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# CARINA AEROTHERMAL TEST AT MACH 8

M. G. Hammond
Calspan Corporation/AEDC Operations

July 1991

Final Report for April 16-18, 1991



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13. ABSTRACT (Maximum 200 words)

Surface pressure, heat-transfer, force and moment, base pressure, and oil flow visualization data were acquired on four model configurations of the Carina Space Recovery Vehicle. The test was conducted in the AEDC Hypersonic Wind Tunnel B at Mach 8 and free-stream Reynolds number of 0.75, 1.0, and 2.0 million per foot.

Angle of attack was varied from 0 to 20 deg at roll angles of -180 to 180 deg.

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## NOMENCLATURE

| | |
|---|---|
| AB | Model base area (see Table 2) |
| ALPHA | Model angle of attack, deg |
| ALPI | Indicated sector pitch angle, deg |
| CA | Total axial-force coefficient, body axis, axial force/(Q * SREF) |
| CAB | Axial-force coefficient for model base pressures, -CPBA * AB/SREF |
| CAF | Forebody axial-force coefficient, body axis, CA - CAB |
| CCW | Cross-wind coefficient, wind axis |
| CDW | Drag coefficient, wind axis |
| CLL | Rolling-moment coefficient, body axis, rolling-moment/(Q * SREF * LREFL) |
| CLLW | Rolling-moment coefficient, wind axis |
| CLM | Pitching-moment coefficient, body axis pitching moment/(Q*SREF*LREFM) |
| CLMW | Pitching-moment coefficient, wind axis |
| CLN | Yawing-moment coefficient, body axis, yawing moment/(Q*SREF*LREFN) |
| CLNW | Yawing-moment coefficient, wind axis |
| CLW | Lift coefficient, wind axis |
| CN | Normal-force coefficient, body axis, normal force/(Q*SREF) |
| CONFIGURATION | Model configuration designation (see Table 1) |
| CP | Pressure coefficient, (PW-P)/Q |
| CPBA | Average base pressure coefficient, (PBA - P)/Q |
| C.R. | Center of rotation |
| CY | Side-force coefficient, body axis, side force/(Q*SREF) |
| FCRN | Flow correction run number |

| | |
|---|---|
| GAGE ID | Gage identification number |
| H(TT) | Heat-transfer coefficient based on TT, H(TT) = QDOT/(TT-TW), Btu/ft$^2$-sec-°R or W/M$^2$-°K |
| ITT | Enthalpy based on TT, Btu/lbm |
| ITW | Enthalpy based on TW, Btu/lbm |
| (L/D)W | Lift-to-drag ratio, wind axis |
| LM | Model length (see Table 2) |
| LREFL<br>LREFM<br>LREFN | Model moment reference lengths, (see Table 2) |
| M | Free-stream Mach number |
| MODEL PRESSURE | Model pressure identification number |
| MU | Dynamic viscosity based on free-stream temperature, lbf-sec/ft$^2$ or PA-sec |
| P | Free-stream static pressure, psia or PA |
| PB1-4 | Model base pressures, psia or PA |
| PBA | Average model base pressure, (PB1+PB2+PB3+PB4)/4, psia or PA |
| PHI | Total model roll angle, deg |
| PHII | Indicated roll angle, deg |
| PK101<br>PK116<br>PK201<br>PK232 | Reference pressure measured by ESP® module 1, channels 1 and 16, and ESP® module 2, channel 1 and 32, psia |
| PKNOWN 7<br>PKNOWN 8<br>PKNOWN S | Reference pressure measured by the standard pressure system and Sonics® transducer, psia |
| PN | Data point number |
| PT | Tunnel stilling chamber total pressure, psia or PA |
| PT2 | Stagnation pressure downstream of a normal shock, psia or PA |
| PTNK | Installation tank pressure, psia or PA |
| PW | Calculated model pressure, psia or PA |

| | |
|---|---|
| Q | Free-stream dynamic pressure, psia or PA |
| QDOT | Measured heat-transfer rate, Btu/ft$^2$-sec or W/M$^2$ |
| RE | Free-stream unit Reynolds number, ft$^{-1}$ or M$^{-1}$ |
| RHO | Free-stream density, lbm/ft$^3$ or KG/M$^3$ |
| RUN | Data set identification number |
| S(TT) | Stanton number based on TT, S(TT) = QDOT/(RHO*V*(ITT-ITW)) |
| S/R | Surface distance to model instrumentation location where R = 5.0, S/R = 0 at model stagnation point (see Table 4) |
| SREF | Model reference area, (see Table 2) |
| T | Free-stream static temperature, °R or °K |
| THETA, θ | Angular location of model instrumentation, deg (see Table 4) |
| TIMEINJ | Time of model injection, elapsed time from lift-off to arrival at tunnel centerline, sec |
| TIMERD | Time from lift-off at which heat-transfer gage data were reduced, sec |
| TT | Tunnel stilling chamber total temperature, °R or °K |
| TW | Gage surface temperature, °R or °K |
| V | Free-stream velocity, ft/sec or M/sec |
| XCPN | X-coordinate of the pitch-plane center-of-pressure location expressed in terms of LREFM |
| XMRC | Axial distance from model nose to model moment reference center, (see Table 2) |

# 1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 921Z39, Control Number 9Z39, at the request of the Directorate of Aerospace Flight Dynamics Test (DOF), AEDC, Arnold AFB, TN 37389, for Science Applications International Corporation (SAIC), 501 Office Center Drive, Suite 420, Fort Washington, PA 19034. The AEDC/DOF project manager was 1LT Thomas Greenman and the SAIC project manager was Mr. Anthony Martellucci. The test results were obtained by Calspan Corporation, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Base, Tennessee. The test was conducted in the Hypersonic Wind Tunnel B of the von Karman Gas Dynamics Facility (VKF), during the period from April 16, 1991 to April 18, 1991, under AEDC Project Number CR23VB.

The purpose of this test was to determine the effects of corner radius and afterbody angle on surface pressure, heat-transfer rate, and static stability data needed to validate vehicle design/analysis codes and confirm performance of the Carina Space Recovery Vehicle. Carina is a low-cost, recoverable reentry vehicle designed as a microgravity research platform.

Surface pressure and heat-transfer data were acquired on the baseline configuration at Mach 8 and a Reynolds number of 0.75, 1.0, and 2.0 million per foot. Discrete angles of attack were set between 0 and 20 deg, and roll angles were set between -165 and 180 deg. Static stability and base pressure data were acquired on the baseline configuration and three additional configurations at Mach 8 and a Reynolds number of 1.0 and 2.0 million per foot. Oil flow visualization data were obtained on all four configurations at Mach 8 at a Reynolds number of 1.0 million per foot. Angle-of-attack and roll angle variations for each configuration are defined in the Test Run Summary.

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

The final data from the test have been transmitted to SAIC. Requests for the data should be addressed to AEDC/DOF, Arnold AFB, TN 37389. A copy of the data is on file at the AEDC.

# 2.0 APPARATUS

## 2.1 TEST FACILITY

Tunnel B (Fig. 1) is a continuous, closed-circuit, variable density wind tunnel with a 50-in.-diam test section and two interchangeable axisymmetric contoured nozzles to provide Mach numbers of 6 and 8. The tunnel can be operated continuously over a range of pressure from 40 to 300 psia at Mach number 6, and 100 to 900 psia at Mach number 8, with air supplied by the main compressor plant. Stagnation temperatures sufficient to avoid air liquefaction in the test section (up to 1350°R) are obtained through the use of a natural gas-fired combustion heater. The entire tunnel (throat, nozzle, test section, and diffuser) is cooled by integral, external water jackets.

The tunnel is equipped with a model injection system, which allows removal of the model from the test section while the tunnel remains in operation. A description of the tunnel may be found in the <u>Test Facilities Handbook</u> (Ref. 1).

## 2.2 TEST ARTICLES

The test articles furnished by SAIC were scaled models of the Carina Space Recovery Vehicle. All models were designed and fabricated by Micro Craft, Inc. of Tullahoma, TN. Carina is an axisymmetric model of a blunt, low lift-to-drag reentry vehicle. The baseline configuration consisted of a 0.5-in. corner radius and a 13-deg after-body angle. Additional model components were used to achieve different corner radii and after body angles. A separate model of the baseline configuration was used during the heat-transfer/pressure phase of the test. Details of the different configurations can be seen in Fig. 2, and a photograph of model components is provided in Fig. 3. The models were constructed of stainless steel (17-4). Boundary-layer trips were not used. Model configuration designations are outlined in Table 1, and coefficient reference lengths and areas are presented in Table 2. Installation sketches are provided in Fig. 4, and an installation photograph is presented in Fig. 5.

Base pressure tubes were aligned 0.05 in. from the model base during the force phase of the test. A windshield assembly was also used at the base of the model to protect the aft portion of the balance and the water cooling lines. A schematic of base pressure locations is presented in Fig. 6. The pressure tubes and windshield assembly can be seen in Fig. 7.

## 2.3 TEST INSTRUMENTATION

The instrumentation, recording devices, and calibration methods used for all measured parameters are listed in Table 3.

### 2.3.1 Model Force Instrumentation

Model forces and moments were measured with a six-component, 500-lb strain gage balance (ID No. 4.00-Y-36-043) supplied and calibrated by AEDC.

### 2.3.2 Pressure Instrumentation

Model base pressures and surface pressures were measured with an Electronically Scanned Pressure (ESP®) module. The module contains 16 fast-response pressure transducers with a range of ± 1.0 psid. The relatively small size of the pressure module made it possible to mount the instrument in a sting segment downstream of the model base during the force phase. In addition to the ± 1.0-psid module, a 48-channel, ± 2.5-psid pressure module was mounted on-board the model during the heat transfer/pressure phase to measure 35 surface pressures. Only base pressures were measured during the force phase.

### 2.3.3 Heat-Transfer Instrumentation

The heat-transfer/pressure model was instrumented with 9 coax gages and 17 Schmidt-Boelter gages. The coax gage is a surface thermocouple that is comprised of an insulated Chromel wire fixed concentrically within a constantan jacket. The Schmidt-Boelter gage consists of a 0.025-in.-thick anodized aluminum wafer wrapped with a small (0.002-in.-diam) thermocouple wire. One half of the wire-wrapped wafer was copper plated creating a series thermocouple. The wafer was potted into an aluminum heat sink. Each gage also used an iron constantan thermocouple to provide the gage temperature. The thermocouple outputs were used to determine the rate of heat flux and the gage surface temperature using gage calibration factors determined using laboratory techniques traceable to the National Institute of Standards and Technology (formerly National Bureau of Standards). Heat flux and surface temperature were used in calculating the heat-transfer coefficient. Figure 8 provides the layout for the heat-transfer gages and pressure orifices, and Table 4 gives the actual locations.

### 2.3.4 Flow Visualization

Model flow-field shadowgraph/schlieren still photographs were obtained on all configurations at selected model attitudes. The photographs were obtained with a single-pass optical flow-visualization system. Color schlieren movies were obtained for selected runs, and 70-mm still photographs were obtained for each oil flow run. Prior to performing the oil flow portion of the test, a dummy balance was installed to avoid oil contamination of the strain gages on the force balance.

## 3.0 TEST DESCRIPTION

### 3.1 TEST CONDITIONS

A test summary showing all configurations tested and the variables for each is presented in Table 5. A summary of nominal test conditions is given below:

| M | PT, psia | TT, °F | Q, psia | P, psia | T, °F | V, ft/sec | RE, $ft^{-1}$ |
|---|---|---|---|---|---|---|---|
| 7.98 | 455.0 | 850 | 2.107 | 0.047 | 97.4 | 3859 | $2.0 \times 10^6$ |
| 7.93 | 207.5 | 785 | 0.981 | 0.022 | 93.1 | 3753 | $1.0 \times 10^6$ |
| 7.88 | 150.0 | 760 | 0.716 | 0.016 | 91.5 | 3712 | $0.75 \times 10^6$ |

## 3.2 TEST PROCEDURES

### 3.2.1 General

In Tunnel B, 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. 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, the model is injected into the airstream, and the fairing doors are closed. 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. The sequence is repeated for each configuration or test condition change.

### 3.2.2 Data Acquisition

#### 3.2.2.1 Force Data

Model attitude positioning and data recording were accomplished with the point-pause and continuous-sweep modes of operation, using the Model Attitude Control System (MACS). Model pitch and roll requirements were entered into the controlling computer prior to the test. Model positioning and data recording operations were performed automatically during the test by selecting the list of desired model attitudes and initiating the system.

Point-pause data were obtained for selected values of ALPHA and PHI. Each data point for this mode of operation represents the result of a Kaiser-Bessel digital filter utilizing 16 samples taken over a span of 0.50 sec. Continuous-sweep data were obtained for a fixed value of PHII with a pitch rate of 1.0 deg/sec. A data sample was recorded every 0.0320 sec and a sliding Kaiser-Bessel digital filter was applied to 16 samples to produce a data point every 0.48 deg in pitch. The data were then interpolated to obtain the data desired for the requested model attitudes.

#### 3.2.2.2 Heat-Transfer/Pressure Data

Model attitude positioning was performed manually before each inject. Each inject was performed at discrete pitch and roll angles, and the angles were constant throughout the run. The data acquisition sequence was started just prior to injection while the model was still in the tank and continued until the model was retracted into the tank.

#### 3.2.2.3 Oil Flow Visualization

Each oil flow run was performed at discrete pitch and roll angles. Prior to each run, oil was blotted on the model surface with a corrugated sponge. The model was then injected into the tunnel where

70-mm still photographs were taken every 4 sec until the flow pattern had established. The model was then retracted.

## 3.3 DATA REDUCTION

### 3.3.1 Force Data

Model static force and base pressure data were obtained simultaneously utilizing the data acquisition procedures as described in Section 3.2. The force and moment measurements were reduced to coefficient form using the digitally filtered data points and correcting for first- and second-order balance interaction effects, model tare weight, and balance-sting deflections. Model attitude and tunnel stilling chamber pressure were also calculated from digitally filtered values.

Model force and moment coefficients are presented in the body and wind axis systems. The static stability and total axial-force coefficients were corrected for small tunnel flow nonuniformities. Wind axis system coefficients were calculated using the forebody axial-force coefficient (CAF). Reference lengths and areas for model aerodynamic coefficients are given in Table 2 for each configuration.

