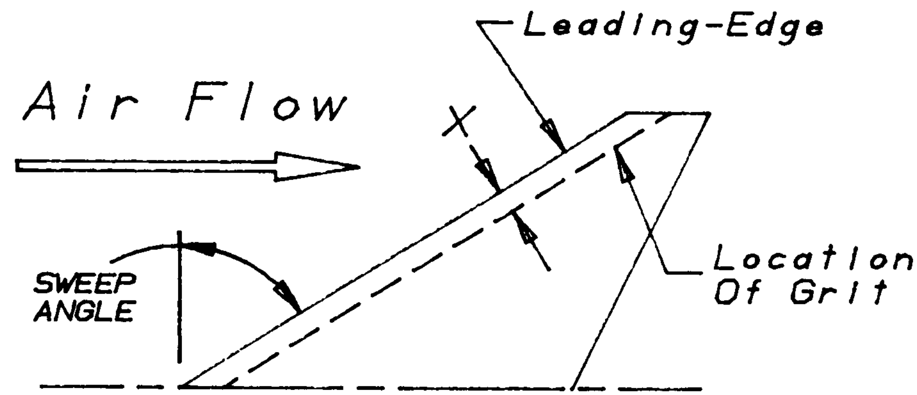


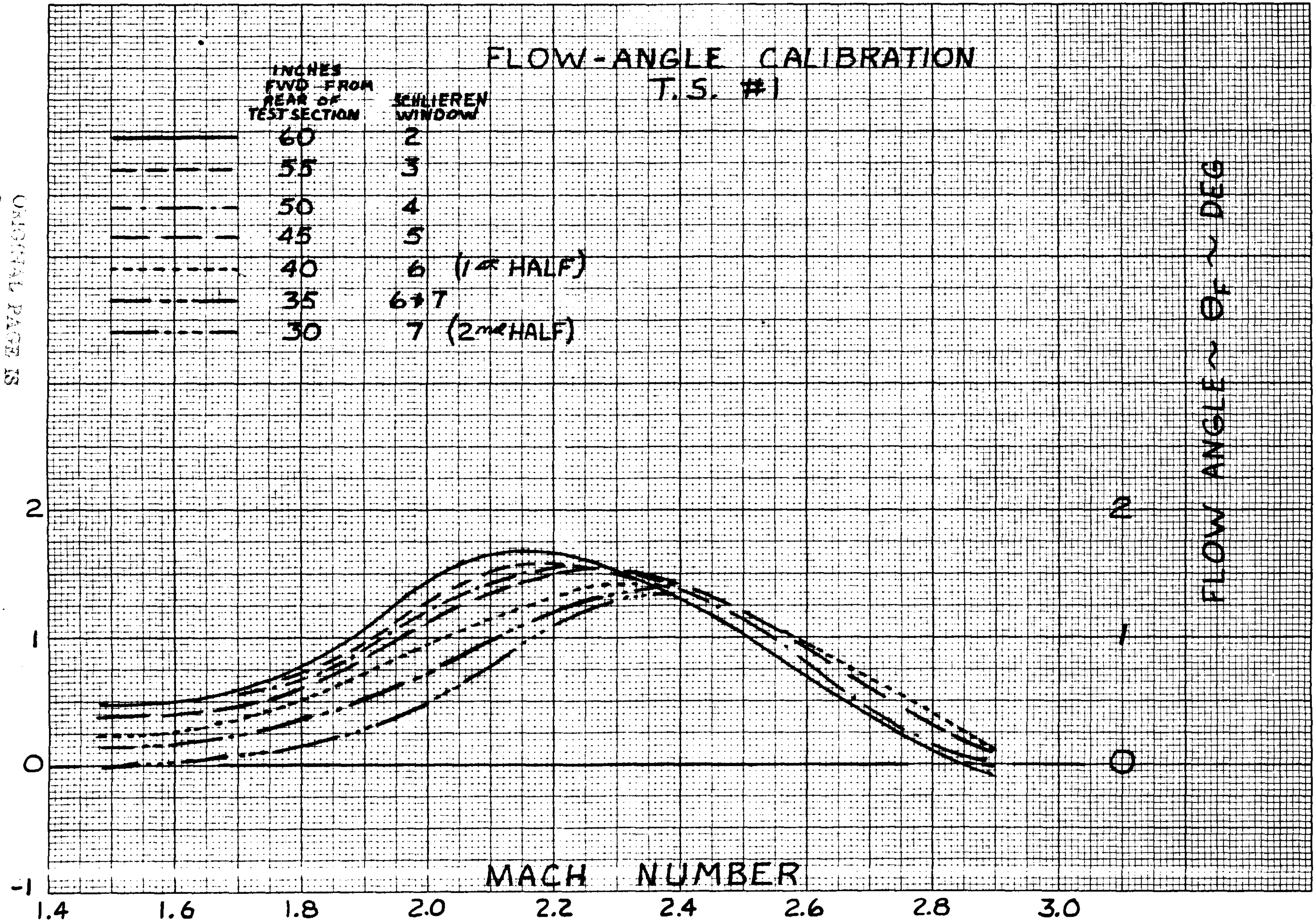
Enclosure 3c

LOCATION FOR FIXED TRANSITION (0.400 INCHES STREAMWISE)

