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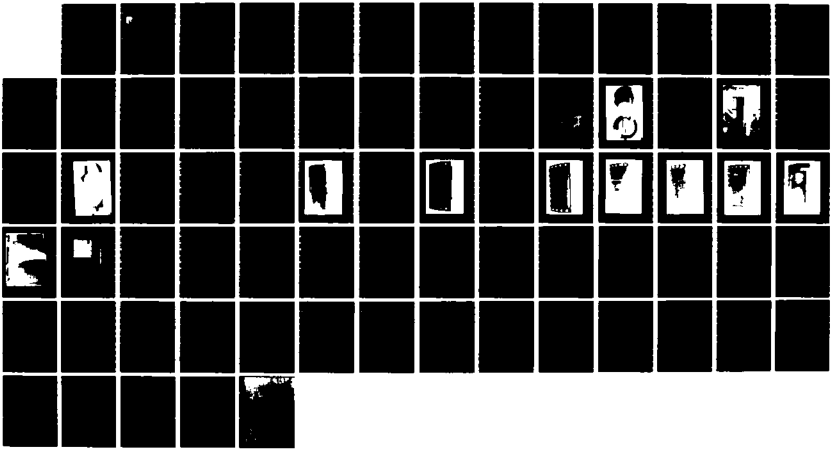

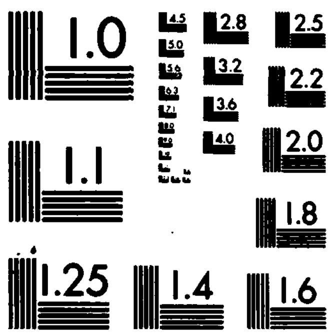

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AEROTHERMAL WIND TUNNEL TEST OF THE SPACE SHUTTLE OMS POD AFRSI MATERIAL

S. A. Stepanek

Calspan Field Services, Inc.

September 1983

Final Report for Period 27 May to 11 August 1983

ARNOLD ENGINEERING DEVELOPMENT CENTER
ARNOLD AIR FORCE STATION, TENNESSEE
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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APPROVAL STATEMENT

This report has been reviewed and approved.

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FOR THE COMMANDER

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Wind tunnel tests on Advanced Flexible Reusable Surface Insulation (AFRSI) used to protect the Orbital Maneuvering System (OMS) Pod of the Space Shuttle Orbiter were performed in the von Karman Gas Dynamics Facility Aerothermal Wind Tunnel (C). A wedge was used to subject the AFRSI to the desired local flow conditions in a free stream Mach 4 flow with the objective of duplicating the AFRSI material failure that occurred during the STS-6 flight. Selected results are presented to illustrate the test techniques and typical data obtained.

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NOMENCLATURE

ALPHA, ALPHA ANGLE	Indicated pitch angle, deg
C1	Gardon gage calibration factor measured at 70°F, Btu/ft^2-sec-mv
C2	Temperature corrected Gardon gage calibration factor, Btu/ft^2-sec-mv
CL	Tunnel event indication of model reaching centerline
CONF	Phase type (1000 for pressure calibration, 2000 for thermal calibration, 3000 for material evaluation)
CP	Pressure coefficient
CST	Central Standard Time
DB, db	Sound pressure level of the root mean square acoustic pressure, decibel
DC	Tunnel event indication of the closing of the tunnel fairing doors
DO	Tunnel event indication of the opening of the tunnel fairing doors
E	Gardon gage output, mv
EVENT,CAMERA	Indication of tunnel injection sequence (DO, LO, CL, DC, OCL) and camera firings (SHG, IR)
f/xx	IR camera f stop setting xx
FLANGE	Static pressure measured on the Aerothermal nozzle exit flange, psia
GAGE NO.,Ti	Gardon gage identification number
H(TT), H(RTT), H(0.915TT)	Heat transfer coefficient based on TT, RTT or 0.915TT; i.e., H(RTT) = QDOT/(RTT-TW), Btu/ft^2-sec-°F
IR	Camera firing indication for infrared color monitor camera
Ki, Kulite No.	Kulite gage identification number
KG	Gardon gage temperature calibration factor, °F/mv

LO	Tunnel event indication of the lift-off of the model in the tank
M	Free-stream Mach number
MU	Dynamic viscosity based on free-stream temperature, lbf-sec/ft^2
OCL	Tunnel event indication of the model leaving centerline
P,PIN	Free-stream static pressure, psia
PIC NO.	Photograph number for each camera and each run
POD ANGLE	Angular rotation of the OMS Pod contour about its leading edge; positive being trailing edge down, deg
PT	Tunnel stilling chamber pressure, psia
PW	Surface static pressure, psia
Q	Free-stream dynamic pressure, psfa
QDOT	Measured heat-transfer rate, Btu/ft^2-sec
R	Multiplier on total temperature
RE	Free-stream unit Reynolds number, ft^{-1}
RHO	Free-stream density, lbm/ft^3
RMS	Root mean square acoustic pressure, psia
RTT	Relationship for recovery temperature, product of a multiplier, R, and the total temperature, TT, °F
RUN	Data set identification number
SAMPLE	Sample identification letter
SHG	Camera firing indication for shadowgraph camera
ST(TT), ST(RTT), ST(0.915TT)	Stanton number based on TT, RTT, or 0.195TT; i.e.;

$$ST(RTT) = H(RTT)/[RHO*V*(0.2235 + 1.35 \times 10^{-5} (RTT + TW)]$$

T	Free-stream static temperature, °F
TAP, STATIC NO.	Static tap identification number
TG,TGE	Gardon gage edge temperature, °F

TGDEL	Temperature differential from the center to the edge of the Gardon gage disc, °F
TIME	Elapsed time from start of wedge injection (lift-off), sec
TIMECL	Time at which the wedge reached tunnel centerline, Central Standard Time or sec
TIMEEXP	Time of exposure to the tunnel flow when the data were recorded, [TIME - (32/57)(TIMEINJ)], sec
TIMEINJ	Time of model injection; elapsed time from lift-off to arrival at tunnel centerline, sec
TIMERD	Time from lift-off at which Gardon gage data were reduced, sec
TK_i	Temperature measurement from a thermocouple located near the i^{th} Kulite gage, °F
TP	Wedge cavity thermocouple temperature, °F
TPTi	Temperature measurement from a thermocouple located on the i^{th} ESP pressure module, °F
TSi	Thermal model surface, i = 1 to 13, and backside thermocouple, i = 14 to 16; Sample backside thermocouple, i = 1 to 3, °F
TT	Tunnel stilling chamber temperature, °F
TW	Gage surface temperature, °F
V	Free-stream velocity, ft/sec
WA, WEDGE ANGLE	Wedge angle, deg (see Fig. 4)
X, Y, Z	Orthogonal body axis system directions (see Fig. 4 and 5)
ε	Sample emissivity

1.0 INTRODUCTION

The work reported herein was performed by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 921E01, Control Number 9E01, at the request of the National Aeronautics and Space Administration (NASA/JSC), Houston, TX. The NASA project manager was Mr. Jack Barneburg and the Rockwell International (RI) project engineer was Mr. Paul Lemoine. The results were obtained by Calspan Field Services, Inc./AEDC Division, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Station, Tennessee. The tests were performed in the von Karman Gas Dynamics Facility (VKF), Aerothermal Wind Tunnel (C), on May 27, August 8 and 11, 1983 under AEDC Project No. CA76VC (Calspan No. V41C-3E).

During the sixth flight of the Space Shuttle, portions of the Advanced Flexible Reusable Surface Insulation (AFRSI) on the Orbital Maneuvering System (OMS) Pod failed. The objective of this test program was to investigate the thermostructural performance of the AFRSI under aeroheating conditions to help interpret the physical mechanism by which the failure was incurred.

In order to simulate the aerodynamic environment in which the STS-6 failure occurred, and therefore duplicate the failure in the tunnel, various flow requirements were identified. To investigate the degree to which these flow characteristics could be achieved using the proposed test article, a Feasibility Checkout Phase was performed in a separate tunnel entry. The principal objective of this feasibility study was to maintain and control a turbulent boundary layer separation upstream of the proposed AFRSI location at the low Reynolds number desired for specific flight simulation.

The second tunnel entry began with a Calibration Phase intended to establish the testing environment in terms of static and acoustic pressure distributions and aerodynamic heating levels. The equilibrium temperature of the surface of the insulation material was also determined. The test was completed with the evaluation of 3 AFRSI test samples at total pressures of 20 and 25 psia and total temperatures ranging up to 1115°F.

Inquiries to obtain copies of the test data should be directed to NASA/JSC/ES2, Houston, TX 77058. A microfilm record of the tabulated data has been retained at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

The Mach 4 Aerothermal Tunnel (C) is a closed-circuit, high temperature, supersonic freejet wind tunnel with an axisymmetric contoured nozzle and a 25 in.-diam nozzle exit, Fig. 1. This tunnel utilizes parts of the Tunnel C circuit (the electric air heater, the Tunnel C test section and injection system) and operates continuously over a range of pressures from nominally 15 psia at a minimum stagnation temperature of 250°F to 180 psia at a stagnation temperature of 1110°F. Using the normal Tunnel C Mach 10 circuit (Series Heater Circuit), the Aerothermal Mach 4 nozzle operates at a maximum pressure and temperature of 100 psia and 1440°F, respectively. The air temperatures and pressures are normally achieved by mixing high temperature air (up to 1790°F) from the primary flow discharged from the electric heater with the bypass air flow (at 980°F) from the natural gas-fired heater. The primary and the bypass air flows discharge into a mixing chamber just upstream of the Aerothermal Tunnel C stilling chamber. The entire Aerothermal nozzle insert (the mixing chamber, throat and nozzle sections) is water cooled by integral, external water jackets. Since the test unit utilizes the Tunnel C model injection system, it allows for the removal of the model from the test section while the freejet tunnel remains in operation. A description of the Tunnel C equipment may be found in Ref. 1.

2.2 TEST ARTICLE

The standard Aerotherm Materials Wedge, used for all phases of this test in Tunnel C, is a 12 inch wide by 34 inch long water-cooled flat plate with a backstep 14 inches from the leading edge for material sample installation. The installation of this wedge for the Feasibility Checkout Entry is shown in Fig. 2. The wedge was modified to include lateral extensions upstream of the backstep to reduce any edge effects on the material sample. This is depicted in Fig. 3 and characterized in the sketch of Fig. 4. The wedge was instrumented with Gardon-type heat gages to measure the local wedge heating environment, and the locations of these gages are given in Table 1.

Duplicating the OMS Pod geometry for the test models was a primary simulation requirement. A portion of the actual contour of the pod at the location of the flight failure was used to develop a two-dimensional representation for these test needs. For the feasibility study, a 0.13-scale model, referred to as contour 1 and depicted in Fig. 5, was fabricated from wood and covered with a thin ceramic layer. This shape represented the foremost edge of the OMS Pod up to and including the area of failure. A second wooden model tested was similar to contour 1, except that it had been reduced in size to investigate the controllability of the separation characteristics.

The installation of the wedge for the Calibration and Material Evaluation Phases is shown in Fig. 6. The sketch in Fig. 7 illustrates the locations of the extensive instrumentation installed for the calibrations including Gardon gages, Kulite acoustic pressure gages, and surface static pressure ports. The locations of the static pressure taps and Kulite acoustic sensors are given in Tables 2 and 3, respectively.

For the calibration models and material samples, a 0.20-scale contour of the OMS Pod was used. This shape is depicted in Fig. 8 and a tabulation of the contour coordinates is given in Table 4. The pressure model, shown in Fig. 9, was constructed of 1020 mild steel. The model has 32 flush orifice pressure taps on the contour surface and 24 Kulite transducers installed adjacent to selected tap positions, located as tabulated in Tables 2 and 3.

The thermal model, shown in Fig. 10, was constructed of Low-temperature Reusable Surface Insulation (LRSI) tile material in the same shape as the pressure model. The model had 13 Chromel®-Alumel® thermocouples located very near the LRSI surface in the location shown in Fig. 10b and tabulated in Table 5. Also, three thermocouples were installed on the backside of the LRSI material.

The mounting hardware for all test models was built with the capability to rotate the entire contoured shape about its leading edge. This provided additional control of the boundary layer separation characteristics and the OMS Pod surface environment. The configuration chosen for all calibration and sample tests was with the pod reclined 8 deg down. The instrumentation locations tabulated and all model sketches are representative of that configuration.

Three AFRSI test samples were conformed to the selected contour and bonded similar to the actual flight installation. A typical sample is shown in Fig. 11, prior to its evaluation. The samples are identified in Table 6, as characterized by the conditioning each underwent before testing. As shown in the photograph, the samples were attached using 17 bolts in a Silfrax® border around the AFRSI. The bolt holes were then plugged with uncoated LRSI material to provide a smooth surface. Each sample had three Chromel-Alumel thermocouples installed on its undersurface.

To insure a turbulent boundary layer along the wedge surface, boundary layer trips were installed one inch downstream of the wedge leading edge. The trip balls were 0.093 inches in diameter and were arranged in a three-row configuration, as shown in Fig. 4.

Posttest photographs of the thermal body and the AFRSI samples are shown in Fig. 12.

2.3 TEST INSTRUMENTATION

The instrumentation, recording devices, and calibration methods used to measure the primary tunnel and test data parameters are listed in Table 7a along with the estimated measurement uncertainties. The range and estimated uncertainties for primary parameters that were calculated from the measured parameters are listed in Table 7b.

To define the convective heating environment experienced by the material specimens, Gardon-type heat transfer gages were mounted in the wedge surface upstream of the OMS body, as shown in Fig. 4. Heat-transfer rate measurements were obtained with high-temperature Gardon gages which were supplied and calibrated by the AEDC. The gages were 0.25-in. in diameter with a sensing foil thickness of 0.010-in. They were instrumented with Chromel-Alumel thermocouples which provided the gage edge temperature measurement. Gage edge temperatures, together with the sensing foil thermocouple output, were used to determine the gage surface temperatures and corresponding gage heat-transfer rate. These data were then used to compute the local heat-transfer coefficient and Stanton number.

The model surface static pressures were measured with two Pressure Systems Incorporated® Model ESP-32 pressure modules with a range of ±15 psid. The ESP-32 pressure sensor module has 32 ports with a silicon pressure transducer per port that can be digitally addressed and calibrated on line. The ESP-32 modules were installed inside the OMS Pod contour in close proximity to the static taps, thus reducing the pressure stabilization time required. The static pressures were measured only during the second entry.

The surface dynamic pressure levels were measured with RI-supplied and installed Kulite sensors and transducers. These dynamic signals were recorded on multi-track tape recorders for user analysis. Selected channels (15) were routed to AEDC rms meters which were incorporated in the data acquisition system.

Several Chromel-Alumel thermocouples were used on the various test models to monitor critical model temperatures. The pressure model had thermocouples near Kulite gages 105, 110, 114, 116 and 124, monitored to insure they did not overheat and fail. The thermal model had 13 surface thermocouples to measure its surface equilibrium temperature, and these were located as shown in Fig. 10b and tabulated in Table 5. All AFRSI test samples and the thermal model had 3 thermocouples on the backside of the insulation to monitor the support structure temperature. The wedge cavity, where all the gage lead wires were routed, and both ESP modules were instrumented to monitor operating temperatures in these areas.

The infrared system which was used to measure model surface temperatures utilizes an AGA® Thermovision 680 camera which scans at a rate of 16 frames per second. The camera has a detector which is sensitive to infrared radiation in the 2 to 6 micron wavelength band. A description of the system is given in Ref. 2.

A total time of exposure to the tunnel flow is required for data reduction. All the events which occur during a run are timed using the digital clock in the DEC-10 computer, which processes all data from the continuous tunnels.

A variety of cameras was used to record the response of the materials to the tunnel environment. The cameras, frame rates and film identifications are summarized in Table 8. A plumb line was attached to the aft window to provide a vertical reference in the shadowgraph stills.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS

The nominal free stream test conditions are given below.

M	PT, psia	TT, °F	Q, psfa
4	20	350	225
│	│	840	220
│	↓	1440	214
│	25	340	281
│	↓	1440	270
│	30	330	336
│	↓	1440	320
↓	60	1440	641

A test summary showing a detailed account of all runs of each phase is presented in Table 9.

3.2 TEST PROCEDURES

In the VKF continuous flow wind tunnels (A, B, C), the model is mounted on a sting support mechanism in an installation tank directly underneath the tunnel test section. The tank is separated from the tunnel by a pair of fairing doors and a safety door. When closed, the fairing doors, except for a slot for the pitch sector, cover the opening to the tank and the safety door seals the tunnel from the tank area. After the model is prepared for a data run, the personnel access door to the installation tank is closed, the tank is vented to the tunnel flow, the safety and fairing doors are opened, and the model is injected into the airstream. After the data are obtained, the model is retracted into the tank and the sequence is reversed with the tank being vented to atmosphere to allow access to the model in preparation for the next run. A given injection cycle is termed a run, and all the data obtained are identified in the data tabulations by a run number.

The standard AEDC materials wedge testing technique was used to support the calibration bodies and material samples and provide the desired local flow condition. A detailed description of this technique may be found in Ref. 3.

Instrumentation outputs were recorded using the digital data scanner in conjunction with the analog subsystem. Data acquisition from all instruments other than the infrared camera was under the control of a Digital Equipment Corporation (DEC) PDP 11/40 computer, utilizing the random access data system (RADS). The data system was started prior to injection, while the model was still in the tank. All the transducer outputs were recorded at the rate specified in Table 10. Additional loops of data were recorded each time the sequence cameras were triggered, thereby providing a time point for each photograph. The data were transmitted to a DEC-10 computer for processing.

The infrared system operates independently of the RADS. During a run the AGA 680 infrared camera scanned the model to produce a complete picture at the rate of 16 frames per second. The camera output was recorded on analog tape and simultaneously displayed on a color television monitor. The developing color patterns were observed as the model surface temperature increased, and the monitor was photographed as described in Table 10 to provide a permanent record. The camera output was also fed to an analog-to-digital converter under the control of a PDP 11/34 computer. Every 4 seconds a single frame was digitized and transmitted to the DEC-10 computer. An additional loop of data from the RADS system was recorded each time a frame was digitized to provide a record of test conditions at the time infrared data were obtained.

Characteristics of the data acquisition peculiar to each test phase will be described individually.

3.2.1 Feasibility Checkout Phase

To determine the flow separation and reattachment characteristics of the proposed OMS Pod contour, several runs of oil flow visualization were obtained at several free stream pressures. The wedge and wooden contoured models were painted with a high-temperature black paint just prior to the application of the white oil. The oil was applied with a sponge to provide a sheet of oil over the entire surface. The model was injected at the desired wedge angle and remained on centerline for at least 5 seconds. During the exposure, views of the oil flow progression were videotaped from the top window port and the forward side window. A typical frame of the tape from the top view is shown in Fig. 13. Also, the shadowgraph system was videotaped and helped qualify the flow on the wedge and OMS Pod model.

Heat transfer measurements were taken on the wedge to define the convective heating environment in the area upstream of the wooden contour.

