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PRESSURE AND HEAT-FLUX RESULTS FROM THE SPACE SHUTTLE/EXTERNAL FUEL TANK INTERACTION TEST AT MACH NUMBERS 16 AND 19 (FH10)

By

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by

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for

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WIND TUNNEL TEST SPECIFICS:

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Test Dates:	January 21-30, 1974
Occupancy Hours:	32

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ABSTRACT

Heat transfer rates and pressures were measured on a 0.0175-scale model of the Space Shuttle External Tank (ET), model MCR0200. Tests were conducted with the ET model separately and while mated with a 0.0175-scale model of the orbiter, model 21-OT (Grumman). The tests were conducted in the AEDC-VKF Hypervelocity Wind Tunnel (F) at Mach numbers 16 and 19. The primary data consisted of the interaction heating rates experienced by the ET while mated with the orbiter in the flight configuration. Data were taken for a range of Reynolds numbers from 0.05×10^6 ft^{-1} to 0.65×10^6 ft^{-1} under laminar flow conditions.

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NOMENCLATURE

Symbol	Definition
H_o, HO	Test gas stagnation enthalpy, Btu/lbm
H_w	Test gas enthalpy at model wall temperature (540°R), Btu/lbm
L, MODEL LENGTH	Length of external tank model, blunt-ogive-cylinder, in.
M-INF, M_∞	Free-stream Mach number
P, PRESSURE, p	Measured pressure, psia
P-INF, p_∞	Free-stream pressure, psia
PO, p_o	Measured arc chamber pressure, psia
POP, p_o'	Measured Pitot pressure, psia
Q, $\dot{q}$	Measured heat-transfer rate, Btu/ft^2-sec
Q-INF, q_∞	Free-stream dynamic pressure, psia
QO, Q-O, $\dot{q}_o$, Q_o	Stagnation heat-transfer rate to a 0.5-in.-radius hemisphere, Btu/ft^2-sec
RHO-INF, ρ_∞	Free-stream density, lbm/ft^3
RE/FT, Re/ft	Free-stream unit Reynolds number, ft^{-1}
r_n	Model blunt nose radius, 0.288 in.
s	Surface distance along model from zero incidence stagnation point, in.
ST-0	Stanton number based on q_o, $q_o/\rho_\infty U_\infty(H_o - H_W)$
t, TIME	Test, section time, msec
T-INF, T_∞	Free-stream temperature, deg R or deg K
TO, T_o	Stagnation temperature, deg R
T_s	Theoretical saturation temperature of nitrogen, deg K
U-INF, U_∞	Free-stream velocity, ft/sec
X	Longitudinal distance along model axis measured from blunt nose stagnation point, in.

NOMENCLATURE (Concluded)

Symbol	Definition
α, ALPHA	Sector angle of attack, deg
ϕ_s, PHI_s	Sector angle of roll, deg
ϕ	Gage location around ET model, deg
ϕ'	Roll orientation of ET model relative to the orbiter model, deg ($\phi' = 0$ corresponds to the heat-transfer-rate gages being directly beneath the orbiter.)

INTRODUCTION

The primary purpose of the test was to obtain interaction heating rates experienced by the Space Shuttle External Tank (ET) while mated with the Space Shuttle orbiter over a wide range of Reynolds numbers under laminar flow conditions. Tests were conducted both with and without the orbiter model mated in order to isolate the interaction heating effects. Both gage data and themographic phosphor paint data were taken to determine the location of the orbiter bow shock impingement on the ET. A lesser amount of pressure data was taken under the same conditions along with Schlieren coverage at both $M_\infty = 16$ and $M_\infty = 19$.

TEST FACILITY DESCRIPTION

The Hypervelocity Wind Tunnel (F) at the Arnold Engineering Development Center, Fig. 1, is an arc-driven wind tunnel of the hotshot type (Refs. 1 and 2) and capable of providing Mach numbers from about 7.5 to 20 over a Reynolds number (per foot) range from 0.05×10^6 to 70×10^6. Test sections of 108 in. diameter (M_∞ = 10 to 17), Figs. 2 and 3, are available using a 4-deg. half-angle conical nozzle. The range of Mach numbers at a particular test station in the conical nozzle is obtained by using various throat diameters. The $M_\infty = 8$ contoured nozzle has a 25-in. exit diameter which connects to the 54-in. diameter test station and provides a free-jet exhaust, as illustrated in Figure 2. The test gas can be either air or nitrogen. The test gas is confined in either a 1.0-cu. ft, a 2.5-cu-ft or a 4.0-cu-ft arc chamber where it is heated and compressed by an electric arc discharge. The increase in pressure results in a diaphragm rupture with the subsequent flow expansion through the nozzle. Test times are typically from 50 to 200 msec. Shadowgraph and Schlieren coverage are available at both test sections.

This test was conducted in the 108-in-diameter test section of the conical nozzle for $M_\infty = 16$ and 19. Nitrogen was the test gas. The 2.5-ft^3 arc chamber was used, and useful test times up to approximately 40 and 60 msec were obtained for the $M_\infty = 16$ and $M_\infty = 19$ conditions, respectively. Because of the relatively short test times, the model wall temperature remained essentially invariant from the initial value of approximately 540°R. Figure 4 presents typical analog data traces and the reduced digital data tunnel conditions for $M_\infty = 16$.

MODEL DESCRIPTION AND TUNNEL INSTALLATION

The model tested consisted of a 0.0175-scale stainless steel ET and an orbiter model made of material G, Fig. 5. The orbiter model tested was model 21-OT (Grumman Drawing SS-H-00550) and was fabricated by Grumman Corporation, Bethpage, N.Y. The ET model was built along the lines of MCR0200 (MSFC Drawing 80M51329) and was fabricated by MSFC, Huntsville, Alabama.

All of the heat-transfer-rate instrumentation was located on one side of the ET model, while all of the pressure instrumentation was located at ϕ= 180 deg. on the opposite side. Due to the symmetry of the ET model, it was possible to obtain both pressure and heat-transfer data with the same ET model by rolling it 180 deg. with respect to the orbiter. Using this procedure, either the pressure or the heat-flux gages could be located adjacent to the orbiter to obtain the type of interaction data desired. The tunnels (three scaled fuel lines) could be positioned on either side of the ET.

The ET model was mounted on tunnel centerline with the nose of the tank located at station 763, Fig. 3. To test the mated configuration, the orbiter model was mounted above the ET model by means of a secondary sting secured to the main ET sting downstream from the test section. Photographs showing tunnel installation are shown in Figs. 9 and 10. A scaled nose tie-down used to position and secure the orbiter nose to the ET was used on all mated tests except one (run 4647). All model instrumentation was located on the ET while the orbiter model served as a shock generator. Besides the ET and the orbiter model, three scaled fuel lines (tunnels) were located on the tank surface to closely simulat the flight vehicle. These tunnels were removed on three runs to determine their effect on the heating rates.

After the first "tank only" run, run 4646, all runs except for the last two were made with the models rolled 37.5 deg. This was necessary to permit a good view of the area of interest during the phosphor paint runs. Three cameras were used to take phosphor paint data. Two of thes (an 80- and a 150-mm Hasselblad camera) were mounted in the center top 45-deg. port, Fig. 3, and one (a 150-mm Hasselblad camera) was mounted on a tripod beside the tunnel to obtain a side view through the

Schlieren window. Ultraviolet light sources were placed in the 45-deg. top, front, and aft ports. The phosphor paint data and procedure are discussed in a later section. The last two runs (4655 and 4656) were made with the model rolled back to $\phi_s = 0$ deg. to enable Schlieren coverage (see figures 11 through 14).

DATA RETRIEVAL

The test section Pitot pressure, stagnation heat-transfer rate, and arc chamber pressure were monitored to determine tunnel flow conditions. The Pitot pressures were measured with 15-psid strain-gage pressure transducers calibrated at the specific pressure level occurring during each test condition. The stagnation heat-transfer rates were inferred from measurements made on the cylindrical section (shoulder) of a 1-in.-diameter hemisphere-cylinder probe. Two such heat-transfer-rate probes were used for this purpose, each probe instrumented with two shoulder gages located on opposite sides of the probe. Two types of gages were used for these shoulder measurements, a 10-mil-resistance thermometer slug calorimeter and a coaxial surface thermocouple. Two separate arc chamber reservoir pressures were measured using strain-gage transducers, each having a full-scale calibrated range of 30,000 psia.