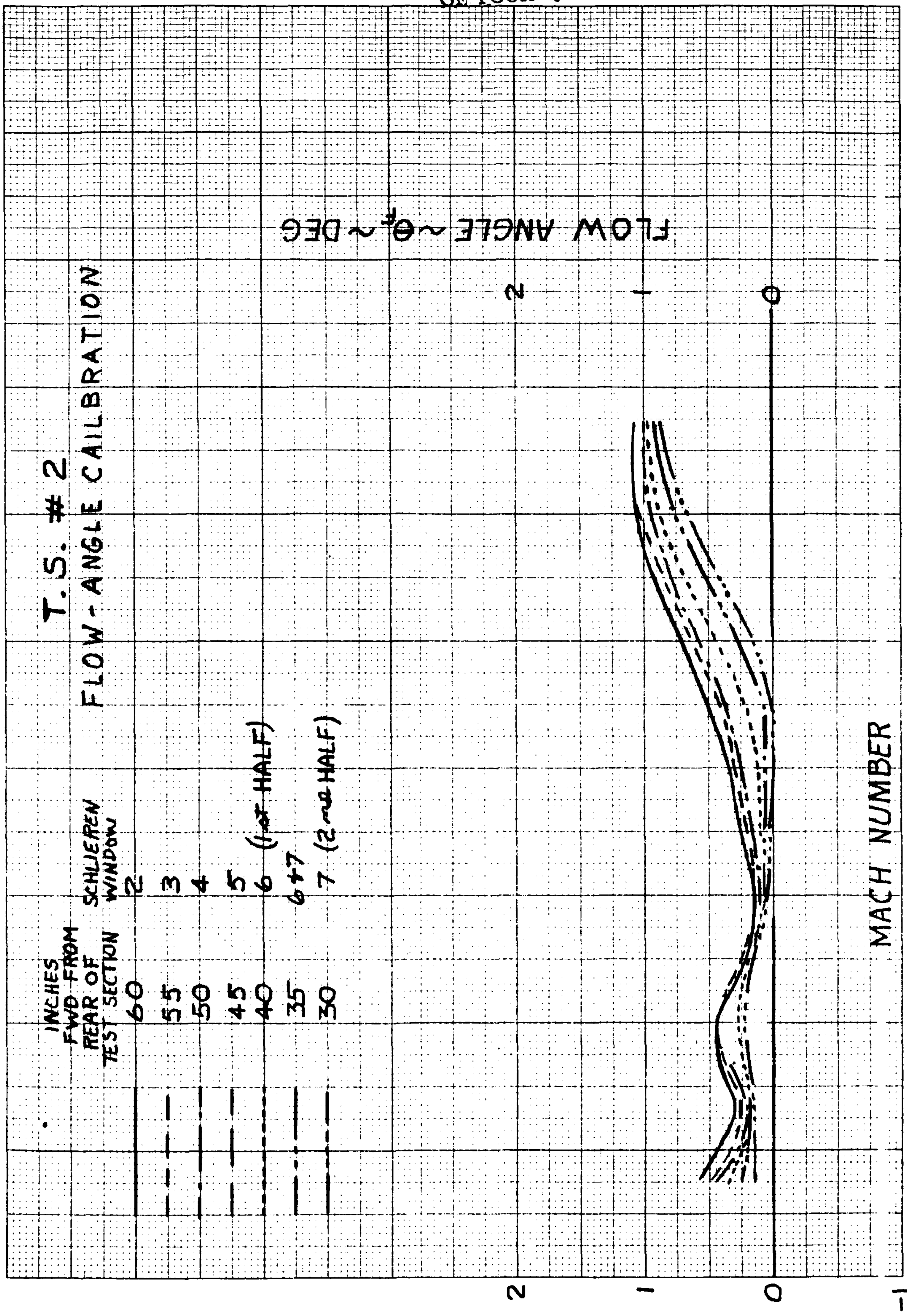
THE DISTANCES TABULATED BELOW ARE PERPENDICULAR TO LEADING - EDGE

SWEEP (DEG)	X (IN)	SWEEP (DEG)	X (IN)	SWEEP (DEG)	X (IN)
0	.400	30	.346	60	.200
1	.400	31	.343	61	.194
2	.400	32	.339	62	.188
3	.399	33	.335	63	.182
4	.399	34	.332	64	.175
5	.398	35	.328	65	.169
6	.398	36	.324	66	.163
7	.397	37	.319	67	.156
8	.396	38	.315	68	.150
9	.396	39	.311	69	.143
10	.394	40	.306	70	.137
11	.393	41	.302	71	.130
12	.391	42	.297	72	.124
13	.390	43	.293	73	.117
14	.388	44	.288	74	.110
15	.386	45	.283	75	.104
16	.385	46	.278	76	.097
17	.383	47	.273	77	.090
18	.380	48	.268	78	.083
19	.378	49	.262	79	.076
20	.376	50	.257	80	.069
21	.373	51	.252	81	.063
22	.371	52	.246	82	.056
23	.368	53	.241	83	.049
24	.365	54	.235	84	.042
25	.363	55	.229	85	.035
26	.360	56	.224	86	.028
27	.356	57	.218	87	.021
28	.353	58	.212	88	.014
29	.350	59	.206	89	.007
30	.346	60	.200	90	.000





Enclosure 3e



Enclosure 3f

Unitary Plan Wind Tunnel
Operating Information

DATE 12/86

PROJECT 1546 PROJECT DESIGNATION SUPER FLYER II

ENGINEERS DOE BALANCE 832D STING 350-8A

POE CLASSIFICATION, MODEL UNC.

DATA UNC.

Data System Analyst(s) DOE

TYPE TEST FORCE & PRESSURE JOB ORDER # R XXXXX

MACH	MODE	BLOCK	POWER MW	HO PSI	HO PSF	To	RN*10^6	Q PSF	THETA F	P INF
1.6	I-1A	333	26	7.5	1079	125	2.0	455	.22	254
2.0	I-1A	660	22	8.7	1253	125	2.0	449	.13	160
2.5	I-II	990	25	11.1	1600	125	2.0	410	.05	94
			ALTERNATE							
1.8	I-1A	0498	23	8.0	1154	125	2.0	456	.18	201

Enclosure 4a

UPWT OPERATING INFORMATION

R = 2.00 X 10**6 T = 125.00 (F)

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS1-MODE I						
1.47	231	24.60	7.25	1044.	449.2	296.95
1.50	253	23.78	7.30	1051.	450.9	286.27
1.60	333	21.65	7.49	1079.	454.8	253.79
1.65	372	21.19	7.61	1095.	455.8	239.18
1.70	414	21.07	7.73	1113.	456.3	225.53
1.75	456	20.97	7.87	1133.	456.1	212.78
1.80	498	20.90	8.01	1154.	455.5	200.85
1.90	580	20.80	8.34	1201.	452.9	179.21
2.00	660	20.77	8.70	1253.	448.5	160.20
2.10	735	19.42	9.11	1312.	442.8	143.44
2.16	777	18.72	9.37	1349.	438.8	134.34

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS2-MODE II						
2.29	12561	29.05	9.98	1438.	428.7	116.79
2.30	12658	28.94	10.03	1445.	427.9	115.55
2.36	13238	28.35	10.34	1489.	422.7	108.42
2.40	13607	28.01	10.55	1520.	419.1	103.95
2.50	14476	27.30	11.11	1600.	409.7	93.64
2.60	15277	26.76	11.71	1686.	399.7	84.48
2.70	16002	25.82	12.34	1777.	389.4	76.31
2.80	16665	25.11	13.01	1873.	378.8	69.03
2.86	17034	24.43	13.43	1934.	372.4	65.04
2.90	17270	24.05	13.72	1975.	368.1	62.52
2.96	17603	23.55	14.16	2039.	361.6	58.95

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS2-MODE IV						
3.82	20684	27.27	22.03	3172.	272.1	26.63
3.90	20856	26.46	22.91	3298.	264.5	24.84
3.95	20960	26.02	23.47	3379.	259.9	23.79
4.00	21057	25.64	24.04	3461.	255.3	22.80
4.18	21370	24.55	26.17	3768.	239.4	19.58
4.20	21402	24.45	26.41	3803.	237.7	19.25
4.30	21550	23.54	27.66	3983.	229.4	17.72
4.41	21696	22.74	29.08	4187.	220.5	16.20
4.50	21807	22.14	30.27	4359.	213.5	15.06
4.60	21921	21.59	31.63	4555.	205.9	13.90
4.63	21955	21.45	32.05	4615.	203.7	13.58

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS1-MODE II						
2.36	910	26.83	10.34	1489.	422.7	108.42
2.40	933	26.11	10.55	1520.	419.1	103.95
2.45	962	25.32	10.83	1559.	414.5	98.64
2.50	990	24.65	11.11	1600.	409.7	93.64
2.55	1016	24.60	11.40	1642.	404.8	88.93
2.60	1041	24.57	11.71	1686.	399.7	84.48
2.65	1064	24.55	12.02	1731.	394.6	80.28
2.70	1087	24.55	12.34	1777.	389.4	76.31
2.75	1108	24.17	12.67	1824.	384.2	72.57
2.80	1128	23.83	13.01	1873.	378.8	69.03
2.86	1152	23.47	13.43	1934.	372.4	65.04