3.2.2 Pressure Calibration Phase

The flow environment on the test article and the wedge plate was extensively measured at many model attitudes and flow conditions to quantify these parameters for the material evaluations. The pressure calibration body, instrumented for static and dynamic pressure measurements, was installed on the aerotherm wedge for this phase.

The injection data-taking sequence was initiated by positioning the wedge at the desired wedge angle and beginning the tape recording of the Kulite transducer outputs. After several seconds, the tunnel doors were opened, the model was injected to the tunnel centerline and the doors were closed. After nominally 20 seconds on centerline, the doors were opened, the model was retracted, the tape recorders were stopped and the data-taking sequence was completed. For the shorter calibration runs, nominally 6 seconds on centerline, the doors were left open throughout. While on centerline, the convective heat transfer environment, the static pressure distribution and selected rms pressure levels were determined. Also, shadowgraph still photographs recorded the shock wave pattern and general TV coverage was videotaped.

3.2.3 Thermal Calibration Phase

To quantify the surface equilibrium temperature expected on the AFRSI samples, the thermal model was installed on the wedge and injected into the tunnel for an extended period of time. Several of the surface thermocouples were monitored during the run to determine when the LRSI had reached an equilibrium temperature. Starting at the maximum tunnel total temperature, 1440°F, four runs of thermal calibrations were achieved until a desired maximum surface equilibrium temperature was obtained. Infrared data were also obtained on the thermal model surface. Also, low and high speed movie coverage of the LRSI was recorded for the approximate 4 minute tunnel exposure.

3.2.4 Material Evaluation Phase

AFRSI test samples A, B and F were evaluated in the tunnel. The test article was positioned at the desired wedge angle and the data-taking sequence was initiated at lift-off from the tank.

The samples remained on centerline nominally 250 seconds, or until a failure was incurred. The convective heat transfer environment and the static pressure distribution on the wedge were determined. The infrared camera was continuously updating the sample surface temperature, and movies and still photographs were taken of the color IR monitor. Movies of the sample were taken starting at lift-off. High speed movies were initiated when the failure was first beginning and the physical apearance of the sample first changed.

3.3 DATA REDUCTION

Measured stilling chamber pressure and temperature and the calibrated test section Mach number were used to compute the free-stream parameters. The equations for a perfect gas isentropic expansion from stilling chamber to test section were modified to account for real gas effects.

Data measurements obtained from the Gardon gages are gage output (E) and gage edge temperature (TGE). The gages are direct reading heat flux transducers and the gage output is converted to heating rate by means of a laboratory calibrated scale factor (C1). The scale factor has been found to be a function of gage temperature and, therefore, must be corrected for gage temperature changes,

$$C2 = C1\ f(TGE) \qquad (1)$$

Heat flux to the gage is then calculated for each data point by the following equation:

$$QDOT = (C2)(E) \qquad (2)$$

The gage wall temperature used in computing the gage heat-transfer coefficient is obtained from two measurements - the output of the gage edge thermocouple (TGE) and the temperature difference (TGDEL) from the gage center to its edge. The measured values used in the reduction equations were filtered using 4 consecutive data points taken within less than a half a second, and typically just one second after centerline. TGDEL is proportional to the gage output, E, and is calculated by:

$$TGDEL = (KG)(E) \tag{3}$$

The gage wall temperature is then computed as

$$TW = TGE + 0.75\ TGDEL \tag{4}$$

where the factor 0.75 represents the average, or integrated, value across the gage.

The heat transfer coefficient for each gage was computed using the following equation

$$H(RTT) = \frac{QDOT}{(RTT-TW)} \tag{5}$$

where QDOT and TW were obtained from gage measurements. The product RTT represents the recovery temperature, which is not known at each measurement location. H(RTT) was calculated for values of R of 1.0 and 0.915.

The heat transfer coefficient was then converted to Stanton number by:

$$ST(RTT) = \frac{H(RTT)}{(RHO)(V)[0.2235 + 1.35 \times 10^{-5}(RTT + TW)]}$$

Prior to each operational shift, the two ESP-32 modules with a total of 64, ±15 psid transducers were calibrated. From these data, scale factors for each transducer were calculated. Prior to each test run the modules were referenced to a hard vacuum to obtain zero readings for each transducer. The appropriate scale factor and zero reading were used to determine the pressure on each transducer. Five consecutive readings, taken within a half a second, were averaged to obtain the static pressure. The readings were obtained when the tunnel doors were closed, except for the shorter calibration runs, and the model was on centerline. This was nominally 10-20 seconds after centerline was reached. A pressure coefficient, CP, was also calculated from:

$$CP = \frac{144\ (PW-P)}{Q}$$

The rms pressure measurements were obtained by sampling the rms meter output and multiplying this output by the user-supplied sensitivity factors. These were related to decibel level by:

$$db = 20 \log_{10} \frac{RMS}{2.9 \times 10^{-9}}$$

As discussed in Section 3.2, the output of the IR camera is displayed in real time on a color television monitor. A 70mm camera was used to photograph the monitor screen simultaneously with a single frame digitizing process. An example of a monitor screen photograph is given in Fig. 14. On the television monitor the temperature range, which the system is set up to measure, is divided, in a nonlinear fashion, into ten separate colors, starting with blue for the lowest temperature and progressing through white for the highest. Each color then represents a temperature band within the total range, and the interface between two colors corresponds to one particular temperature. This provides a view in which unusual temperature patterns would be more easily discerned than in the digital data tabulations.

As noted in Section 3.2, digital infrared data were obtained at the rate of one frame every four seconds. One complete frame of infrared data consists of 70 scan lines with 110 points per line for a total of 7700 discrete but overlapping spots. For most test installations the field of view is such that the model does not fill the complete frame. In order to save storage space in the computer, only the portion of the frame which contains good model data is digitized. For the AFRSI and LRSI test articles, a typical area of interest (see Fig. 14) was approximately 80 lines by 70 points (5600 discrete spots). For each spot, the camera output is digitized and converted to a temperature reading by means of an equation derived from basic laws of radiation and incorporating various constants peculiar to this system. These constants are obtained from laboratory calibrations using a standard black body source.

The temperature calculations were carried out using surface emissivity values determined from AEDC reflectivity measurements made at room temperature. A monochromatic light source was used to illuminate the material sample. The hemispherical spectral reflectivity was then measured. Assuming the sample is opaque to radiation at each discrete wavelength at which reflectivity was measured, and assuming that the material acts as a diffuse-gray surface, the emissivity (ε) was determined from the reflectivity as follows:

$$\varepsilon = 1 - \text{REFLECTIVITY}$$

This reflectivity measurement was made at several wavelengths. The emissivity values for each wavelength were weighed by the response characteristic of the IR camera detector at that wavelength, and the result integrated over the total wavelength range of the IR detector to provide a value of total emissivity. Emissivity values of 0.82 for the LRSI tile (thermal model) and 0.68 for the AFRSI were thus determined.

Note that hemispherical reflectivity measurements were used to evaluate emissivity. Therefore, strictly speaking, the emissivity calculated above is the hemispherical emissivity for an opaque surface. A reasonable approximation (within 2 to 5 percent) for gray-body diffuse emitters is that the directional emissivity is equal to the hemispherical emissivity for surface angles within 40 degrees of the normal. Therefore, the temperature data produced from IR measurements during this test are valid only for surfaces aligned within 40 degrees of horizontal.

The calculated temperatures were tabulated in a two-dimensional array in which each spot location is defined by its Line number and Point number. In order to use the IR data, it is necessary to define the model position in terms of Line and Point number. This was done by taking wind-off infrared scans of the wedge, with a specimen attached, in the tunnel at the test attitude. A wire was positioned along the edge of the specimen, and an external electrical current was provied causing the wire to heat up. Thus, it was possible to locate the specimen on the IR video monitor via the outline produced by the hot wire. A marker is then superimposed on the video monitor by the IR system electronics. This marker is a matrix of dots representing each spot in the digitized IR data. The marker can be controlled so that individual Lines or Points may be identified. In this manner the Lines and Points corresponding to the sample location were defined. Figure 14 identifies the location, in terms of Lines and Points, of several points of interest. The actual field digitized covered the range of all of these points, so that the field did not have to be changed during the test.

The spot size is a function of the camera detector size, the camera optics, and the distance to the test article. However, it must be emphasized that each IR "spot" was about 0.35 in. in diameter and that the measured radiation from this size spot is used to calculate the surface temperature. Also, note that this spot is for a surface normal to the IR camera (i.e., in the horizontal plane). Measurements on surfaces inclined relative to the camera will be influenced by model temperatures over an area larger than this spot size.

3.4 UNCERTAINTY OF MEASUREMENTS

In general, instrumentation calibrations and data uncertainty estimates were made using methods recognized by the National Bureau of Standards (NBS). Measurement uncertainty is a combination of bias and precision errors defined as:

$$U = \pm(B + t_{95}S)$$

where B is the bias limit, S is the sample standard deviation and t_{95} is the 95th percentile point for the two-tailed Student's "t" distribution (95-percent confidence interval), which for sample sizes greater than 30 is taken equal to 2.

Estimates of the measured data uncertainties for this test are given in Table 7a. The data uncertainties for the measurements are determined from in-place calibrations through the data recording system and data reduction program.

Propagation of the bias and precision errors of measured data through the calculated data was made in accordance with Ref. 4 and the results are given in Table 7b.

4.0 DATA PACKAGE PRESENTATION

A sample data tabulation is presented in Appendix III. Included is a tabulation of the heat-transfer data for the feasibility study. For the pressure calibrations, samples of the heat transfer data, the static pressure data, the rms pressure data and the thermocouple data are included. For the thermal calibrations, samples of the heat transfer data, the static pressure data, the surface thermocouple data and an IR tabulation are included. For the material evaluation phase, samples of the heat transfer data, static pressure data, sample thermocouple data and an IR tabulation are included.

REFERENCES

1. Test Facilities Handbook (Eleventh Edition), "von Karman Gas Dynamics Facility, Vol. 3," Arnold Engineering Development Center, April 1981.

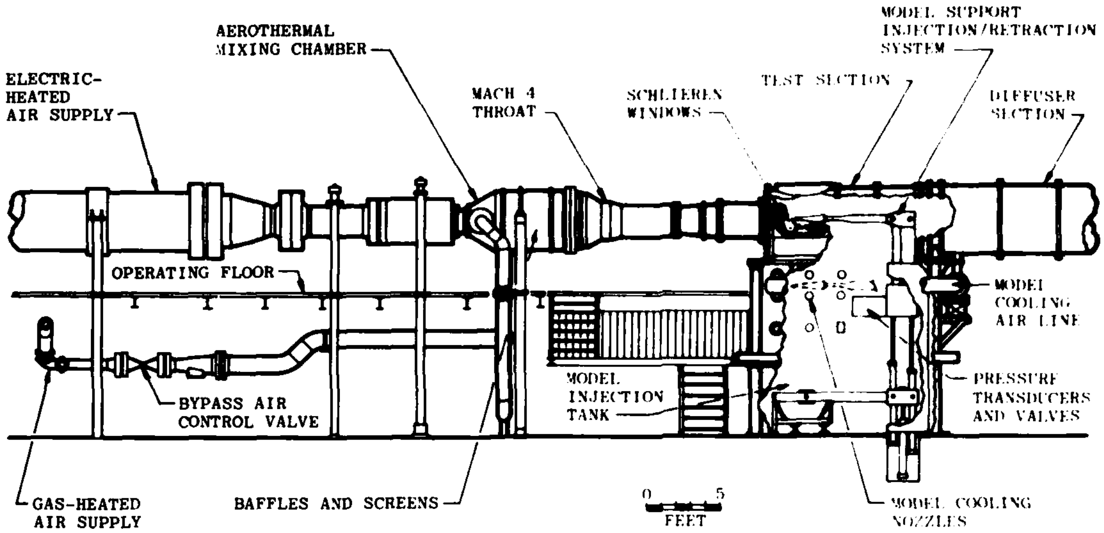
2. Boylan, D. E. Carver, D. B., Stallings, D. W., and Trimmer, L. L. "Measurement and Mapping of Aerodynamic Heating Using a Remote Infrared Scanning Camera in Continuous Flow Wind Tunnels," AIAA Preprint 78-799, April 1978.

3. Matthews, R. K. and Stallings, D. W. "Materials Testing in the VKF Continuous Flow Wind Tunnels," AIAA 9th Aerodynamic Testing Conference, Arlington, TX, June 7-9, 1976.

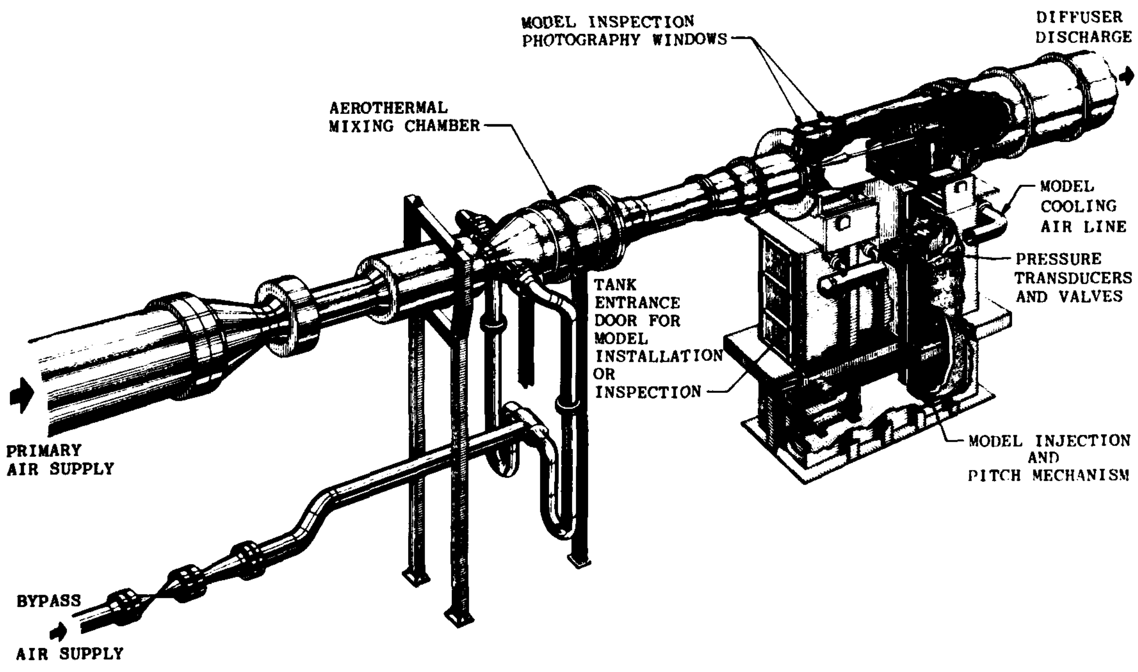
4. Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements," AEDC-TR-73-5 (AD755356), February 1973.