Fifty-five separate heat-transfer-rate measurements and 20 pressure measurements were made on the ET surface, as illustrated in Fig. 6. Of the fifty-five heat-transfer-rate gage locations, fifty-one were instrumented with 10-mil-resistance thermometer slug calorimeters (RTG) while the four forward locations (Q1, Q2, Q3, and Q5) were instrumented with coaxial (co-ax) surface-thermocouple gages. The RTG is a calorimeter-type device utilizing a platinum thin-film resistance thermometer as the temperature sensor and thus is not a self-generating device. Therefore, the transducer operates as the active leg in a Wheatstone bridge circuit. Transducer calibrations performed in the laboratory are transferred to test areas. The calibration procedures include the application of a known and constant heat flux to the sensing surface of the transducer and determining its time resolved output. A precision shunt resistance technique is employed to transfer RTG calibrations from the laboratory to the test areas.

The higher heat-transfer rates near the nose of the model were measured with the coaxial surface-thermocouple gage because of its higher measuring range, 3 to 300 Btu/ft^2-sec. The co-ax gage is comprised of an electrically insulated chromel wire enclosed in a cylindrical constantan jacket. A thin-film junction is made between the chromel and constantan at the surface. In practical measurement applications, the co-ax gage behaves as a homogeneous, one-dimensional, semi-infinite solid. The instrument measurement provides an electromotive force (E.M.F.) directly proportional to surface temperature which may be related by theory to incident heat flux.

Nineteen of the model surface pressure measurements (excluding P1) were made using either a variable-reluctance pressure transducer with a range of 0 to 0.1 psid or a strain-gage pressure transducer with a design range of 0.01 to 1 psid. For six of the eleven runs made, a pressure transducer was mounted in the nose of the ET in place of the stagnation heat transfer gage Q1. A strain-gage pressure transducer with a design range of 0.2 to 30 psid was used for P1.

A general description of Tunnel F instrumentation is given in Refs. 3 and 4.

The thermographic phosphor paint technique (Refs. 2 and 5) works on the principle of phosphorescence, which is the emission of luminescent light. The process is temperature-dependent. When the phosphor paint is excited with long-wave ultraviolet light, it emits a yellow-green light of a given brightness level. As the paint temperature increases, the brightness of the emitted light decreases. Therefore, by measuring the paint brightness, it is possible to obtain thermal contour distributions of a model to which the paint is applied.

Phosphor paint contour distributions are used in conjunction with heat gages to obtain thermal maps.

The paint data consist of a "tare" photograph taken prior to the run at room temperature to record the initial paint brightness level. Then at some desirable time in the run, another photograph is taken to record the run brightness level. The photographs record paint brightness in terms of film optical density; i.e., the brighter a region is on the model, the denser, or darker, it will appear on the negative.

The phosphor paint data are reduced by reading the change in optical density from tare to run, over the model surface, and converting this into a color photograph contour map. The color contours were then related to model heat flux through the gage measurements of the heat-transfer rates. The Data Color System 703-32, manufactured by Spatial Data Systems, Goleta, California, was used to reduce the photographic data. Basically, the Data Color System is a closed-circuit television network consisting of a camera and a color monitor console. The camera reads the film optical density (i.e., paint brightness). The continuous camera signal is then broken into a preselected number of color steps (32 maximum) and the results are displayed on the monitor. The monitor is then photographed to record the color contour mapping of the model heating distribution.

For this test, 8 color steps were used to depict the heating distribution recorded by the 150-mm camera.

To establish the validity of the phosphor paint data to be taken, pictures were taken on runs 4650 and 4651 with a high-temperature paint (No. 3003). From these pictures it was determined that shock glow would prevent getting any useful data at $M_\infty \simeq 19$, but useful data could be obtained at the $M_\infty = 16$ condition. Of the two $M_\infty = 16$ runs which followed (runs 4652 and 4653), paint (No. 1807) data were obtained on the high Reynolds number run (4452). Figure 15 shows the paint test results. The heating rates at the low Reynolds number condition were too low for the sensitivity of the paint (No. 1807).

Since phosphor paint data were a secondary effort, the time involved in preparing a model with paint prevented the acquisition of paint data on more than one run.

DATA ACCURACY

The determination of the free-stream and reservoir conditions is based on the measured monitor values p_o', p_o, and $\dot{q}_o$, according to the method of Ref. 6. The uncertainties of p_o' (average of two values), p_o (average of two values), and $\dot{q}_o$ (average of four values) are $\pm$ 4, $\pm$ 5, and $\pm$ 5 percent, respectively. These uncertainties are based primarily on calibration linearity and accuracy, system acquisition accuracy, and uncertainties associated with testing under dynamic conditions and are defined using the Taylor series method of error analysis. These uncertainties are then propagated through the appropriate equations by the Taylor series method of error propagation to yield the following uncertainties in tunnel conditions:

Parameter	Percent Uncertainty
M_∞	$\pm$ 1.5
Re/ft	$\pm$ 10.0
T_∞	$\pm$ 6.0
p_∞	$\pm$ 6.0
T_o	$\pm$ 4.0
H_o	$\pm$ 5.0
q_∞	$\pm$ 4.0

The uncertainties in the absolute values of model pressures and heat-transfer rates are $\pm$ 5 and $\pm$ 9 percent, respectively, for normal operation within the gages optimum range. A tabulation of the model data uncertainties follows:

Parameter	Percent Uncertainty
p	$\pm$ 5
$\dot{q}$	$\pm$ 9
p/p_o'	$\pm$ 6
$\dot{q}/\dot{q}_o$	$\pm$ 10

The data uncertainty in the color mappings from the thermographic mapping technique is estimated as $\pm$ 0.010 in $\dot{q}/\dot{q}_o$ based on the $\dot{q}/\dot{q}_o$ versus color plots. The uncertainty is undefined for $\dot{q}/\dot{q}_o$ values quoted above 0.10 because of the extrapolation outside the calibrated range of the colors.

RESULTS

Tabulated data for each run are listed in the Appendix. Each run includes the model data taken on that run in two different forms; i.e., P, p/p_o', $\dot{q}$, and $\dot{q}/\dot{q}_o$. Several different time points are listed for each run to give the widest Reynolds number range possible for that run. Flow conditions at the test section are listed for each time point. On any one run the maximum number of model gages that could be recorded was sixty. Since the total model pressure and heat-transfer instrumentation exceeded this number, only sixty or fewer of the total model instrumentation locations are included for any run. The orientation of the pressure gages during any of the first nine runs should be noted. During these runs, the pressure gages were located on the bottom of the tank away from the orbiter and do not reflect the shock interaction effects.

This also holds true for the heat-transfer data taken on the last two runs when the heat-transfer gages were rolled to the bottom of the tank with respect to the orbiter.

Due to the fact that the primary purpose of the test was to obtain interaction heat-transfer data while the ET was mated with the orbiter, Schlieren coverage was sacrificed on the first 9 runs (4646-4654) to obtain an additional view through the side Schlieren window to obtain thermographic phosphor paint data.

Schlieren stills for runs 4655 and 4656 are shown in figures 11 through 14. Thermographic phosphor paint data results are shown in figure 15.

Figures 7 and 8 include X/L plots of the top row of gages for each of the eleven runs. The first nine runs (4646 through 4654) were primarily heat-transfer runs and are represented by $\dot{q}/\dot{q}_o$ vs. X/L plots in Fig. 7. The last two runs (4655 and 4656) were pressure runs and are represented by p/p_o' vs. X/L plots in Fig. 8.