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS2-MODE III						
3.00	17813	27.93	14.46	2083.	357.2	56.70
3.10	18292	27.77	15.25	2196.	346.4	51.49
3.20	18726	27.67	16.07	2314.	335.6	46.81
3.22	18808	27.66	16.24	2339.	333.4	45.94
3.30	19129	26.60	16.93	2438.	324.8	42.61
3.40	19497	25.55	17.83	2568.	314.3	38.84
3.50	19830	24.73	18.77	2703.	303.9	35.44
3.58	20071	24.03	19.55	2815.	295.7	32.96
3.60	20129	23.88	19.75	2843.	293.7	32.37
3.70	20397	23.21	20.76	2989.	283.7	29.60
3.71	20422	23.15	20.86	3004.	282.7	29.34

Enclosure 4b

R = 2.00 X 10**6 T = 150.00 (F)

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS1-MODE I						
1.47	231	25.65	7.66	1103.	474.8	313.86
1.50	253	24.79	7.71	1111.	476.6	302.61
1.60	333	22.54	7.92	1141.	480.9	268.38
1.65	372	21.90	8.04	1158.	482.1	252.98
1.70	414	21.77	8.18	1178.	482.7	238.59
1.75	456	21.67	8.32	1199.	482.7	225.14
1.80	498	21.59	8.48	1221.	482.1	212.56
1.90	580	21.49	8.83	1271.	479.5	189.75
2.00	660	21.45	9.22	1328.	475.1	169.69
2.10	735	20.09	9.65	1390.	469.2	152.00
2.16	777	19.39	9.93	1430.	465.1	142.40
TS2-MODE II						
2.29	12561	30.31	10.59	1525.	454.7	123.87
2.30	12658	30.20	10.64	1533.	453.8	122.56
2.36	13238	29.59	10.97	1580.	448.5	115.03
2.40	13607	29.24	11.20	1613.	444.7	110.30
2.5C	14476	28.49	11.80	1699.	434.9	99.41
2.60	15277	27.93	12.43	1790.	424.6	89.72
2.70	16002	26.94	13.11	1888.	413.8	81.09
2.80	16665	26.19	13.83	1991.	402.7	73.38
2.86	17034	25.47	14.28	2056.	396.0	69.16
2.90	17270	25.05	14.59	2101.	391.5	66.50
2.96	17603	24.52	15.07	2169.	384.7	62.72
TS2-MODE IV						
3.82	20684	28.67	23.52	3387.	290.5	28.44
3.90	20858	27.80	24.46	3523.	282.5	26.53
3.95	20960	27.34	25.07	3610.	277.6	25.42
4.00	21057	26.93	25.68	3698.	272.8	24.36
4.18	21370	25.77	27.98	4029.	256.0	20.93
4.20	21402	25.67	28.24	4067.	254.2	20.59
4.30	21550	24.70	29.59	4261.	245.4	18.96
4.41	21696	23.85	31.11	4481.	236.0	17.33
4.50	21807	23.22	32.40	4666.	228.5	16.12
4.60	21921	22.64	33.87	4878.	220.5	14.89
4.63	21955	22.49	34.32	4942.	218.2	14.54

M	BLOCK	POWER	H-PSI	H-PSF	Q-PSF	P-INF
TS1-MODE II						
2.36	910	28.13	10.97	1580.	448.5	115.03
2.40	933	27.36	11.20	1613.	444.7	110.30
2.45	962	26.52	11.49	1655.	439.9	104.70
2.50	990	25.81	11.80	1699.	434.9	99.41
2.55	1016	25.75	12.11	1744.	429.8	94.43
2.60	1041	25.71	12.43	1790.	424.6	89.72
2.65	1064	25.69	12.77	1838.	419.2	85.28
2.70	1087	25.68	13.11	1888.	413.8	81.09
2.75	1108	25.28	13.47	1939.	408.3	77.13
2.80	1128	24.93	13.83	1991.	402.7	73.38
2.86	1152	24.56	14.28	2056.	396.0	69.16
TS2-MODE III						
3.00	17813	29.32	15.39	2216.	380.1	60.33
3.10	18292	29.13	16.23	2337.	368.7	54.81
3.20	18726	29.02	17.12	2465.	357.4	49.85
3.22	18808	29.01	17.30	2491.	355.1	48.92
3.30	19129	27.89	18.04	2598.	346.1	45.40
3.40	19497	26.78	19.01	2737.	335.0	41.39
3.50	19830	25.91	20.01	2882.	324.0	37.79
3.58	20071	25.17	20.85	3003.	315.4	35.16
3.60	20129	25.01	21.06	3033.	313.3	34.53
3.70	20397	24.30	22.16	3190.	302.8	31.59
3.71	20422	24.24	22.27	3206.	301.7	31.32

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Enclosure 4b

UNITARY PLAN WIND TUNNEL STING-BALANCE DEFLECTION LOADS

Project # 1546 Job Order # R XXXXX Date 7-5-86

T.S. # 1 Knuckle # 3 Roll Coupling # 2 Observer WASSUM-MARTIN

Balance UT33A Bal. Mom. Ctr. 3.2" AFT OF ℄ OF FWD. DOWEL Sting # 350-7B

NORMAL

Bal. Limit 700 lb. Sting Limit 600 lb.

Weight@M.C. lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg
50	-1°12'	-1.20°	-1°8'	-1.13°
250	-13'	-.22°	-1°7'	-1.12°
450	+49'	.82°	-1°5'	-1.08
250	-12'	-.20	-1°6'	-1.10
50	-1°10'	-1.17°	-1°6'	-1.10°
450	+50'	.83°	-1°5'	-1.08°
50	-1°11'	-1.18°	-1°6'	-1.10°

$\frac{[.83° - (-1.18°)] - [-1.08° - (-1.10°)]}{400 \text{ lb}} = \frac{2.01 - .02}{400} =$ 0.004975

K_N = 0.004975°/lb

PITCH

Limit 2000 in.-lb. Lever Arm 2.0 in.

Weight on Arm lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg
50	-1°1'	-1.02°	-1°6'	-1.10
250	+15'	.25°	-1°6'	-1.10
450	1°32'	1.53°	-1°5'	-1.08
250	+16'	.27°	-1°6'	-1.10°
50	-59'	-.98°	-1°6'	-1.10°
450	1°33'	1.55°	-1°5'	-1.08°
50	-59'	-.98	-1°6'	-1.10°

$\frac{[1.55° - (-.98°)] - [-1.08° - (-1.10°)] - 1.99}{400 \text{ lb} \times 2.0 \text{ in.}} = \frac{2.53 - .02 - 1.99}{800} = \frac{.52}{800} =$ 0.00065000

K_M = 0.00065000°/in-lb

SIDE

Bal. Limit 400 lb. Sting Limit 600 lb.