APPENDIX I

ILLUSTRATIONS

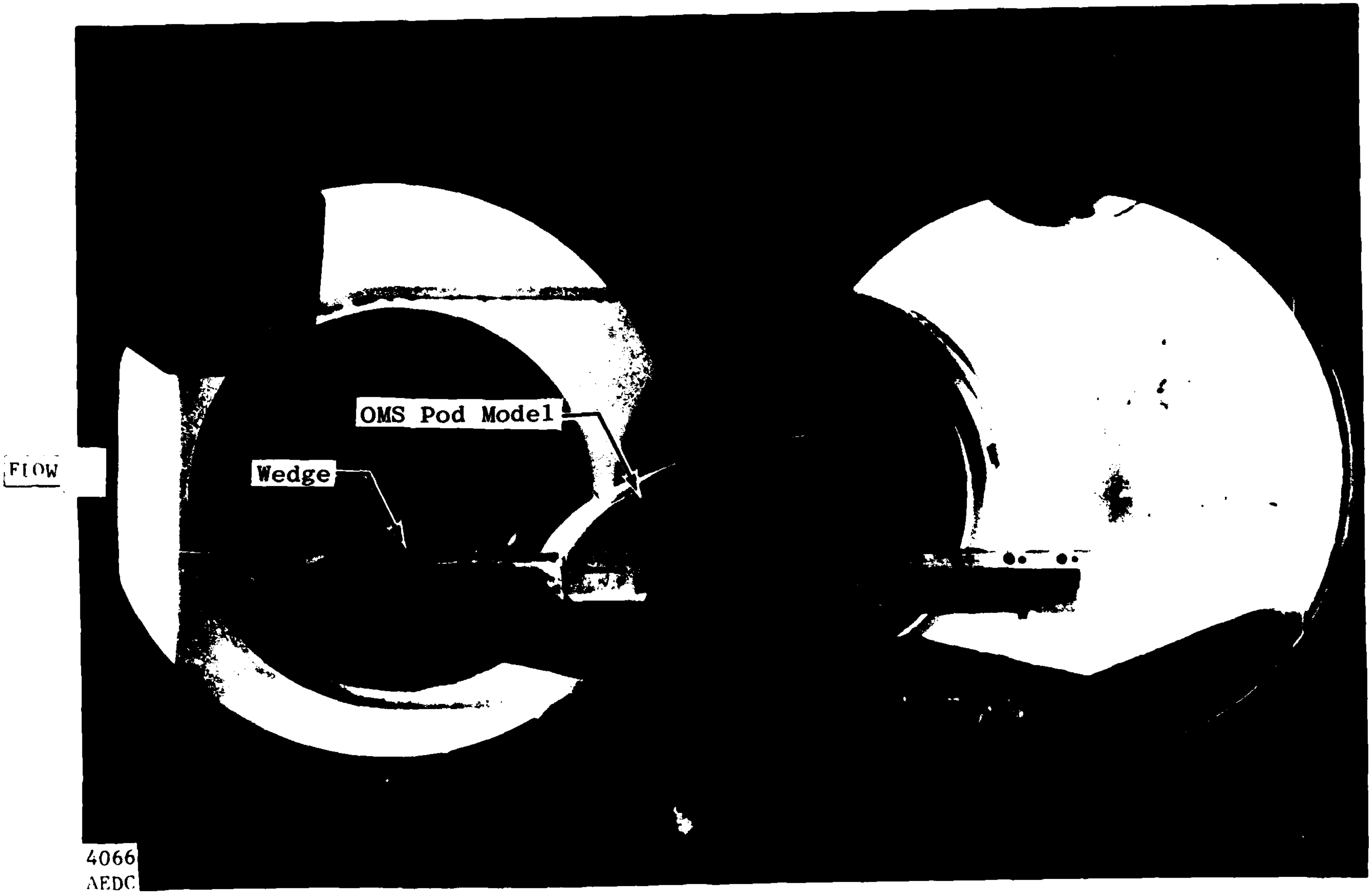


a. Tunnel assembly

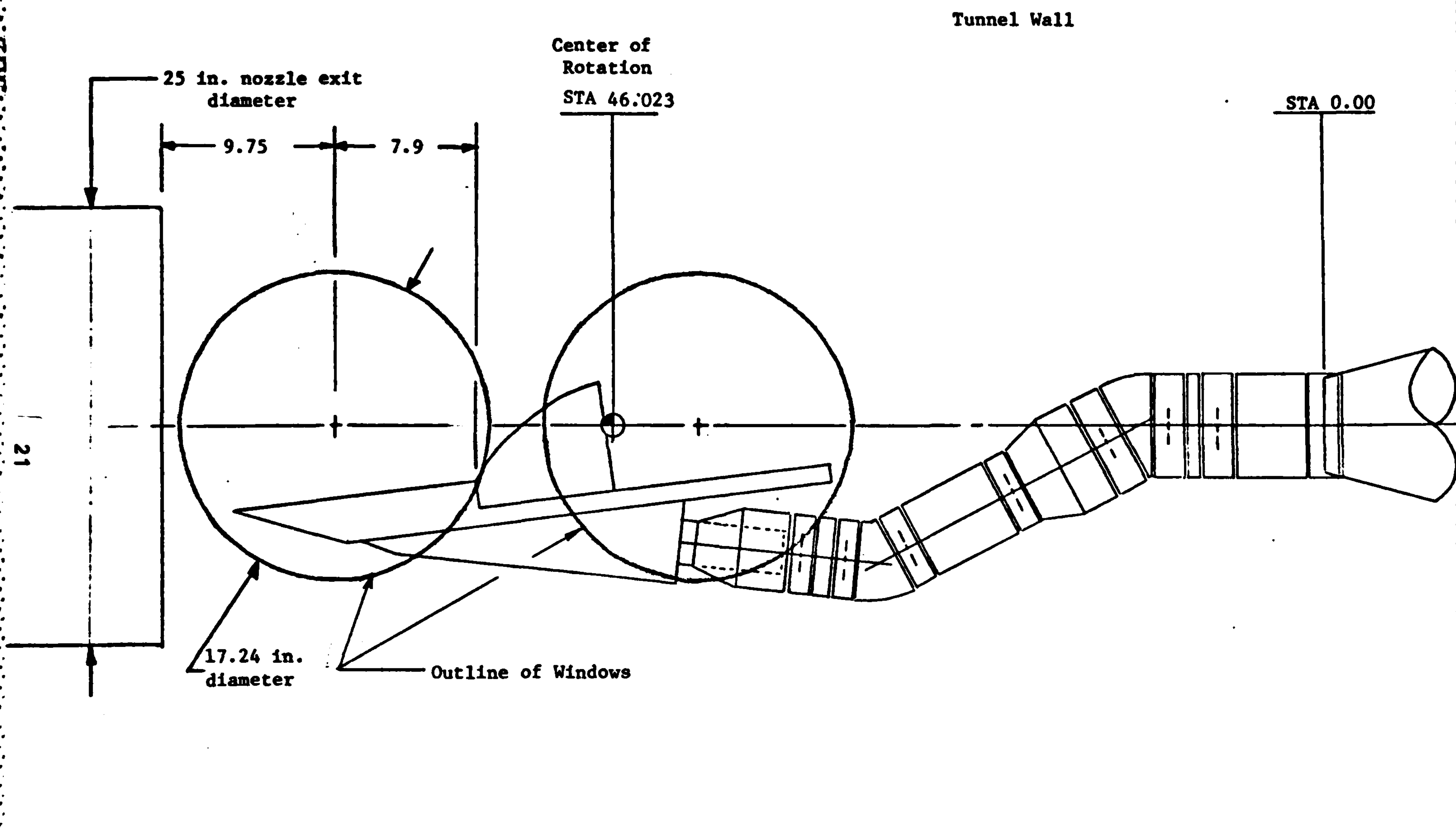


b. Perspective of tunnel test section area

Fig. 1 Tunnel C Mach 4.0 Configuration

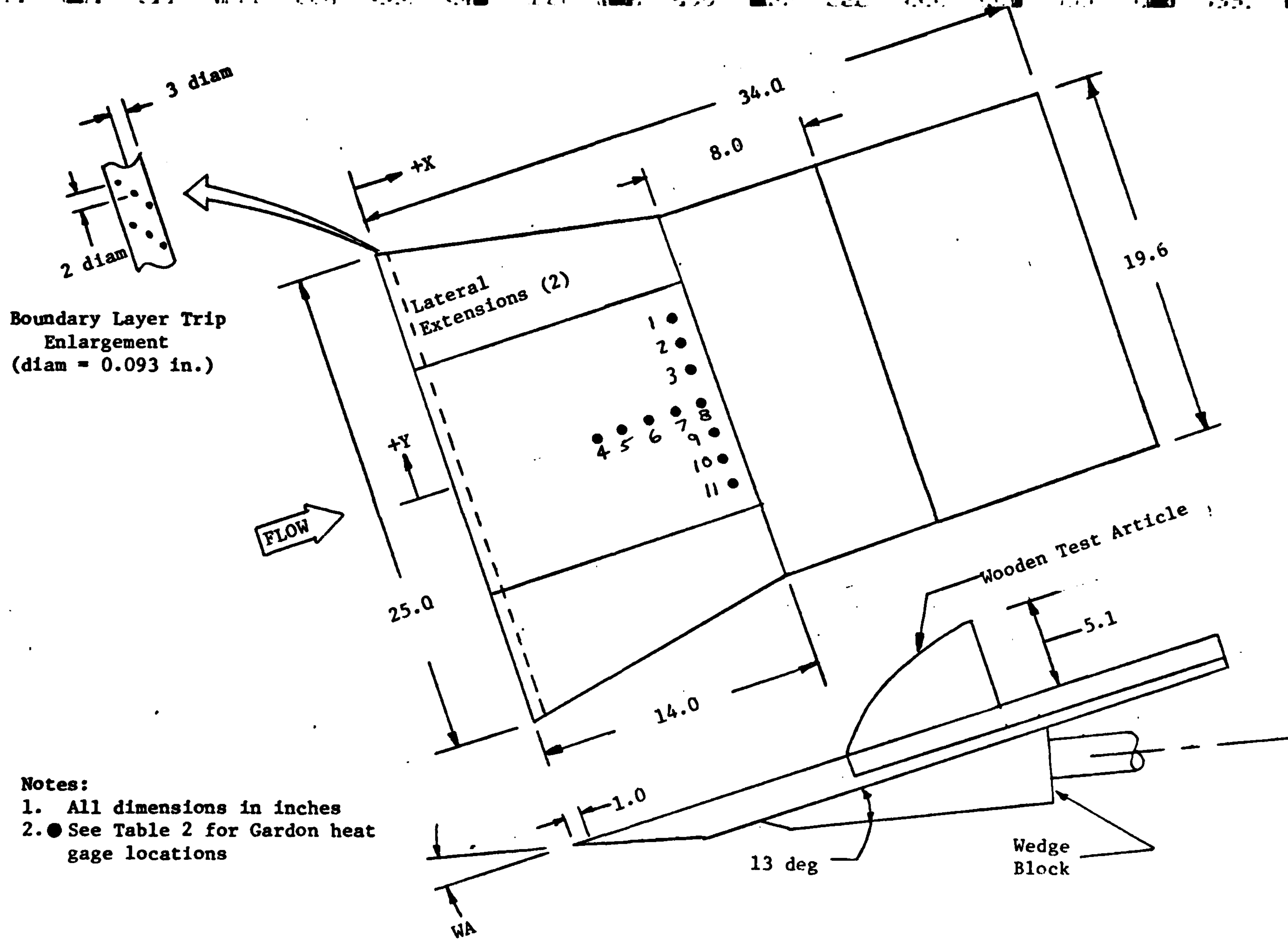


a. Tunnel C Installation Photograph, M = 4
Figure 2. Installation of Test Article - Feasibility Checkout Entry



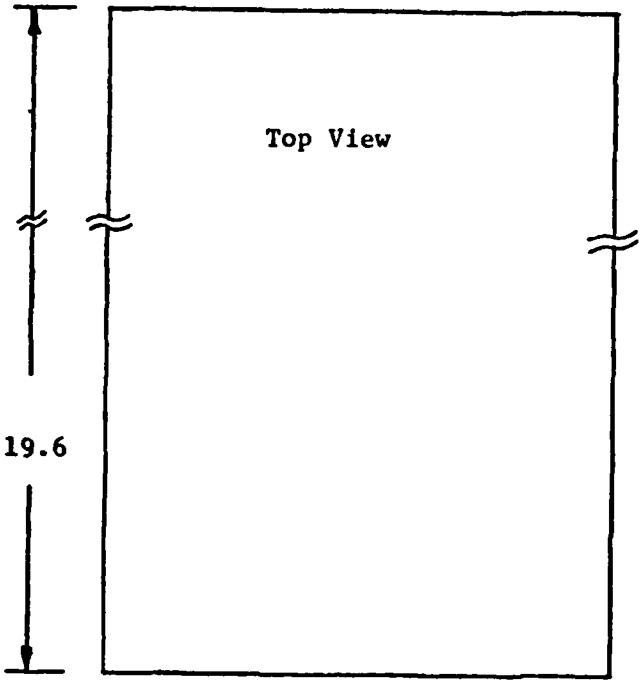
b. Tunnel C Installation Sketch
Figure 2. Concluded

Figure 3. Feasibility Test Article in Tunnel Tank

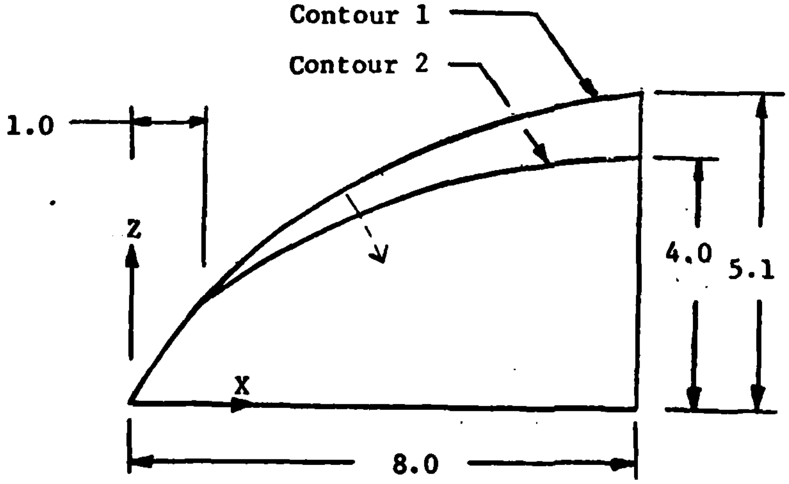


Notes:
1. All dimensions in inches
2. ● See Table 2 for Gardon heat gage locations

Figure 4. Aerotherm Wedge - Feasibility Checkout Entry



Contour 1* (0.13 scale)	
X,in.	Z,in.
0	0
0.155	0.362
0.554	1.069
0.788	1.375
1.304	1.933
2.566	2.905
3.305	3.352
4.204	3.806
5.265	4.249
6.536	4.675
8.042	5.100

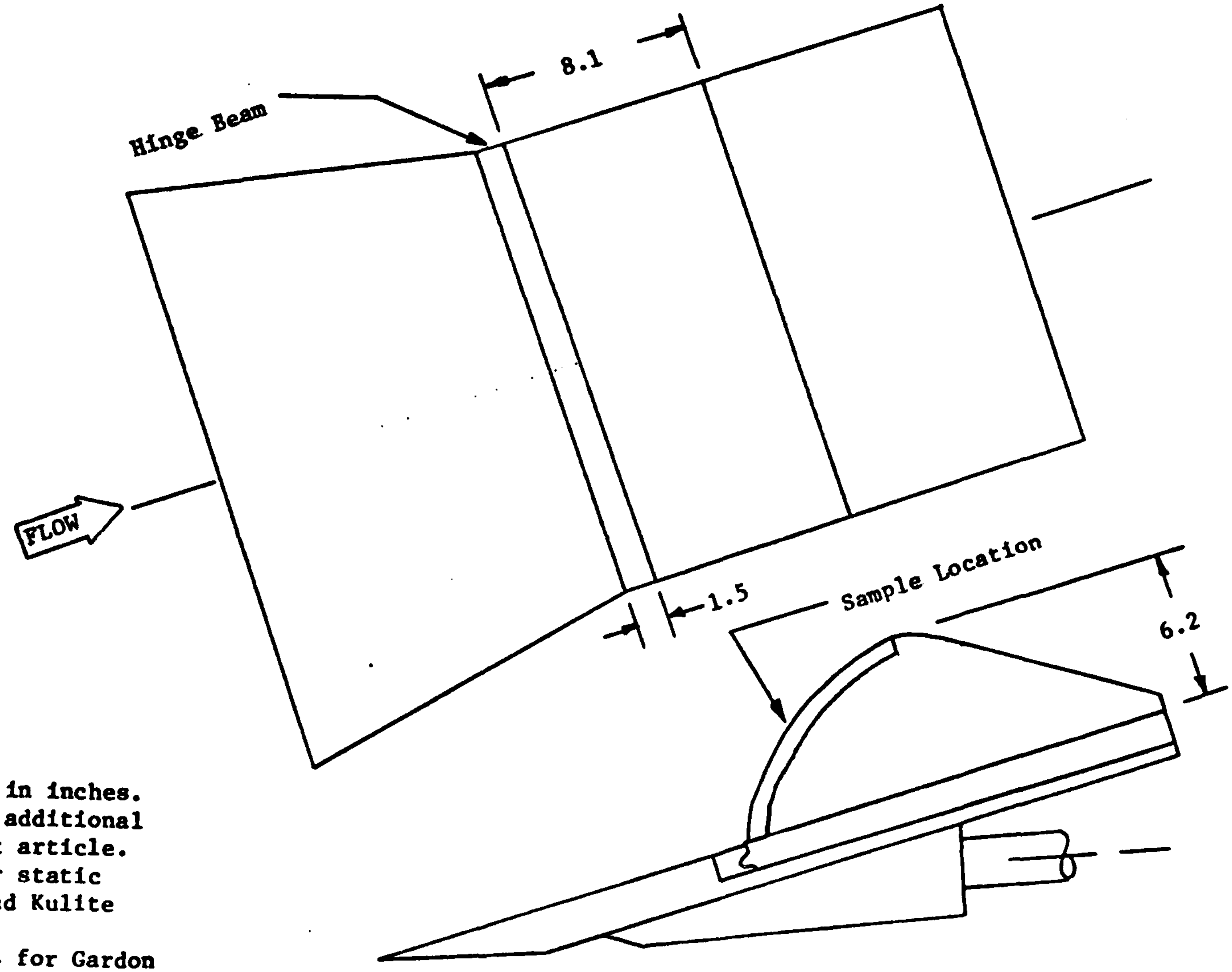


*Note: Contour 2 was obtained by rotating the identical contour downward as shown above.

Figure 5. Feasibility Test Models

a. Tunnel C Installation Photograph, $M = 4$

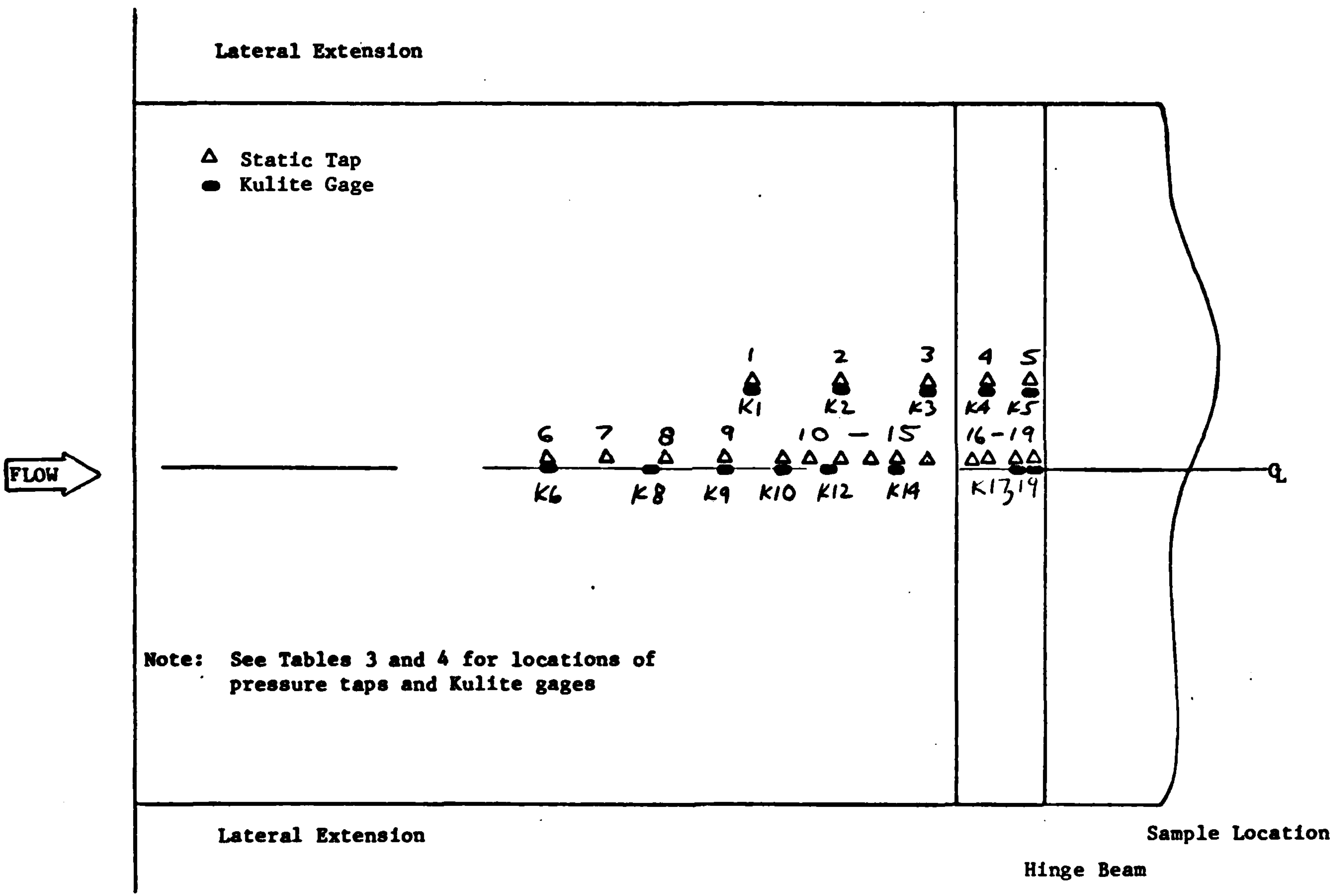
Figure 6. Installation of Test Article - Calibration and Material Evaluation Entry



Notes:
1. All dimensions in inches.
2. See Fig. 4 for additional details of test article.
3. See Fig. 7b for static pressure tap and Kulite Gage locations.
4. Refer to Fig. 4 for Gardon Gage locations.