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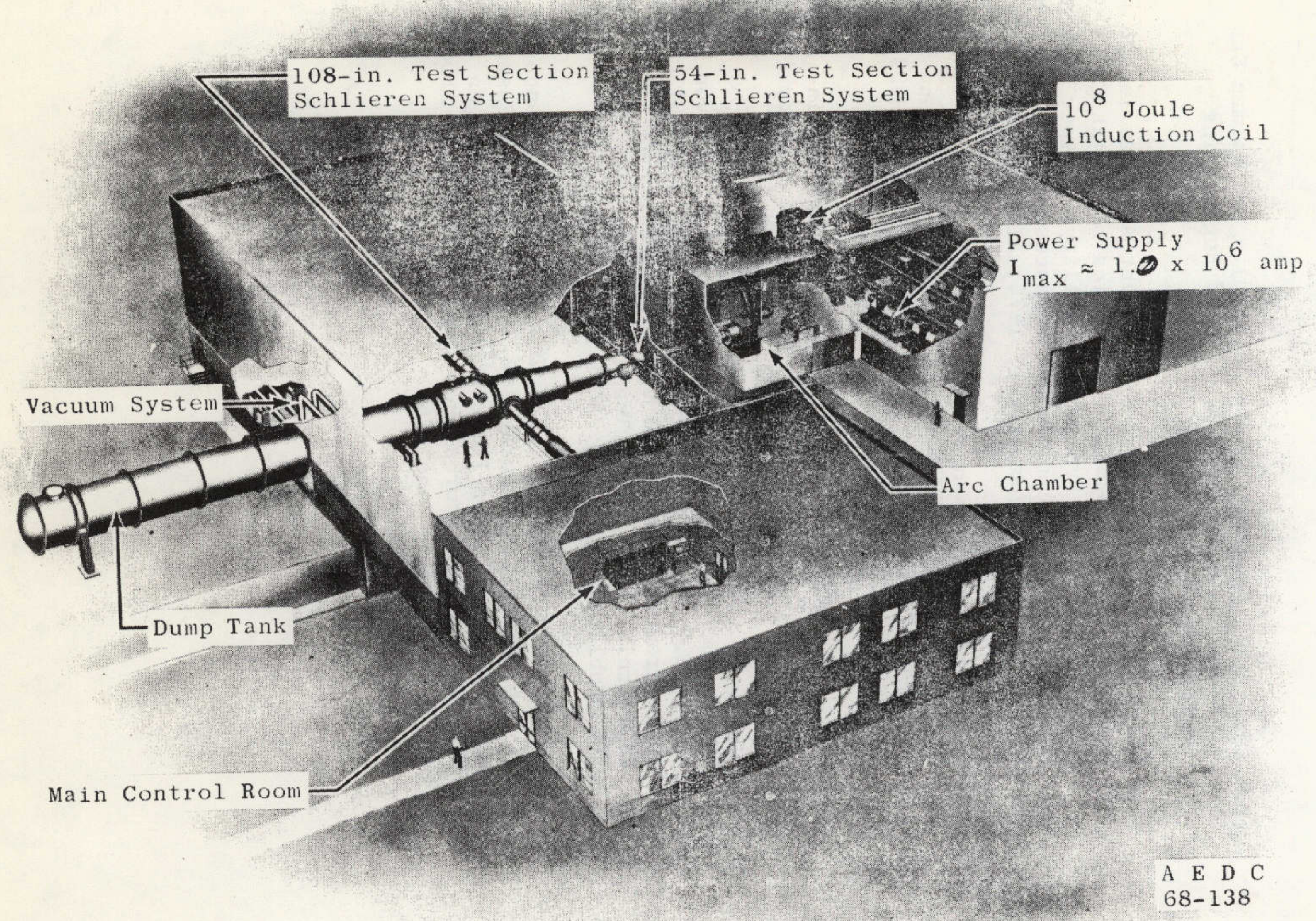
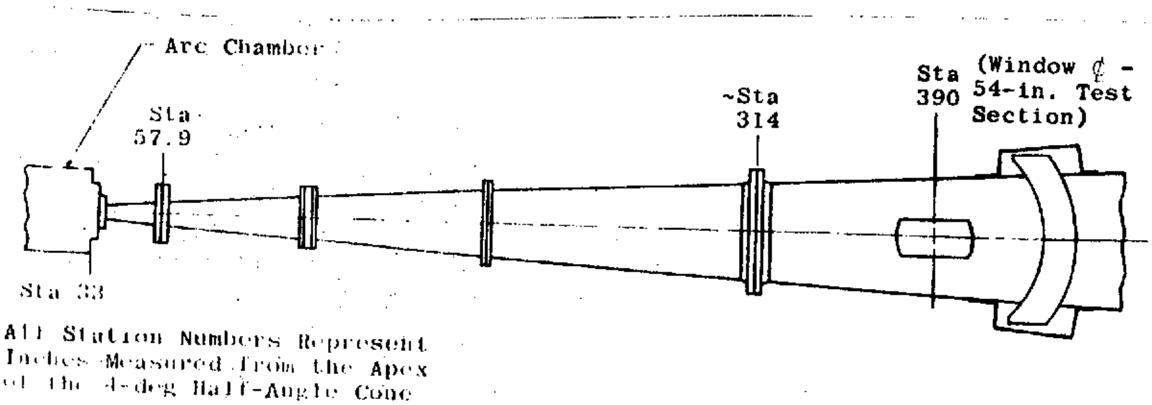
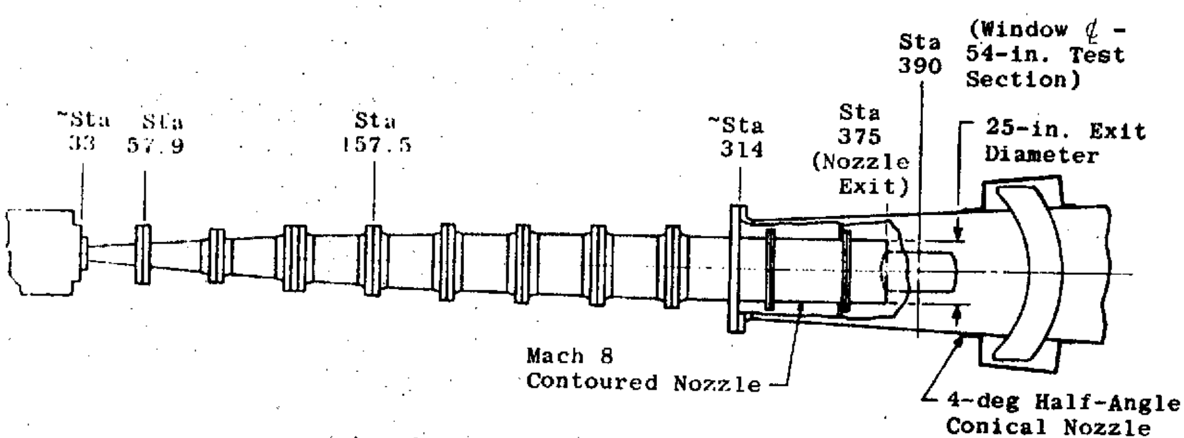


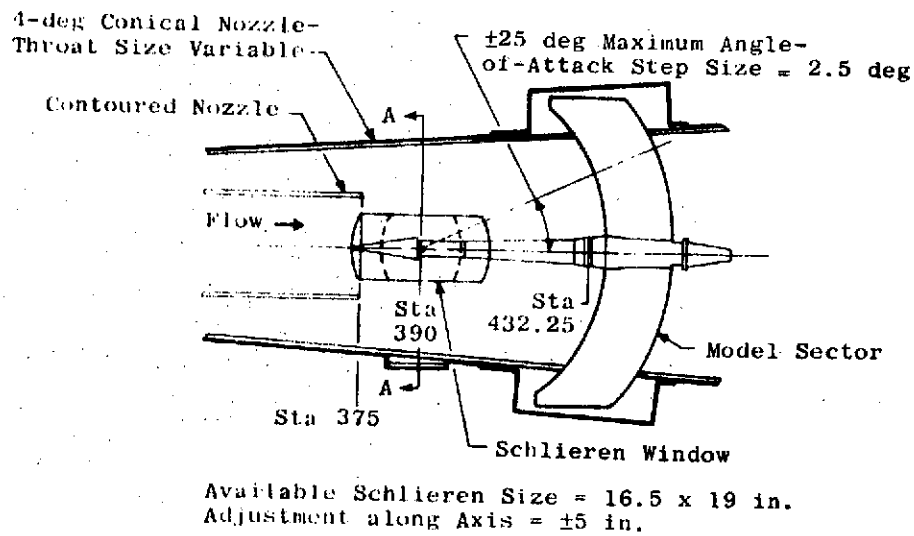
Fig. 1 AEDC-VKF Tunnel F Plant



a. 4.0-deg Half-Angle Conical Nozzle, M_∞ = 10 to 17



b. M_∞ = 8 Contoured Nozzle



c. 54-in. Diam Test Section

Figure 2. Tunnel F Nozzles and 54-inch Dia. Test Section

NOTE: (1) Thermographic paint data were taken from one camera through the 36-inch-dia side Schlieren window and by two cameras through the 45° top-center viewing port. Ultraviolet light sources were placed at the 45° top forward and aft ports.

(2) The monitor probes were located 16 inches above tunnel center-line with the stagnation point of the 1-inch diameter heat-transfer-rate probes at station 782.