Weight@M.C. lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg
50	-1°10'	-1.17°	-1°7'	-1.12°
250	-9'	-.15°	-1°7'	-1.12°
400	+37'	+.62°	-1°6'	-1.10°
250	-8'	-.13°	-1°6'	-1.10°
50	-1°9'	-1.15°	-1°7'	-1.12°
400	+38'	+.63°	-1°6'	-1.10°
50	-1°9'	-1.15°	-1°7'	-1.12°

$\frac{[.63° - (-1.15°)] - [-1.10° - (-1.12°)]}{300 \text{ lb}} = \frac{1.78 - .02}{300} =$

$\frac{1.76}{300} =$ 0.0050286

K_Y = 0.0050286°/lb

YAW

Limit 1000 in.-lb. Lever Arm 2.0 in.

Weight on Arm lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg
50	-47'	-.78°	-1°6'	-1.10°
250	+34'	+.57°	-1°6'	-1.10°
400	1°45'	1.75°	-1°5'	-1.08°
250	+35'	+.58°	-1°5'	-1.08°
50	-46'	-.77°	-1°6'	-1.10°
400	1°45'	1.75°	-1°5'	-1.08°
50	-46'	-.77°	-1°6'	-1.10°

$[1.75 - (-.77)] - [-1.10 - (-1.08)] - 1.76 =$

$2.52 - .02 - 1.76 = \frac{.74}{350 \times 2} =$ 0.0010571

K_n = 0.0010571 °/in-lb

$K = \frac{\Delta \text{Bal Defl} - \Delta \text{Knu Defl}}{\Delta \text{Wt}}$

$K = \frac{[\Delta \text{Bal Defl} - \Delta \text{Knu Defl}] - \Delta N/S_Y \text{ Defl}}{\Delta \text{Wt} \times \text{Arm}}$

- FINAL

BALANCE UT34A

CALIBRATION DATE 09/10/85

FINAL

***** NASA *****

LANGLEY RESEARCH CENTER

STRAIN-GAGE BALANCE CALIBRATION RESULTS

	NORMAL	AXIAL	PITCH	ROLL	YAW	SIDE
(1) NOMINAL BRIDGE RESISTANCE(OHM)	350.	350.	350.	350.	350.	350.
(2) COLOR CODES						
A- POS. INPUT	RED	RED	RED	RED	RED	RED
B- NEG. OUTPUT	WHITE	WHITE	WHITE	WHITE	WHITE	WHITE
C- NEG. INPUT	BLACK	BLACK	BLACK	BLACK	BLACK	BLACK
D- POS. OUTPUT	YELLOW	GREEN	ORANGE	BROWN	PURPLE	BLUE
(3) DEFLECTION CONSTANTS (MIN/LB OR MIN/IN-LB)	.0067	0.0000	.0240	.0733	.0300	.0067
(4) DEFLECTION CONSTANTS (MIN/NT OR MIN/CM-NT)	.0015	0.0000	.0021	.0065	.0027	.0015

LEADS LENGTH = 10 FT. MINICABLE

ACCURACIES ARE + OR - .5 PERCENT UNLESS OTHERWISE NOTED

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Enclosure 5b

ORIGINAL PAGE IS
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- FINAL

BALANCE UT34A

CALIBRATION DATE 09/10/85

REFERENCE 1.

***** NASA *****

LANGLEY RESEARCH CENTER

STRAIN-GAGE BALANCE CALIBRATION RESULTS

FINAL

TYPE OF READOUT SYSTEM CRT

INSTRUMENT PROJECT ENGINEER W.F. QUINN

COMPONENT NO.	NAME	CALIBRATION RANGE (LB OR IN-LB)	(NT OR CM-NT)	INDICATOR OUTPUT (MILLIVOLTS/VOLT)	SENSITIVITY CONSTANT LB/MV/V OR IN-LB/MV/V	CONSTANT FOR IRD AND DPS ONLY NT/MV/V OR CM-NT/MV/V
1	NORMAL FORCE	600.0 -600.0	2668.8 -2668.8	1.966	305.1882	1357.4771
2	AXIAL FORCE	50.0 .0	222.4 .0	1.478	33.8295	150.4736
3	PITCHING MOMENT	1000.0 -1000.0	11298.0 -11298.0	1.270	787.4016	8896.0633
4	ROLLING MOMENT	300.0 -300.0	3389.4 -3389.4	.991	302.7245	3420.1814
5	YAWING MOMENT	600.0 -600.0	6778.8 -6778.8	1.245	481.9277	5444.8192
6	SIDE FORCE	300.0 -300.0	1334.4 -1334.4	1.660	180.7229	803.8555

MOMENT CENTER = 3.500 INCHES AFT. OF CNT/LN OF FWD DWL

BALANCE VOLTAGE = 5.000 VOLTS

DELTA W = 0.00 LBS

SPECIAL REMARKS

VOLTAGE PARALLED AT BALANCE TAPER

USE OF PARALLEL/NON-PARALLEL-WIRED BALANCES IN U.P.W.T.

T.S. #1 and T.S. #2 (Data Room To-Test Section)

Balance cables 1 and 2 are parallel-wired.

Balance cable 3 is non-parallel wired.

NORMAL HOOK-UP WHEN USING A NON-PARALLEL-WIRED BALANCE

a. Use a non-parallel mini-plug cable.

b. Must use a non-parallel plug adaptor also.

c. Set the balance power-supply such that the voltage at the balance is 5 volts.

d. Span check can be made either at the balance taper or 10' from the taper between the mini-cable 31 pin plug and the plug adaptor.

Note: A parallel wired mini-cable can be used with a non-parallel wired balance. If this is done, DO NOT use a non-parallel plug adaptor. Span check can only be made at the taper.

NORMAL HOOK-UP WHEN USING A PARALLEL-WIRED BALANCE

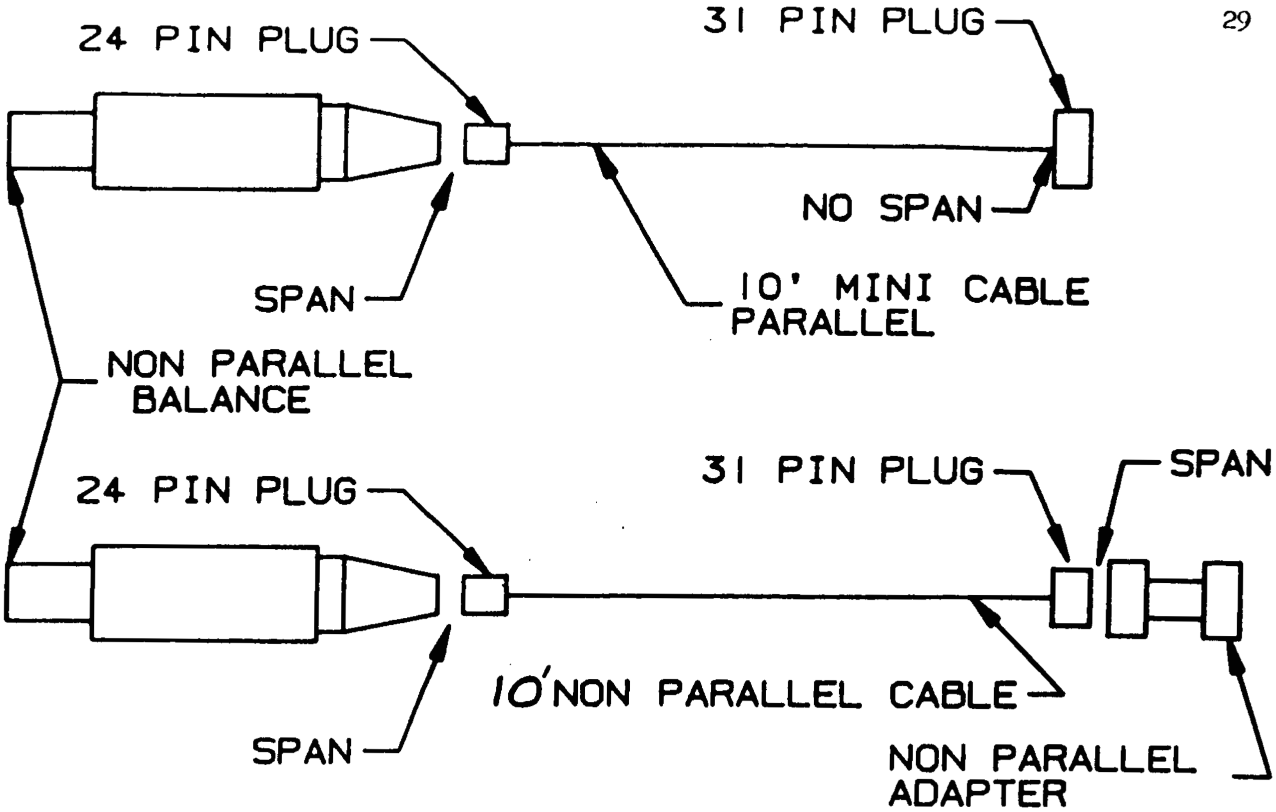
a. Use a parallel mini-plug cable, if required. Most, if not all, parallel wired balances are hard-wired to a 31 pin plug connector.