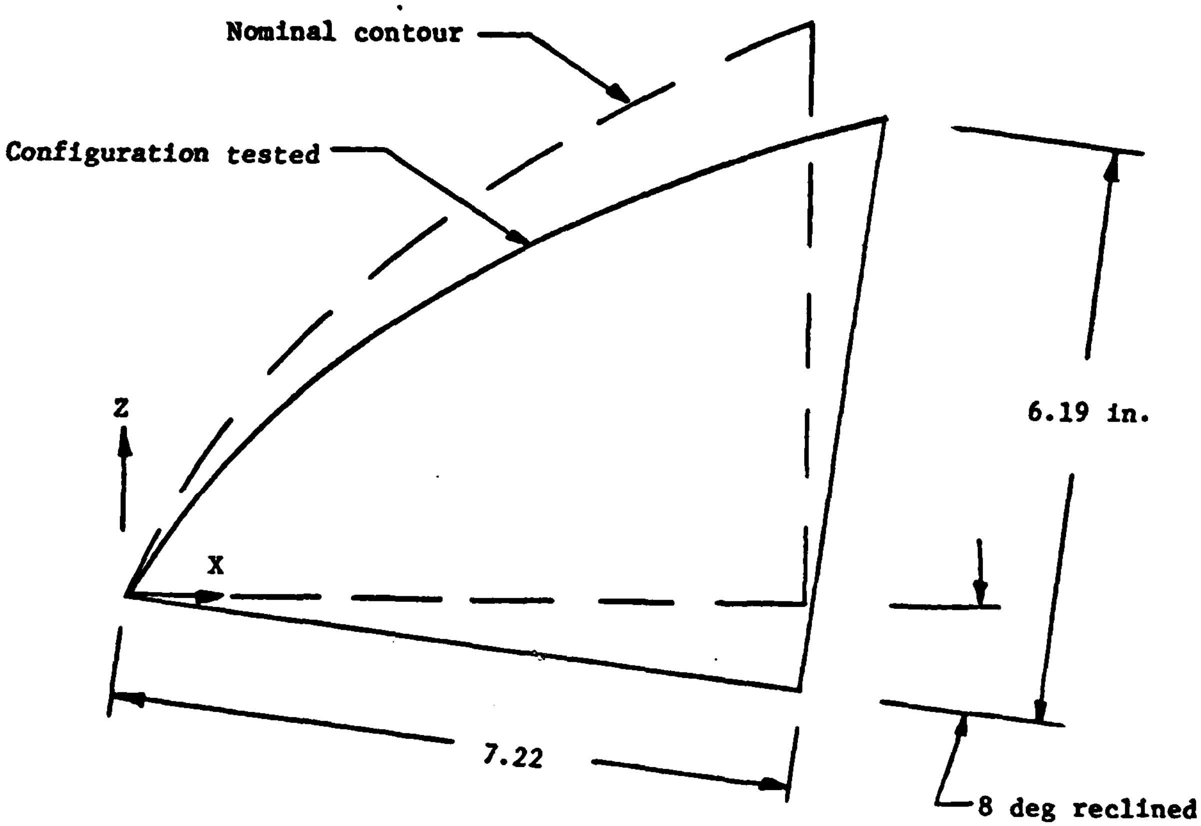
a. Aerotherm Wedge

Figure 7. Test Article - Calibration and Material Evaluation Entry



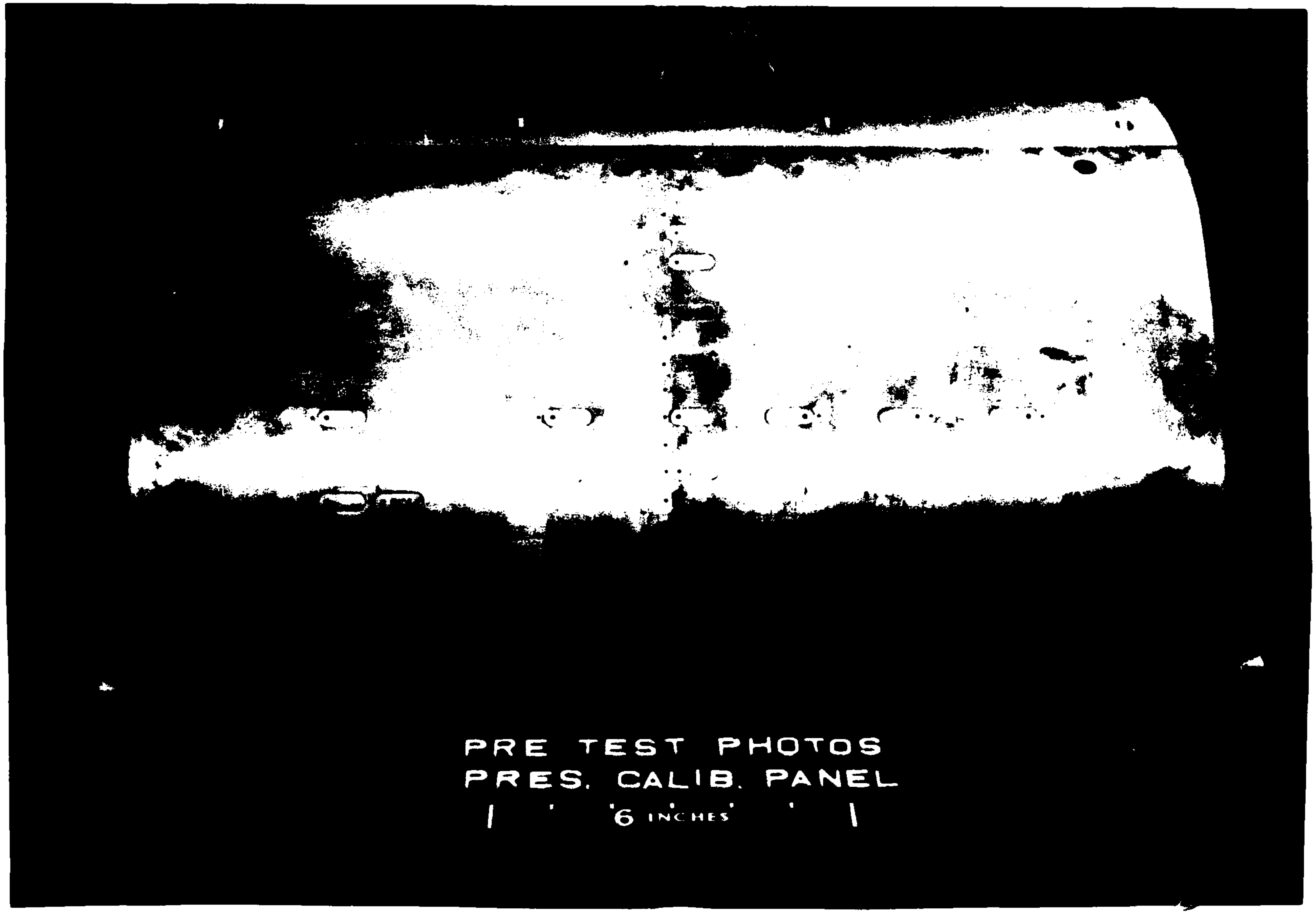
b. Wedge Pressure Instrumentation

Figure 7. Concluded

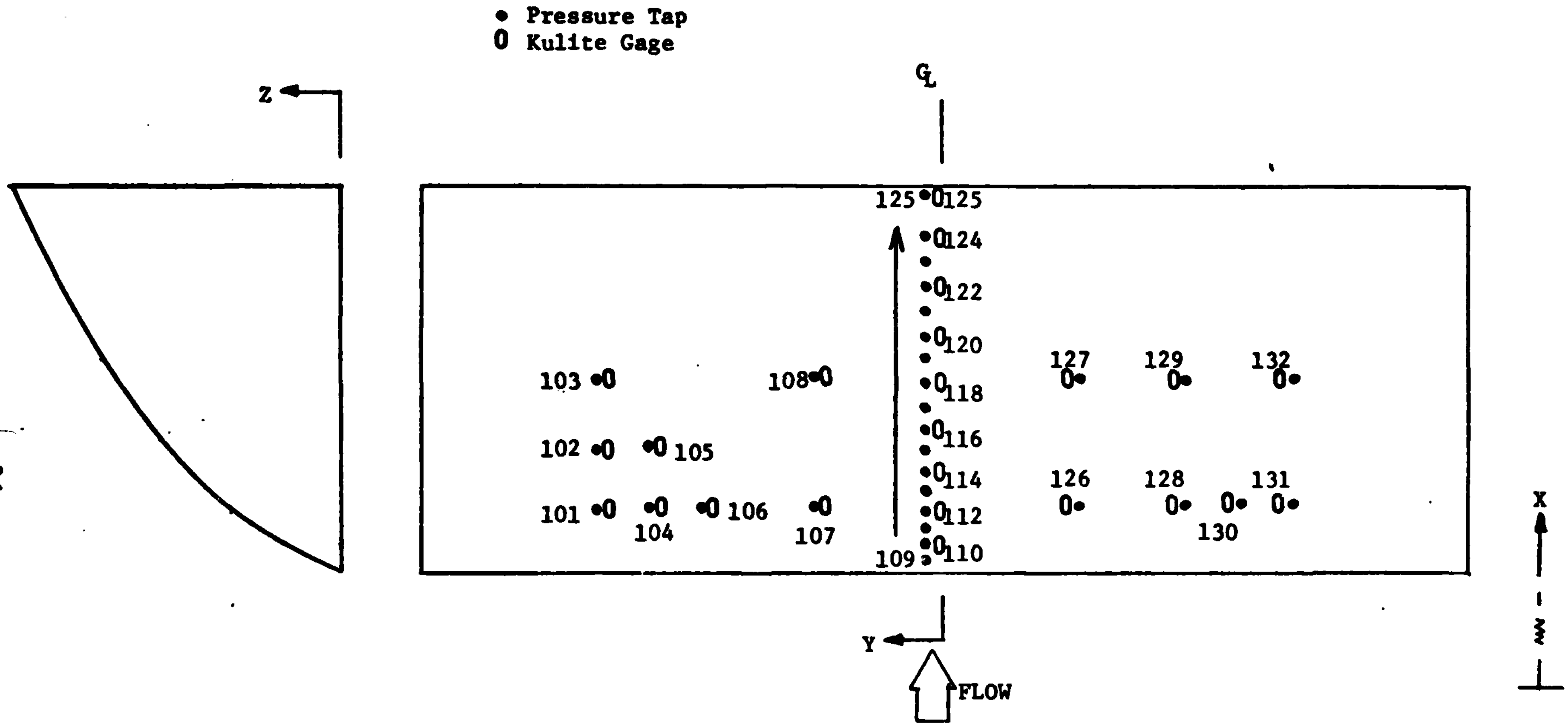


See Table 5 for coordinates of nominal 0.20-scale contour

Figure 8. Contour of OMS Pod Test Models



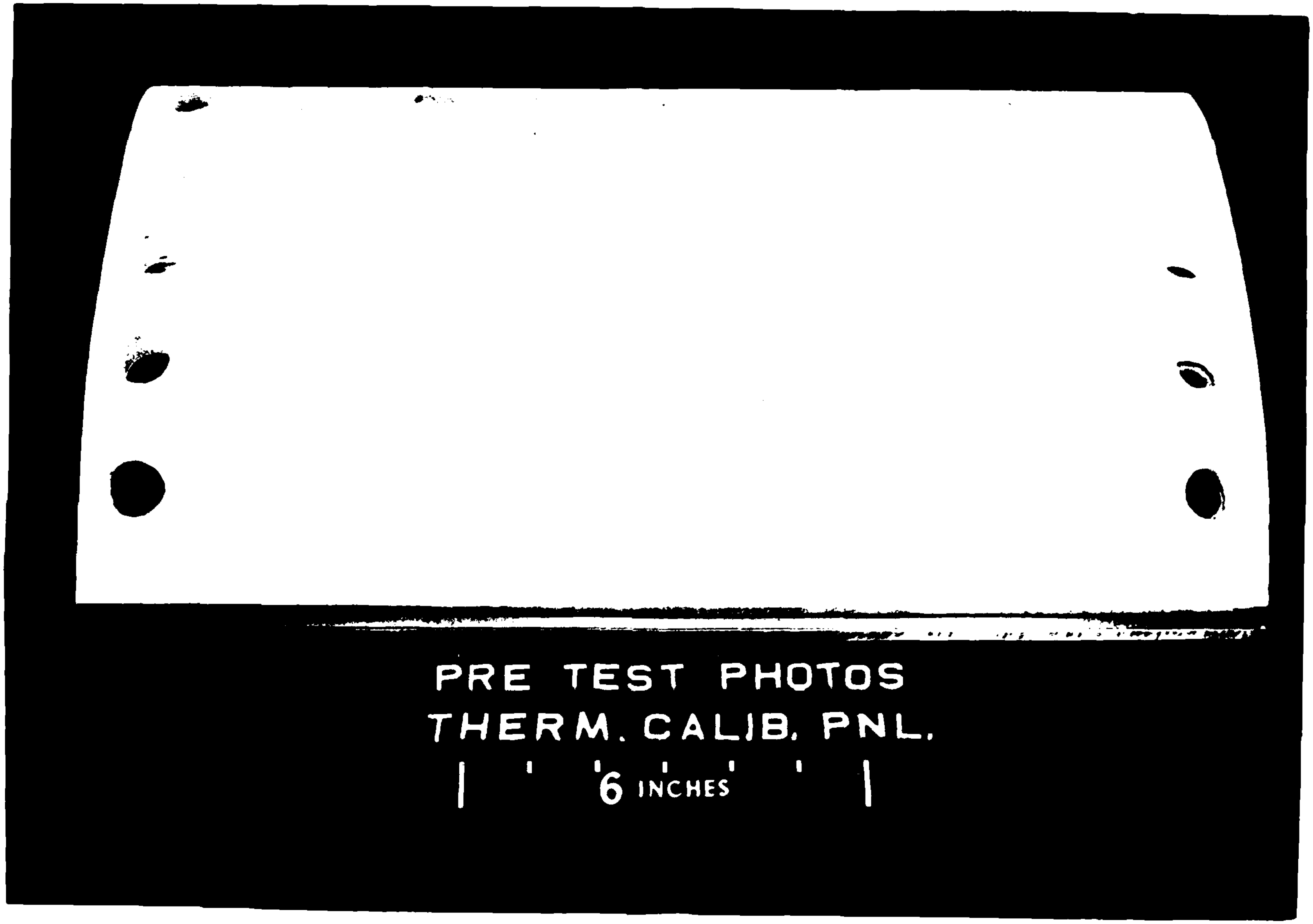
a. Pressure Calibration Model
Figure 9. Pressure Calibration Test Article



NOTES:
1. See Tables 3 and 4 for instrumentation locations.
2. Identifying numbers refer to both types of instrumentation, except on centerline.

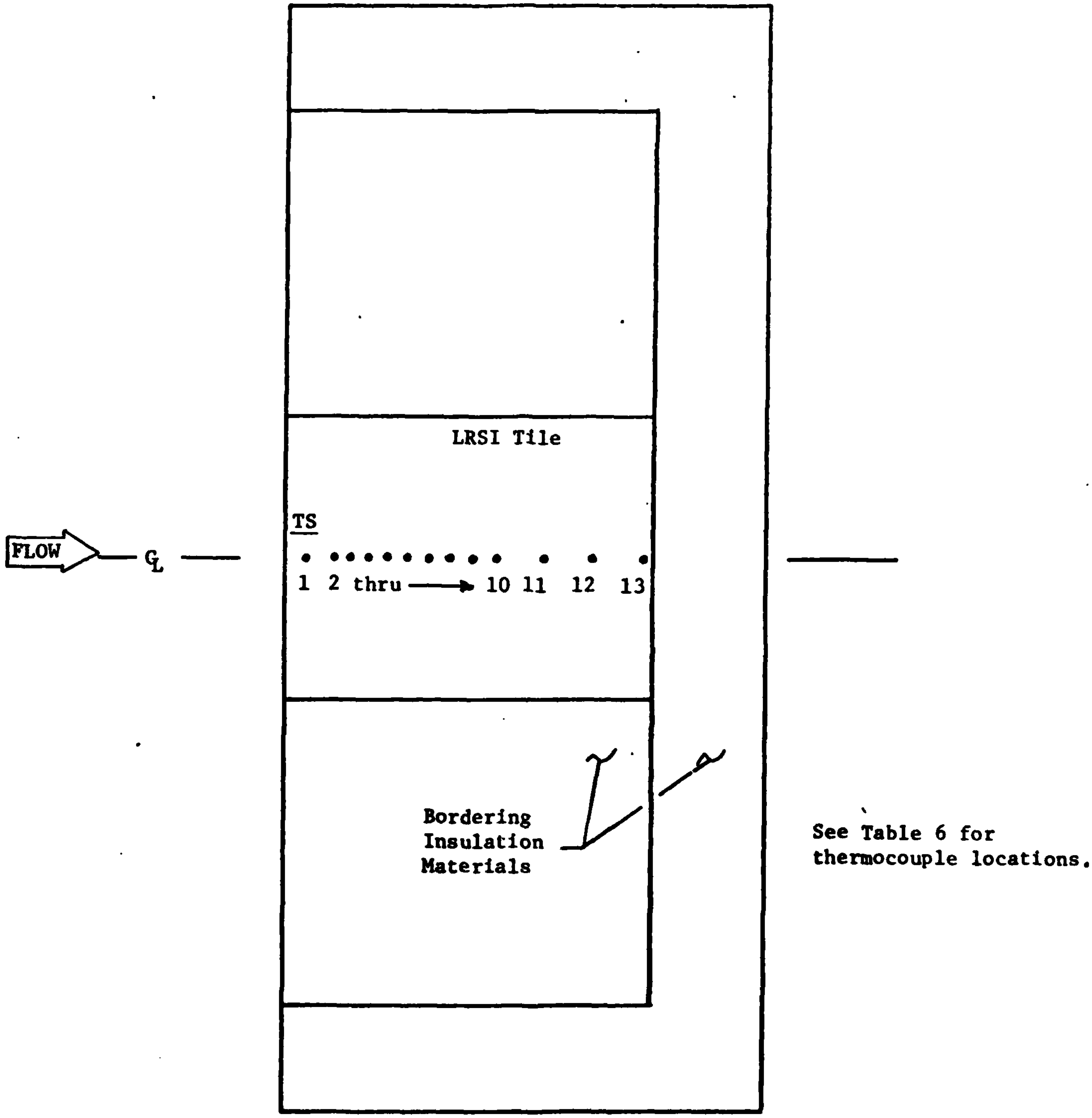
b. Pressure Calibration Model Instrumentation Sketch