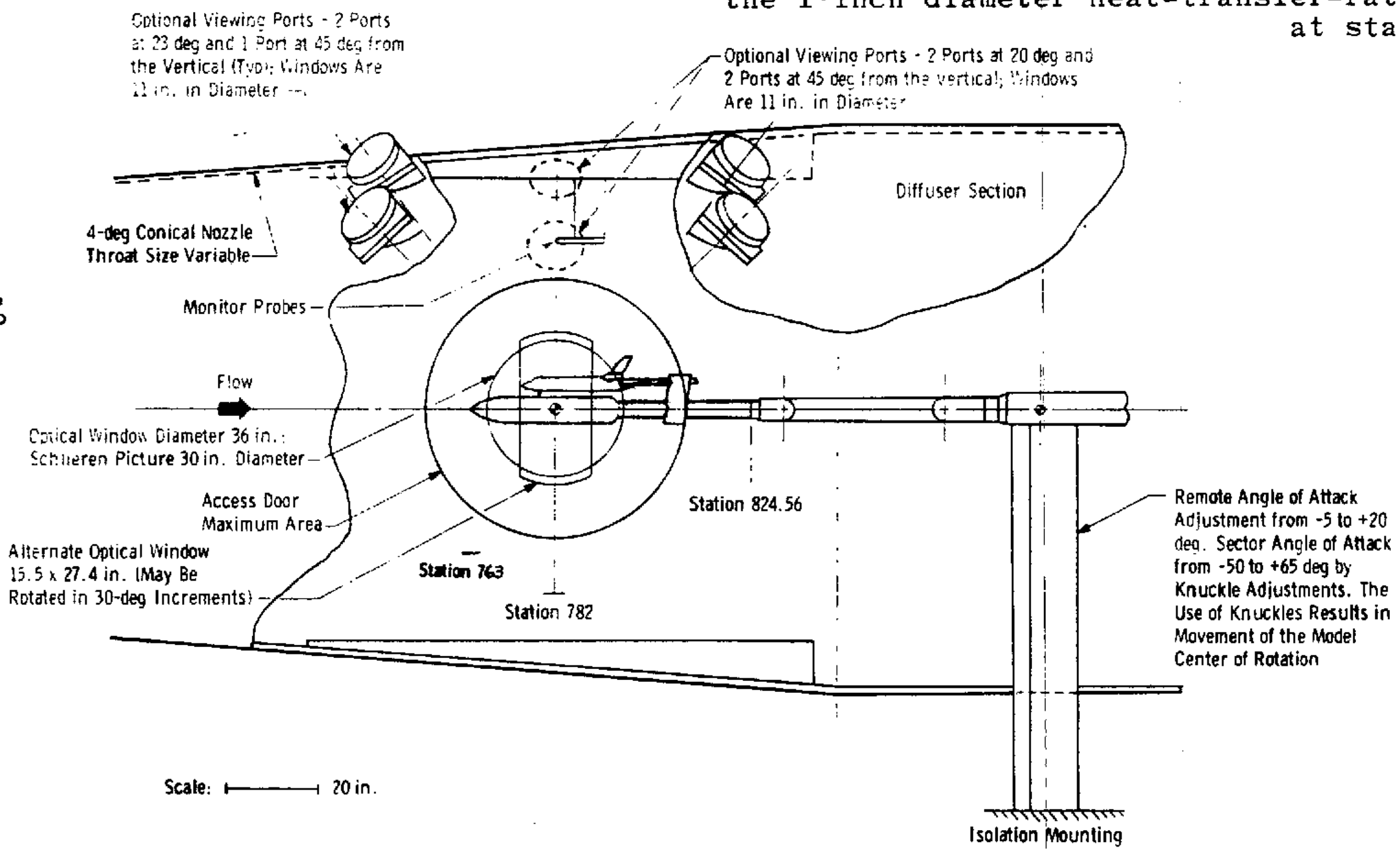


Figure 3. Tunnel F 108-inch Test Section

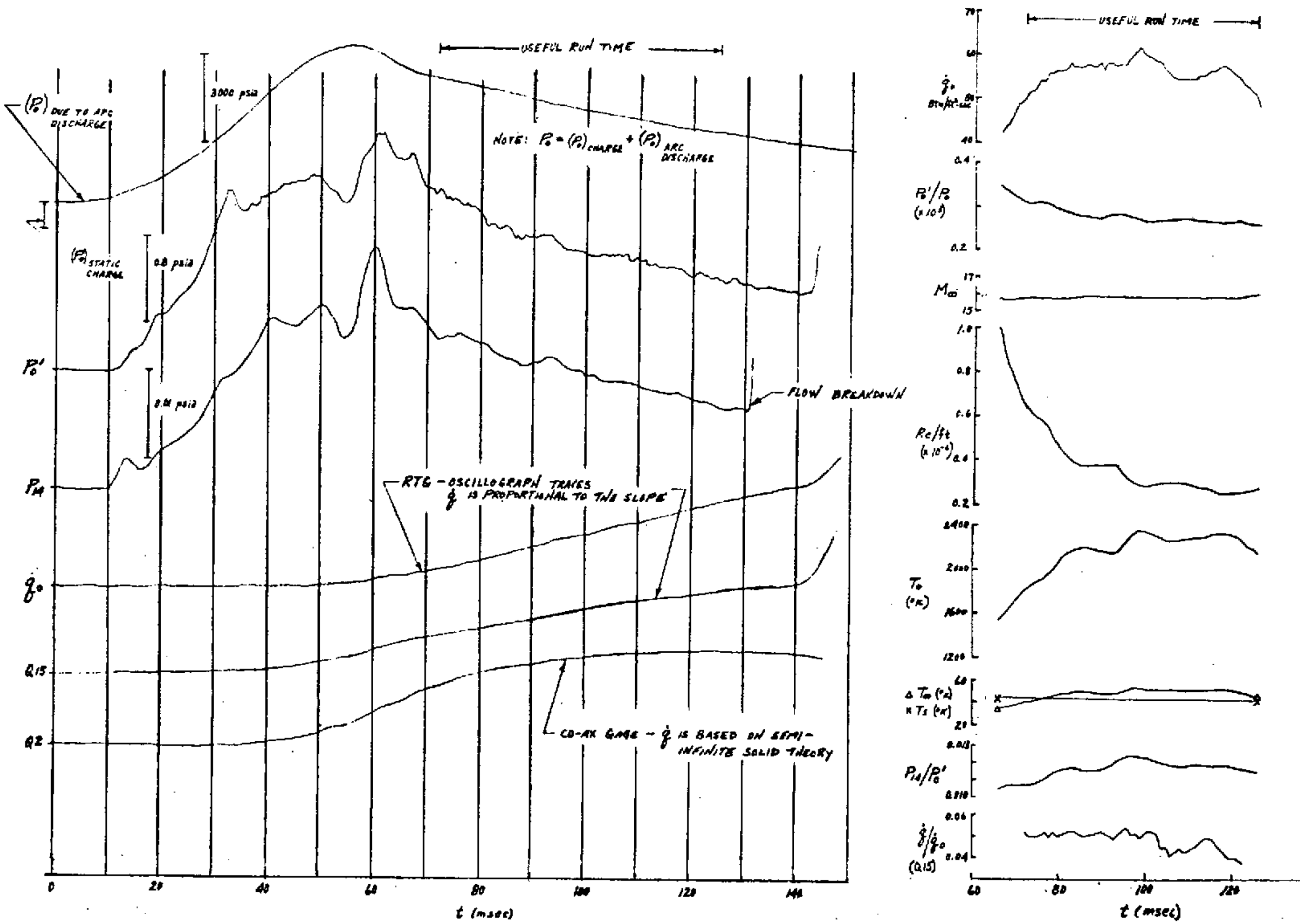


Figure 4. Typical Analog Data Traces and Variation of Tunnel Conditions with Time, $M_\infty \cong 16$