b. Set the balance power-supply such that the voltage at the balance is 5 volts.

c. A parallel-wired balance cannot generally be spanned.

Mini-Cable Identification:

1. Painted red means cable is 10 feet long.
2. A parallel-wired mini-cable is marked as such. Also, there is a small knot in the cable near the mini-plug.
3. If not marked, it is a non-parallel cable.



TORQUE ON FRONT END "EXPANDERS"

DIAMETER	TORQUE
.750	45 IN/Lb
1.000	125 IN/Lb
1.250	125 IN/Lb
1.375	125 IN/Lb
1.750	250 IN/Lb
2.000	250 IN/Lb

UNITARY PLAN WIND TUNNEL

T.S. #2

ELECTRONIC PRESSURE SCAN SYSTEM

Project 1533 Title SUPER PLATE Configuration WEDGED + 6A Date 12-21-87

Port	Module # 1		Module # 2		Module # 3		Module # 4		Module #		Module #		Module #		Module #		Module #		Module #	
	5 psia		5 psia		7½ psia		15 psia		psia		psia		psia		psia		psia		psia	
#	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube
1	1	1	33	19	65	9	97	41	129		161		193		225		257		289	
2	2	2	34	20	66	10	98	42	130		162		194		226		258		290	
3	3	3	35	21	67	57	99	43	131		163		195		227		259		291	
4	4	4	36	22	68	58	100	44	132		164		196		228		260		292	
5	5	5	37	23	69	59	101	45	133		165		197		229		261		293	
6	6	6	38	24	70	60	102	46	134		166		198		230		262		294	
7	7	7	39	25	71	61	103	47	135		167		199		231		263		295	
8	8	8	40	26	72	62	104	48	136		168		200		232		264		296	
9	9	11	41	27	73	63	105	49	137		169		201		233		265		297	
10	10	12	42	28	74	64	106	66	138		170		202		234		266		298	
11	11	13	43	29	75	65	107	67	139		171		203		235		267		299	
12	12	14	44	30	76	81	108	68	140		172		204		236		268		300	
13	13	15	45	31	77	82	109	69	141		173		205		237		269		301	
14	14	16	46	32	78	83	110	70	142		174		206		238		270		302	
15	15	17	47	33	79	84	111	71	143		175		207		239		271		303	
16	16	18	48	34	80	100	112	72	144		176		208		240		272		304	
17	17	41	49	35	81	101	113	73	145		177		209		241		273		305	
18	18	42	50	36	82	102	114	74	146		178		210		242		274		306	
19	19	43	51	37	83	103	115	75	147		179		211		243		275		307	
20	20	44	52	38	84	1080 REF	116	85	148		180		212		244		276		308	
21	21	45	53	39	85		117	86	149		181		213		245		277		309	
22	22	46	54	40	86		118	87	150		182		214		246		278		310	
23	23	47	55	49	87		119	88	151		183		215		247		279		311	
24	24	48	56	50	88		120	89	152		184		216		248		280		312	
25	25	70	57	51	89		121	95	153		185		217		249		281		313	
26	26	80	58	52	90		122	96	154		186		218		250		282		314	
27	27	90	59	53	91		123	97	155		187		219		251		283		315	
28	28	91	60	54	92		124	98	156		188		220		252		284		316	
29	29	92	61	55	93		125	99	157		189		221		253		285		317	
30	30	93	62	56	94		126	1440 REF	158		190		222		254		286		318	
31	31	94	63	5" REF	95		127		159		191		223		255		287		319	
32	32	5" REF	64	5" REF	96		128		160		192		224		256		288		320	

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Enclosure 6a

PROJECT 1533 T.S. #2 TITLE SUPER PLATE DATE 12/87

CHANNEL NO.	S.V. #1 5 PSI TUBE #	S.V. #2 5 PSI TUBE #	S.V. #3 7½ PSI TUBE #	S.V. #4 7½ PSI TUBE #	S.V. # __ PSI TUBE #	S.V. # __ PSI TUBE #	S.V. # __ PSI TUBE #
0	VACUUM	VACUUM	VACUUM	VACUUM			
1	288 REF	288 REF	576 REF	576 REF			
2	"	"	"	"			
3	144 REF	144 REF	288 REF	288 REF			
4	"	"	"	"			
5	72 REF	72 REF	144 REF	144 REF			
6	"	"	"	"			
7	1	25	T (49)	72 REF			
8	2	26	49	72 REF			
9	3	27	50	74			
10	4	28	51	75			
11	5	29	52	76			
12	6	30	53	77			
13	7	31	54	78			
14	8	32	55	79			
15	9	33	56	80			
16	10	34	57	81			
17	11	35	58	82			
18	12	36	59	83			
19	13	37	60	84			
20	14	38	61	85			
21	15	39	62	86			
22	16	40	63	87			
23	17	41	64	88			
24	18	42	65	89			
25	19	43	66	90			
26	20	44	67	91			
27	21	45	68	92			
28	22	46	69	93			
29	23	47	70	94			
30	24	48	71	BAL. BOX			
31	BAL. BOX	BAL. BOX	72				
32			73				
33			BAL. BOX				
34							
35							
36							
37							
38							
39							
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41							
42							
43							
44							
45							
46							
47							

WING DING MISSILE

Project 1335

RUN NUMBER

Mach 3.0

φ	-45	0	22.5	45	67.5	90	180	P		→
β	0°								→	
α	P						→	5	10	15
Run number	—	1	-	2	-	3	4	5	6	7

Mach 3.5

φ	-45	0	22.5	45	67.5	90	180	P		→
β									>	
α	P						→	5	10	15
Run number	8	9	10	11	12	13	14	15	16	17