Figure 9. Concluded



a. Thermal Calibration Model

Figure 10. Thermal Calibration Test Article



b. Thermal Calibration Model Instrumentation

Figure 10. Concluded

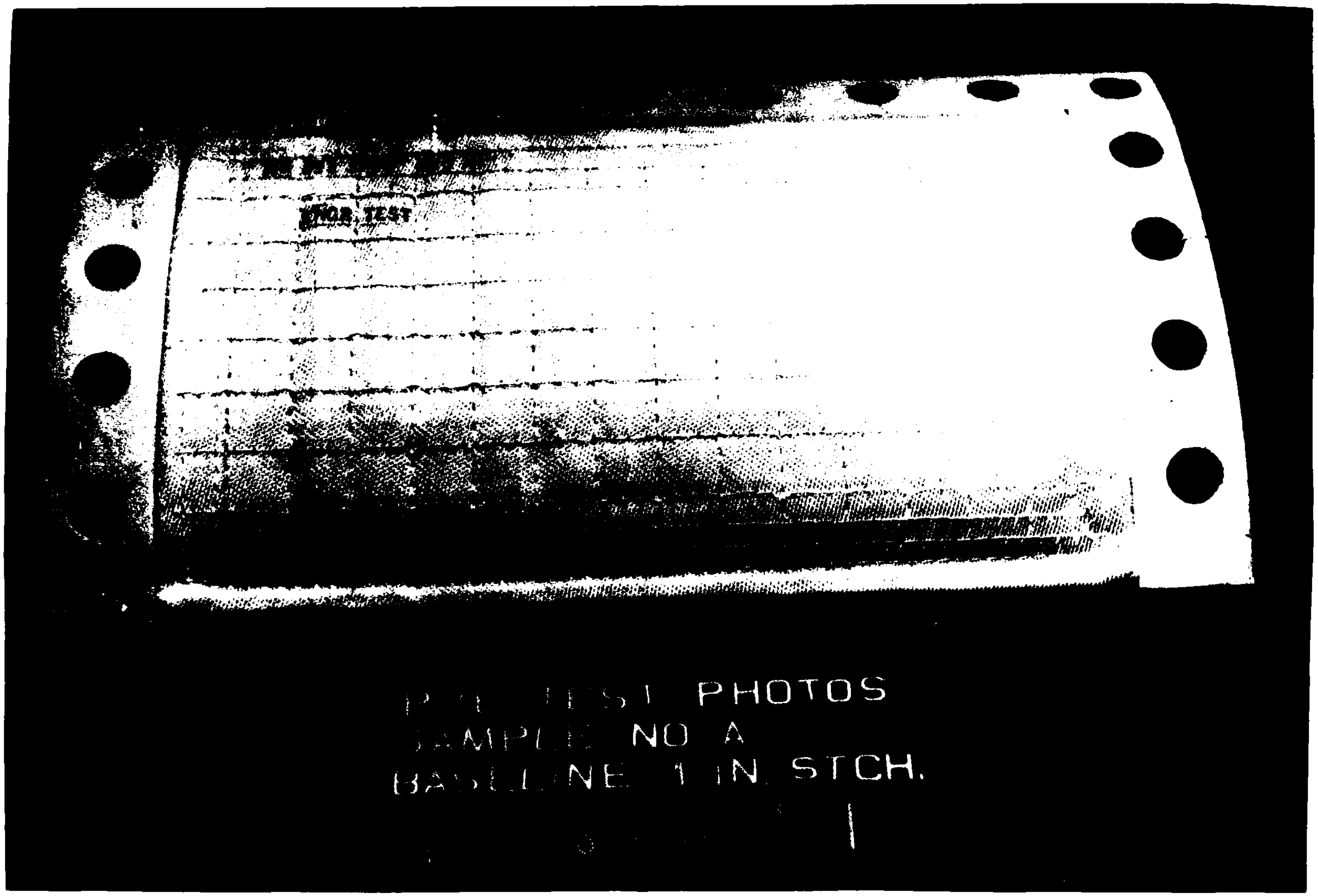
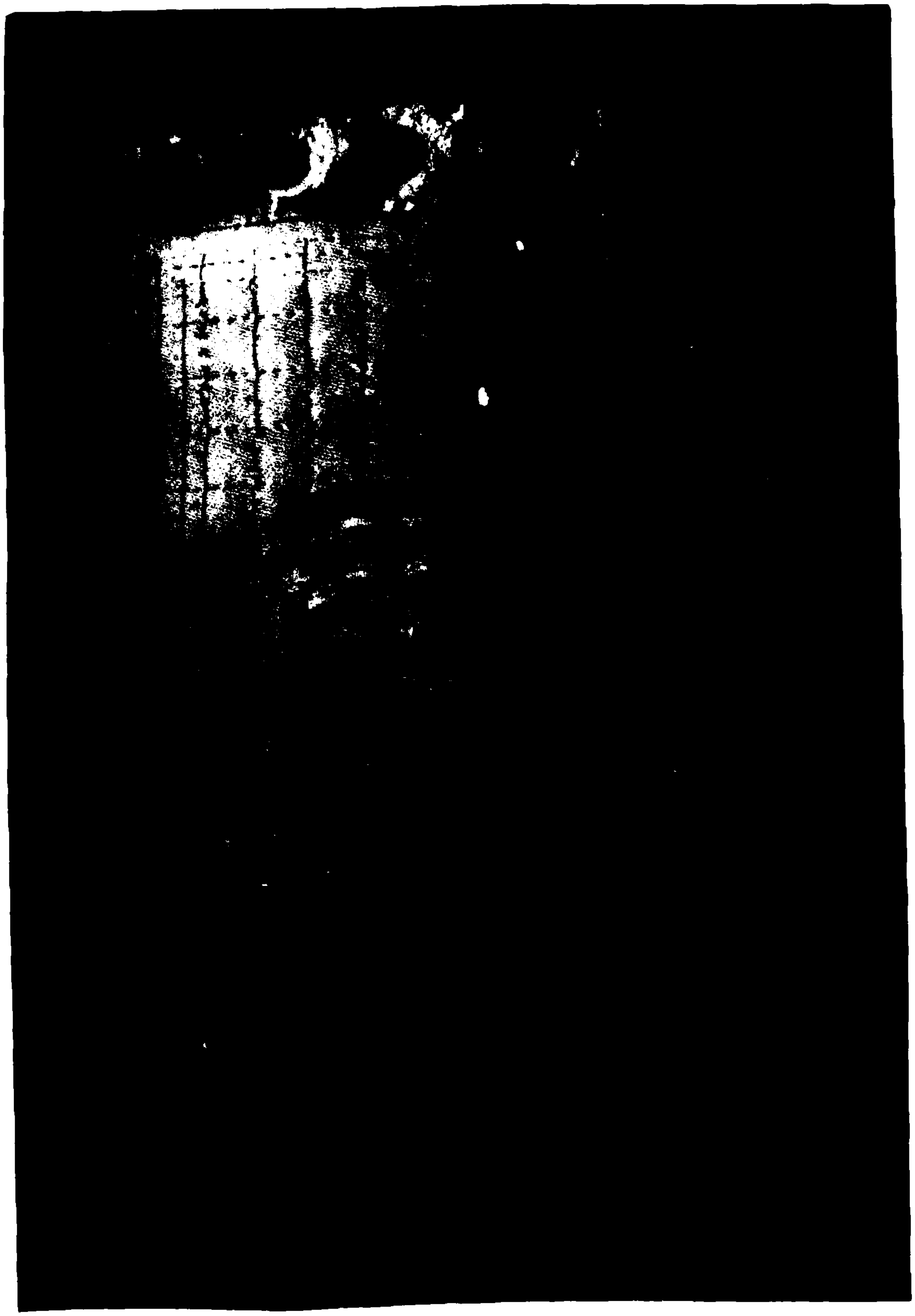