### 3.3.2 Coax Gage Data

The coax gage provides a measurement of the surface temperature of the test panel material, which is assumed to be a homogenous, one-dimensional, semi-infinite solid. For this reason it is important that the thermophysical properties of the gage parts and the test panel material be closely matched. The coax gage heat flux at each instrumented location was computed for each time point ($t_n$) from the measured surface temperature by the following equation derived from semi-infinite solid considerations

$$QDOT(tn) = \frac{2C\left(t_n\right)}{\sqrt{\pi}} \sum_{j=1}^{n} \frac{TW\left(t_j\right) - TW\left(t_{j-1}\right)}{\sqrt{t_n - t_j} + \sqrt{t_n - t_{j-1}}} \qquad (1)$$

The coax gage surface temperature, TW ($t_j$), was computed using a curve fit of voltage versus temperature published by the National Institute of Standards and Technology (formerly National Bureau of Standards) (1974). The value of $C(t_n)$ for the coax gages was calculated from

$$C\left(t_n\right) = 5.26 \times 10^{-4} \left[\frac{TW\left(t_n\right) + TW\left(t_1\right)}{2}\right] + 0.12688 \qquad (2)$$

To reduce the effects of any noise in the gage output, the values of QDOT were averaged for fifteen consecutive readings after the test article reached the tunnel centerline. The gage surface temperature was also averaged.

The heat-transfer coefficient, H(TT), for each coax gage was computed from

$$H(TT) = \frac{QDOT}{(TT - TW)} \tag{3}$$

### 3.3.3 Model Surface Pressures

Prior to the operating shift the ESP pressure modules were calibrated by applying known and zero pressure differentials across the modules. From this data, scale factors were calculated for each port of each module. Model pressure (PW) for each orifice was calculated with a second-order curve fit,

$$PW = A_0 + A_1 \left[Reading - CZ\right] + A_2 \left[Reading - CZ\right]^2 + Reference\,Pressure \tag{4}$$

where $A_0$, $A_1$, and $A_2$ are calibration coefficients, and CZ is the corrected zero calculated by

$$CZ = Updated\ zero\ reading - Zero\ reading\ at\ calibration \tag{5}$$

Reference pressure was measured using a miniature vacuum gage.

A pressure coefficient (CP) was calculated for each orifice

$$CP = (PW - P)/Q \tag{6}$$

The known pressure measurement was calculated using

$$PKNOWN = (Reading - Zero\,Reading)(SF) + Reference\,Pressure \tag{7}$$

where SF is the calibration scale factor.

### 3.3.4 Schmidt-Boelter Gage Data

Measurements obtained from the Schmidt-Boelter gages are gage output (E) and gage temperature (TGE). The gage output is converted to heating rate via a laboratory calibrated gage scale factor (CSF):

$$QDOT = (E)\,(CSF) \tag{8}$$

The gage wall temperature used in computing the gage heat-transfer coefficient is obtained from the output of the gage thermocouple (TGE) and the temperature difference (TGDEL) across the gage wafer. TGDEL is proportional to the gage output, E, and is calculated by:

$$TGDEL = (KG)\,(E) \tag{9}$$

where KG is the gage temperature calibration factor. The gage wall temperature is:

$$TW = TGE + TGDEL \tag{10}$$

The heat-transfer coefficient for each gage was computed using Eq. (3).

### 3.3.5 Oil Flow Data

Tunnel conditions were the only data tabulated for oil flow runs.

## 3.4 MEASUREMENT UNCERTAINTIES

In general, instrumentation calibrations and data uncertainty estimates were made using methods described in Ref. 2. Measurement uncertainty is a combination of bias and precision errors defined as:

$$U = \pm\left(B + t_{95}\,S\right) \tag{11}$$

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 are given in Table 3a. Static load hangings on the force and moment balance simulated the range of loads and center-of-pressure locations anticipated during the test, and measurement errors were based on differences between applied loads and corresponding values calculated from the balance equations used in the data reduction. Load hangings to verify each balance calibration are made in place on the assembled model. Data uncertainties for the coax and Schmidt-Boelter gages were determined from laboratory calibrations. Other data uncertainties were 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. 2 and results are given in Table 3b.

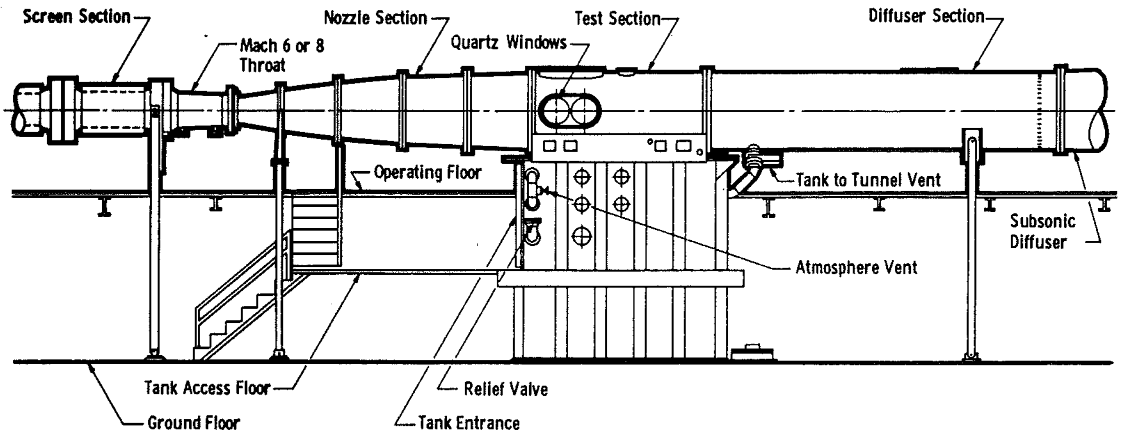
## 4.0 DATA PACKAGE PRESENTATION

The data package contains tabulated data presented in English and SI units. The force data included coefficients in the body and wind axes. Sample tabulations of heat-transfer/pressure data, force data, and tunnel conditions are presented in Samples 1-4. All photographic data, including model installation and shadowgraph/schlieren photographs, were a part of the data package.

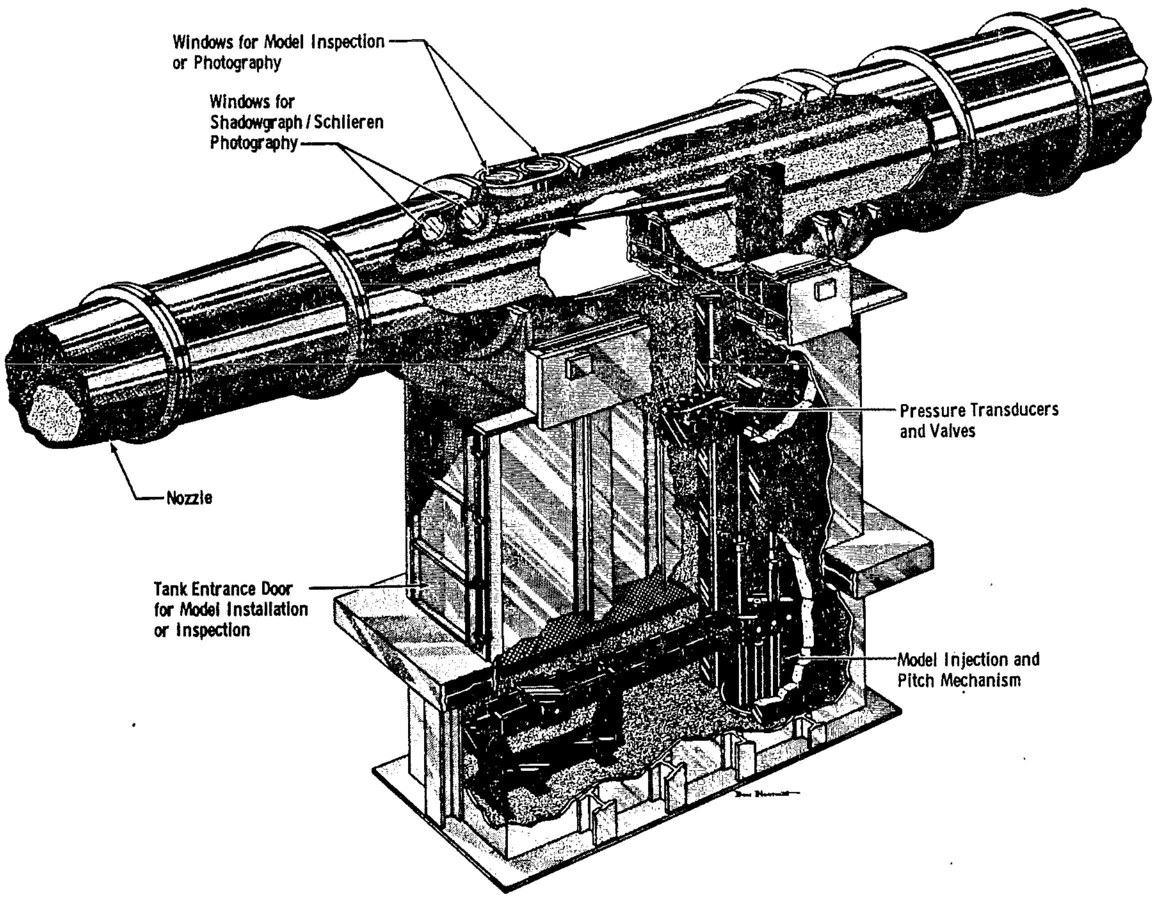
## 5.0 REFERENCES


1. Test Facilities Handbook (Twelfth Edition). "von Karman Gas Dynamics Facility, Vol. 3." Arnold Engineering Development Center, March 1984.

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




a. Tunnel assembly




b. Tunnel test section

Fig. 1. Tunnel B

| CONFIGURATION | $R_C$ ,in. | A , deg | D, in. | B, in. |
|---|---|---|---|---|
| 1 | 0.50 | 13 | 9.860 | 5.812 |
| 2 | 0.25 | 13 | 9.968 | 5.812 |
| 3 | 1.00 | 13 | 9.659 | 5.812 |
| 4 | 0.50 | 8 | 9.860 | 7.492 |

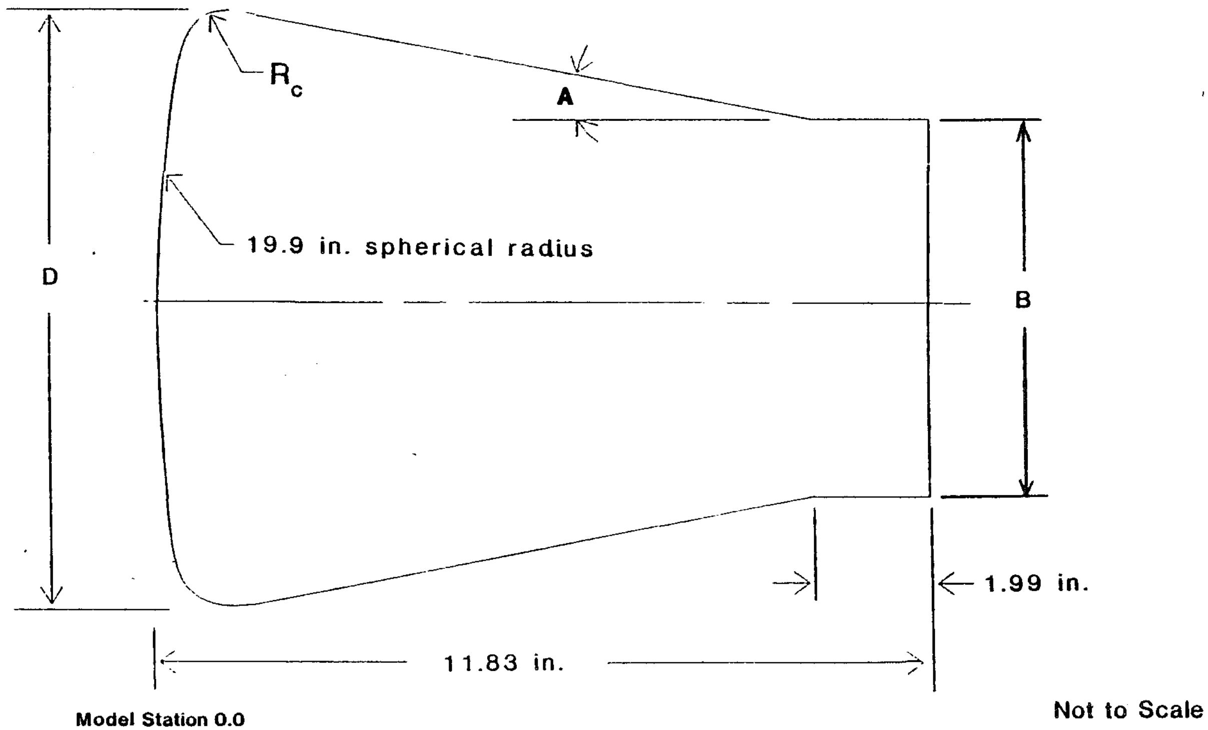
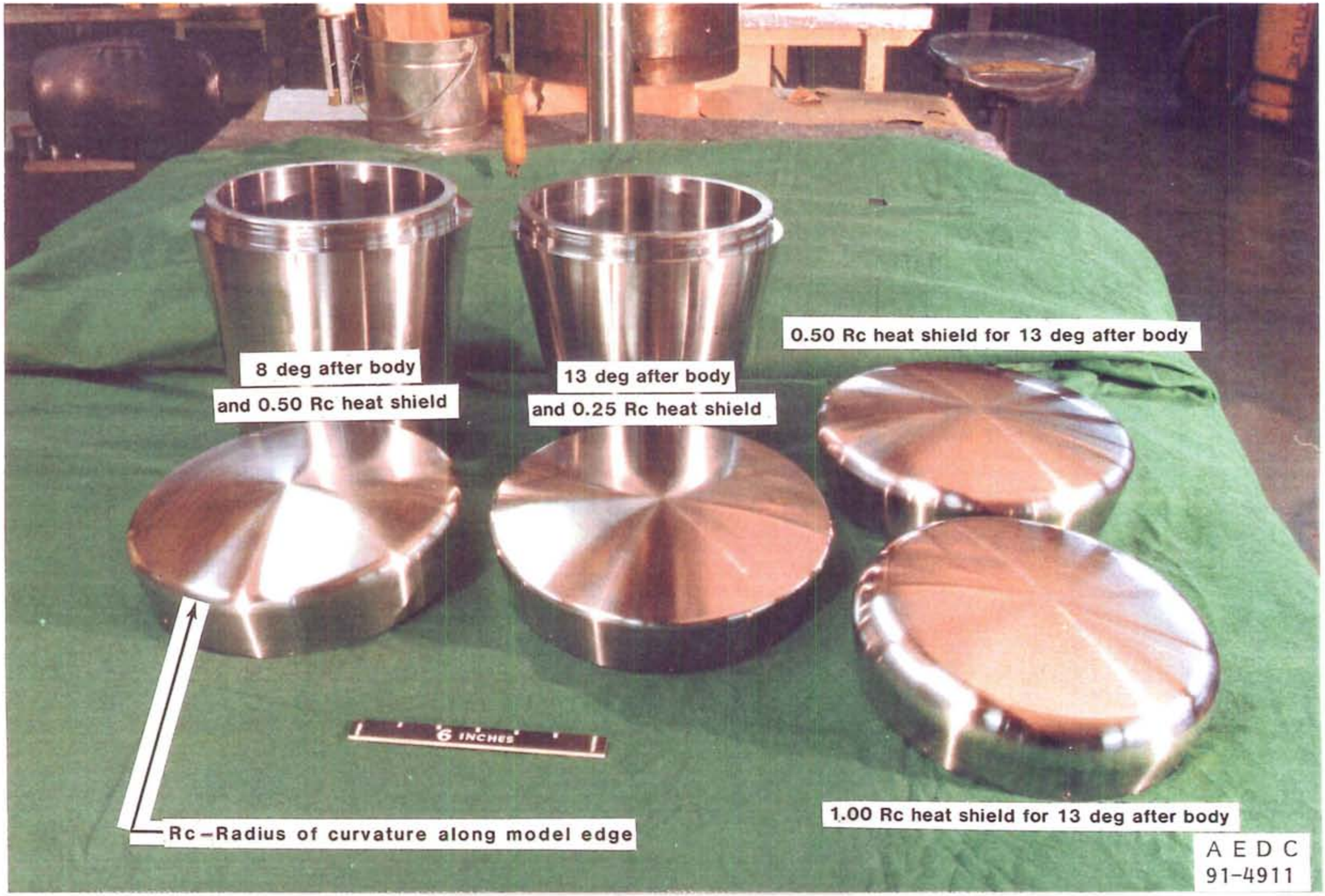