Mach 4.0

φ	-45	0	22.5	45	67.5	90	180	P		→
β									>	
α	P						→	5	10	15
Run number	-	18	-	19	-	20	21	22	23	24

Mach 4.5

φ	-45	0	22.5	45	67.5	90	180	P		→
β										→
α	P						→	5	10	15
Run number	-	25	-	26	-	27	28	-	-	-

Comments: BASIC, No SCH

Batch	Configuration	Controls δ_{F1}	δ_{F2}	δ_{F3}	δ_{F4}
01	B1, N1, T200 C100	0°	0°	0°	0°
02	C85				
03	C75				
04	C65				
05	C40				
06	C85				
07					
08					
09					
10					
11	↓				
12	C40				
13	C85	↓	↓	↓	↓
14		-10	10	10	-10
15					
16					
17					
18		↓	↓	↓	↓
19		10	-10	-10	10
20					
21					
22					
23		↓	↓	↓	↓
24		20	-20	-20	20
25					
26					
27					
28	↓	↓	↓	↓	↓

α (P) = -2,0,2,4,6,8,10,12,14,16,18,20,0

φ (P) = 0,11.25,22.5,33.75,45,56.25,67.5,78.75,90,101.25,112.5,123.75,135,146.25,157.5,168.75,180

Enclosure 7a

UNITARY PLAN WIND TUNNEL

PROJECT 1117 DESIGNATION F-22 SCRAMBLER T.S. 1 ENGINEER BUKER DATE 4-18-86

BATCH	PRIOR.	CONFIGURATION	δ_{LEF}	δ_e	δ_A	δ_r	δ_{SP}	θ_M	RUN NUMBER M=1.60 B=0 α=V	M=1.60 B=Var. 0	M=1.60 B=Var. 10	M=1.60 B=Var. 16	M=2.00 B=0 α=V	M=2.00 B=Var. 0	M=2.00 B=Var. 10	M=2.00 B=Var. 18	M=2.16 B=0 α=V	M=2.16 B=Var. 0	M=2.16 B=Var. 10	M=2.16 B=Var. 18
01	1	1 WITH C_{DI} RAKE	0/0	0/0	0/0	0	–	0	x 1	–	–	–	x 2	–	–	–	x 3	–	–	–
02	1	WITH RAKE OFF	↓	↓	↓	↓	↓	↓	x 4	x 5	x 6	x 7	x 8	x 9	x 10	x 11	x 12	x 13	x 14	x 15
03	1	2 (INVERTED RUN)						180	x 20	–	–	–	x 21	–	–	–	x 30	–	–	–
04	1	UPRIGHT						0	x 16	x 17	x 18	x 19	x 22	x 23	x 24	x 25	x 26	x 27	x 28	x 29
06	1	+ SW-6 TIP MISSILES					↓		x	x	x	x	x	x	x	x	–	–	–	–
07	1	+ S4 SPOILERS					38°		x	x	x	–	x	x	x	–	–	–	–	–
08	2	+ S16b SPOILERS		↓					x	x	x	–	x	x	x	–	–	–	–	–
09	2			-25/25	↓		–		x	–	–	–	x	–	–	–	–	–	–	–
13	3			10/10	10/10				x	–	–	–	x	–	–	–	–	–	–	–
10	2			-5/-5	-5/-5				x	–	–	–	x	–	–	–	–	–	–	–
11	3		↓	5/5	0/0				x	–	–	–	x	–	–	–	–	–	–	–
12	3		-5/-5	↓	5/5				x	–	–	–	x	–	–	–	–	–	–	–
05	1	↓ +(2) LWR SURF. SW-6L	0/0	0/0	0/0	↓	↓	↓	x	–	x	x	x	–	x	x	–	–	–	–

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Enclosure 7b

UNITARY PLAN WIND TUNNEL

DATA REDUCTION INFORMATION

Date 1/87

Project No. 1546 J.O. R xxxx RTR xxx xx xxxx Account No. xxxx

PROJECT ENGINEER J. HEATH

DATA SYSTEM ANALYST P. ABAL

Model Name SUPER FLYER II Balance 832-B

Balance Orientation In Model ☑ Upright ☐ Inverted

Roll Coupling ☑ Yes ☐ No Attach Calibration

Tares All Roll Angles ☑ Yes ☐ No

Angle Of Attack Mechanism #3 Calibration Date 11/86

Flow Angles ☑ From Upright And Inverted Runs
☐ From Other Source (name)

Internal Flow ☐ Yes ☑ No (attach instructions, constants and identification of tubes)

Axial Force Corrected-for ☑ Base ☑ Chamber

Special Requirements ☐ Yes ☑ No
(attach instructions for any requirements other than standard 6 components, base or chamber pressure data)

Output Requirements: Data Disbursement

	Yes	No	
Plot Tape	☑	☐	
BCD Tape	☑	☐	Attach Format
Xerox Copies	☑	☐	No.
Beta Derivatives	☑	☐	
Beta Derivatives Plot Tapes	☑	☐	

Classification Of Final Listing: UNCLASSIFIED

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Sting No. 350-8A

Deflections List and Give Source or Attach Results

N 0.004975 °/lb. n 0.001571 °/lb.

M 0.000650 °/in.-lb. Y 0.0050286 °/in.-lb.

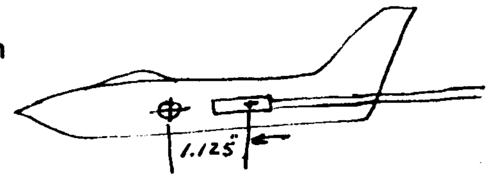
Gamma

Balance misalinement angle= NONE

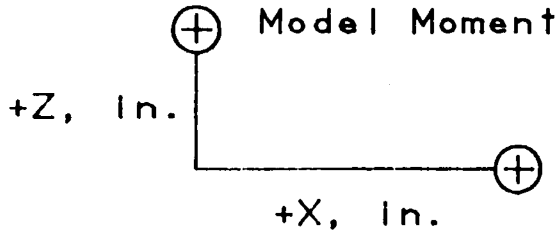
Moment Transfer: X = + 1.125"

Z = 0.0

Sketch



Sign Orientation:



Reference Area, S_W = 1.0 sq ft

Wing Span, b_W = 20.0 in.

Wing Chord, $\bar{c}_W$ = 10.0 in.