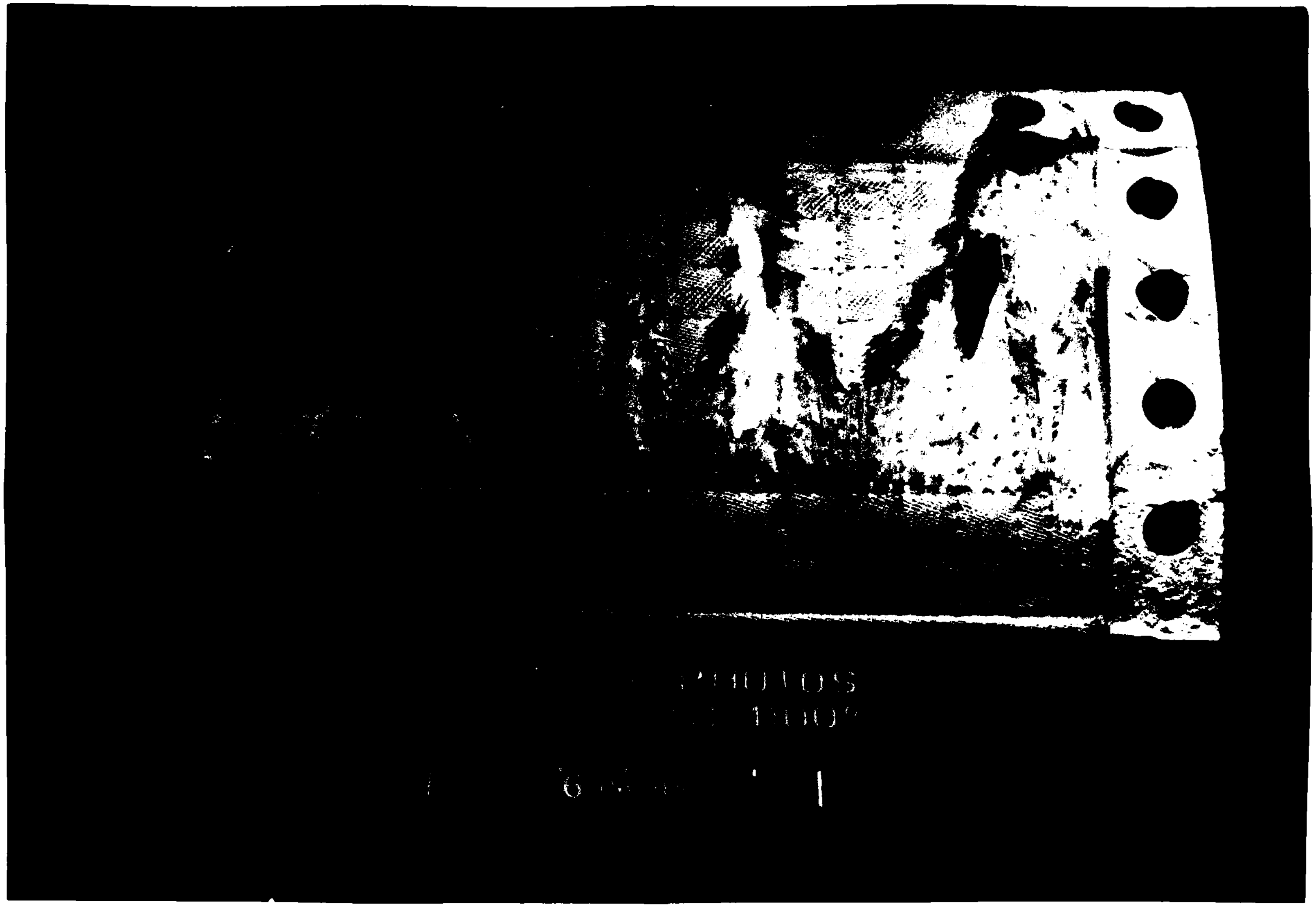
Figure 11. Typical AFRSI Test Sample

a. Thermal Calibration Panel
Figure 12. Tunnel-Exposed Test Articles



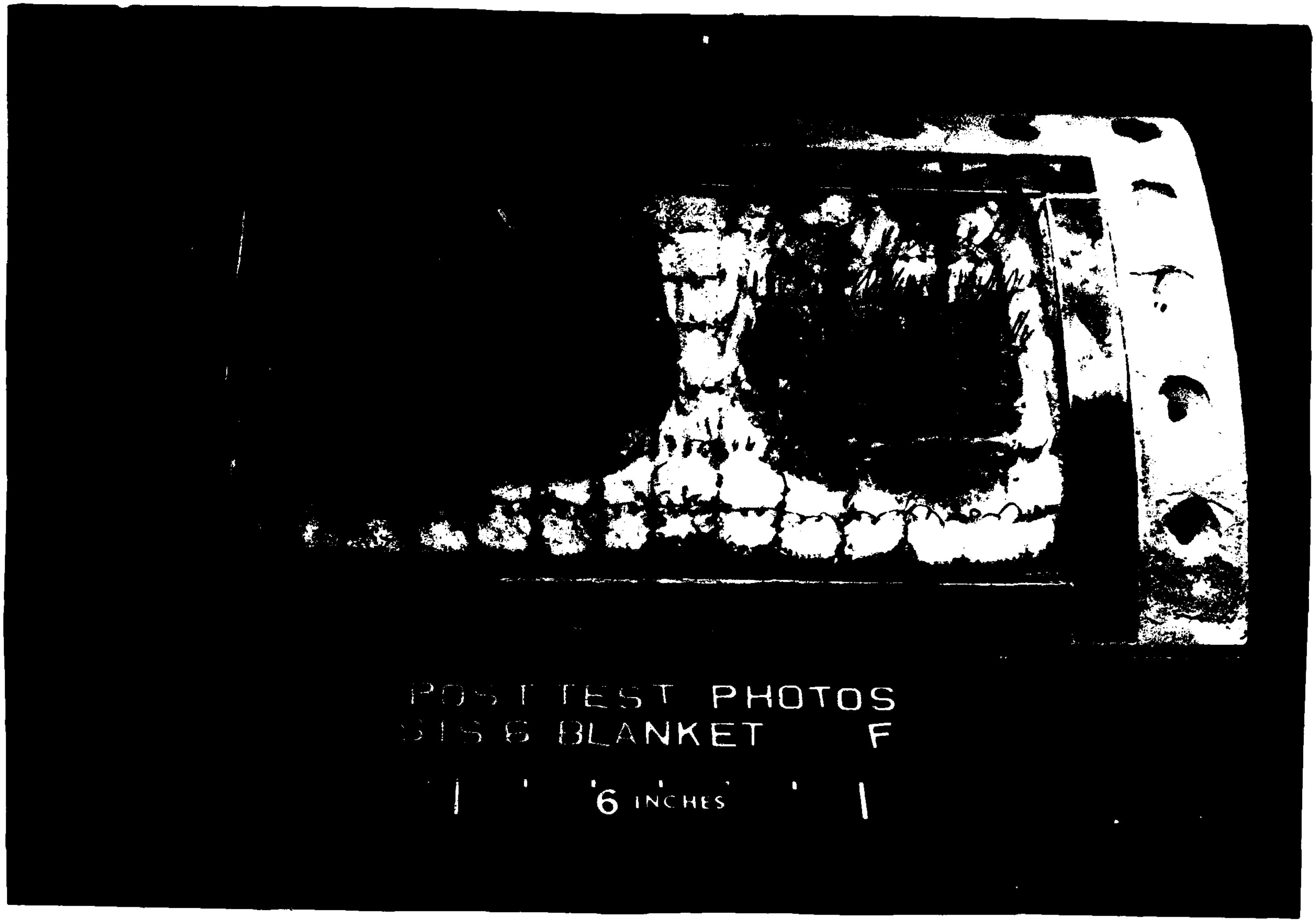
b. Sample A

Figure 12. Continued



c. Sample B

Figure 12. Continued



d. Sample F

Figure 12. Concluded

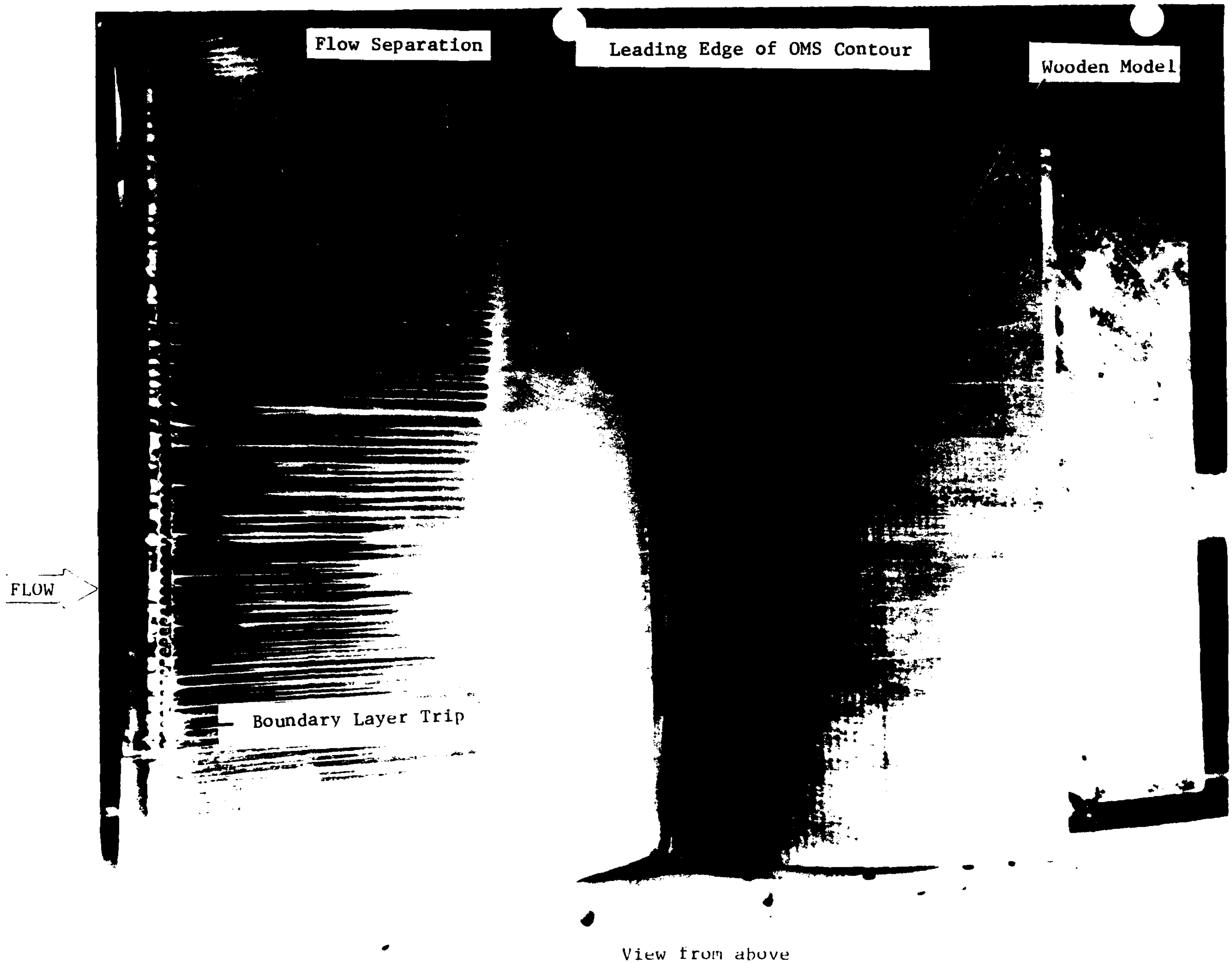


Figure 13. Typical Oil-Flow Visualization Data

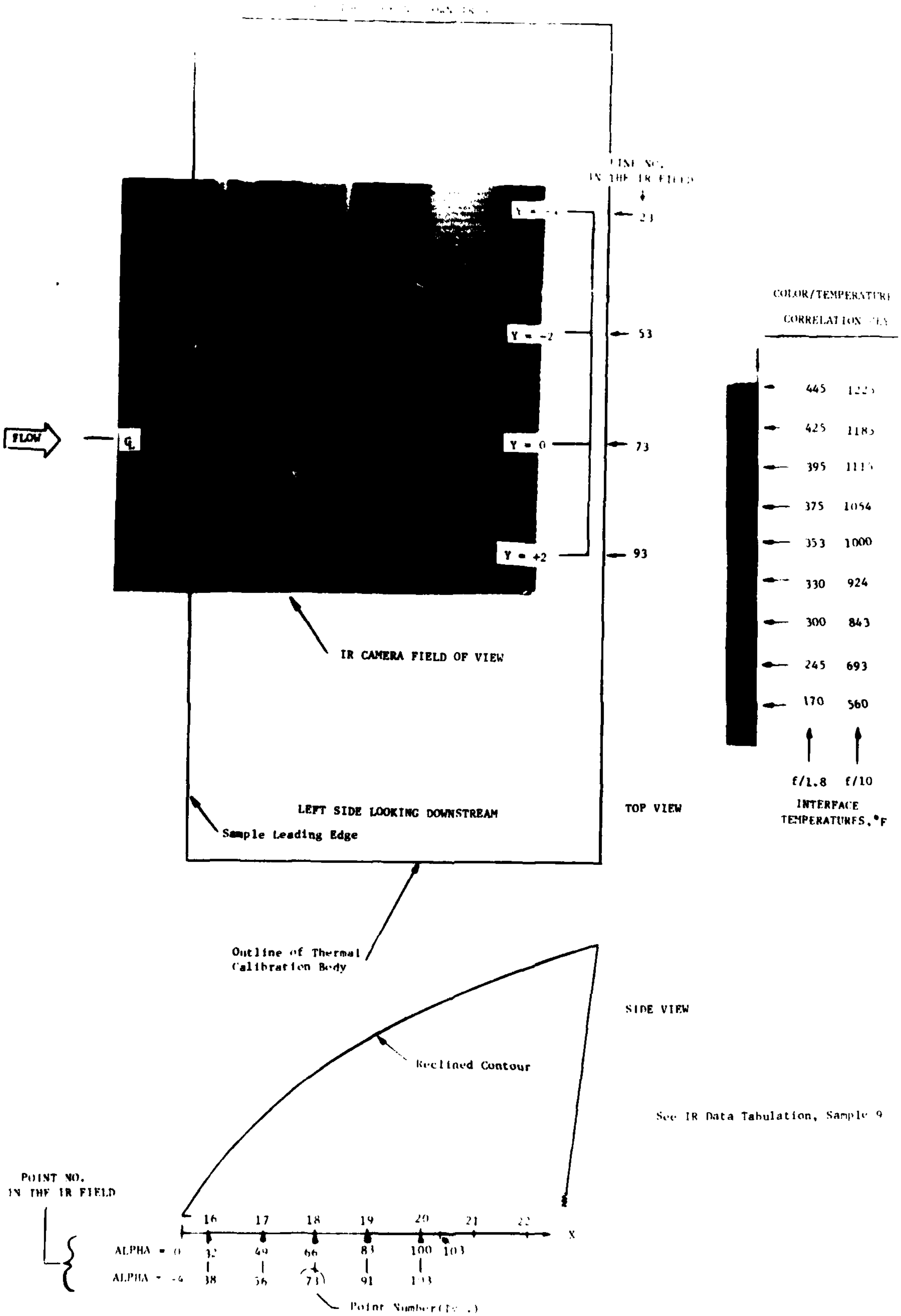


Figure 14. Spatial Correlation of Digitized IR Data with Camera Field of View and Test Article

APPENDIX II

TABLES

Table 1. Gardon Heat Gage Locations

Gage No.*	X	Y
1	13.5	4.50
2	↓	3.10
3	↓	1.80
4	7.5	0
5	9.0	↓
6	10.5	↓
7	12.0	↓
8	13.5	↓
9	↓	-1.80
10	↓	-3.10
11	↓	-4.50

*Note: For the Feasibility Checkout Phase, these gages were referred to as T1 through T11.

Table 2. Static Pressure Tap Locations
a. Wedge Taps

TAP	X	Y	TAP	X	Y
1	10.5	2.5	11	11.5	0.25
2	12.0		12	12.0	
3	13.5		13	12.5	
4	14.5		14	13.0	
5	15.25		15	13.5	
6	7.0	0.25	16	14.25	
7	8.0		17	14.5	
8	9.0		18	15.0	
9	10.0		19	15.25	
10	11.0				

Table 2. Concluded
b. Pressure Calibration Panel Taps

Tap	X	Y	Z
101	16.68	6.5	1.61
102	17.80	6.5	2.60
103	19.07	6.5	3.40
104	16.68	5.5	1.61
105	17.80	5.5	2.60
106	16.68	4.5	1.61
107	16.68	2.5	1.61
108	19.07	2.5	3.40
109	15.76	0.25	0.43
110	16.05	0.25	0.84
111	16.35	0.25	1.23
112	16.68	0.25	1.61
113	17.03	0.25	1.96
114	17.41	0.25	2.29
115	17.80	0.25	2.60
116	18.21	0.25	2.89

Tap	X	Y	Z
117	18.63	0.25	3.16
118	19.07	0.25	3.40
119	19.51	0.25	3.63
120	19.97	0.25	3.84
121	20.42	0.25	4.05
122	20.88	0.25	4.24
123	21.35	0.25	4.42
124	21.82	0.25	4.60
125	22.76	0.25	4.92
126	16.68	-2.5	1.61
127	19.07	-2.5	3.40
128	16.68	-4.5	1.61
129	19.07	-4.5	3.40
130	16.68	-5.5	1.61
131	16.68	-6.5	1.61
132	19.07	-6.5	3.40

Table 3. Kulite Dynamic Pressure Gage Locations

Wedge Kulite Gages

Kulite	X	Y
1	10.5	2.25
2	12.0	
3	13.5	
4	14.5	
5	15.25	
6	7.0	0
8	8.75	
9	10.0	
10	11.0	
12	11.75	
14	13.0	
17	15.0	
19	15.25	

Pressure Calibration Panel Kulite Gages

Kulite	X	Y	Z	Kulite	X	Y	Z
101	16.68	6.25	1.61	118	19.07	0	3.40
102	17.80	6.25	2.60	120	19.97	0	3.84
103	19.07	6.25	3.40	122	20.88	0	4.24
104	16.68	5.25	1.61	124	21.82	0	4.60
105	17.80	5.25	2.60	125	22.76	0	4.92
106	16.68	4.25	1.61	126	16.68	-2.25	1.61
107	16.68	2.25	1.61	127	19.07	-2.25	3.40
108	19.07	2.25	3.40	128	16.68	-4.25	1.61
110	16.05	0	0.84	129	19.07	-4.25	3.40
112	16.68	0	1.61	130	16.68	-5.25	1.61
114	17.41	0	2.29	131	16.68	-6.25	1.61
116	18.21	0	2.89	132	19.07	-6.25	3.40

Table 4. Coordinates of 0.2-Scale Partial OMS Pod Contour

X, in.	Z, in.
0 0	0
0.0975	0.2625
0.2391	0.5574
0.3747	0.8052
0.5310	1.1181
0.6846	1.3776
0.8529	1.6284
1.0329	1.8879
1.2129	2.1150
1.4193	2.3598
1.6170	2.5782
1.8177	2.7846
2.0064	2.9736
2.5317	3.4365
2.9361	3.7611
3.2724	3.9972
3.6294	4.2627
3.9480	4.4691
4.2489	4.6785
4.6266	4.8969
5.0841	5.1564
5.4765	5.3748
5.9898	5.6226
6.4680	5.8554
7.2204	6.1860

Note: See Fig. 8 for definition of contour coordinates.

Table 5. Thermal Model Surface Thermocouple Locations

T/C No.	X	Y	Z
1	15.90	0	0.63
2	16.52		1.42
3	16.86		1.79
4	17.22		2.13
5	17.60		2.45
6	18.00		2.75
7	18.42		3.03
8	18.85		3.28
9	19.29		3.52
10	19.74		3.74
11	20.65		4.15
12	21.58		4.51
13	22.53		4.84

Table 6. AFRSI Sample Descriptions

Sample No.	Description
A	Baseline (1-inch stitching)
B	Baseline thermally conditioned (TC) to 1100°F
F	STS-6 blanket (panel removed after STS-6 mission)

Table 7. Estimated Uncertainties
a. Basic Measurements

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
STILLING CHAMBER PRESSURE,PT,psia		0.12	>30		0.75		0.425	<156	Wiancko variable reluctance pressure transducer	Digital data acquisition system analog-to-digital converter	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory
TOTAL TEMPERATURE, TT,°F		1	>30		2		4	32 to 530	Chromel®-Alumel® thermocouple	Doric temperature instrument digital multiplexer	Thermocouple verification of NBS conformity/voltage substitution calibration
		1	>30	0.375		(.375% + 2)		530 to 2300			
PITCH ANGLE,ALPI, deg		0.026	>30				0.05	15	Potentiometer		Heidenhain rotary encoder ROD700 Resolution:0.0006° Overall accuracy: 0.001°
TIME		$5x10^{-4}$	>30	Runtime(sec)x $5x10^{-6}$		Runtime(sec)x $5x10^{-6} + 10^{-3}$		ms to 365 days	Systron Donner time code generator	Digital data acquisition system	Instrument lab calibration against Bureau of Standards
HEAT TRANSFER, QDOT,BTU/ft²-sec		0.015	>30	2		(0.03 + 2%)		1	Gardon Gage	Digital data acquisition system analog-to-digital converter	Radiant heat source and secondary standard
	1.5		>30	2		5%		1 to 10			
E,mV	0.1		>30	0.01		(0.2% + 0.01)			DEC-10/Multiverter Preston Amplifier		Millivolt standard, referenced to lab standard
TEMPERATURE,TGE, TG,TB,TPTi,TKi, TSi,°F		1	>30		2		4	32 to 530	CrAl Thermocouple		
		1	>30	3/8%		(3/8% + 2)		530 to 2300			
IR Spot Temperature,°K	0.5		>30	0.2		1.2			AGA 680 Thermavision	Analog-to-Digital Converter	Secondary Standard Black Body Temperature Source

*REFERENCE: Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5, February 1973
NOTES:

GC-35 (Combines GC-35 & GC-120) 1/82 Previous editions will be used

Table 7. Continued
a. Concluded

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
STATIC PRESSURE, PW, psia		4×10^{-3}	2		0.01		0.03	$0.2 < p < 15$	Pressure Systems Incorporated ESP32 Pressor Sensor	Analog to digital converter/digital data acquisition system	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory

*REFERENCE: Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5, February 1973
NOTES:

GC-35 (Combines GC-35 & GC-120) 1/82 Previous editions will be used

Table 7. Concluded
b. Calculated Parameters

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	Range
HEAT TRANSFER COEFFICIENT, H(TT), H(.915TT), Btu/ft^2-sec-°R	2.0		30	2.0		6.0		
MACH NUMBER, M	0.38		30			0.76		3.9-4.0
WALL TEMPERATURE, TW, °F		1	30		2	4		All
WEDGE ANGLE, WA, deg		0.05	30		0+		0.10	All
REYNOLDS NUMBER, RE	0.70		30	0.56		1.96		0.5×10^6 ft^{-1}
	0.36		30	0.45		1.17		3.7×10^6 ft^{-1}

*Reference: Abernethy, R. B. et al. and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5, February 1973

+Assumed to be zero

Table 8. Photographic Data Summary

PHASE	CAMERA TYPE	APPROX. FRAME RATE	CAMERA VIEW	FILM I.D.
Feasibility checkout	Varitron 70 mm sequence stills	1 per run	Top view of oil flow on test article at centerline	Roll No. 938
	Television	Real time videotape	Top view of test article	NA
	Television	Real time videotape	Side view of test article	NA
	Television	Real time videotape	Shadowgrpah, fwd and aft	NA
Calibration and Material Evaluation	Varitron 70 mm sequence stills	1 per run or 1 every 30 sec	Shadowgraph, aft	Roll Nos. 540, 546, 932
	Varitron 70 mm sequence stills	1 per run or 1 every 30 sec	Schlieren, fwd	Roll Nos. 539, 545, 937
	DBM-55 motion picture	24 frames per sec	Forward onlooking test article	Reel Nos. 4637, 4738, 4639
	DBM-55 motion picture	400 frames per sec	Forward onlooking test article	Reel Nos. 4640-4643
	Bolex 16 mm motion picture	8 frames per sec	Infrared color video monitor	Reel No. 4644
	Varitron 70 mm sequence still	1 every 4 sec	Infrared color video monitor	Roll Nos. 547, 548
Material Evaluation	Hasselblad 70 mm sequence stills	After each sample tested	Test article in tank	Roll No. 1

Table 9. Test Summary
a. Feasibility Checkout Phase

RUN	OMS POD MODEL	PT,psia	TT,°F	WA,deg
1001	None	30	1440	0
1002				-2
1003				-4
1004				-6
1005				0
1006		↓		
1007		60		
1008		20		
1009	↓			
1010*	Contour 1	↓		
1011*	Contour 1	60		
1012*	Contour 2 - Reclined	20		
1013*	Contour 2 - Reclined	30		
1014*	Contour 1			
1015	None	↓	↓	↓

* Oil flow runs

Table 9. Continued
b. Calibration Phase

RUN	PT,psia	TT,°F	WA,deg	TIME ON CENTERLINE (approx.),sec
2	30	318	0	14
3	↓	329	0	11
4	↓	254	0	28
5	↓	301	-4	23
6	25	318	0	29
9	↓	340	-2	22
11	20	347	-4	23
12	↓	349	-2	22
13	↓	840	0	31
14	↓	↓	-4	23
15	↓	↓	-2	25
17	↓	1440	-4	7
18	↓	↓	-2	9
19	↓	↓	0	8
20	25	1420	0	8
21	↓	1440	-4	9
22	↓	↓	-2	8

Table 9. Concluded
c. Material Evaluation Phase

RUN	PT, psia	TT, °F	WA, deg	SAMPLE	EXPOSURE TIME (approx.), sec
23	20	180*	-2	A - Baseline	250
24	25	313	-2	A - Baseline	250
25	20	1440	0	Thermal Calibration Model	250
26		1315			93
27		1215			250
28	25	1215			250
29	20	1115		B-Baseline TC to 100°F	94
30	20	975		F-STS-6 Blanket	106

* The total temperature climbed approximately 6°F/minute throughout this run, and TT = 204°F at the time of model retraction.

Table 10. Summary of Data Acquisition and Tabular Print

Gardon Gage Data	
Data Acquisition (data taking rate)	Approx. every 0.1 sec
Tabular Printed Data	Data at 1 sec after centerline
Magnetic Tape	All recorded data
Thermocouple Data	
Data Acquisition (data taking rate)	Approx. every 0.1 sec for first 15 sec of run, then once every 2 sec (calibration) or 4 sec (Mat'l Evaluation)
Tabular Printed Data	Once every 2 sec (Calib.) or 4 sec (Mat'l Eval.) and also at camera firings
Magnetic Tape	All recorded data
Static Pressure Data	
Data Acquisition (data taking rate)	Same as for thermocouples
Tabular Printed Data	Data averaged over 5 consecutive readings 10-15 seconds after centerline as indicated on data
Magnetic Tape	All recorded data
Dynamic Pressure Data	
Data Acquisition	Continuously recorded on magnetic tape. RMS meter data read once same time as static pressure reduced.
Tabular Printed Data	One data reading per run for 15 rms measurements
Magnetic Tape	Raw signal
Infrared Data (using 8 deg lens)	
Digital Data	1 frame every 4 sec
Tabular Printed Data (final)	Assorted frames
Magnetic Tape	All recorded data
Photographic Data (Calib. and Mat'l Eval. Phases)	
Shadowgraph Stills	Nominally, 1 sec after centerline
Sequence Still Camera (photos of IR monitor)	1 every 4 sec
Motion Picture Camera (movies of IR monitor)	8 frames per sed
Motion Picture Camera (2) (movies of sample)	24 and 400 frames per sec

APPENDIX III

SAMPLE TABULATED DATA

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI TEST
PAGE 1
RUN 1001

DATE COMPUTED 8-SEP-83
TIME COMPUTED 12:55:44
DATE RECORDED 27-MAY-83
TIME RECORDED 19:37:51
PROJECT NUMBER V C-3E

FEASIBILITY CHECKOUT PHASE
OMS MODEL: NONE

*** HEAT TRANSFER DATA ***

GAGE NO.	X IN	Y IN	TG DEGR	TW DEGR	QDOT BTU/FT2-SEC	H(TT) BTU/FT2-SEC-DEG-R	ST(TT)
1	7.50	0.0	534.1	550.8	2.958	2.200E-03	1.764E-03
2	9.00	0.0	532.1	542.7	2.742	2.027E-03	1.626E-03
3	10.50	0.0	530.9	545.3	2.358	1.747E-03	1.401E-03
4	12.00	0.0	530.9	544.1	2.111	1.562E-03	1.253E-03
5	13.50	4.5	533.0	543.9	2.241	1.658E-03	1.330E-03
6	13.50	3.1	533.7	548.0	2.214	1.642E-03	1.318E-03
7	13.50	1.8	533.5	543.5	2.445	1.809E-03	1.451E-03
8	13.50	0.0	534.0	547.2	2.381	1.766E-03	1.416E-03
9	13.50	-1.8	533.6	542.2	2.334	1.724E-03	1.384E-03
10	13.50	-3.1	532.2	543.6	2.332	1.725E-03	1.384E-03
11	13.50	-4.5	532.9	547.3	2.316	1.717E-03	1.378E-03

RUN	PT PSIA	TT DEGR	RE FT-1	M	P PSIA	T DEGR	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	ALPHA DEG	TIMECL	TIMERD
1001	2[illegible].9	1895.7	4.23E+05	3.92	2.072E-01	488.5	320.64	4245.1	1.145E-03	3.567E-07	6.92	2.51	4.5170

FLANGE	FLANGE/PIN	WEDGE ANGLE DEG
0.123	0.59	0.08

Sample 1. Gardon Gage Data - Feasibility Checkout Entry

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI
PAGE 1

DATE COMPUTED -AUG-
TIME COMPUTED :00:47
DATE RECORDED -AUG-83
TIME RECORDED 8:19:56
PROJECT NUMBER V--C-3E

CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC
1000	10.05	-0.05	0.0	10.86	9.75

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	FLANGE/PIN
2	30.0	318.0	1.66E+06	3.93	2.172E-01	-269.0	338.08	2660.1	3.074E-03	1.535E-07	1.59