Figure 2. Model Configuration Details




a. Force Model
Figure 3. Model Components


b. Heat-transfer/pressure model

Figure 3. Concluded.

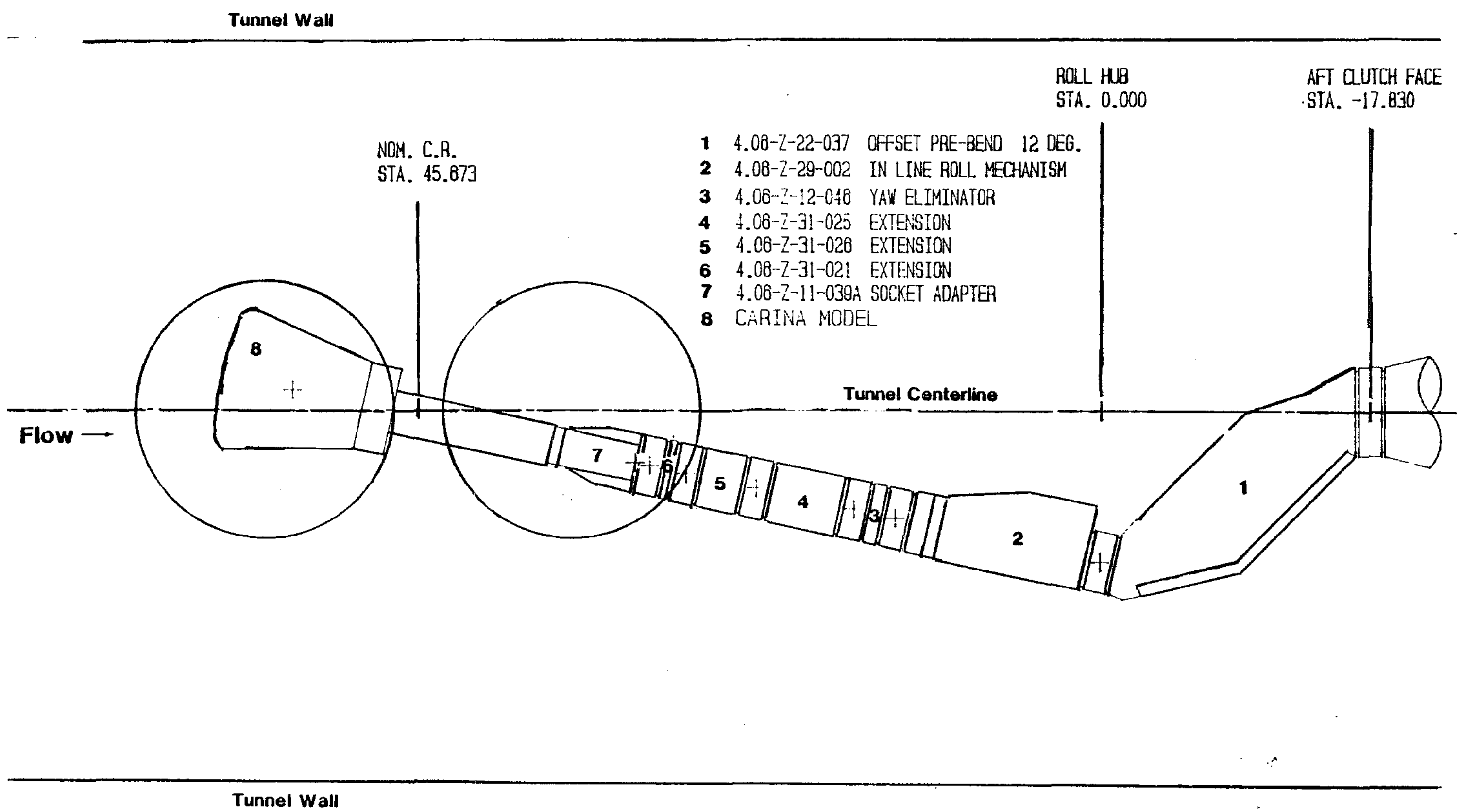



**Figure 4. Carina Installation in Tunnel B**

**a. Heat-Transfer/Pressure Installation**

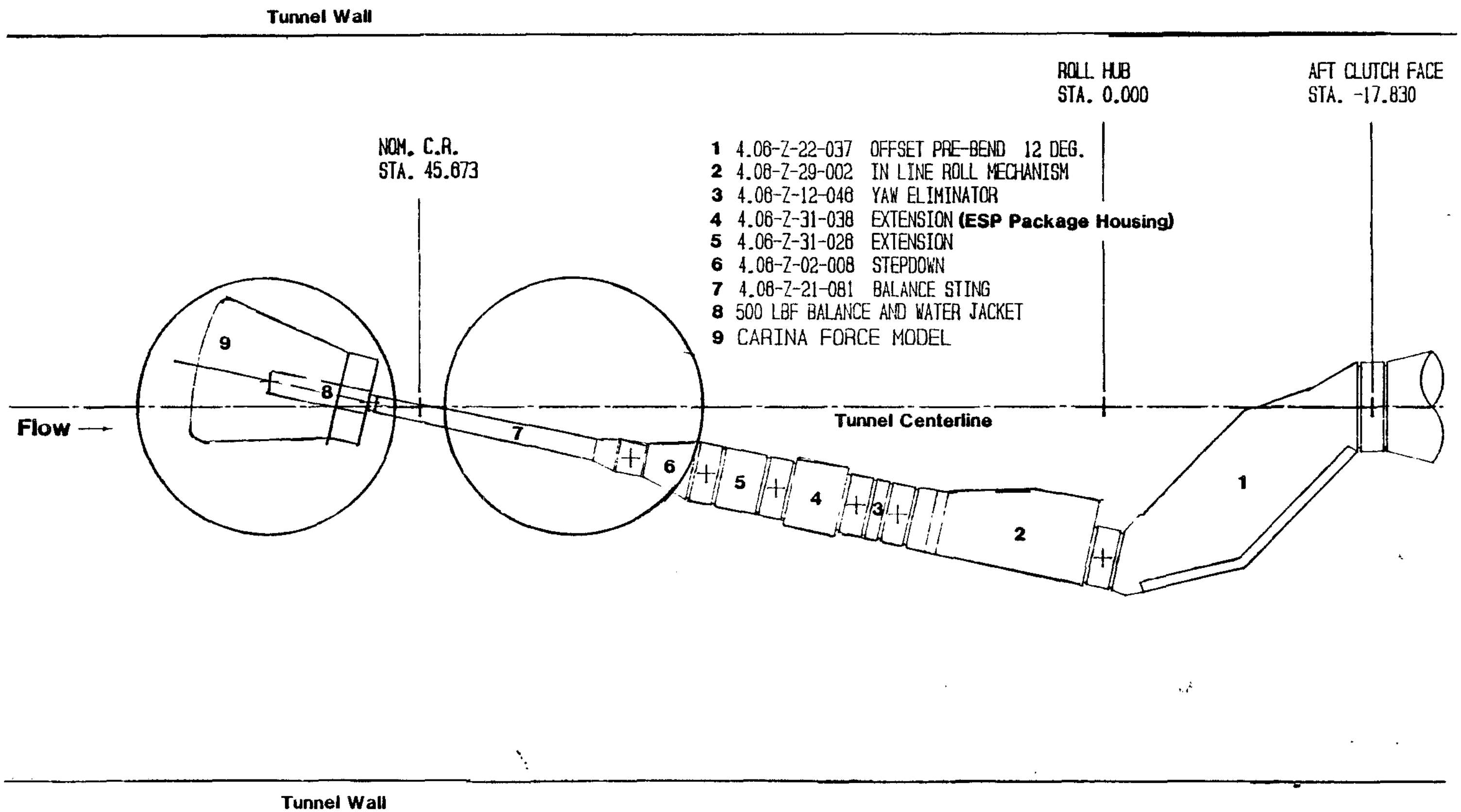



**Figure 4. Continued**

**b. Force Installation**

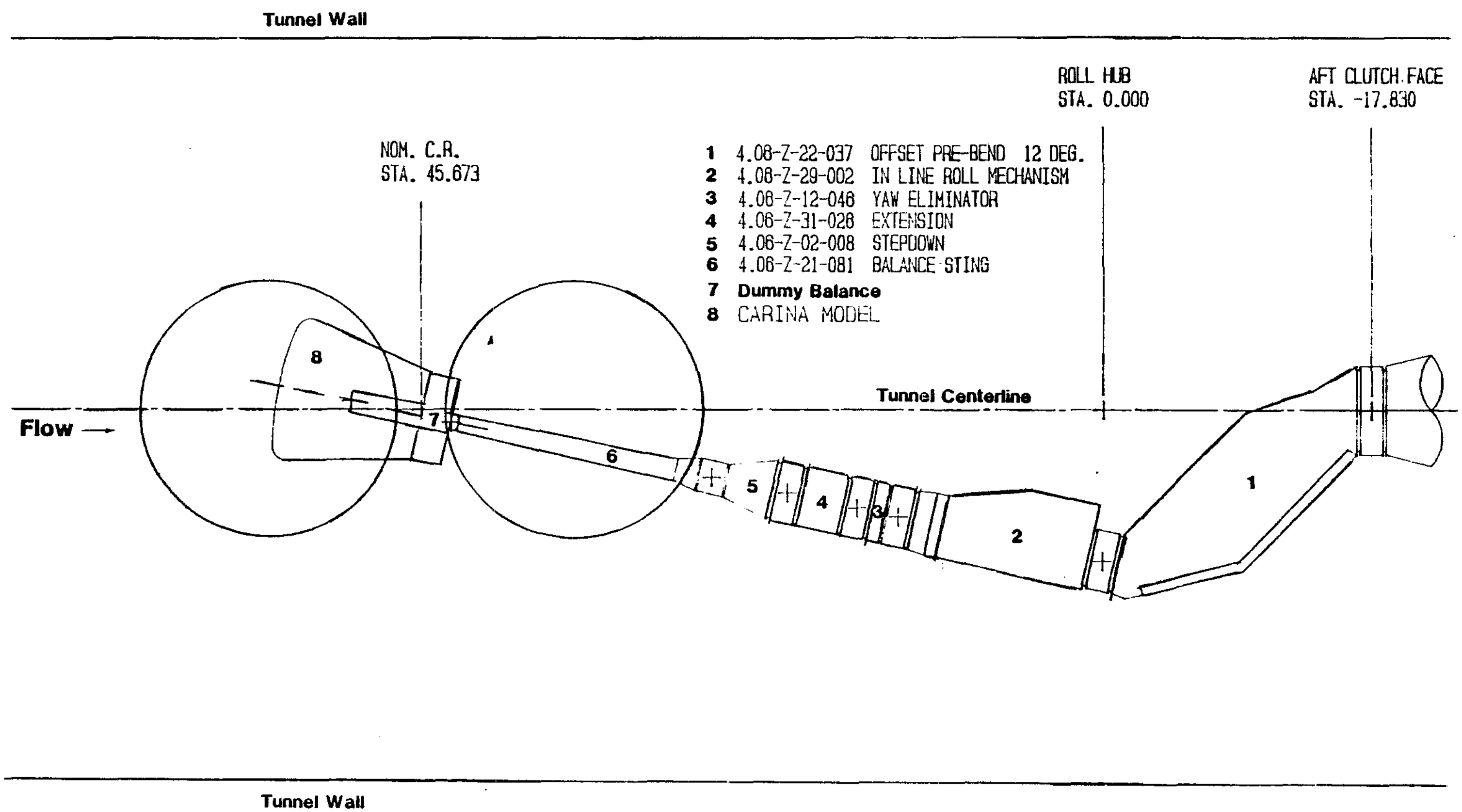



**Figure 4. Concluded**

**c. Oil Flow Installation**


Figure 5. Carina heat-transfer/pressure model installed in Tunnel B

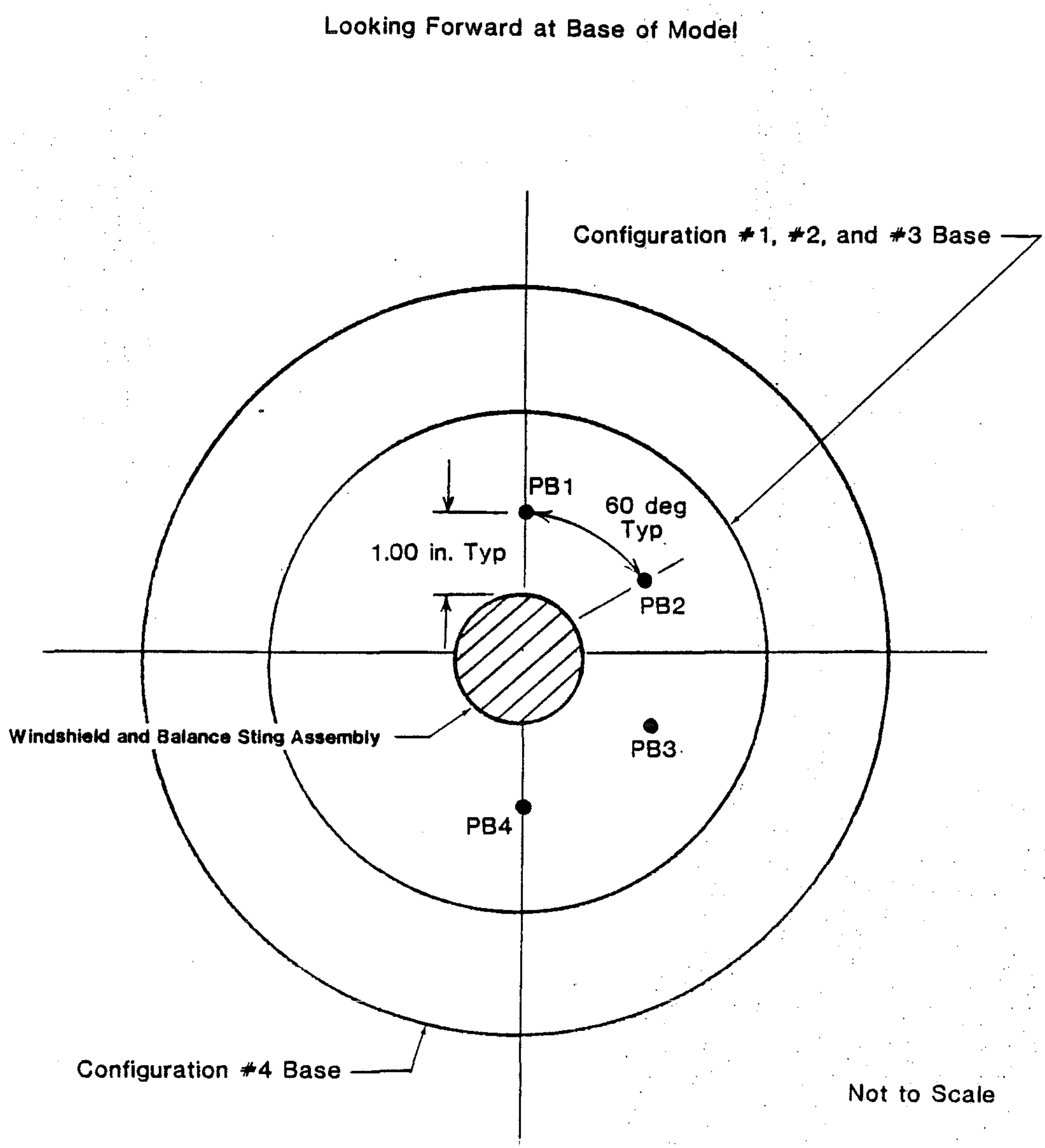



**Figure 6. Carina Force Model Base Pressure Orifice Locations**

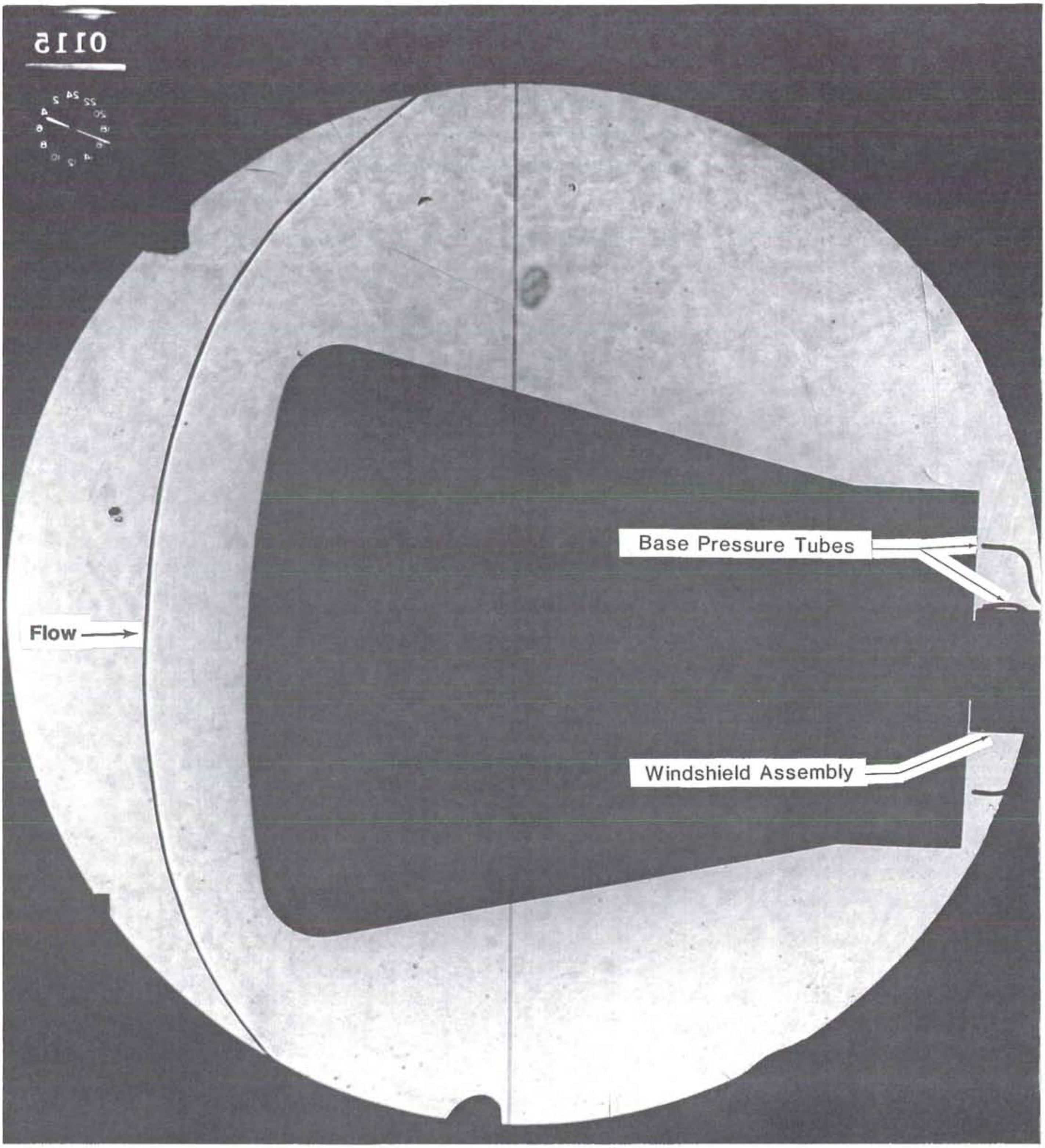



Figure 7. Carina model configuration 3 in Tunnel B

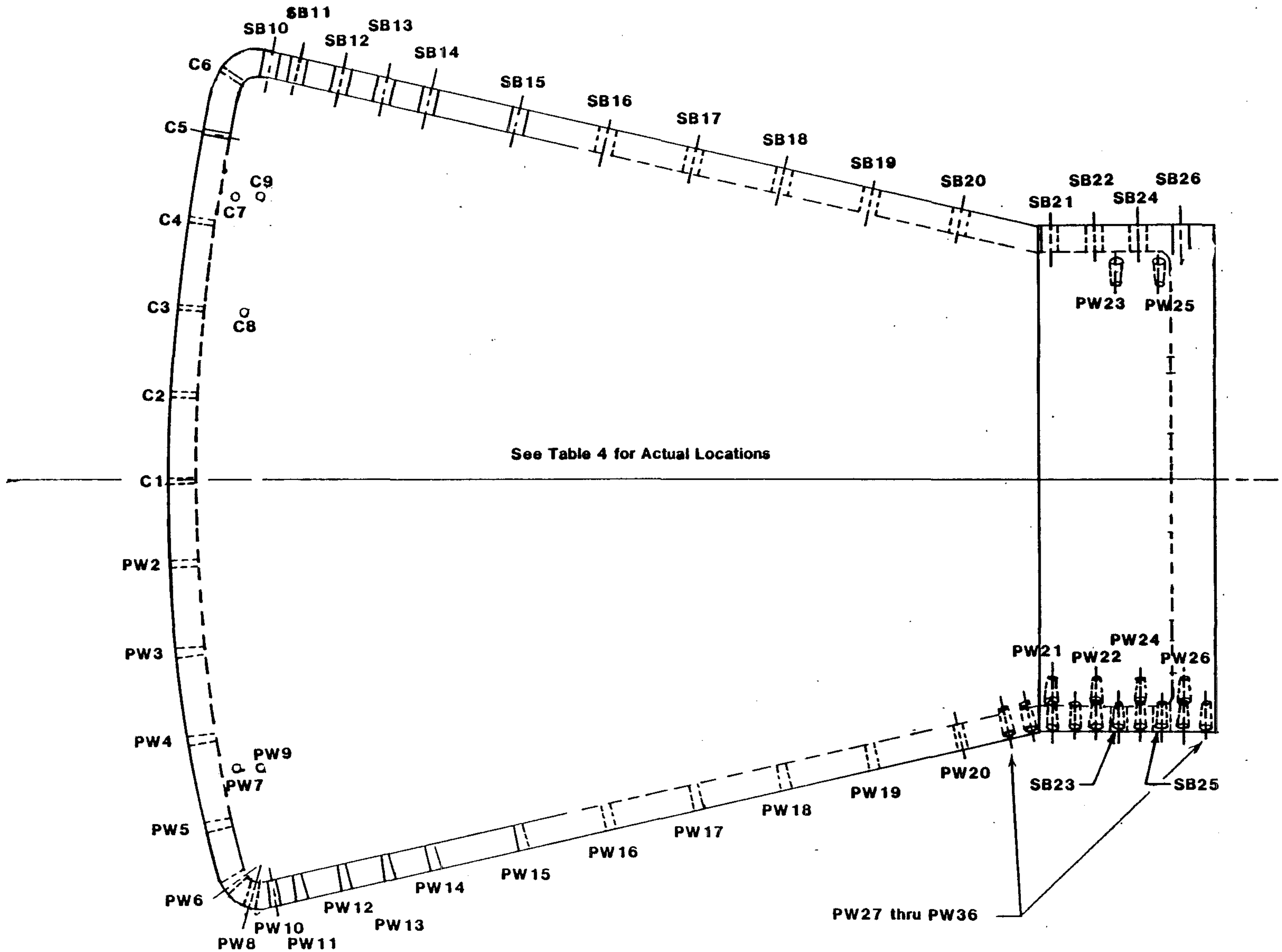



**Figure 8. Heat-Transfer/Pressure Model Instrumentation Locations**

Table 1. Model Configuration Designation