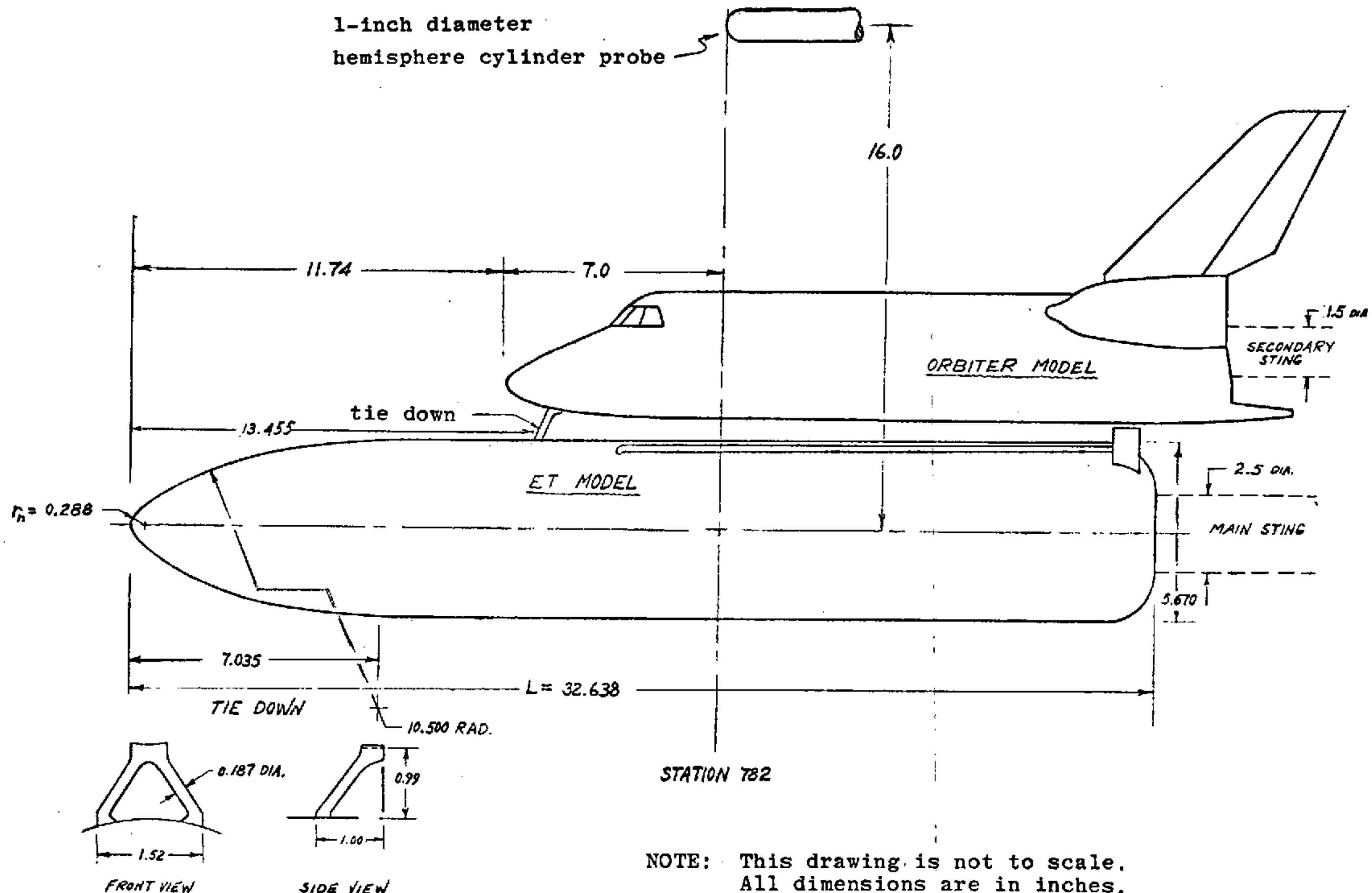


Figure 5. Mated Configuration as Tested