*** PRESSURE CALIBRATION HEAT TRANSFER DATA ***

GAGE NO.	X (IN)	Y (IN)	TGE (DEG R)	TW (DEG R)	QDOT (BTU/FT2-SEC)	H(TT) (BTU/FT2-SEC-R)	ST(TT)	H(0.915 TT) (BTU/FT2-SEC-R)	ST(0.915 TT)
T 1	13.50	4.50	533.2	535.0	3.616E-01	1.490E-03	7.553E-04	2.048E-03	1.042E-03
T 2	13.50	3.10	533.4	535.9	3.850E-01	1.593E-03	8.074E-04	2.192E-03	1.115E-03
T 3	13.50	1.80	533.5	534.9	3.540E-01	1.458E-03	7.393E-04	2.004E-03	1.020E-03
T 4	7.50	0.00	532.6	533.9	3.122E-01	1.281E-03	6.492E-04	1.757E-03	8.941E-04
T 5	9.00	0.00	532.9	534.0	2.538E-01	1.041E-03	5.279E-04	1.429E-03	7.271E-04
T 6	10.50	0.00	532.8	534.1	1.664E-01	6.831E-04	3.463E-04	9.374E-04	4.770E-04
T 7	12.00	0.00	533.4	534.6	2.819E-01	1.159E-03	5.878E-04	1.593E-03	8.103E-04
T 8	13.50	0.00	533.4	534.8	3.543E-01	1.459E-03	7.396E-04	2.005E-03	1.020E-03
T 9	13.50	-1.80	533.8	535.1	3.571E-01	1.473E-03	7.464E-04	2.024E-03	1.030E-03
T10	13.50	-3.10	533.9	536.0	4.258E-01	1.762E-03	8.931E-04	2.425E-03	1.234E-03
T11	13.50	-4.50	533.8	536.0	3.619E-01	1.498E-03	7.591E-04	2.061E-03	1.049E-03

Sample 2. Gardon Gage Data - Calibration and Material Evaluation Entry

RUN 2

CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI
PAGE 2

DATE COMPUTED [illegible]-AUG-83
TIME COMPUTED 10:47
DATE RECORDED 5-AUG-83
TIME RECORDED 8:19:56
PROJECT NUMBER V--C-3E

CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC
1000	10.05	-0.05	0.0	10.86	9.75

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	FLANGE/PIN
2	30.0	318.0	1.66E+06	3.93	2.172E-01	-269.0	338.08	2660.1	3.074E-03	1.535E-07	1.59

EVENT	PIC NO.	C.S.T. HRS	MIN	SEC	TIME SEC	TIMEEXP SEC	TP DEG F	TPT1 DEG F	TPT2 DEG F	TK105 DEG F	TK110 DEG F	TK114 DEG F	TK116 DEG F	TK124 DEG F
		8	19	57.378			80.	82.	82.	82.	81.	82.	82.	82.
		8	19	59.537			80.	82.	82.	82.	82.	82.	82.	82.
		8	20	1.753			80.	82.	82.	82.	82.	82.	82.	82.
		8	20	3.910			80.	82.	82.	82.	82.	82.	83.	82.
DO		8	20	6.068			80.	82.	82.	82.	82.	82.	83.	82.
		8	20	7.175			80.	82.	82.	82.	82.	82.	83.	82.
		8	20	9.334			80.	82.	82.	82.	82.	82.	83.	82.
		8	20	11.549			80.	82.	82.	82.	82.	82.	83.	82.
		8	20	13.707			80.	82.	82.	82.	82.	82.	83.	82.
LO		8	20	14.814	0.00		80.	82.	82.	82.	82.	82.	83.	82.
		8	20	15.874	1.06		80.	82.	82.	82.	82.	82.	83.	82.
		8	20	18.032	3.22		80.	82.	82.	82.	82.	82.	83.	82.
		8	20	20.248	5.43		80.	82.	82.	82.	82.	82.	83.	82.
		8	20	22.405	7.59		80.	82.	82.	82.	82.	82.	83.	83.
CL		8	20	24.563	9.75	4.28	80.	82.	81.	83.	82.	86.	85.	84.
		8	20	25.670	10.86	5.38	80.	82.	81.	86.	83.	89.	87.	85.
		8	20	27.827	13.01	7.54	80.	82.	82.	91.	84.	93.	91.	87.
		8	20	29.986	15.17	9.70	80.	82.	82.	97.	86.	97.	95.	91.
SHG	1	8	20	31.094	16.28	10.81	80.	82.	82.	100.	87.	99.	97.	92.
		8	20	32.201	17.39	11.91	80.	82.	82.	102.	88.	101.	99.	94.
OCL		8	20	34.369	19.56	14.08	80.	82.	82.	108.	89.	104.	103.	97.

Sample 3. Thermocouple and Camera Data - Pressure Calibration

RUN 2

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI
PAGE 2

DATE COMPUTED . AUG-83
TIME COMPUTED 08:17:36
DATE RECORDED 11-AUG-83
TIME RECORDED 9: 6:11
PROJECT NUMBER V--C-3E

SAMPLE	CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC	TIMEEXP SEC
TH CALIB	2000	9.91	0.09	-8.0	6.58	5.53	94.12

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	\FLANGE/PIN
26	19.9	1315.0	3.13E+05	3.92	1.398E-01	-5.1	215.92	4092.1	8.297E-04	3.368E-07	0.50

CAMERA	PIC NO.	TIME SEC	TIMEEXP SEC	TS 1 DEG F	TS 2 DEG F	TS 3 DEG F	TS 4 DEG F	TS 5 DEG F	TS 6 DEG F	TS 7 DEG F	TS 8 DEG F	TS 9 DEG F	TS10 DEG F	TS11 DEG F
		0.00		154.4	155.5	157.2	157.6	158.1	149.1	159.3	157.9	154.8	156.4	156.3
		4.02		155.5	157.5	164.7	154.4	163.0	155.2	166.9	161.3	162.6	164.6	158.1
IR	1	5.70	2.60	179.5	191.4	456.5	293.5	288.5	307.3	274.7	219.1	260.3	232.7	173.3
SHG	1	7.77	4.66	317.2	381.1	682.6	531.0	529.4	553.5	464.6	415.3	468.1	415.5	335.7
		8.11	5.00	337.2	404.0	708.9	558.4	559.5	582.4	489.8	443.3	495.4	441.3	359.9
IR	2	10.06	6.95	445.5	550.9	824.3	690.9	697.9	713.1	607.1	577.1	622.6	568.1	465.2
		12.12	9.02	535.9	656.2	900.2	786.0	793.8	799.1	695.1	675.8	713.1	663.8	585.1
IR	3	14.29	11.18	607.0	744.2	948.9	853.7	856.4	855.1	761.2	749.3	778.5	735.6	661.4
		16.15	13.05	654.4	796.3	978.3	893.8	893.7	887.4	802.8	793.9	816.9	779.9	709.1
IR	4	18.64	15.54	701.1	840.7	1004.8	926.9	924.5	914.7	843.1	835.7	852.9	822.3	756.9
		20.17	17.06	725.4	867.5	1017.7	943.4	939.4	927.6	862.1	854.6	868.3	840.5	777.7
IR	5	22.94	19.83	756.9	895.6	1033.5	968.6	957.4	943.7	888.3	879.6	889.5	865.9	807.3
		25.58	22.47	778.9	912.9	1043.3	976.6	970.8	955.1	905.7	896.6	903.4	883.3	827.5
IR	6	27.28	24.17	790.4	921.2	1049.4	985.0	976.8	960.9	914.6	905.1	910.7	891.9	838.1
		29.69	26.58	805.2	934.1	1055.6	998.7	985.0	966.9	924.9	913.4	918.0	900.8	848.9
IR	7	31.56	28.46	812.9	938.3	1059.6	1002.6	987.6	970.3	930.6	920.0	922.5	906.2	856.1
		33.79	30.68	821.0	949.7	1063.3	1006.6	992.9	974.1	937.5	925.7	928.4	913.0	863.6
IR	8	35.90	32.79	828.2	951.3	1067.0	1012.5	997.1	977.7	942.7	930.5	931.7	917.4	868.8
SHG	2	37.77	34.66	832.8	958.4	1070.1	1010.4	999.8	980.1	946.3	934.6	934.6	921.6	873.6
		37.83	34.72	833.1	959.8	1069.9	1016.4	999.3	980.1	946.3	934.2	935.2	921.6	873.6
IR	9	40.18	37.07	838.0	959.6	1072.2	1012.1	1003.6	982.4	950.7	938.6	938.2	926.1	877.9
		41.99	38.88	840.8	961.3	1074.0	1021.3	1004.9	985.9	953.4	941.3	940.4	927.9	882.1
IR	10	44.51	41.40	846.0	968.0	1077.2	1021.5	1007.2	988.1	956.7	944.4	943.3	931.4	885.2
		46.09	42.98	848.6	967.6	1078.3	1025.4	1009.6	989.6	958.7	946.7	944.5	933.2	887.2
IR	11	48.84	45.74	853.1	975.3	1081.1	1022.7	1011.2	992.7	961.8	948.9	947.3	936.3	890.6
		50.19	47.08	854.2	972.5	1082.4	1024.6	1013.2	992.7	963.1	950.4	948.4	937.5	891.9
IR	12	53.12	50.01	859.5	983.7	1085.7	1025.8	1016.5	994.6	965.6	952.8	950.3	939.9	895.0
		54.29	51.18	858.6	980.6	1086.5	1031.6	1017.3	995.9	967.1	953.9	951.3	941.0	895.8
IR	13	57.45	54.35	863.3	987.1	1087.3	1030.4	1019.2	998.4	969.2	956.2	952.8	943.5	898.9
		58.45	55.34	864.4	986.2	1089.2	1032.4	1020.0	998.1	969.0	957.1	953.8	944.8	899.2
IR	14	61.74	58.63	866.8	969.3	1090.5	1031.4	1021.4	1000.7	971.8	959.2	955.3	946.2	902.6
		62.56	59.45	867.2	988.6	1090.9	1033.3	1021.5	1000.7	972.5	959.7	956.4	946.6	903.0
IR	15	66.07	62.97	869.3	987.7	1092.6	1036.9	1023.6	1002.6	974.3	962.2	957.5	948.6	905.3
		66.66	63.55	870.2	991.5	1092.3	1034.9	1024.0	1003.0	974.4	962.0	957.9	949.1	905.1
SHG	3	67.77	64.67	870.7	990.4	1091.7	1041.3	1024.4	1003.1	975.2	962.7	958.3	949.7	906.0
IR	16	70.35	67.24	873.7	995.3	1094.1	1044.5	1026.2	1004.0	975.9	964.0	959.5	951.1	907.2
		70.76	67.65	873.0	994.7	1093.5	1036.7	1025.7	1003.2	976.3	963.8	959.6	951.5	907.6
IR	17	74.68	71.58	876.3	994.9	1094.8	1039.7	1027.3	1003.6	976.8	965.0	959.8	952.5	909.8

Sample 4. Thermocouple and Camera Data - Thermal Calibration

RUN 26

ARVIN/CALSPAN .IELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/HI OMS POD AFRSI
PAGE 3

DATE COMPUTED . AUG-83
TIME COMPUTED 06:17:37
DATE RECORDED 11-AUG-83
TIME RECORDED 9: 6:11
PROJECT NUMBER V--C-3E

SAMPLE	CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC	TIMEEXP SEC
TH CALIB	2000	9.91	0.09	-0.0	6.58	5.53	94.12

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	\ FLANGE/PIN
26	19.9	1315.0	3.13E+05	3.92	1.398E-01	-5.1	215.92	4092.1	8.297E-04	3.368E-07	0.50

CAMERA	PIC NO.	TIME SEC	TIMEEXP SEC	TS 1 DEG F	TS 2 DEG F	TS 3 DEG F	TS 4 DEG F	TS 5 DEG F	TS 6 DEG F	TS 7 DEG F	TS 8 DEG F	TS 9 DEG F	TS10 DEG F	TS11 DEG F
		74.86	71.75	875.4	993.3	1093.7	1044.6	1026.4	1004.7	977.1	965.1	960.2	952.9	909.3
		78.96	75.85	877.8	997.7	1096.7	1040.6	1028.9	1005.9	979.7	966.9	962.4	954.5	911.0
IR	18	79.02	75.91	878.7	995.6	1097.1	1045.9	1029.5	1006.7	979.3	967.2	962.3	954.4	911.5
		83.06	79.95	880.0	1000.8	1098.0	1048.8	1030.3	1008.0	981.2	969.0	963.8	955.7	913.4
IR	19	83.30	80.19	880.6	997.2	1098.5	1047.0	1030.2	1008.0	981.3	968.7	963.4	956.5	914.1
		87.16	84.05	882.6	998.5	1099.8	1043.9	1031.6	1009.4	982.5	970.6	965.4	957.8	915.0
IR	20	87.63	84.52	882.7	1003.9	1100.2	1050.3	1032.5	1009.3	982.5	970.4	965.5	958.3	915.5
		91.26	88.15	884.0	1004.2	1099.8	1046.2	1033.8	1011.1	983.7	971.9	966.7	958.6	916.5
IR	21	91.91	88.81	884.1	1009.0	1100.8	1052.7	1033.8	1010.5	983.9	971.8	966.8	959.3	917.2
		95.37	92.26	885.6	1006.3	1100.7	1046.5	1035.7	1011.1	985.3	972.7	967.6	959.6	917.4
IR	22	96.25	93.14	886.3	1008.1	1101.5	1047.3	1035.5	1012.5	985.5	973.4	968.0	960.4	918.3
			94.12	MODEL HAS LEFT CENTERLINE										

Sample 4. Continued

RUN 26

ARVIN/CALSPAN .ELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI
PAGE 4

DATE COMPUTED 3 UG-83
TIME COMPUTED 08:17:37
DATE RECORDED 11-AUG-83
TIME RECORDED 9: 6:11
PROJECT NUMBER V--C-3E

SAMPLE	CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC	TIMEEXP SEC
TH CALIB	2000	9.91	0.09	-8.0	6.58	5.53	94.12

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	FLANGE/PIN
26	19.9	1315.0	3.13E+05	3.92	1.398E-01	-5.1	215.92	4092.1	8.297E-04	3.368E-07	0.50

CAMERA	PIC NO.	TIME SEC	TIMEEXP SEC	TS12 DEG F	TS13 DEG F	TS14 DEG F	TS15 DEG F	TS16 DEG F	TP DEG F	TPT1 DEG F	TPT2 DEG F
		0.00		153.9	169.2				108.0		85.0
		4.02		161.0	174.3				108.0		85.0
IR	1	5.70	2.60	194.4	191.1				108.0		65.0
SHG	1	7.77	4.66	331.4	325.2				108.0		85.0
		8.11	5.00	352.2	344.9				108.0		85.0
IR	2	10.06	6.95	456.5	449.4				108.0		85.0
		12.12	9.02	544.5	535.3				108.0		85.0
IR	3	14.29	11.18	614.4	602.8				107.0		85.0
		16.15	13.05	660.9	649.1				108.0		85.0
IR	4	18.64	15.54	709.2	693.9				108.0		85.0
		20.17	17.06	731.7	716.1				108.0		85.0
IR	5	22.94	19.83	764.2	746.8				108.0		85.0
		25.58	22.47	787.2	768.5				108.0		85.0
IR	6	27.28	24.17	798.2	779.5				108.0		85.0
		29.69	26.58	810.9	792.6				108.0		85.0
IR	7	31.56	28.46	818.5	799.8				108.0		85.0
		33.79	30.68	826.3	808.3				108.0		85.0
IR	8	35.90	32.79	833.5	815.6				108.0		85.0
SHG	2	37.77	34.66	838.4	820.5				108.0		85.0
		37.83	34.72	838.8	820.0				108.0		85.0
IR	9	40.18	37.07	844.1	825.7				108.0		85.0
		41.99	38.88	847.6	829.3				108.0		85.0
IR	10	44.51	41.40	851.1	833.7				108.0		85.0
		46.09	42.98	853.5	836.6				108.0		85.0
IR	11	48.84	45.74	856.8	839.9				108.0		85.0
		50.19	47.08	859.3	841.6				108.0		85.0
IR	12	53.12	50.01	861.5	845.0				108.0		85.0
		54.29	51.18	862.7	846.5				108.0		85.0
IR	13	57.45	54.35	865.4	849.6				108.0		85.0
		58.45	55.34	866.4	850.7				108.0		85.0
IR	14	61.74	58.63	869.0	853.4				108.0		86.0
		62.56	59.45	869.2	853.5				108.0		86.0
IR	15	66.07	62.97	872.0	856.4				108.0		86.0
		66.66	63.55	871.7	857.8				108.0		86.0
SHG	3	67.77	64.67	872.4	856.8				108.0		66.0
IR	16	70.35	67.24	873.9	859.0				108.0		86.0
		70.76	67.65	874.6	859.2				108.0		86.0
IR	17	74.68	71.58	876.8	861.4				108.0		86.0

Sample 4. Continued

RUN 26

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI
PAGE 5

DATE COMPUTED . AUG-83
TIME COMPUTED 08:17:38
DATE RECORDED 11-AUG-83
TIME RECORDED 9: 6:11
PROJECT NUMBER V--C-3E

SAMPLE	CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC	TIMEEXP SEC
TH CALIB	2000	9.91	0.09	-8.0	6.58	5.53	94.12

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	\FLANGE/PIN
26	19.9	1315.0	3.13E+05	3.92	1.398E-01	-5.1	215.92	4092.1	8.297E-04	3.368E-07	0.50

CAMERA	PIC NO.	TIME SEC	TIMEEXP SEC	TS12 DEG F	TS13 DEG F	TS14 DEG F	TS15 DEG F	TS16 DEG F	TP DEG F	TPT1 DEG F	TPT2 DEG F
		74.86	71.75	876.3	861.1				108.0		86.0
		78.96	75.85	878.2	863.7				108.0		86.0
IR	18	79.02	75.91	878.2	864.5				108.0		86.0
		83.06	79.95	880.0	865.1				108.0		86.0
IR	19	83.30	80.19	880.3	865.8				108.0		86.0
		87.16	84.05	881.4	867.5				108.0		86.0
IR	20	87.63	84.52	882.2	867.5				108.0		86.0
		91.26	88.15	883.6	869.3				108.0		86.0
IR	21	91.91	88.81	883.8	869.8				108.0		86.0
		95.37	92.26	885.2	870.6				108.0		86.0
IR	22	96.25	93.14	885.4	871.5				108.0		86.0
			94.12	MODEL HAS LEFT CENTERLINE							

Sample 4. Concluded

MIN 26

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/MI OPS POD AFMSI
PAGE 2

DATE COMPUTED 16-AUG-83
TIME COMPUTED 14:14:45
DATE RECORDED 11-AUG-83
TIME RECORDED 11: 5:18
PROJECT NUMBER V--C-3E

SAMPLE	CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC	TIMEEXP SEC
F	3000	9.92	0.08	-8.0	6.59	5.56	109.08

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	FLANGE/PIN
30	20.2	978.0	4.41E+05	3.92	1.450E-01	-98.0	224.45	3652.7	1.082E-03	2.786E-07	0.50