| Configuration | Corner Radius, in. | Afterbody Angle, deg |
|---|---|---|
| #1 | 0.50 | 13 |
| #2 | 0.25 | 13 |
| #3 | 1.00 | 13 |
| #4 | 0.50 | 8 |

**Table 2. Coefficient Reference Lengths and Areas**

a. English Units

| Configuration | #1 | #2 | #3 | #4 |
|---|---|---|---|---|
| SREF, $in.^2$ | 76.356 | 78.038 | 73.275 | 76.356 |
| AB, $in.^2$ | 26.530 | 26.530 | 26.530 | 44.084 |
| LM, in. | 11.83 | 11.83 | 11.83 | 11.83 |
| XMRC, in. | 0.0 | 0.0 | 0.0 | 0.0 |
| LREFL, LREFM, LREFN, in. | 9.860 | 9.968 | 9.659 | 9.860 |

b. SI Units

| Configuration | #1 | #2 | #3 | #4 |
|---|---|---|---|---|
| SREF, $m^2$ | 0.0493 | 0.0503 | 0.0473 | 0.0493 |
| AB, $m^2$ | 0.0171 | 0.0171 | 0.0171 | 0.0284 |
| LM, m | 0.3005 | 0.3005 | 0.3005 | 0.3005 |
| XMRC, m | 0.0 | 0.0 | 0.0 | 0.0 |
| LREFL, LREFM, LREFN, m | 0.2504 | 0.2532 | 0.2453 | 0.2504 |