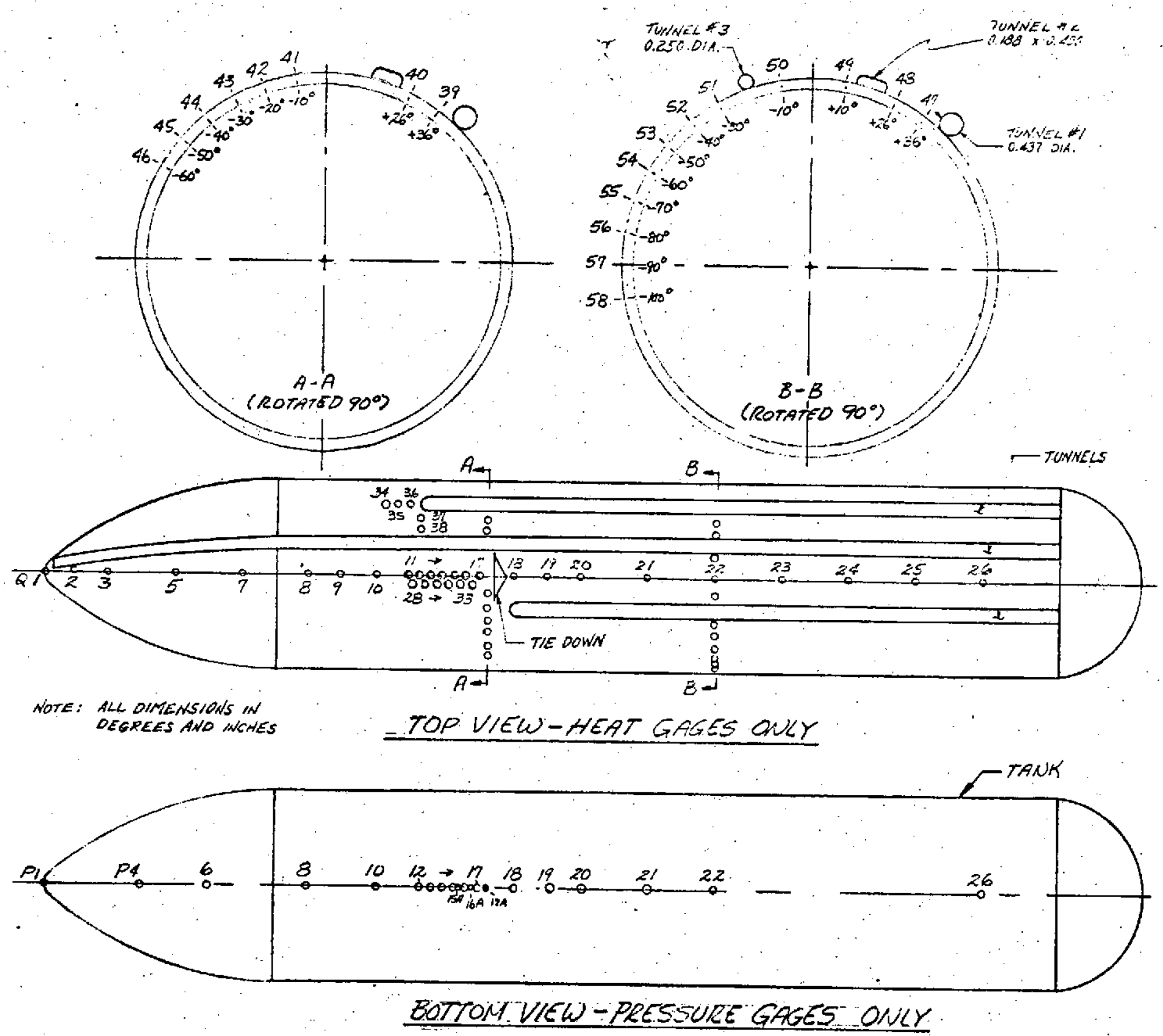
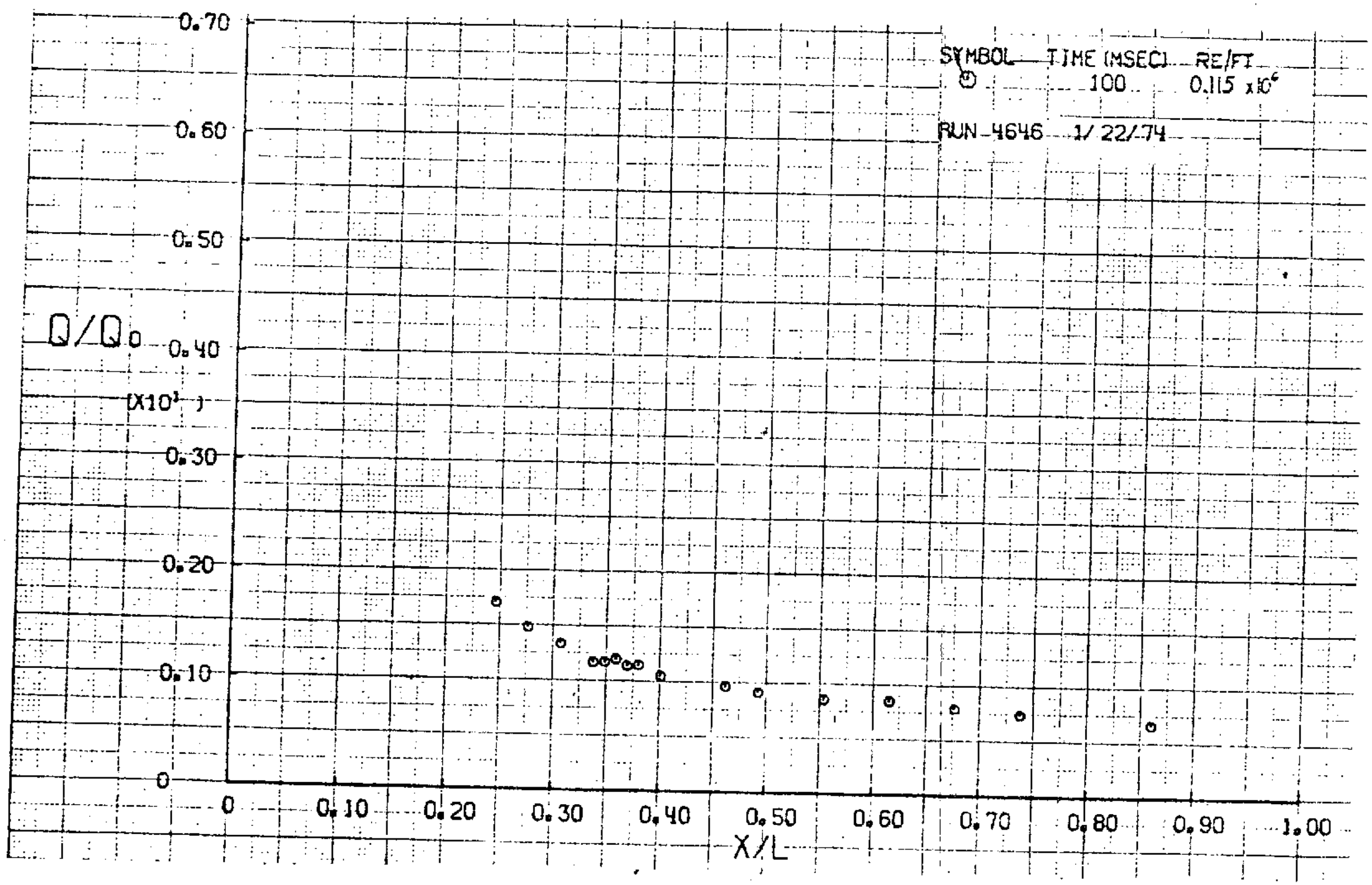
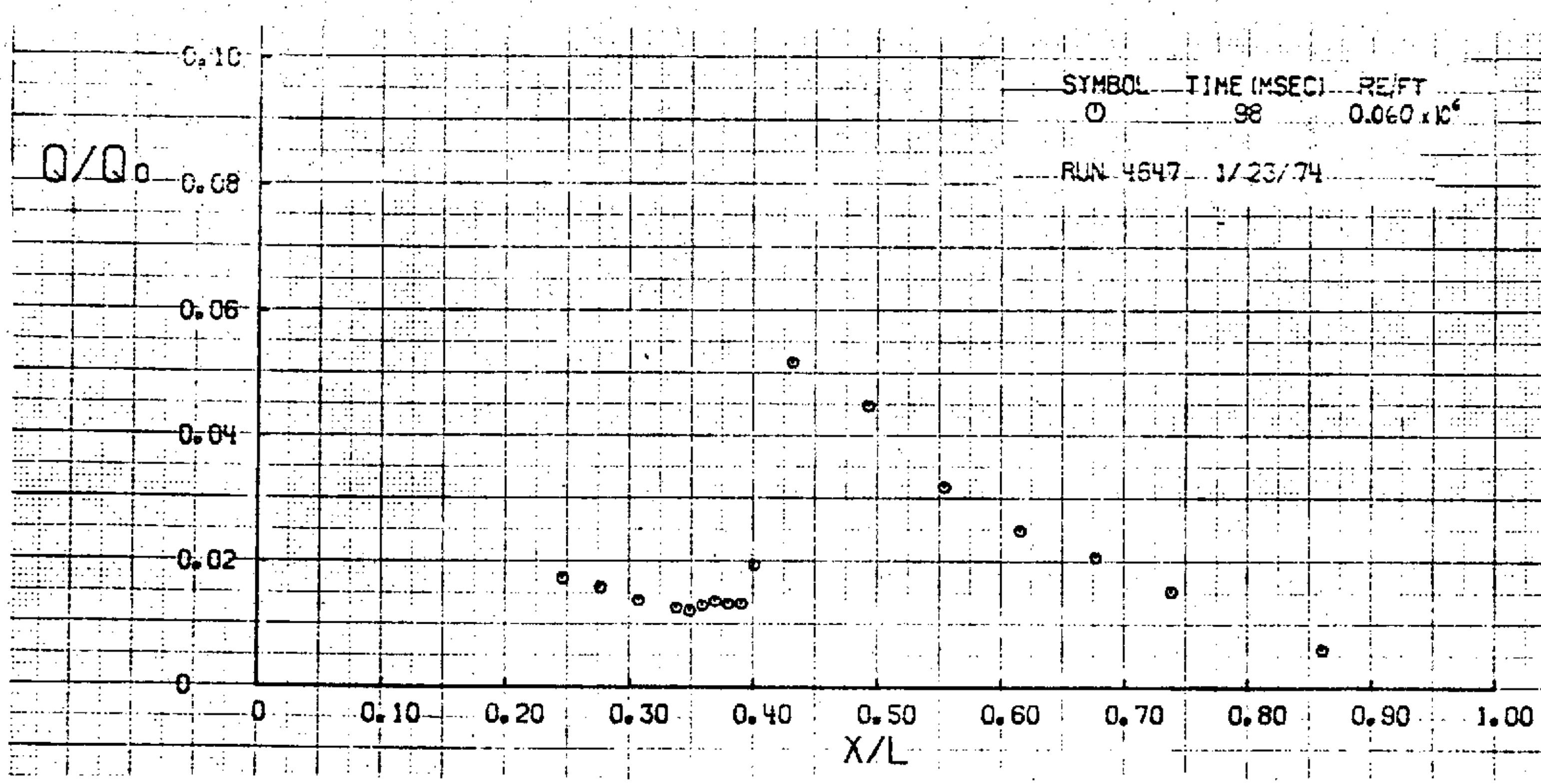