CAMERA	PIC NO.	TIME SEC	TIMEEXP SEC	TS 1 DEG F	TS 2 DEG F	TS 3 DEG F	TP DEG F	TPT1 DEG F	TPT2 DEG F
		0.00		94.7	97.7		98.0		84.0
		4.02		94.6	97.6		98.0		84.0
IR	1	5.32		94.8	98.0		98.0		84.0
SHG	1	7.78	4.66	90.5	88.7		98.0		84.0
		8.12	5.00	91.5	94.7		98.0		84.0
IR	2	9.63	6.51	91.0	89.7		98.0		84.0
		12.13	9.01	91.2	90.5		98.0		84.0
IR	3	13.87	10.75	91.5	92.9		98.0		85.0
		16.15	13.03	89.4	88.0		98.0		85.0
IR	4	18.21	15.09	87.4	86.4		98.0		85.0
		20.17	17.05	89.3	89.6		98.0		85.0
IR	5	22.49	19.37	89.0	86.5		98.0		85.0
		26.12	23.00	90.5	90.9		98.0		85.0
IR	6	26.82	23.70	87.5	87.9		98.0		85.0
		30.22	27.10	88.9	86.8		98.0		85.0
IR	7	31.10	27.98	90.0	94.0		98.0		85.0
		34.32	31.20	87.1	90.9		98.0		85.0
IR	8	35.43	32.32	87.9	86.9		98.0		85.0
SHG	2	37.78	34.66	90.8	90.4		98.0		85.0
		38.42	35.30	88.2	86.8		98.0		85.0
IR	9	39.77	36.65	87.6	85.9		98.0		85.0
		42.53	39.41	91.7	90.7		98.0		85.0
IR	10	44.05	40.93	89.2	91.4		98.0		85.0
		46.63	43.51	91.3	91.3		98.0		85.0
IR	11	48.39	45.27	87.7	85.3		98.0		85.0
		50.74	47.62	88.5	88.2		98.0		85.0
IR	12	52.67	49.55	88.7	87.6		98.0		85.0
		54.84	51.72	89.7	87.4		98.0		85.0
IR	13	57.01	53.89	90.6	89.8		98.0		85.0
		58.93	55.82	91.0	88.9		98.0		85.0
IR	14	61.28	58.16	87.6	89.1		98.0		85.0
		63.04	59.92	91.4	89.5		98.0		85.0
IR	15	65.62	62.50	88.4	86.1		98.0		85.0
		67.20	64.08	87.9	91.1		98.0		85.0
SHG	3	67.79	64.67	89.9	88.7		98.0		85.0
IR	16	69.96	66.84	91.1	88.8		98.0		85.0
		71.31	68.19	90.9	87.4		98.0		85.0
IR	17	74.23	71.11	87.1	89.5		98.0		85.0

Sample 5. Thermocouple and Camera Data - Material Evaluation

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI
PAGE 3

DATE COMPUTED 16-AUG-83
TIME COMPUTED 14:14:46
DATE RECORDED 11-AUG-83
TIME RECORDED 11: 5:18
PROJECT NUMBER V--C-3E

SAMPLE	CONF	ALPHA ANGLE DEG	WEDGE ANGLE DEG	POD ANGLE DEG	TIMERD SEC	TIMECL SEC	TIMEEXP SEC
F	3000	9.92	0.08	-8.0	6.59	5.56	109.08

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2	FLANGE/PIN
30	20.2	978.0	4.41E+05	3.92	1.450E-01	-98.0	224.45	3652.7	1.082E-03	2.786E-07	0.50

CAMERA	PIC NO.	TIME SEC	TIMEEXP SEC	TS 1 DEG F	TS 2 DEG F	TS 3 DEG F	TP DEG F	TPT1 DEG F	TPT2 DEG F
		75.40	72.29	93.8	93.3		98.0		85.0
IR	18	78.57	75.45	88.3	90.5		98.0		85.0
		79.52	76.40	87.5	85.8		98.0		85.0
IR	19	82.86	79.74	91.8	93.0		98.0		85.0
		83.62	80.50	88.9	86.8		98.0		85.0
IR	20	87.19	84.07	92.5	90.5		98.0		85.0
		87.72	84.60	90.2	89.1		98.0		85.0
IR	21	91.47	88.35	89.6	90.7		98.0		85.0
		91.82	88.70	91.1	88.6		98.0		85.0
IR	22	95.80	92.68	91.5	89.5		98.0		85.0
		95.92	92.80	92.1	91.6		98.0		85.0
SHG	4	97.74	94.62	92.3	89.1		98.0		85.0
		100.02	96.90	94.2	91.4		98.0		85.0
IR	23	100.14	97.02	94.7	92.4		98.0		85.0
		104.18	101.06	90.4	86.8		98.0		85.0
IR	24	104.42	101.30	90.8	91.4		98.0		85.0
		108.28	105.16	90.5	87.9		98.0		85.0
IR	25	108.75	105.63	94.8	90.3		98.0		85.0
			109.08	MODEL HAS LEFT CENTERLINE					

Sample 5. Concluded

ARO/C...AN ... SCIENCES
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
NASA/RI OMS POD

DATE COMPUTED 15-SEP-
DATE RECORDED 5-AUG-
TIME RECORDED 8:19: 56
TIME COMPUTED 12:41: 44
PROJECT NO V C-3E

ALPHA DEG	WEDGE ANGLE DEG	POD ANGLE DEG
10.05	-0.05	0.00

RUN	CONF	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2
2	1000	30.0	315.0	1.67E+06	3.93	2.171E-01	-269.7	338.0	2655.	3.075E-03	1.528E-07

*** RMS SURFACE PRESSURE ***

KULITE NO.	X IN	Y IN	Z IN	RMS PSIA	DB
101	16.45	6.25	1.75	0.3745	162.
102	17.42	6.25	2.90	0.3988	163.
103	18.56	6.25	3.86	0.5262	165.
104	16.45	5.25	1.75	0.2067	157.
105	17.42	5.25	2.90	0.0000	
106	16.45	4.25	1.75	0.1978	157.
107	16.45	2.25	1.75	0.3055	160.
108	17.42	2.25	3.86	0.4541	164.
110	15.92	0.00	0.90	0.0012	112.
112	16.45	0.00	1.75	0.2453	159.
114	17.07	0.00	2.54	0.5196	165.
116	17.78	0.00	3.24	0.5459	165.
118	18.46	0.00	3.86	0.4887	165.
122	20.24	0.00	4.95	0.1741	156.
125	22.01	0.00	5.88	0.0790	149.

Sample 6. RMS Pressure Data - Pressure Calibration

RUN 2

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
NASA/RI OMS POD

DATE COMPUTED 15-SEP-[illegible]
DATE RECORDED 5-AUG-
TIME RECORDED 8:19: [illegible]
TIME COMPUTED 12:41: 44
PROJECT NO V C-3E

ALPHA DEG	WEDGE ANGLE DEG	POD ANGLE DEG
10.05	-0.05	0.00

RUN	CONF	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2
2	1000	30.0	315.0	1.67E+06	3.93	2.171E-01	-269.7	338.0	2655.	3.075E-03	1.526E-07

TIME FROM CENTER LINE 5. SECS

*** SURFACE PRESSURE DATA ***

STATIC NO	X IN	Y IN	Z IN	PW PSIA	PW/PIN	PW-PIN PSIA	CP
1	10.50	2.50	0.00	0.775	3.57	0.558	0.24
2	12.00	2.50	0.00	0.765	3.52	0.548	0.23
3	13.50	2.50	0.00	0.755	3.48	0.538	0.23
4	14.50	2.50	0.00	0.791	3.64	0.574	0.24
5	15.25	2.50	0.00	0.926	4.26	0.709	0.30
6	7.00	0.25	0.00	0.770	3.55	0.553	0.24
7	8.00	0.25	0.00	0.781	3.60	0.564	0.24
8	9.00	0.25	0.00	0.780	3.59	0.563	0.24
9	10.00	0.25	0.00	0.798	3.68	0.581	0.25
10	11.00	0.25	0.00	0.798	3.67	0.580	0.25
11	11.50	0.25	0.00	0.789	3.63	0.572	0.24
12	12.00	0.25	0.00	0.786	3.63	0.571	0.24
13	12.50	0.25	0.00	0.782	3.60	0.564	0.24
14	13.00	0.25	0.00	0.779	3.59	0.561	0.24
15	13.50	0.25	0.00	0.770	3.55	0.553	0.24
16	14.25	0.25	0.00	0.785	3.61	0.567	0.24
17	14.50	0.25	0.00	0.799	3.68	0.582	0.25
18	15.00	0.25	0.00	0.849	3.91	0.632	0.27
19	15.25	0.25	0.00	0.898	4.14	0.681	0.29
101	16.45	6.50	1.75	1.172	5.40	0.954	0.41
102	17.42	6.50	2.90	2.221	10.23	2.003	0.85
103	18.56	6.50	3.86	3.074	14.16	2.857	1.22
104	16.45	5.50	1.75	1.210	5.57	0.993	0.42
105	17.42	5.50	2.90	2.187	10.07	1.970	0.84
106	16.45	4.50	1.75	1.090	5.02	0.872	0.37
107	16.45	2.50	1.75	1.011	4.65	0.794	0.34
108	18.56	2.50	3.86	2.525	11.63	2.308	0.98
109	15.70	0.25	0.46	0.829	3.82	0.612	0.26
110	15.92	0.25	0.90	0.824	3.80	0.607	0.26
111	16.18	0.25	1.34	0.895	4.12	0.678	0.29
112	16.45	0.25	1.75	1.052	4.85	0.835	0.36
113	16.75	0.25	2.16	1.340	6.17	1.123	0.48
114	17.07	0.25	2.54	1.672	7.70	1.455	0.62
115	17.42	0.25	2.90	2.043	9.41	1.826	0.78
116	17.78	0.25	3.24	2.262	10.42	2.045	0.87

Sample 7. Static Pressure Data - Pressure Calibration

RUN 2

PAGE 2

ALPHA DEG	WEDGE ANGLE DEG	POD ANGLE DEG
10.05	-0.05	0.00

RUN	CONF	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2
2	1000	30.0	315.0	1.67E+06	3.93	2.171E-01	-269.7	338.0	2655.	3.075E-03	1.528E-07

*** SURFACE PRESSURE DATA ***

STATIC NO	X IN	Y IN	Z IN	PW PSIA	PW/PIN	PW-PIN PSIA	CP
117	18.16	0.25	3.56	2.396	11.03	2.179	0.93
118	18.46	0.25	3.86	2.497	11.50	2.280	0.97
119	18.97	0.25	4.15	2.516	11.59	2.299	0.98
120	19.39	0.25	4.43	2.450	11.28	2.233	0.95
121	19.81	0.25	4.69	2.336	10.76	2.119	0.90
122	20.24	0.25	4.95	2.285	10.52	2.067	0.88
123	20.68	0.25	5.19	2.135	9.83	1.918	0.82
124	21.12	0.25	5.43	2.044	9.41	1.827	0.78
125	22.01	0.25	5.88	1.917	8.83	1.700	0.72
126	16.45	-2.50	1.75	1.051	4.84	0.833	0.36
127	18.56	-2.50	3.86	2.214	10.19	1.996	0.85
128	16.45	-4.50	1.75	1.065	4.91	0.848	0.36
129	18.56	-4.50	3.86	2.702	12.45	2.485	1.06
130	16.45	-5.50	1.75	1.155	5.32	0.938	0.40
131	16.45	-6.50	1.75	1.290	5.94	1.073	0.46
132	18.56	-6.50	3.86	3.612	16.64	3.395	1.45

Sample 7. Concluded

RUN 2

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
NASA/RI OMS POD

DATE COMPUTED 15-SEP-[illegible]
DATE RECORDED 11-AUG
TIME RECORDED 9: [illegible]
TIME COMPUTED 12:38: 22
PROJECT NO V C-3E

ALPHA DEG	WEDGE ANGLE DEG	POD ANGLE DEG
9.91	0.09	-8.00

RUN	CONF	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2
26	2000	19.9	1314.0	3.13E+05	3.92	1.397E-01	-5.4	215.9	4091.	8.272E-04	3.366E-07

TIME FROM CENTER LINE 20. SECS

*** SURFACE PRESSURE DATA ***

STATIC NO	X IN	Y IN	Z IN	PW PSIA	PW/PIN	PW-PIN PSIA	CP
1	10.50	2.50	0.00	0.448	3.21	0.308	0.21
2	12.00	2.50	0.00	7.282	52.14	7.143	4.77
3	13.50	2.50	0.00	0.543	3.89	0.404	0.27
4	14.50	2.50	0.00	0.555	3.97	0.416	0.28
5	15.25	2.50	0.00	0.589	4.22	0.449	0.30
6	7.00	0.25	0.00	0.176	1.26	0.036	0.02
7	8.00	0.25	0.00	0.204	1.46	0.064	0.04
8	9.00	0.25	0.00	0.278	1.99	0.138	0.09
9	10.00	0.25	0.00	0.391	2.80	0.252	0.17
10	11.00	0.25	0.00	0.475	3.40	0.336	0.22
11	11.50	0.25	0.00	0.493	3.53	0.353	0.24
12	12.00	0.25	0.00	0.514	3.68	0.375	0.25
13	12.50	0.25	0.00	0.514	3.68	0.374	0.25
14	13.00	0.25	0.00	0.528	3.78	0.389	0.26
15	13.50	0.25	0.00	10.762	77.05	10.622	7.09
16	14.25	0.25	0.00	0.543	3.89	0.403	0.27
17	14.50	0.25	0.00	0.565	4.04	0.425	0.28
18	15.00	0.25	0.00	0.582	4.16	0.442	0.29
19	15.25	0.25	0.00	0.627	4.49	0.488	0.33

Sample 8. Static Pressure Data -Thermal Calibration and Material Evaluation

RUN 26

AEDC DIV. _ON
ARVIN/CALSPAN FIELD SERVICES, INC.
VON KARMAN GAS DYNAMICS FACILITY (VKF)
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/RI OMS POD AFRSI TEST
PROJECT V4 C-3E

DATE COMPUTED 12-SEP-83
TIME COMPUTED 13:01
DATE RECORDED 11-AUG-83
TIME RECORDED 9: 6?

SAMPLE	CONF	ALPHA	WEDGE ANGLE	POD ANGLE	TIMEINJ SEC	TIMECL HOUR MIN SEC MSEC
TH CALIB	MATL EVAL PHASE	9.91	0.09	-8.00	5.54	9 6 22 967

RUN	PT PSIA	TT DEG F	RE FT-1	M	P PSIA	T DEG F	Q PSF	V FT/SEC	RHO LBM/FT3	MU LBF-SEC/FT2
26	19.9	1314.0	3.12E+05	3.92	1.397E-01	-5.4	215.9	4091.	8.272E-04	3.306E-07

MODEL EMISSIVITY 0.82

IR TEMPERATURE RECORD -- TW F
TIME EXP 67.249 SEC

RUN 26 FRAME 16 PAGE 1

*** POINT ***

LINE	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
33	332.	332.	335.	335.	335.	335.	338.	343.	343.	346.	351.	353.	370.	410.	482.	546.	609.	668.	725.	778.
34	326.	326.	329.	329.	335.	338.	340.	338.	346.	343.	351.	351.	363.	406.	472.	540.	602.	663.	720.	773.
35	320.	320.	320.	320.	317.	329.	326.	332.	332.	335.	343.	348.	358.	405.	474.	542.	604.	663.	719.	773.
36	317.	320.	317.	317.	326.	326.	329.	332.	335.	335.	346.	346.	365.	415.	483.	549.	611.	672.	727.	780.
37	320.	320.	317.	323.	326.	323.	320.	335.	335.	340.	340.	351.	365.	417.	488.	555.	617.	675.	732.	783.
38	314.	308.	320.	317.	317.	323.	317.	329.	329.	335.	340.	348.	368.	427.	502.	565.	627.	685.	738.	789.
39	314.	314.	317.	314.	317.	320.	323.	326.	332.	338.	340.	348.	372.	437.	506.	574.	632.	689.	743.	790.
40	314.	311.	317.	314.	314.	317.	320.	323.	323.	329.	332.	343.	372.	434.	506.	571.	631.	685.	740.	788.
41	314.	314.	314.	314.	317.	317.	314.	326.	326.	335.	338.	346.	365.	436.	508.	571.	629.	685.	737.	786.
42	311.	311.	311.	314.	317.	314.	332.	320.	332.	332.	346.	365.	422.	498.	564.	623.	679.	733.	779.	818.
43	311.	308.	311.	314.	314.	317.	317.	320.	326.	332.	346.	363.	427.	500.	566.	623.	680.	731.	778.	818.
44	304.	308.	304.	304.	311.	311.	314.	317.	320.	329.	332.	340.	365.	429.	503.	572.	628.	683.	735.	782.
45	308.	308.	301.	311.	311.	314.	311.	320.	314.	326.	338.	343.	372.	429.	503.	569.	628.	683.	737.	783.
46	311.	311.	308.	308.	314.	311.	317.	323.	323.	326.	332.	340.	376.	440.	510.	576.	634.	689.	742.	789.
47	308.	308.	308.	308.	308.	314.	317.	323.	326.	326.	332.	351.	376.	442.	512.	577.	637.	693.	742.	788.
48	308.	308.	311.	308.	320.	314.	317.	320.	320.	332.	338.	346.	372.	437.	503.	568.	628.	685.	738.	785.
49	317.	314.	314.	323.	317.	317.	323.	326.	329.	332.	340.	346.	372.	431.	502.	565.	625.	679.	733.	782.
50	314.	311.	314.	314.	317.	314.	326.	329.	323.	332.	338.	348.	368.	417.	467.	554.	611.	669.	724.	772.
51	320.	314.	314.	317.	320.	326.	326.	323.	326.	335.	343.	351.	365.	412.	483.	549.	610.	668.	723.	774.
52	317.	320.	317.	323.	320.	326.	329.	329.	335.	340.	343.	351.	370.	421.	487.	554.	618.	680.	739.	793.
53	320.	320.	323.	329.	329.	329.	329.	338.	338.	346.	351.	361.	374.	426.	492.	563.	634.	698.	760.	816.
54	329.	326.	329.	329.	335.	329.	338.	343.	343.	351.	353.	365.	389.	437.	510.	587.	657.	725.	789.	847.
55	335.	332.	335.	338.	329.	338.	338.	348.	351.	356.	356.	370.	393.	448.	521.	601.	676.	747.	812.	871.
56	338.	338.	340.	335.	340.	343.	346.	348.	353.	358.	361.	374.	395.	442.	515.	601.	679.	751.	821.	884.
57	338.	335.	340.	343.	338.	346.	348.	353.	358.	365.	363.	372.	393.	440.	517.	599.	679.	751.	822.	885.
58	340.	338.	343.	343.	338.	348.	351.	353.	358.	365.	365.	376.	387.	431.	505.	587.	608.	742.	811.	873.
59	346.	346.	346.	351.	346.	353.	356.	358.	361.	361.	368.	376.	391.	429.	502.	583.	603.	735.	803.	805.
60	358.	358.	358.	361.	356.	358.	353.	363.	361.	363.	366.	379.	395.	434.	505.	587.	604.	736.	803.	884.
61	358.	356.	351.	353.	351.	353.	353.	358.	358.	365.	370.	381.	391.	432.	505.	586.	601.	732.	798.	857.

Sample 9. Infrared Data - Thermal Calibration and Material Evaluation

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