## Table 3. Estimated Uncertainties
### a. Measured Parameters

| PARAMETER DESIGNATION | STEADY STATE ESTIMATED MEASUREMENT* PRECISION (S) Percent of Reading | PRECISION (S) Unit of Meas. | PRECISION (S) DF | BIAS (B) Percent of Reading | BIAS (B) Unit of Meas. | UNCERTAINTY $\pm(B+t_{95}S)$ Percent of Reading | UNCERTAINTY $\pm(B+t_{95}S)$ Unit of Meas. | RANGE | TYPE OF MEASURING DEVICE | TYPE OF RECORDING DEVICE | METHOD OF SYSTEM CALIBRATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PT | | 0.1 | >30 | | 0.1 | | 0.3 | 0-900 psia | Paroscientific Digiquartz Pressure Transducer | Digital Data Acquisition System | In place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory |
| TT | | 1.0<br>1.0 | >30<br>>30 | <br>0.375 | 2.0 | <br>2.0+0.375% | 4.0 | 32-530°F<br>530-2300°F | Cr-Al Thermocouples | Microprocessor Averaged Digital Thermometer | Thermocouple verification of NITS conformity/voltage substitution calibration |
| ALPI<br>PHII | | 0.025<br>0.15 | >30<br>>30 | | 0+<br>0+ | | 0.05<br>0.30 | ±15 deg<br>±180 deg | Rotary Potentiometers | Digital Data Acquisition System/Analog to Digital Converter | Multiple comparisons with a digital inclinometer calibrated in the standards laboratory |
| Reference pressure for PWi | | 0.0004 | 10 | | 0.001 | | 0.002 | 0 to 0.015 psia | VKF Miniature Vacuum Gage (MVG) | 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 |
| PWi, i = 10, 12, 14, 16, 18, 20, 21, 24, 26, 27, 29, 31, 33, 35<br>PBi, i = 1-4 | | 0.001 | 30 | | 0.002 | | 0.004 | ±1 psid | Electronically Scanned Pressure transducer (ESP) | 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 |
| PWi, i = 2-9, 11, 13, 15, 17, 19, 22, 23, 25, 28, 30, 32, 34, 36 | | 0.002 | 30 | | 0.003 | | 0.007 | ±2.5 psid | Electronically Scanned Pressure transducer (ESP) | 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 |
| Reference Pressure for PTNK | | 25 | >30 | 10 | | 50+10% | | 0-1000μHg | DV-3 Hastings Gage | Digital Data Acquisition System/Analog to Digital Converter | Comparisons to facility reference gage |
| PTNK | | 0.00075<br>0.00200 | 30<br>30 | 1.0<br>0.1 | | 0.0015+1.0%<br>0.0040+0.1% | | 0.00-0.15<br>0.15-1.50<br>psid | Tunnel B/C Mech MUX System(±1psid Druck®) | 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 |
| QDOT (Schmidt-Boelter gages) | 3 | 0.03 | 30<br>30 | 3<br>3 | | 0.06+3%<br>9% | | 0-1<br>1-10<br>Btu/ft²sec | Schmidt-Boelter Gage | Digital Data Acquisition System/Analog to Digital Converter | Radiant Heat Source / Secondary Standard |
| TG (Schmidt-Boelter gages) | | 1 | >30 | | 2 | | 4 | 32-530°F | Schmidt-Boelter Gage (Fe-Cn Thermocouple) | Digital Data Acquisition System/Analog to Digital Converter | Thermocouple verification of NITS conformity/voltage substitution calibration |
| TW (Coax Gages) | | 1 | >30 | | 2 | | 4 | 80-300°F | Coaxial Gage (Cr-Cn Thermocouple) | Digital Data Acquisition System/Analog to Digital Converter | Thermocouple verification of NITS conformity/voltage substitution calibration |
| Moment transfer distance, in. | | 0.0025 | >30 | | 0+ | | 0.005 | | Precision height gages, micrometers | Manual | Calibrated in the Standards Laboratory |
| Normal Force<br>Pitching Moment<br>Side Force<br>Yawing Moment<br>Rolling moment<br>Axial Force | | 0.594<br>2.176<br>0.303<br>1.113<br>0.109<br>0.275 | 95<br>95<br>95<br>95<br>95<br>95 | | 0.063<br>0.274<br>0.019<br>0.086<br>0.033<br>0.218 | | 1.251<br>4.625<br>0.625<br>2.313<br>0.250<br>0.768 | ±500 lb<br>±1850 in.-lb<br>±250 lb<br>±925 in.-lb<br>±100 in.-lb<br>±300 lb | Six component strain gage balance (4.00-Y-36-043) | Digital Data Acquisition System/Analog to Digital Converter | Static Loadings |

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

## Table 3. Concluded

### b. Calculated Parameters

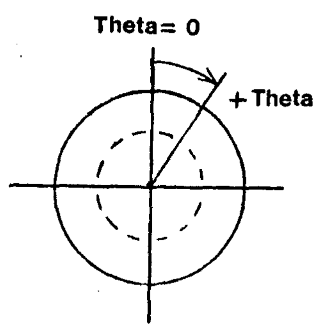
| Parameter Designation | Steady-State Estimated Measurement* Precision Index (S) Percent of Reading | Precision Index (S) Unit of Measurement | Bias (B) Percent of Reading | Bias (B) Unit of Measurement | Uncertainty ±(B+t95*S) Percent of Reading | Uncertainty ±(B+t95*S) Unit of Measurement | Nominal Reynolds Number | Nominal Parameter Value |
|---|---|---|---|---|---|---|---|---|
| M | | 0.010 | | 0+ | | 0.020 | 1.004E+6 | 7.93 |
| | | 0.010 | | 0+ | | 0.020 | 2.006E+6 | 7.98 |
| P | 0.819 | | 0.048 | | 1.686 | | 1.004E+6 | 0.022 |
| | 0.814 | | 0.022 | | 1.650 | | 2.006E+6 | 0.047 |
| Q | 0.567 | | 0.048 | | 1.183 | | 1.004E+6 | 0.981 |
| | 0.563 | | 0.022 | | 1.149 | | 2.006E+6 | 2.107 |
| RE | | 3.7E+3 | | 3.6E+3 | | 1.1E+4 | 1.004E+6 | 1.004E+6 |
| | | 7.2E+3 | | 7.3E+3 | | 2.2E+4 | 2.006E+6 | 2.006E+6 |
| CN | | 0.0080 | | 0.0008 | | 0.0168 | 1.004E+6 | 0.1887 |
| | | 0.0038 | | 0.0004 | | 0.0081 | 2.006E+6 | 0.1851 |
| CLM | | 0.00635 | | 0.00070 | | 0.01341 | 1.004E+6 | 0.12970 |
| | | 0.00304 | | 0.00033 | | 0.00641 | 2.006E+6 | 0.12730 |
| CY | | 0.0040 | | 0.0003 | | 0.0083 | 1.004E+6 | 0.0125 |
| | | 0.0019 | | 0.0001 | | 0.0039 | 2.006E+6 | 0.0077 |
| CLN | | 0.00324 | | 0.00021 | | 0.00669 | 1.004E+6 | 0.00791 |
| | | 0.00154 | | 0.00010 | | 0.00319 | 2.006E+6 | 0.00473 |
| CLL | | 0.00015 | | 0.00004 | | 0.00035 | 1.004E+6 | 0.00258 |
| | | 0.00008 | | 0.00002 | | 0.00018 | 2.006E+6 | 0.00159 |
| CAF | | 0.0097 | | 0.0032 | | 0.0226 | 1.004E+6 | 1.5610 |
| | | 0.0091 | | 0.0015 | | 0.0197 | 2.006E+6 | 1.5680 |
| CA | | 0.0096 | | 0.0030 | | 0.0222 | 1.004E+6 | 1.5590 |
| | | 0.0090 | | 0.0014 | | 0.0194 | 2.006E+6 | 1.5690 |
| H(TT) | | | | | 10** | | - | - |
| S(TT) | | | | | 10** | | - | - |
| ALPHA | | | | | | 0.2** | - | ±15 |
| PHI | | | | | | 0.1** | - | ±180 |

* Reference: Abernethy, R.B. et al and Thompson, J.W. "Handbook of Uncertainty in Gas Turbine Measurements AEDC-TR-73-5, 5 Feb 73.
** Estimated value.
+ Assumed to be zero.

## Table 4. Heat Transfer/ Pressure Model Instrumentation Locations

### a. Heat Transfer Gages

| GAGE | THETA | S/R |
|---|---|---|
| | deg | |
| C1 | 0 | 0 |
| C2 | 0 | 0.200 |
| C3 | 0 | 0.401 |
| C4 | 0 | 0.602 |
| C5 | 0 | 0.807 |
| C6 | 0 | 0.960 |
| C7 | 30 | 0.999 |
| C8 | 60 | 1.028 |
| C9 | 30 | 1.059 |
| SB10 | 0 | 1.089 |
| SB11 | 0 | 1.150 |
| SB12 | 0 | 1.253 |
| SB13 | 0 | 1.356 |
| SB14 | 0 | 1.458 |
| SB15 | 0 | 1.664 |
| SB16 | 0 | 1.865 |
| SB17 | 0 | 2.070 |
| SB18 | 0 | 2.275 |
| SB19 | 0 | 2.481 |
| SB20 | 0 | 2.686 |
| SB21 | 0 | 2.891 |
| SB22 | 0 | 2.991 |
| SB23 | 180 | 3.041 |
| SB24 | 0 | 3.091 |
| SB25 | 180 | 3.141 |
| SB26 | 0 | 3.191 |




View Looking Aft

Table 4. Concluded

b. Surface Pressure Orifices

| PRESSURE ORIFICE | THETA | S/R |
|---|---|---|
| PW2 | 180 | 0.200 |
| PW3 | 180 | 0.401 |
| PW4 | 180 | 0.602 |
| PW5 | 180 | 0.807 |
| PW6 | 180 | 0.960 |
| PW7 | 210 | 0.999 |
| PW8 | 180 | 1.028 |
| PW9 | 210 | 1.059 |
| PW10 | 180 | 1.089 |
| PW11 | 180 | 1.150 |
| PW12 | 180 | 1.253 |
| PW13 | 180 | 1.356 |
| PW14 | 180 | 1.458 |
| PW15 | 180 | 1.664 |
| PW16 | 180 | 1.865 |
| PW17 | 180 | 2.070 |
| PW18 | 180 | 2.275 |
| PW19 | 180 | 2.481 |
| PW20 | 180 | 2.686 |
| PW21 | 210 | 2.891 |
| PW22 | 210 | 2.991 |
| PW23 | 30 | 3.041 |
| PW24 | 210 | 3.091 |
| PW25 | 30 | 3.141 |
| PW26 | 210 | 3.191 |
| PW27 | 165 | 2.788 |
| PW28 | 165 | 2.839 |
| PW29 | 165 | 2.891 |
| PW30 | 165 | 2.941 |
| PW31 | 165 | 2.991 |
| PW32 | 165 | 3.041 |
| PW33 | 165 | 3.091 |
| PW34 | 165 | 3.141 |
| PW35 | 165 | 3.191 |
| PW36 | 165 | 3.242 |

**Table 5. Test Run Summary**

a. Heat/Pressure Runs

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2001 | #1 0.50 in. Corner Radius, 13 Deg Body | 0 | 0 | 2 |
| 2002 | | 2 | 0 | 2 |
| 2003 | | 5 | 0 | 2 |
| 2004 | | 10 | 0 | 2 |
| 2005 | | 15 | 0 | 2 |
| 2006 | | 20 | 0 | 2 |
| 2007 | | 0 | -30 | 2 |
| 2008 | | 2 | -30 | 2 |
| 2009 | | 5 | -30 | 2 |
| 2010 | | 10 | -30 | 2 |
| 2011 | | 15 | -30 | 2 |
| 2012 | | 20 | -30 | 2 |
| 2013 | | 0 | 30 | 2 |
| 2014 | | 5 | 30 | 2 |
| 2015 | | 5 | 60 | 2 |
| 2016 | | 5 | 180 | 2 |
| 2017 | | 0 | 0 | 1 |
| 2018 | | 0 | 0 | 1 |
| 2019 | | 2 | 0 | 1 |
| 2020 | | 5 | 0 | 1 |
| 2021 | | 10 | 0 | 1 |
| 2022 | | 15 | 0 | 1 |
| 2023 | | 20 | 0 | 1 |
| 2024 | | 0 | 0 | 1 |

Table 5. Continued

a. Continued

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2025 | #1 0.50 in. Corner Radius, 13 Deg Body | 2 | -30 | 1 |
| 2026 | | 5 | -30 | 1 |
| 2027 | | 10 | -30 | 1 |
| 2028 | | 15 | -30 | 1 |
| 2029 | | 20 | -30 | 1 |
| 2030 | | 0 | 30 | 1 |
| 2031 | | 2 | 30 | 1 |
| 2032 | | 5 | 30 | 1 |
| 2033 | | 10 | 30 | 1 |
| 2034 | | 15 | 30 | 1 |
| 2035 | | 20 | 30 | 1 |
| 2036 | | 0 | 60 | 1 |
| 2037 | | 2 | 60 | 1 |
| 2038 | | 5 | 60 | 1 |
| 2039 | | 10 | 60 | 1 |
| 2040 | | 15 | 60 | 1 |
| 2041 | | 20 | 60 | 1 |
| 2042 | | 0 | 90 | 1 |
| 2043 | | 2 | 90 | 1 |
| 2044 | | 5 | 90 | 1 |
| 2045 | | 10 | 90 | 1 |
| 2046 | | 15 | 90 | 1 |
| 2047 | | 20 | 90 | 1 |

Table 5. Continued

a. Continued

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2048 | #1 0.50 in. Corner Radius, 13 Deg Body | 0 | 120 | 1 |
| 2049 | | 2 | 120 | 1 |
| 2050 | | 5 | 120 | 1 |
| 2051 | | 10 | 120 | 1 |
| 2052 | | 15 | 120 | 1 |
| 2053 | | 20 | 120 | 1 |
| 2054 | | 0 | 150 | 1 |
| 2055 | | 2 | 150 | 1 |
| 2056 | | 5 | 150 | 1 |
| 2057 | | 10 | 150 | 1 |
| 2058 | | 15 | 150 | 1 |
| 2059 | | 20 | 150 | 1 |
| 2060 | | 0 | 180 | 1 |
| 2061 | | 2 | 180 | 1 |
| 2062 | | 5 | 180 | 1 |
| 2063 | | 10 | 180 | 1 |
| 2064 | | 15 | 180 | 1 |
| 2065 | | 20 | 180 | 1 |
| 2066 | | 0 | -165 | 1 |
| 2067 | | 2 | -165 | 1 |
| 2068 | | 5 | -165 | 1 |
| 2069 | | 10 | -165 | 1 |
| 2070 | | 15 | -165 | 1 |
| 2071 | | 20 | -165 | 1 |
| 2072 | | 20 | -120 | 1 |

**Table 5. Continued**

a. Concluded

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2073 | #1 0.50 in. Corner Radius, 13 Deg Body | 0 | 0 | 0.5 |
| 2074 | | 5 | 0 | 0.5 |
| 2075 | | 0 | 0 | 0.75 |
| 2076 | | 5 | 0 | 0.75 |
| 2077 | | 5 | -30 | 0.75 |
| 2078 | | 5 | 30 | 0.75 |
| 2079 | | 5 | 60 | 0.75 |
| 2080 | | 5 | 90 | 0.75 |
| 2081 | | 5 | 120 | 0.75 |
| 2082 | | 5 | 150 | 0.75 |
| 2083 | | 5 | 180 | 0.75 |
| 2084 | | 5 | -165 | 0.75 |
| 2085 | | 5 | -120 | 0.75 |
| 2086 | | 10 | 0 | 0.75 |
| 2087 | | 10 | -30 | 0.75 |
| 2088 | | 10 | 30 | 0.75 |
| 2089 | | 10 | 60 | 0.75 |
| 2090 | | 10 | 90 | 0.75 |
| 2091 | | 10 | 120 | 0.75 |
| 2092 | | 10 | 150 | 0.75 |
| 2093 | | 10 | 180 | 0.75 |
| 2094 | | 10 | -165 | 0.75 |