PRESSURES

Channel No.	Gage No.	Location on Model	Sensi-tivity	Calibration Date	Area sq ft	Average	Correct Axial
1							
2							
3							
4			NONE				
5							
6							

Sketch

Attach Special Listing or Data Reduction ☐ Yes ☑ No

On-Line Requirements:

Plots: C_L, C_D, C_m vs. α ; C_l, C_n, C_Y vs β

Parameters:

Scales:

Project No. 1455 Title Winged Cone Date Dec 1986

Job Order ______ Balance UT-12- Sting 350-12 Observer ______

Knuckle #4 Roll Coupling #1 Strut ______

Configuration and Remarks	Mach	Block	H_o psf	Batch	Run	Point	α deg	α counts	β deg	β cts.	θ_m	θ_β	Sch.
							-4						
							-2						
							0						
							1						
							2						
							3						
							4						
							6						
							8						
							10						
							14						
							16						
							18						
							20						
							0						
							-4						
							-2						
							0						
							1						
							2						
							3						
							4						
							6						
							8						
							10						
							14						
							18						
							20						
							0						

Enclosure 9a

Project No. 1455 Title WINGED CONE Date DEC 1986

Job Order ______ Balance UT42- Sting 350-12 Observer ______

Knuckle #4 Roll Coupling #1 Strut ______

Configuration and Remarks	Mach	Block	H_o psf	Batch	Run	Point	α deg	α counts	β deg	β cts.	θ_m	θ_β	Sch.
							0		-6				
									-4				
									-2				
									-1				
									0				
									1				
									2				
									4				
									6				
									8				
									0				
							10		-6				
									-4				
									-2				
									-1				
									0				
									1				
									2				
									4				
									6				
									8				
									0				
							20		-6				
									-4				
									-2				
									1				
									0				
									1				
									2				
									4				
									6				
									8				
									0				

Enclosure 9b

Project No. 1455 Title Winged Cone Date Dec 1986

Job Order ______ Balance UT42 Sting 350-12 Observer ______

Knuckle #4 Roll Coupling #1 Strut ______

Configuration and Remarks	Mach	Block	H_0 psf	Batch	Run	Point	Model α deg	α counts	β deg	β cts.	θ_m	θ_β	Sch.
							+6						
							5						
							4						
Inverted							3						
							2						
							1						
							0						
							-1						
							-2						
							-3						
							-4						
							-5						
							-6						
							6						
							5						
							4						
							3						
Inverted.							2						
							1						
							0						
							-1						
							-2						
							-3						
							-4						
							-5						
							-6						
							6						
							5						
							4						
Inverted							3						
							2						
							1						
							0						
							-1						
							-2						
							-3						
							-4						
							-5						
							-6						

Enclosure 9c

UNITARY PLAN WIND TUNNEL

BALANCE ZERO LOG

PROJECT 1117 TITLE F-22 SCRAMBLER T.S. #1

BA	RUN	Pt	ID	DATA CHANNEL 01	02	03	04	05	06	07	09	10	155	160	TIME	DATE
01	01	42	0	-33	457	1205	-511	2201	113	5002	17640	1863	2120.1	2119.9	14:20	5-13-87
		43	3	-32	457	1206	-509	2201	115	5002	17642	1862	372.5	372.3	14:31	
		44	3	-32	458	1206	-509	2202	115	5001	17642	1863	380.2	380.0	14:32	
	06	75	3	-23	462	1195	-516	2187	121	5002	17650	1872	212.5	212.2	15:10	
		76	3	-23	462	1196	-516	2187	122	5002	17651	1872	220.6	220.5	15:11	
	10	101	3	-19	461	1192	-521	2174	119	5001	17650	1856	273.4	273.2	16:07	
		102	3	-19	461	1192	-524	2174	119	5002	17650	1856	290.5	290.3	16:08	
		103	0	-20	461	1193	-520	2176	120	5002	17649	1857	2122.4	2122.2	16:15	
02	11	104	0													

Enclosure 10

UNITARY PLAN WIND TUNNEL SCHEDULE SHEET

Date______________

Title______________________________ Project Engineer(s)______________________

RTOP______________________________ Data System Analyst(s)____________________

Job Order__________________________ Sponsor__________________________________

Model Available Date_______________ Desired Schedule Date____________________

T.S.__________ Mach Nos.____________________ Reynolds No(s).________________

Pitch Range_________________ Yaw Range________________ Roll Range______________

Schlieren___________________ Vapor Screen_____________ Oil Flow________________

Overall Model Dimensions____

Estimated Model Loads____

Number of Test Configurations_________________ Est.Occupancy Time______________

Est. Run Time per Config.____________________ Est.Total Run Time______________

Est. Time per Model Change___________________ Est. Total Power KWH____________

Test Objective____

Instrumentation Required____

Data Reduction Requirements____

Remarks____

Enclosure 11a

UNITARY PLAN WIND TUNNEL PROJECT INSTALLATION CHECK SHEET

Project No.________________ J.O.______

Model________________________________

Project Engineers____________________

Data System Analysis_________________

Test Starts__________Ends____________

Type Test: Force_______Pressure_______
Other________________

Operating Conditions:

Compressor Modes_____________________

Mach Nos.____________________________

Power Range__________________________MW

Pitch Range_________________________deg.

Yaw Range___________________________deg.

Roll Range__________________________deg.

Minimum Dew Point -10 deg.F. (Std.)

Transition:
Grit No.__________Width__________
Sprinkle__________Single Space_____

Location (Perpendicular to L.E.):
Nose_______Wing__________
Tail_______Other_________

θ_M From: Cage-----Upright____Invert.____
Model---Upright____Invert.____

Orientation:
Roll Coupling________________
Balance______________________
Model/Balance Adapter________
Model________________________

Pressure Transducers:
Type_________________________
Number Required______________
Designation
#1__________ #2__________
#3__________ #4__________
#5__________ #6__________
#7__________ #8__________

Vapor Runs__________Oil Flow__________

Mercury Lamps________Laser__________

Test Section__________Date__________

Classification_______________________

Balance:
Designation__________________
Engineer_____________________

Balance Parallel Wired?______________

Cable: Parallel_____Non-Parallel_______
Non-Parallel Adapter_______

Axial Force: Limit_______________lb.
Dead Load___________lb.

Span Check: At Balance Taper__________
10 ft. from Taper__________

....

Sting:
Furnished by____________No.__________
Deflections: NF____,PM____,SF____,YM____

....

Adapters:
Model-to-Balance_____________
Balance-to-Sting_____________
Sting-to-Knuckle_____________

Knuckle No.______ Std. Arm____Other______
Calibration__________________________

Angular Coupling_____________________

Roll Coupling_____Number_____Adapter______
Calibration @___________________deg.

Fouling Strip Required_______________

Photography: Model__________________
Schlieren______________
Other__________________

Remarks:_____________________________

Enclosure 11b

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Unitary Plan Wind Tunnel
Operating Information

DATE ____________

PROJECT ____________ PROJECT DESIGNATION ____________

ENGINEERS ____________ BALANCE ________ STING ____________

____________ CLASSIFICATION, MODEL ____________

____________ DATA ____________

Data System Analyst(s) ____________________________

TYPE TEST ____________ JOB ORDER # ________

MACH	MODE	BLOCK	POWER MW	Ho PSI	Ho PSF	To	$RN*10^6$	Q PSF	THETA F	P INF

Enclosure 11c

UNITARY PLAN WIND TUNNEL STING-BALANCE DEFLECTION LOADS

Project # ______________ Job Order # ______________ Date ________________

T.S. # _____ Knuckle # _____ Roll Coupling # _____ Observer ______________

Balance ________ Bal. Mom. Ctr. ___________________________ Sting # ________

NORMAL

Bal. Limit _______ lb. Sting Limit __________ lb.

Weight@M.C. lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg

K_N = 0.________ °/lb

PITCH

Limit _______ in.-lb. Lever Arm _____ in.

Weight on Arm lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg

K_M = 0.________ °/in-lb

SIDE

Bal. Limit _______ lb. Sting Limit __________ lb.