Fig. 6 Model Instrumentation Locations

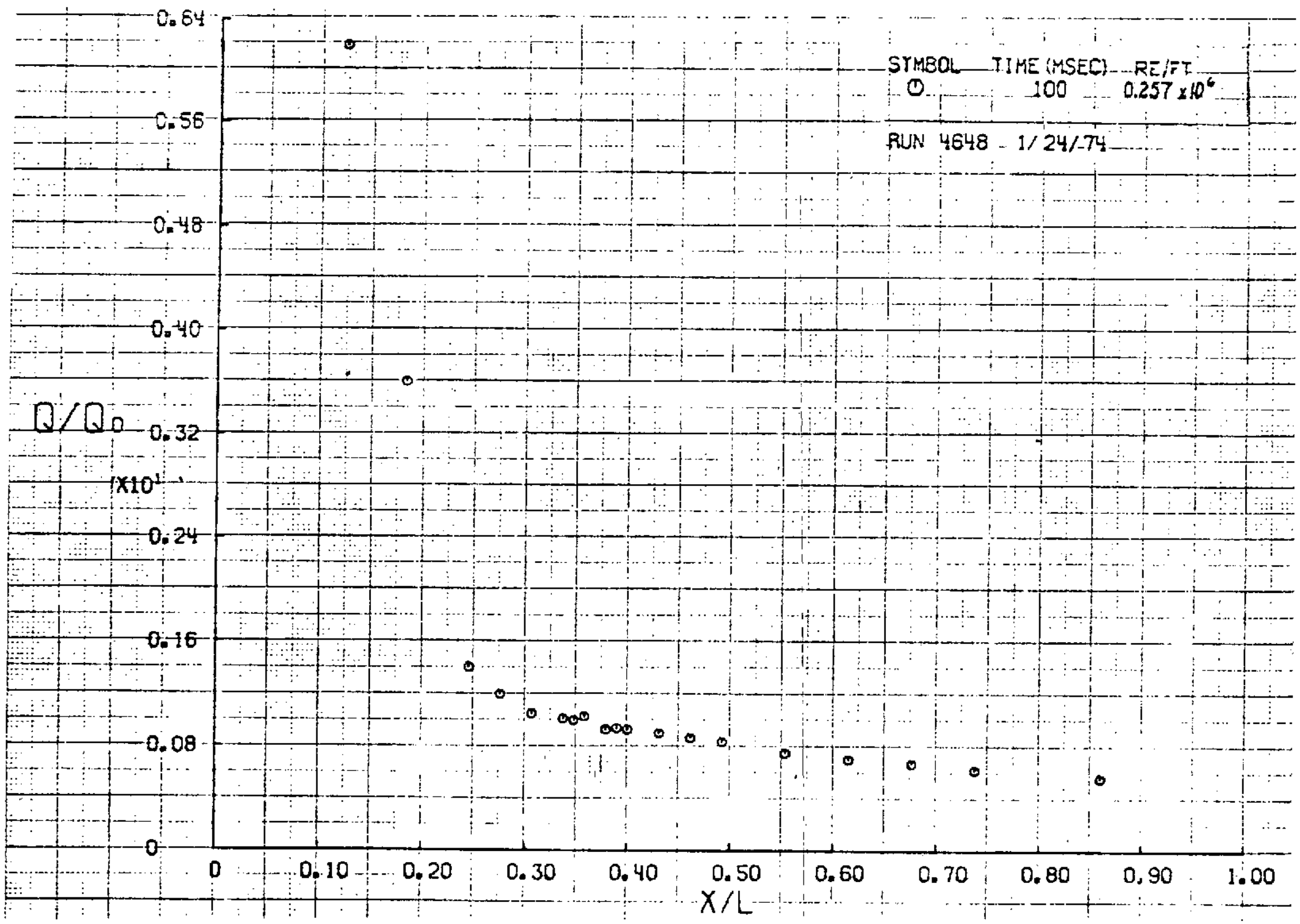


a. $M_{\infty} \cong 19$, ET only, no Tunnels
Figure 7 Tank Heat-Transfer-Rate Distributions



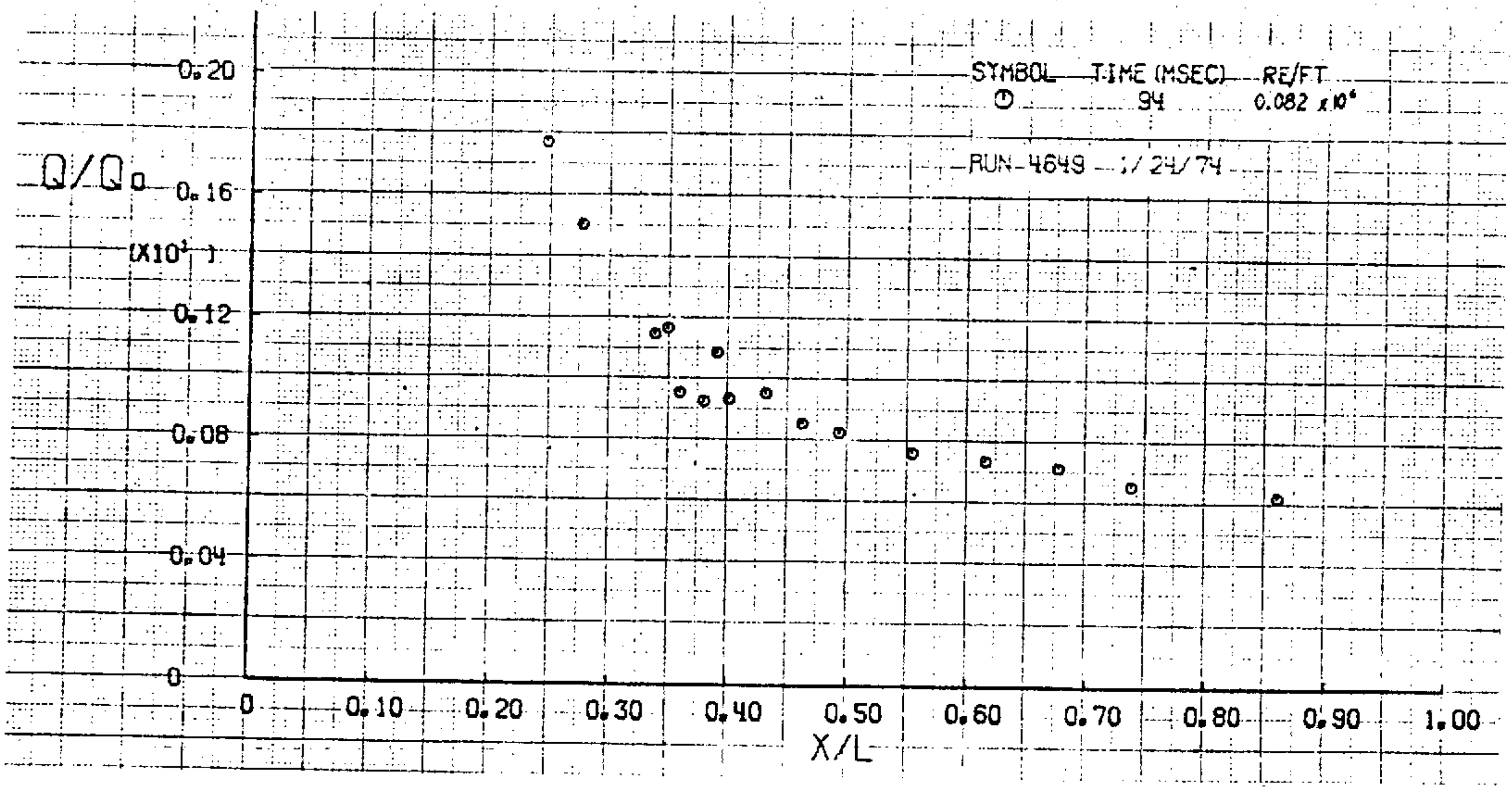
b. $M_\infty \cong 19$, Mated, no Tunnels, no Tie Down