**Table 5. Continued**

b. Force Runs

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2095 | #1 0.50 in. Corner Radius, 13 Deg Body | 0 to 20 | 0 | 2 |
| 2096 | | 20 to 0 | 0 | 2 |
| 2097 | | 0 to 20 | 0 | 2 |
| 2098 | | 20 to 0 | -180 | 2 |
| 2099 | #2 0.25 in. Corner Radius, 13 Deg Body | 0 to 20 | 0 | 2 |
| 2100 | | 20 to 0 | 0 | 2 |
| 2101 | | 0 to 20 | 0 | 2 |
| 2102 | | 20 to 0 | -180 | 2 |
| 2103 | #3 1.00 in. Corner Radius, 13 Deg Body | 0 to 20 | 0 | 2 |
| 2104 | | 20 to 0 | 0 | 2 |
| 2105 | | 0 to 20 | 0 | 2 |
| 2106 | | 20 to 0 | -180 | 2 |
| 2107 | #4 0.50 in. Corner Radius, 8 Deg Body | 0 to 20 | 0 | 2 |
| 2108 | | 20 to 0 | 0 | 2 |
| 2109 | | 0 to 20 | 0 | 2 |
| 2110 | | 20 to 0 | -180 | 2 |
| 2111 | #4 0.50 in. Corner Radius, 8 Deg Body | 0 to 20 | 0 | 1 |
| 2112 | | 20 to 0 | 0 | 1 |
| 2113 | | 0 to 20 | 0 | 1 |
| 2114 | | 20 to 0 | -180 | 1 |
| 2115 | #1 0.50 in. Corner Radius, 13 Deg Body | 0 to 20 | 0 | 1 |
| 2116 | | 20 to 0 | 0 | 1 |
| 2117 | | 0 to 20 | 0 | 1 |
| 2118 | | 20 to 0 | -180 | 1 |

**Table 5. Continued**

b. Concluded

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2119 | #2 0.25 in. Corner Radius, 13 Deg Body | 0 to 20 | 0 | 1 |
| 2120 | | 20 to 0 | 0 | 1 |
| 2121 | | 0 to 20 | 0 | 1 |
| 2122 | | 20 to 0 | -180 | 1 |
| 2123 | #3 1.00 in. Corner Radius, 13 Deg Body | 0 to 20 | 0 | 1 |
| 2124 | | 20 to 0 | 0 | 1 |
| 2125 | | 0 to 20 | 0 | 1 |
| 2126 | | 20 to 0 | -180 | 1 |

**Table 5. Concluded**

c. Oil Flow Runs

| RUN | CONFIGURATION | ALPHA (deg) | PHI (deg) | RE x $10^{-6}$ ($ft^{-1}$) |
|---|---|---|---|---|
| 2128 | #1 0.50 in. Corner Radius, 13 Deg Body | 0 | 0 | 1 |
| 2129 | | 5 | 0 | 1 |
| 2130 | | 2 | 0 | 1 |
| 2131 | | 3.5 | 0 | 1 |
| 2132 | #3 1.00 in. Corner Radius, 13 Deg Body | 3.5 | 0 | 1 |
| 2133 | | 2 | 0, | 1 |
| 2134 | #2 0.25 in. Corner Radius, 13 Deg Body | 0 | 0 | 1 |
| 2135 | #1 0.50 in. Corner Radius, 13 Deg Body | 2 | 0 | 1 |
| 2136 | | 0 | 0 | 1 |
| 2137 | #4 0.50 in. Corner Radius, 8 Deg Body | 0 | 0 | 1 |
| 2138 | | 2 | 0 | 1 |
| 2139 | | 5 | 0 | 1 |

Notes:

1. Runs 2xxx are in English units.

   Runs 3xxx are the same as runs 2xxx except the tabulated values are in SI units.

2. There is no run 2127.

3. Runs 2073, 2074 were taken with unsteady flow.

DATE COMPUTED: 9-MAY-91
TIME COMPUTED: 10:34:38
DATE RECORDED: 18-APR-91
TIME RECORDED: 0:58:38
000001037

CARINA AEROTHERMAL

PAGE 1

ENGLISH UNITS

| RUN | CONFIGURATION | SREF, IN2 | LREF ( M, N, L), IN | | | XMRC | FCRN | PTNK | AB, IN2 |
|---|---|---|---|---|---|---|---|---|---|
| 2097 | 0.50RC 13 DEG BODY | 76.356 | 9.860 | 9.860 | 9.860 | 0.000 | 5095 | 0.323 | 26.53 |

| M | PT PSIA | TT DEG R | T DEG R | P PSIA | PT2 PSIA | Q PSIA | V FT/SEC | RHO LBM/FT3 | MU LBF-SEC/FT2 | RE FT-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 455.2 | 1293.7 | 96.1 | 0.0473 | 3.914 | 2.11 | 3833.59 | 0.133E-02 | 0.773E-07 | 0.205E+07 |

--- TUNNEL CONDITIONS AND BASE PRESSURES ---

| PN | ALPI | PHII | PT | TT | Q | P | PB1 | PB2 | PB3 | PB4 | PBA | CPBA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -12.03 | 0.00 | 455.24 | 1293.7 | 2.109 | 0.047 | 0.0553 | 0.0504 | 0.0537 | 0.0494 | 0.0522 | 0.0023 |
| 2 | -11.03 | 0.00 | 455.50 | 1292.7 | 2.110 | 0.047 | 0.0550 | 0.0505 | 0.0509 | 0.0500 | 0.0516 | 0.0020 |
| 3 | -10.02 | 0.00 | 455.63 | 1293.7 | 2.111 | 0.047 | 0.0553 | 0.0513 | 0.0521 | 0.0504 | 0.0523 | 0.0023 |
| 4 | -7.02 | 0.00 | 455.71 | 1293.7 | 2.111 | 0.047 | 0.0575 | 0.0522 | 0.0548 | 0.0505 | 0.0537 | 0.0030 |
| 5 | -2.02 | 0.00 | 455.79 | 1293.7 | 2.111 | 0.047 | 0.0591 | 0.0518 | 0.0592 | 0.0471 | 0.0543 | 0.0033 |
| 6 | 3.01 | 0.00 | 455.44 | 1293.7 | 2.110 | 0.047 | 0.0500 | 0.0435 | 0.0543 | 0.0374 | 0.0463 | -0.0005 |
| 7 | 8.00 | 0.00 | 455.58 | 1294.7 | 2.110 | 0.047 | 0.0387 | 0.0333 | 0.0461 | 0.0290 | 0.0368 | -0.0050 |

**Sample 1. Tabulated Force and Pressure Data, English Units**

DATE COMPUTED: 9-MAY-91
TIME COMPUTED: 10:34:38
DATE RECORDED: 18-APR-91
TIME RECORDED: 0:58:38
600001038

CARINA AEROTHERMAL

PAGE 2

ENGLISH UNITS

| RUN | CONFIGURATION | SREF,IN2 | LREF ( M, N, L),IN | | | XMRC | FCRN | PTNK | AB,IN2 |
|---|---|---|---|---|---|---|---|---|---|
| 2097 | 0.50RC 13 DEG BODY | 76.356 | 9.860 | 9.860 | 9.860 | 0.000 | 5095 | 0.323 | 26.53 |

| M | PT PSIA | TT DEG R | T DEG R | P PSIA | PT2 PSIA | Q PSIA | V FT/SEC | RHO LBM/FT3 | MU LBF-SEC/FT2 | RE FT-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 455.2 | 1293.7 | 96.1 | 0.0473 | 3.914 | 2.11 | 3833.59 | 0.133E-02 | 0.773E-07 | 0.205E+07 |

—— BODY AXES FORCE AND MOMENT COEFFICIENTS ——

| PN | ALPHA | PHI | CN | CLM | CY | CLN | CLL | CA | CAB | CAF | XCPN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.05 | -0.08 | -0.0001 | 0.0002 | 0.0063 | -0.0035 | 0.0007 | 1.5021 | -0.0008 | 1.5029 | 0.6514 |
| 2 | 1.06 | -0.08 | 0.0066 | -0.0050 | 0.0064 | -0.0036 | 0.0007 | 1.5014 | -0.0007 | 1.5021 | 0.6517 |
| 3 | 2.07 | -0.08 | 0.0138 | -0.0106 | 0.0064 | -0.0036 | 0.0007 | 1.5017 | -0.0008 | 1.5025 | 0.6384 |
| 4 | 5.09 | -0.08 | 0.0349 | -0.0272 | 0.0065 | -0.0038 | 0.0006 | 1.4972 | -0.0010 | 1.4983 | 0.6512 |
| 5 | 10.15 | -0.08 | 0.0686 | -0.0536 | 0.0064 | -0.0037 | 0.0006 | 1.4784 | -0.0011 | 1.4796 | 0.6516 |
| 6 | 15.24 | -0.08 | 0.1023 | -0.0765 | 0.0065 | -0.0036 | 0.0006 | 1.4466 | 0.0002 | 1.4464 | 0.6233 |
| 7 | 20.32 | -0.08 | 0.1378 | -0.0974 | 0.0067 | -0.0037 | 0.0006 | 1.3964 | 0.0017 | 1.3947 | 0.5888 |

**Sample 1. continued**

CARINA AEROTHERMAL

PAGE 3

ENGLISH UNITS

DATE COMPUTED: 9-MAY-91
TIME COMPUTED: 10:34:38
DATE RECORDED: 18-APR-91
TIME RECORDED: 0:58:38
000001039

| RUN | CONFIGURATION | SREF, IN2 | LREF ( M, N, L), IN | | | XMRC | FCRN | PTNK | AB, IN2 |
|---|---|---|---|---|---|---|---|---|---|
| 2097 | 0.50RC 13 DEG BODY | 76.356 | 9.860 | 9.860 | 9.860 | 0.000 | 5095 | 0.323 | 26.53 |

| M | PT PSIA | TT DEG R | T DEG R | P PSIA | PT2 PSIA | Q PSIA | V FT/SEC | RHO LBM/FT3 | MU LBF-SEC/FT2 | RE FT-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 455.2 | 1293.7 | 96.1 | 0.0473 | 3.914 | 2.11 | 3833.59 | 0.133E-02 | 0.773E-07 | 0.205E+07 |

—— WIND AXES FORCE AND MOMENT COEFFICIENTS ——

| PN | ALPHA | PHI | CLW | CLMW | CCW | CLNW | CLLW | CDW | (L/D)W |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.05 | -0.08 | -0.0014 | 0.0002 | 0.0050 | -0.0035 | 0.0007 | 1.5029 | -0.0009 |
| 2 | 1.06 | -0.08 | -0.0211 | -0.0050 | 0.0050 | -0.0036 | 0.0006 | 1.5020 | -0.0140 |
| 3 | 2.07 | -0.08 | -0.0406 | -0.0106 | 0.0049 | -0.0036 | 0.0005 | 1.5020 | -0.0270 |
| 4 | 5.09 | -0.08 | -0.0983 | -0.0272 | 0.0050 | -0.0038 | 0.0003 | 1.4955 | -0.0657 |
| 5 | 10.15 | -0.08 | -0.1932 | -0.0536 | 0.0048 | -0.0037 | 0.0000 | 1.4685 | -0.1315 |
| 6 | 15.24 | -0.08 | -0.2815 | -0.0765 | 0.0048 | -0.0036 | -0.0003 | 1.4224 | -0.1979 |
| 7 | 20.32 | -0.08 | -0.3550 | -0.0974 | 0.0049 | -0.0036 | -0.0006 | 1.3558 | -0.2618 |

**Sample 1. concluded**

DATE COMPUTED: 13-MAY-91
TIME COMPUTED: 08:32:15
DATE RECORDED: 18-APR-91
TIME RECORDED: 1:21:11
000001380

CARINA AEROTHERMAL

PAGE 1

SI UNITS

| RUN | CONFIGURATION | SREF,M2 | LREF | ( M, | N, | L),M | XMRC | FCRN | PTNK | AB,M2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 3099 | 0.25RC 13 DEG BODY | 0.050 | 0.253 | 0.253 | | 0.253 | 0.000 | 5096 | 2123.259 | 0.02 |

| M | PT PA | TT DEG K | T DEG K | P PA | PT2 PA | Q PA | V M/SEC | RHO KG/M3 | MU PA-SEC | RE M-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 3147143.5 | 723.7 | 53.8 | 327.2614 | 27055.648 | 14576.86 | 1172.77 | 0.212E-01 | 0.373E-05 | 0.619E+06 |