Weight@M.C. lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg

K_Y = 0.________ °/lb

YAW

Limit _______ in.-lb. Lever Arm _____ in.

Weight on Arm lbs.	Bal. Defl. deg-min	Bal. Defl. deg	Knu. Defl. deg-min	Knu. Defl. deg

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K_n = 0.________ °/in-lb

$$K = \frac{\Delta \text{Bal Defl} - \Delta \text{Knu Defl}}{\Delta \text{Wt}}$$

$$K = \frac{[\Delta \text{Bal Defl} - \Delta \text{Knu Defl}] - \Delta N/S_P \text{ Defl}}{\Delta \text{Wt} \times \text{Arm}}$$

Enclosure 11d

UNITARY PLAN WIND TUNNEL

ELECTRONIC PRESSURE SCAN SYSTEM

Project__________ Title____________________ Configuration________________________ Date____________

Port #	Module #		Module #		Module #		Module #		Module #		Module #		Module #		Module #		Module #		Module #	
		psia		psia		psia		psia		psia		psia		psia		psia		psia		psia
	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube	Cell	Tube
1	1		33		65		97		129		161		193		225		257		289	
2	2		34		66		98		130		162		194		226		258		290	
3	3		35		67		99		131		163		195		227		259		291	
4	4		36		68		100		132		164		196		228		260		292	
5	5		37		69		101		133		165		197		229		261		293	
6	6		38		70		102		134		166		198		230		262		294	
7	7		39		71		103		135		167		199		231		263		295	
8	8		40		72		104		136		168		200		232		264		296	
9	9		41		73		105		137		169		201		233		265		297	
10	10		42		74		106		138		170		202		234		266		298	
11	11		43		75		107		139		171		203		235		267		299	
12	12		44		76		108		140		172		204		236		268		300	
13	13		45		77		109		141		173		205		237		269		301	
14	14		46		78		110		142		174		206		238		270		302	
15	15		47		79		111		143		175		207		239		271		303	
16	16		48		80		112		144		176		208		240		272		304	
17	17		49		81		113		145		177		209		241		273		305	
18	18		50		82		114		146		178		210		242		274		306	
19	19		51		83		115		147		179		211		243		275		307	
20	20		52		84		116		148		180		212		244		276		308	
21	21		53		85		117		149		181		213		245		277		309	
22	22		54		86		118		150		182		214		246		278		310	
23	23		55		87		119		151		183		215		247		279		311	
24	24		56		88		120		152		184		216		248		280		312	
25	25		57		89		121		153		185		217		249		281		313	
26	26		58		90		122		154		186		218		250		282		314	
27	27		59		91		123		155		187		219		251		283		315	
28	28		60		92		124		156		188		220		252		284		316	
29	29		61		93		125		157		189		221		253		285		317	
30	30		62		94		126		158		190		222		254		286		318	
31	31		63		95		127		159		191		223		255		287		319	
32	32		64		96		128		160		192		224		256		288		320	

Enclosure 11e

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SCANIVALVE SYSTEM

PROJECT ______________ TITLE ______________ DATE ______

CHANNEL NO.	S.V. #__ ____PSI	S.V. #__ ____PSI	S.V. #__ ____PSI	S.V. #__ ____PSI	S.V. #__ ____PSI	S.V. #__ ____PSI	S.V. #__ ____PSI
	TUBE #	TUBE #	TUBE #	TUBE #	TUBE #	TUBE #	TUBE #
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
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Enclosure 11f

UNITARY PLAN WIND TUNNEL

DATA REDUCTION INFORMATION

Date ________

Project No. ______ J.O. _______ RTR _________ Account No. _______

PROJECT ENGINEER ________________________

DATA SYSTEM ANALYST ________________________

Model Name ____________________ Balance ____________________

Balance Orientation In Model ☐ Upright ☐ Inverted

Roll Coupling ☐ Yes ☐ No Attach Calibration

Tares All Roll Angles ☐ Yes ☐ No

Angle Of Attack Mechanism _______ Calibration Date _______

Flow Angles ☐ From Upright And Inverted Runs
☐ From Other Source (name)

Internal Flow ☐ Yes ☐ No (attach instructions, constants and identification of tubes)

Axial Force Corrected-for ☐ Base ☐ Chamber

Special Requirements ☐ Yes ☐ No
(attach instructions for any requirements other than standard 6 components, base or chamber pressure data)

Output Requirements: Data Disbursement

	Yes	No	
Plot Tape	☐	☐	
BCD Tape	☐	☐	Attach Format
Xerox Copies	☐	☐	No. ____________
Beta Derivatives	☐	☐	
Beta Derivatives Plot Tapes	☐	☐	

Classification Of Final Listing: ________________________

Enclosure 11g

Sting No. ______________

Deflections   List and Give Source or Attach Results

N   n

M   Y

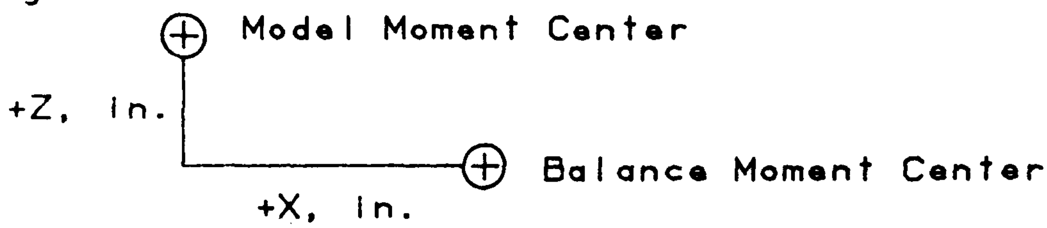
Gamma

Balance misalinement angle=

Moment Transfer:

Sketch

Sign Orientation:



Reference Area, S_W = ______________ sq ft

Wing Span, b_W = ______________ in.

Wing Chord, $\bar{c}_W$ = ______________ in.

PRESSURES

Channel No.	Gage No.	Location on Model	Sensitivity	Calibration Date	Area sq ft	Average	Correct Axial
1							
2							
3							
4							
5							
6							

Sketch

Attach Special Listing or Data Reduction ☐ Yes ☐ No

On-Line Requirements:

Plots:

Parameters:

Scales:

Project No.____________ Title ________________________________ Date ________

Job Order ____________ Balance ________________ Sting __________ Observer ______

Knuckle ________________________ Roll Coupling _________________ Strut ________

Configuration and Remarks	Mach	Block	H_o psf	Batch	Run	Point	α deg	α counts	β deg	β cts.	θ_m	θ_β	Sch

Enclosure 11h

UNITARY PLAN WIND TUNNEL

BALANCE ZERO LOG

PROJECT NUMBER ______________ TITLE ______________ T.S. ________

				DATA CHANNEL												
BA	RUN	Pt	ID												TIME	DATE

Enclosure 11i

Standard Bibliographic Page

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15. Supplementary Notes

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Curtis E. Hyman, Jr.: PRC Kentron, Inc., Hampton, Virginia.

16. Abstract

Information is presented to assist those interested in conducting wind-tunnel testing within the Langley Unitary Plan Wind Tunnel. Procedures, requirements, forms and examples necessary for tunnel entry are included.

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