—— TUNNEL CONDITIONS AND BASE PRESSURES ——

| PN | ALPI | PHII | PT | TT | Q | P | PB1 | PB2 | PB3 | PB4 | PBA | CPBA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -13.52 | -0.02 | 3147143.50 | 723.7 | 14576.863 | 327.261 | 360.8309 | 352.1942 | 348.2056 | 338.7666 | 349.9993 | 0.0016 |
| 2 | -13.07 | -0.02 | 3147036.50 | 723.7 | 14576.381 | 327.251 | 361.5492 | 352.5143 | 348.1625 | 339.3936 | 350.4049 | 0.0016 |
| 3 | -12.07 | -0.02 | 3147470.25 | 723.7 | 14578.349 | 327.294 | 360.3300 | 350.0336 | 346.3342 | 340.9316 | 349.4073 | 0.0015 |
| 4 | -11.08 | -0.02 | 3148308.00 | 723.7 | 14582.145 | 327.378 | 359.2373 | 348.1014 | 344.9819 | 343.1852 | 348.8764 | 0.0015 |
| 5 | -10.09 | -0.02 | 3147678.00 | 723.7 | 14579.287 | 327.315 | 358.4970 | 347.8506 | 345.9180 | 345.4202 | 349.4215 | 0.0015 |
| 6 | -9.09 | -0.03 | 3148915.00 | 723.7 | 14584.893 | 327.439 | 356.0610 | 349.7874 | 347.7143 | 346.9590 | 350.1304 | 0.0016 |
| 7 | -7.11 | -0.02 | 3148685.75 | 723.7 | 14583.857 | 327.416 | 350.4754 | 348.7693 | 349.3834 | 348.3854 | 349.2534 | 0.0015 |
| 8 | -5.12 | -0.05 | 3148441.25 | 723.7 | 14582.749 | 327.391 | 348.6109 | 343.3849 | 353.7958 | 349.3700 | 348.7904 | 0.0015 |
| 9 | -2.15 | -0.04 | 3148736.75 | 723.7 | 14584.086 | 327.421 | 339.4887 | 328.2872 | 346.7191 | 334.2329 | 337.1820 | 0.0007 |
| 10 | -0.17 | -0.07 | 3148224.75 | 723.7 | 14581.767 | 327.370 | 326.2455 | 311.7387 | 332.0927 | 313.8080 | 320.9712 | -0.0004 |
| 11 | 2.80 | -0.04 | 3148224.75 | 723.7 | 14581.767 | 327.370 | 302.1397 | 285.3899 | 300.2831 | 278.4179 | 291.5576 | -0.0025 |
| 12 | 4.77 | -0.06 | 3147762.75 | 723.7 | 14579.671 | 327.323 | 284.5857 | 267.5067 | 276.3543 | 254.9335 | 270.8450 | -0.0039 |
| 13 | 7.73 | -0.07 | 3148759.50 | 723.7 | 14584.191 | 327.423 | 260.7194 | 245.0279 | 243.3575 | 222.8162 | 242.9803 | -0.0058 |
| 14 | 8.01 | -0.07 | 3148435.00 | 723.7 | 14582.720 | 327.391 | 253.3510 | 230.9219 | 232.3455 | 213.9320 | 232.6376 | -0.0065 |

MODEL FLOWFIELD PHOTOGRAPHS TAKEN AT ALPHA = 0.19, 2.17, 5.10, 10.24, 15.36, 20.26,

**Sample 2. Tabulated Force and Pressure Data, SI Units**

| | |
|---|---|
| DATE COMPUTED: | 13-MAY-91 |
| TIME COMPUTED: | 08:32:15 |
| DATE RECORDED: | 18-APR-91 |
| TIME RECORDED: | 1:21:11 |
| | 000001381 |

CARINA AEROTHERMAL

PAGE 2

SI UNITS

| RUN | CONFIGURATION | SREF,M2 | LREF ( M, N, L),M | | | XMRC | FCRN | PTNK | AB,M2 |
|---|---|---|---|---|---|---|---|---|---|
| 3099 | 0.25RC 13 DEG BODY | 0.050 | 0.253 | 0.253 | 0.253 | 0.000 | 5096 | 2123.259 | 0.02 |

| M | PT PA | TT DEG K | T DEG K | P PA | PT2 PA | Q PA | V M/SEC | RHO KG/M3 | MU PA-SEC | RE M-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 3147143.5 | 723.7 | 53.8 | 327.2614 | 27055.648 | 14576.86 | 1172.77 | 0.212E-01 | 0.373E-05 | 0.619E+06 |

––– BODY AXES FORCE AND MOMENT COEFFICIENTS –––

| PN | ALPHA | PHI | CN | CLM | CY | CLN | CLL | CA | CAB | CAF | XCPN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -1.46 | -0.09 | -0.0096 | 0.0077 | 0.0045 | -0.0026 | 0.0007 | 1.5634 | -0.0005 | 1.5639 | 0.7134 |
| 2 | -1.00 | -0.09 | -0.0068 | 0.0053 | 0.0046 | -0.0027 | 0.0007 | 1.5638 | -0.0005 | 1.5643 | 0.7103 |
| 3 | 0.00 | -0.09 | -0.0006 | 0.0001 | 0.0046 | -0.0027 | 0.0007 | 1.5651 | -0.0005 | 1.5656 | 0.7036 |
| 4 | 1.00 | -0.09 | 0.0058 | -0.0052 | 0.0046 | -0.0027 | 0.0007 | 1.5653 | -0.0005 | 1.5658 | 0.7003 |
| 5 | 2.00 | -0.09 | 0.0122 | -0.0105 | 0.0046 | -0.0027 | 0.0007 | 1.5655 | -0.0005 | 1.5660 | 0.7050 |
| 6 | 3.00 | -0.11 | 0.0184 | -0.0157 | 0.0047 | -0.0028 | 0.0007 | 1.5640 | -0.0005 | 1.5646 | 0.7182 |
| 7 | 5.00 | -0.09 | 0.0309 | -0.0264 | 0.0046 | -0.0027 | 0.0007 | 1.5599 | -0.0005 | 1.5604 | 0.7196 |
| 8 | 7.00 | -0.13 | 0.0429 | -0.0372 | 0.0048 | -0.0029 | 0.0007 | 1.5531 | -0.0005 | 1.5536 | 0.7311 |
| 9 | 10.00 | -0.11 | 0.0605 | -0.0518 | 0.0047 | -0.0028 | 0.0007 | 1.5382 | -0.0002 | 1.5384 | 0.7203 |
| 10 | 12.00 | -0.15 | 0.0721 | -0.0606 | 0.0049 | -0.0028 | 0.0007 | 1.5255 | 0.0001 | 1.5253 | 0.7073 |
| 11 | 15.00 | -0.12 | 0.0894 | -0.0726 | 0.0047 | -0.0026 | 0.0007 | 1.5014 | 0.0008 | 1.5006 | 0.6842 |
| 12 | 17.00 | -0.13 | 0.1015 | -0.0802 | 0.0049 | -0.0027 | 0.0007 | 1.4819 | 0.0013 | 1.4806 | 0.6660 |
| 13 | 20.00 | -0.14 | 0.1204 | -0.0914 | 0.0050 | -0.0027 | 0.0007 | 1.4470 | 0.0020 | 1.4450 | 0.6394 |
| 14 | 20.28 | -0.14 | 0.1226 | -0.0928 | 0.0050 | -0.0027 | 0.0006 | 1.4429 | 0.0022 | 1.4407 | 0.6377 |

**Sample 2. continued**

DATE COMPUTED: 13-MAY-91
TIME COMPUTED: 08:32:15
DATE RECORDED: 18-APR-91
TIME RECORDED: 1:21:11
000001382

CARINA AEROTHERMAL

PAGE 3

SI UNITS

| RUN | CONFIGURATION | SREF,M2 | LREF ( M, N, L),M | | | XMRC | FCRN | PTNK | AB,M2 |
|---|---|---|---|---|---|---|---|---|---|
| 3099 | 0.25RC 13 DEG BODY | 0.050 | 0.253 | 0.253 | 0.253 | 0.000 | 5096 | 2123.259 | 0.02 |

| M | PT PA | TT DEG K | T DEG K | P PA | PT2 PA | Q PA | V M/SEC | RHO KG/M3 | MU PA-SEC | RE M-1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 3147143.5 | 723.7 | 53.8 | 327.2614 | 27055.648 | 14576.86 | 1172.77 | 0.212E-01 | 0.373E-05 | 0.619E+06 |

—— WIND AXES FORCE AND MOMENT COEFFICIENTS ——

| PN | ALPHA | PHI | CLW | CLMW | CCW | CLNW | CLLW | CDW | (L/D)W |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -1.46 | -0.09 | 0.0302 | 0.0077 | 0.0032 | -0.0025 | 0.0008 | 1.5636 | 0.0193 |
| 2 | -1.00 | -0.09 | 0.0205 | 0.0053 | 0.0033 | -0.0027 | 0.0008 | 1.5642 | 0.0131 |
| 3 | 0.00 | -0.09 | -0.0006 | 0.0001 | 0.0033 | -0.0027 | 0.0007 | 1.5656 | -0.0004 |
| 4 | 1.00 | -0.09 | -0.0215 | -0.0052 | 0.0033 | -0.0028 | 0.0007 | 1.5657 | -0.0138 |
| 5 | 2.00 | -0.09 | -0.0424 | -0.0105 | 0.0032 | -0.0027 | 0.0006 | 1.5655 | -0.0271 |
| 6 | 3.00 | -0.11 | -0.0635 | -0.0157 | 0.0033 | -0.0028 | 0.0006 | 1.5634 | -0.0406 |
| 7 | 5.00 | -0.09 | -0.1052 | -0.0264 | 0.0031 | -0.0028 | 0.0005 | 1.5571 | -0.0676 |
| 8 | 7.00 | -0.13 | -0.1468 | -0.0372 | 0.0031 | -0.0029 | 0.0004 | 1.5472 | -0.0949 |
| 9 | 10.00 | -0.11 | -0.2075 | -0.0518 | 0.0029 | -0.0029 | 0.0003 | 1.5256 | -0.1360 |
| 10 | 12.00 | -0.15 | -0.2466 | -0.0606 | 0.0028 | -0.0029 | 0.0002 | 1.5070 | -0.1636 |
| 11 | 15.00 | -0.12 | -0.3020 | -0.0726 | 0.0027 | -0.0027 | 0.0001 | 1.4726 | -0.2051 |
| 12 | 17.00 | -0.13 | -0.3358 | -0.0802 | 0.0028 | -0.0028 | 0.0000 | 1.4455 | -0.2323 |
| 13 | 20.00 | -0.14 | -0.3811 | -0.0914 | 0.0027 | -0.0028 | -0.0002 | 1.3991 | -0.2724 |
| 14 | 20.28 | -0.14 | -0.3844 | -0.0928 | 0.0027 | -0.0028 | -0.0002 | 1.3938 | -0.2758 |

**Sample 2. concluded**

CARINA AEROTHERMAL

PAGE 1

ENGLISH UNITS

DATE COMPUTED: 22-APR-91
TIME COMPUTED: 08:46:33
DATE RECORDED: 17-APR-91
TIME RECORDED: 2:55:40
000001475

| RUN | ALPHA (DEG) | PHI (DEG) | CONFIGURATION | TIMERD (SEC) | TIMEINJ (SEC) |
|---|---|---|---|---|---|
| 2013 | -0.020 | 29.99 | #1 .50 CORNER RADIUS | 3.809 | 2.796 |

| M | PT PSIA | TT DEG R | T DEG R | P PSIA | Q PSIA | V FT/SEC | RHO LBM/FT3 | MU LBF-SEC/FT2 | RE FT-1 |
|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 456.1 | 1309.7 | 97.4 | 0.0474 | 2.11 | 3858.59 | 1.315E-03 | 7.836E-08 | 2.012E+06 |

HEAT TRANSFER GAGE DATA

| GAGE ID | S/R | THETA DEG | TW DEG R | QDOT (BTU/FT2-SEC) | H(TT) (BTU/FT2-SEC-R) | S(TT) |
|---|---|---|---|---|---|---|
| C 1 | 0.000 | 0.0 | 574.4 | 4.185E+00 | 5.691E-03 | 4.507E-03 |
| C 2 | 0.200 | 0.0 | 574.5 | 5.373E+00 | 7.309E-03 | 5.788E-03 |
| C 3 | 0.401 | 0.0 | 568.9 | 4.991E+00 | 6.737E-03 | 5.337E-03 |
| C 4 | 0.602 | 0.0 | 564.6 | 4.595E+00 | 6.167E-03 | 4.886E-03 |
| C 5 | 0.807 | 0.0 | 560.4 | 4.426E+00 | 5.908E-03 | 4.682E-03 |
| C 6 | 0.960 | 0.0 | 556.8 | 3.824E+00 | 5.079E-03 | 4.026E-03 |
| C 7 | 0.999 | 30.0 | 553.4 | 1.910E+00 | 2.526E-03 | 2.002E-03 |
| C 8 | 1.028 | 60.0 | 556.3 | 8.797E-01 | 1.168E-03 | 9.256E-04 |
| C 9 | 1.059 | 30.0 | 547.1 | 3.499E-01 | 4.588E-04 | 3.639E-04 |
| SB10 | 1.089 | 0.0 | 542.4 | 1.112E-01 | 1.449E-04 | 1.150E-04 |
| SB11 | 1.150 | 0.0 | 542.2 | 1.221E-01 | 1.591E-04 | 1.262E-04 |
| SB12 | 1.253 | 0.0 | 541.5 | 1.115E-01 | 1.451E-04 | 1.152E-04 |
| SB13 | 1.356 | 0.0 | 542.8 | 1.181E-01 | 1.540E-04 | 1.222E-04 |
| SB14 | 1.458 | 0.0 | 543.4 | 1.165E-01 | 1.521E-04 | 1.206E-04 |
| SB15 | 1.664 | 0.0 | 544.3 | 1.192E-01 | 1.557E-04 | 1.235E-04 |
| SB16 | 1.865 | 0.0 | 545.2 | 1.345E-01 | 1.759E-04 | 1.395E-04 |
| SB17 | 2.070 | 0.0 | 546.7 | 1.625E-01 | 2.129E-04 | 1.689E-04 |
| SB18 | 2.275 | 0.0 | 546.5 | 1.590E-01 | 2.084E-04 | 1.653E-04 |
| SB19 | 2.481 | 0.0 | 547.0 | 1.687E-01 | 2.212E-04 | 1.754E-04 |
| SB20 | 2.686 | 0.0 | 547.1 | 1.831E-01 | 2.401E-04 | 1.904E-04 |
| SB21 | 2.891 | 0.0 | 550.8 | 5.895E-01 | 7.769E-04 | 6.160E-04 |
| SB22 | 2.991 | 0.0 | 557.0 | 9.935E-01 | 1.320E-03 | 1.046E-03 |
| SB23 | 3.041 | 180.0 | 564.1 | 1.221E+00 | 1.638E-03 | 1.298E-03 |
| SB24 | 3.091 | 0.0 | 561.1 | 1.412E+00 | 1.886E-03 | 1.495E-03 |
| SB25 | 3.141 | 180.0 | 566.0 | 1.377E+00 | 1.851E-03 | 1.467E-03 |
| SB26 | 3.191 | 0.0 | 562.4 | 1.431E+00 | 1.915E-03 | 1.517E-03 |

RUN2013

**Sample 3. Tabulated Heat-Transfer and Surface Pressure Data, English Units**

DATE COMPU.  22-APR-91
TIME COMPUTED:  08:46:34
DATE RECORDED:  17-APR-91
TIME RECORDED:  2:55:40
000001477

CARINA AEROTHERMAL

PAGE 3

ENGLISH UNITS

| RUN | ALPHA (DEG) | PHI (DEG) | CONFIGURATION | TIMERD (SEC) | TIMEINJ (SEC) |
|---|---|---|---|---|---|
| 2013 | -0.020 | 29.99 | #1 .50 CORNER RADIUS | 3.809 | 2.796 |

| M | PT PSIA | TT DEG R | T DEG R | P PSIA | Q PSIA | V FT/SEC | RHO LBM/FT3 | MU LBF-SEC/FT2 | RE FT-1 |
|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 456.1 | 1309.7 | 97.4 | 0.0474 | 2.11 | 3858.59 | 1.315E-03 | 7.836E-08 | 2.012E+06 |

MODEL PRESSURE DATA

| MODEL PRESSURE | S/R | THETA (DEG) | PW (PSIA) | PW /P | CP |
|---|---|---|---|---|---|
| PW 2 | 0.200 | 180.0 | 3.899 | 8.222E+01 | 1.824E+00 |
| PW 3 | 0.401 | 180.0 | 3.848 | 8.112E+01 | 1.799E+00 |
| PW 4 | 0.602 | 180.0 | 3.690 | 7.781E+01 | 1.725E+00 |
| PW 5 | 0.807 | 180.0 | 3.340 | 7.042E+01 | 1.559E+00 |
| PW 6 | 0.960 | 180.0 | 1.234 | 2.602E+01 | 5.618E-01 |
| PW 7 | 0.999 | 210.0 | 0.449 | 9.471E+00 | 1.902E-01 |
| PW 8 | 1.028 | 180.0 | 0.162 | 3.420E+00 | 5.434E-02 |
| PW 9 | 1.059 | 210.0 | 0.059 | 1.245E+00 | 5.506E-03 |
| PW10 | 1.089 | 180.0 | 0.035 | 7.282E-01 | -6.103E-03 |
| PW11 | 1.150 | 180.0 | 0.031 | 6.483E-01 | -7.898E-03 |
| PW12 | 1.253 | 180.0 | 0.034 | 7.097E-01 | -6.518E-03 |
| PW13 | 1.356 | 180.0 | 0.035 | 7.319E-01 | -6.019E-03 |
| PW14 | 1.458 | 180.0 | 0.041 | 8.544E-01 | -3.269E-03 |
| PW15 | 1.664 | 180.0 | 0.052 | 1.089E+00 | 2.005E-03 |
| PW16 | 1.865 | 180.0 | 0.062 | 1.302E+00 | 6.782E-03 |
| PW17 | 2.070 | 180.0 | 0.072 | 1.512E+00 | 1.149E-02 |
| PW18 | 2.275 | 180.0 | 0.079 | 1.675E+00 | 1.515E-02 |
| PW19 | 2.481 | 180.0 | 0.091 | 1.918E+00 | 2.061E-02 |
| PW20 | 2.686 | 180.0 | 0.107 | 2.251E+00 | 2.808E-02 |
| PW21 | 2.891 | 210.0 | 0.135 | 2.848E+00 | 4.149E-02 |
| PW22 | 2.991 | 210.0 | 0.176 | 3.714E+00 | 6.093E-02 |
| PW23 | 3.041 | 30.0 | 0.199 | 4.192E+00 | 7.168E-02 |
| PW24 | 3.091 | 210.0 | 0.201 | 4.237E+00 | 7.269E-02 |
| PW25 | 3.141 | 30.0 | 0.218 | 4.588E+00 | 8.055E-02 |
| PW26 | 3.191 | 210.0 | 0.215 | 4.541E+00 | 7.951E-02 |
| PW27 | 2.788 | 165.0 | 0.116 | 2.437E+00 | 3.227E-02 |
| PW28 | 2.839 | 165.0 | 0.120 | 2.536E+00 | 3.449E-02 |
| PW29 | 2.891 | 165.0 | 0.137 | 2.898E+00 | 4.262E-02 |
| PW30 | 2.941 | 165.0 | 0.164 | 3.468E+00 | 5.541E-02 |
| PW31 | 2.991 | 165.0 | 0.181 | 3.810E+00 | 6.310E-02 |
| PW32 | 3.041 | 165.0 | 0.195 | 4.120E+00 | 7.005E-02 |
| PW33 | 3.091 | 165.0 | 0.207 | 4.373E+00 | 7.575E-02 |
| PW34 | 3.141 | 165.0 | 0.213 | 4.492E+00 | 7.841E-02 |
| PW35 | 3.191 | 165.0 | 0.220 | 4.647E+00 | 8.190E-02 |
| PW36 | 3.242 | 165.0 | 0.223 | 4.699E+00 | 8.305E-02 |

| | | |
|---|---|---|
| PK101 | = | 0.497 |
| PK116 | = | 0.497 |
| PK201 | = | 0.496 |
| PK232 | = | 0.496 |
| PKNOWN 7 | = | 0.498 |
| PKNOWN 8 | = | 0.497 |
| PKNOWN S | = | 0.502 |

**Sample 3. concluded**

CARINA AEROTHERMAL

PAGE 2

SI UNITS

DATE COMPUTED: 13-MAY-91
TIME COMPUTED: 08:13:49
DATE RECORDED: 17-APR-91
TIME RECORDED: 1:41:22
000002228

| RUN | ALPHA (DEG) | PHI (DEG) | CONFIGURATION | TIMERD (SEC) | TIMEINJ (SEC) |
|---|---|---|---|---|---|
| 3004 | 9.998 | 0.16 | #1 .50 CORNER RADIUS | 3.809 | 2.796 |

| M | PT PA | TT DEG K | T DEG K | P PA | Q PA | V M/SEC | RHO KG/M3 | MU PA-SEC | RE M-1 |
|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 3.152E+06 | 728.1 | 54.1 | 3.278E+02 | 1.460E+04 | 1176.58 | 2.109E-02 | 3.755E-06 | 6.140E+05 |

HEAT TRANSFER GAGE DATA

| GAGE ID | S/R | THETA DEG | TW DEG K | QDOT W/M2 | H(TT) W/M2-K | S(TT) |
|---|---|---|---|---|---|---|
| C 1 | 0.000 | 0.0 | 313.7 | 4.385E+04 | 1.058E+02 | 4.093E-03 |
| C 2 | 0.200 | 0.0 | 312.4 | 4.212E+04 | 1.013E+02 | 3.919E-03 |
| C 3 | 0.401 | 0.0 | 310.9 | 4.104E+04 | 9.836E+01 | 3.806E-03 |
| C 4 | 0.602 | 0.0 | 310.9 | 3.966E+04 | 9.506E+01 | 3.678E-03 |
| C 5 | 0.807 | 0.0 | 310.6 | 3.925E+04 | 9.400E+01 | 3.638E-03 |
| C 6 | 0.960 | 0.0 | 309.0 | 3.072E+04 | 7.328E+01 | 2.836E-03 |
| C 7 | 0.999 | 30.0 | 306.0 | 1.533E+04 | 3.631E+01 | 1.406E-03 |
| C 8 | 1.028 | 60.0 | 306.1 | 6.892E+03 | 1.633E+01 | 6.322E-04 |
| C 9 | 1.059 | 30.0 | 303.6 | 2.788E+03 | 6.566E+00 | 2.542E-04 |
| SB10 | 1.089 | 0.0 | 302.9 | 5.087E-01 | 1.196E-03 | 4.632E-05 |
| SB11 | 1.150 | 0.0 | 302.9 | 5.561E-01 | 1.308E-03 | 5.064E-05 |
| SB12 | 1.253 | 0.0 | 302.8 | 7.436E-01 | 1.748E-03 | 6.770E-05 |
| SB13 | 1.356 | 0.0 | 303.3 | 7.265E-01 | 1.710E-03 | 6.621E-05 |
| SB14 | 1.458 | 0.0 | 303.4 | 7.348E-01 | 1.730E-03 | 6.699E-05 |
| SB15 | 1.664 | 0.0 | 302.8 | 7.583E-01 | 1.783E-03 | 6.904E-05 |
| SB16 | 1.865 | 0.0 | 302.9 | 9.226E-01 | 2.170E-03 | 8.402E-05 |
| SB17 | 2.070 | 0.0 | 303.5 | 1.398E+00 | 3.293E-03 | 1.275E-04 |
| SB18 | 2.275 | 0.0 | 303.6 | 1.757E+00 | 4.140E-03 | 1.603E-04 |
| SB19 | 2.481 | 0.0 | 304.5 | 2.345E+00 | 5.534E-03 | 2.143E-04 |
| SB20 | 2.686 | 0.0 | 305.0 | 2.946E+00 | 6.961E-03 | 2.695E-04 |
| SB21 | 2.891 | 0.0 | 305.2 | 3.700E+00 | 8.747E-03 | 3.386E-04 |
| SB22 | 2.991 | 0.0 | 306.2 | 4.015E+00 | 9.516E-03 | 3.684E-04 |
| SB23 | 3.041 | 180.0 | 309.7 | 1.299E+01 | 3.104E-02 | 1.201E-03 |
| SB24 | 3.091 | 0.0 | 306.2 | 5.254E+00 | 1.245E-02 | 4.821E-04 |
| SB25 | 3.141 | 180.0 | 310.2 | 1.368E+01 | 3.272E-02 | 1.266E-03 |
| SB26 | 3.191 | 0.0 | 307.0 | 6.293E+00 | 1.494E-02 | 5.784E-04 |

RUN3004

**Sample 4. Tabulated Heat-Transfer and Surface Pressure Data, SI Units**

DATE COMPUTED: 13-MAY-91
TIME COMPUTED: 08:13:50
DATE RECORDED: 17-APR-91
TIME RECORDED: 1:41:22
000002230

CARINA AEROTHERMAL

PAGE 4

SI UNITS

| RUN | ALPHA (DEG) | PHI (DEG) | CONFIGURATION | TIMERD (SEC) | TIMEINJ (SEC) |
|---|---|---|---|---|---|
| 3004 | 9.998 | 0.16 | #1 .50 CORNER RADIUS | 3.809 | 2.796 |

| M | PT PA | TT DEG K | T DEG K | P PA | Q PA | V M/SEC | RHO KG/M3 | MU PA-SEC | RE M-1 |
|---|---|---|---|---|---|---|---|---|---|
| 7.98 | 3.152E+06 | 728.1 | 54.1 | 3.278E+02 | 1.460E+04 | 1176.58 | 2.109E-02 | 3.755E-06 | 6.140E+05 |

MODEL PRESSURE DATA

| MODEL PRESSURE | S/R | THETA (DEG) | PW (PA) | PW /P | CP |
|---|---|---|---|---|---|
| PW 2 | 0.200 | 180.0 | 27322.359 | 8.336E+01 | 1.849E+00 |
| PW 3 | 0.401 | 180.0 | 27650.576 | 8.436E+01 | 1.872E+00 |
| PW 4 | 0.602 | 180.0 | 26977.176 | 8.230E+01 | 1.826E+00 |
| PW 5 | 0.807 | 180.0 | 25361.871 | 7.738E+01 | 1.715E+00 |
| PW 6 | 0.960 | 180.0 | 12279.588 | 3.746E+01 | 8.187E-01 |
| PW 7 | 0.999 | 210.0 | 5060.683 | 1.544E+01 | 3.242E-01 |
| PW 8 | 1.028 | 180.0 | 2382.567 | 7.269E+00 | 1.408E-01 |
| PW 9 | 1.059 | 210.0 | 805.417 | 2.457E+00 | 3.272E-02 |
| PW10 | 1.089 | 180.0 | 586.909 | 1.791E+00 | 1.775E-02 |
| PW11 | 1.150 | 180.0 | 682.165 | 2.081E+00 | 2.428E-02 |
| PW12 | 1.253 | 180.0 | 761.272 | 2.323E+00 | 2.970E-02 |
| PW13 | 1.356 | 180.0 | 808.309 | 2.466E+00 | 3.292E-02 |
| PW14 | 1.458 | 180.0 | 958.542 | 2.924E+00 | 4.321E-02 |
| PW15 | 1.664 | 180.0 | 1023.765 | 3.123E+00 | 4.768E-02 |
| PW16 | 1.865 | 180.0 | 1113.551 | 3.397E+00 | 5.383E-02 |
| PW17 | 2.070 | 180.0 | 1123.217 | 3.427E+00 | 5.449E-02 |
| PW18 | 2.275 | 180.0 | 1073.799 | 3.276E+00 | 5.111E-02 |
| PW19 | 2.481 | 180.0 | 986.880 | 3.011E+00 | 4.515E-02 |
| PW20 | 2.686 | 180.0 | 1078.409 | 3.290E+00 | 5.142E-02 |
| PW21 | 2.891 | 210.0 | 1219.649 | 3.721E+00 | 6.110E-02 |
| PW22 | 2.991 | 210.0 | 1632.793 | 4.981E+00 | 8.940E-02 |
| PW23 | 3.041 | 30.0 | 665.254 | 2.030E+00 | 2.312E-02 |
| PW24 | 3.091 | 210.0 | 1796.005 | 5.479E+00 | 1.006E-01 |
| PW25 | 3.141 | 30.0 | 834.349 | 2.546E+00 | 3.470E-02 |
| PW26 | 3.191 | 210.0 | 1773.274 | 5.410E+00 | 9.902E-02 |
| PW27 | 2.788 | 165.0 | 1224.432 | 3.736E+00 | 6.142E-02 |
| PW28 | 2.839 | 165.0 | 1215.337 | 3.708E+00 | 6.080E-02 |
| PW29 | 2.891 | 165.0 | 1281.617 | 3.910E+00 | 6.534E-02 |
| PW30 | 2.941 | 165.0 | 1609.535 | 4.910E+00 | 8.781E-02 |
| PW31 | 2.991 | 165.0 | 1749.336 | 5.337E+00 | 9.738E-02 |
| PW32 | 3.041 | 165.0 | 1798.329 | 5.486E+00 | 1.007E-01 |
| PW33 | 3.091 | 165.0 | 1905.484 | 5.813E+00 | 1.081E-01 |
| PW34 | 3.141 | 165.0 | 1862.146 | 5.681E+00 | 1.051E-01 |
| PW35 | 3.191 | 165.0 | 1879.371 | 5.734E+00 | 1.063E-01 |
| PW36 | 3.242 | 165.0 | 1865.391 | 5.691E+00 | 1.053E-01 |

RUN 3004

**Sample 4. concluded**