Figure 7. Continued

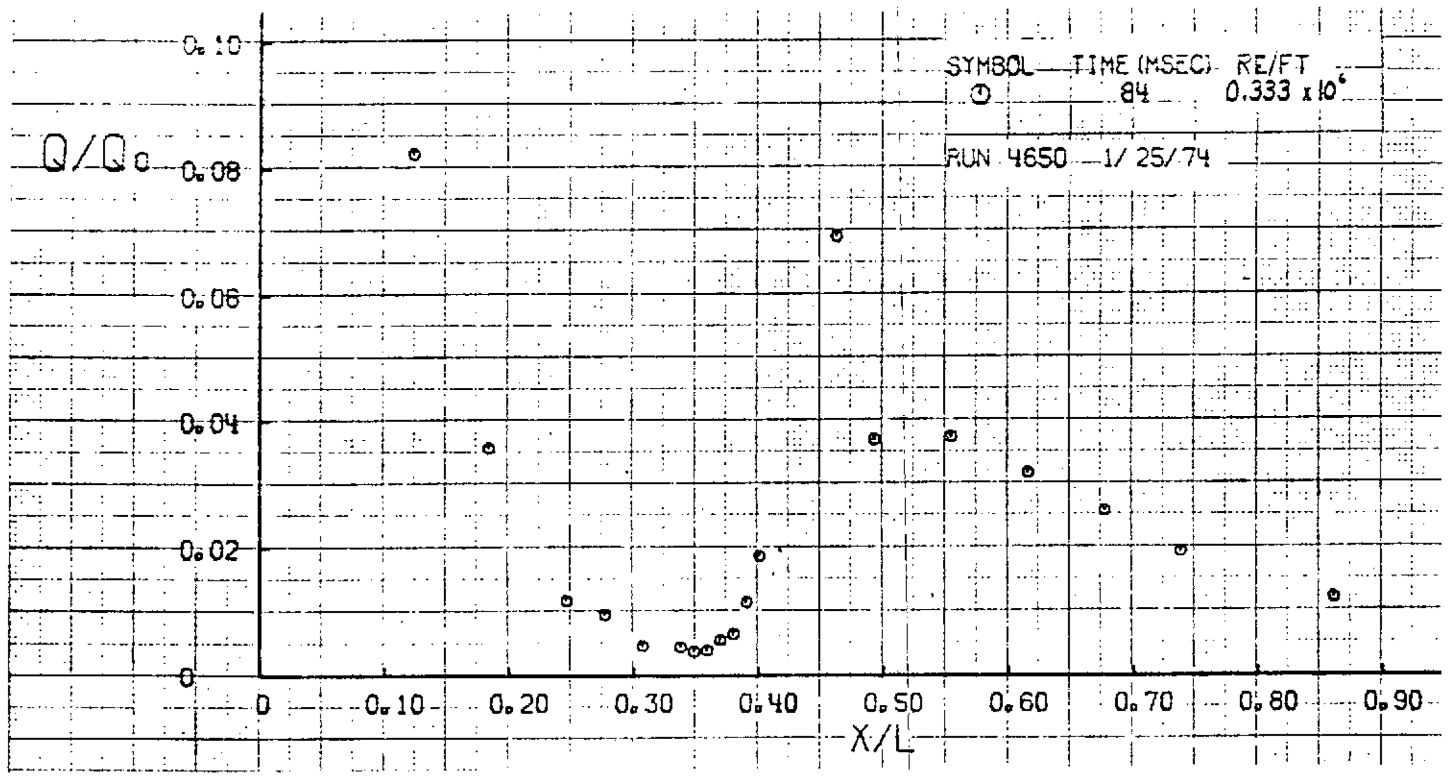


c. $M_\infty \cong 16$, ET only, no Tunnels

Figure 7. Continued

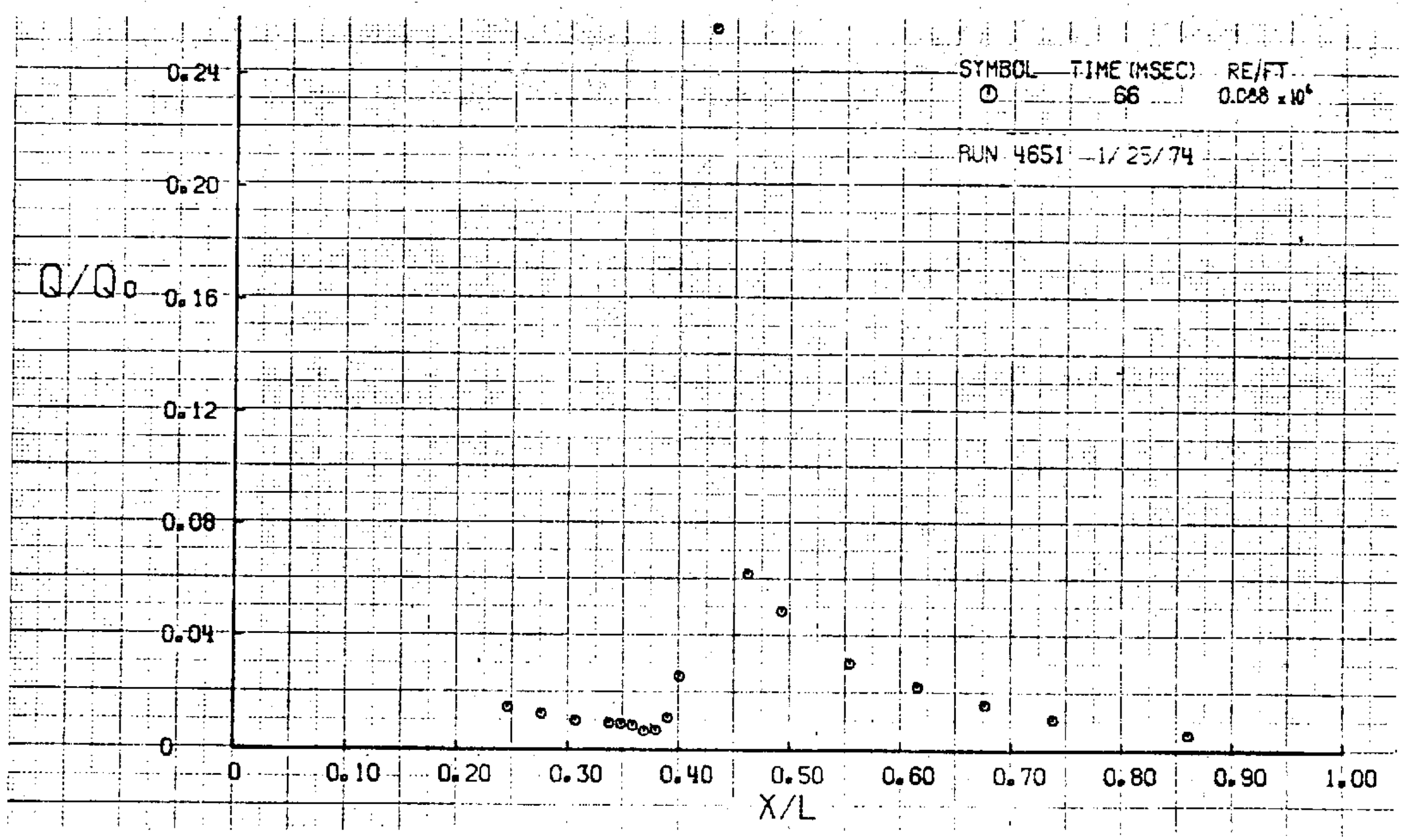


d. $M_\infty \cong 19$, ET only, with Tunnels
Figure 7. Continued

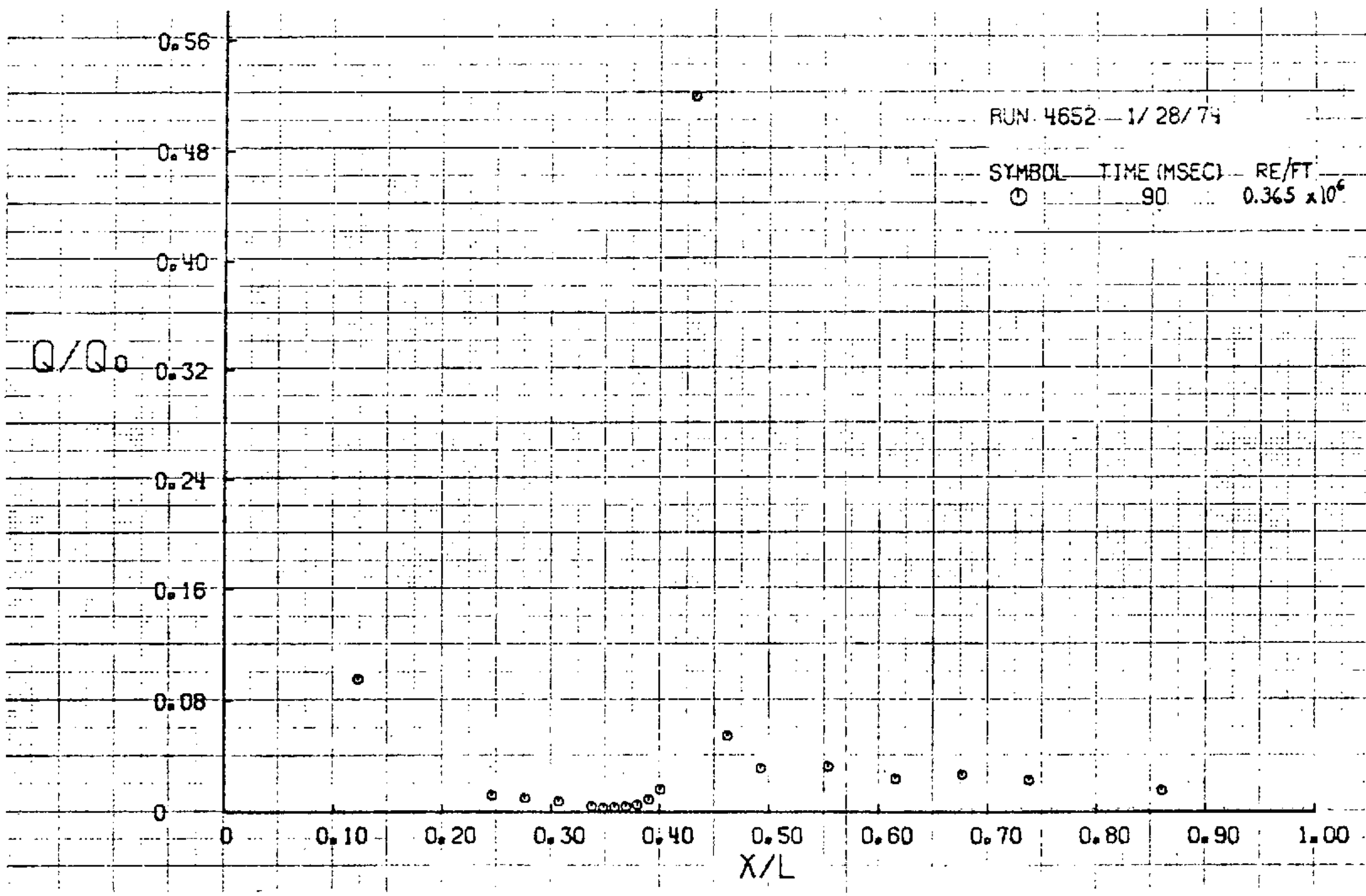


e. $M_\infty \cong 16$, Mated, with Tunnels, with Tie Down

Figure 7. Continued



f. $M_\infty \cong 19$, Mated, with Tunnels, with Tie Down
Figure 7. Continued



g. $M_\infty \cong 16$, Mated, with Tunnels, with Tie Down
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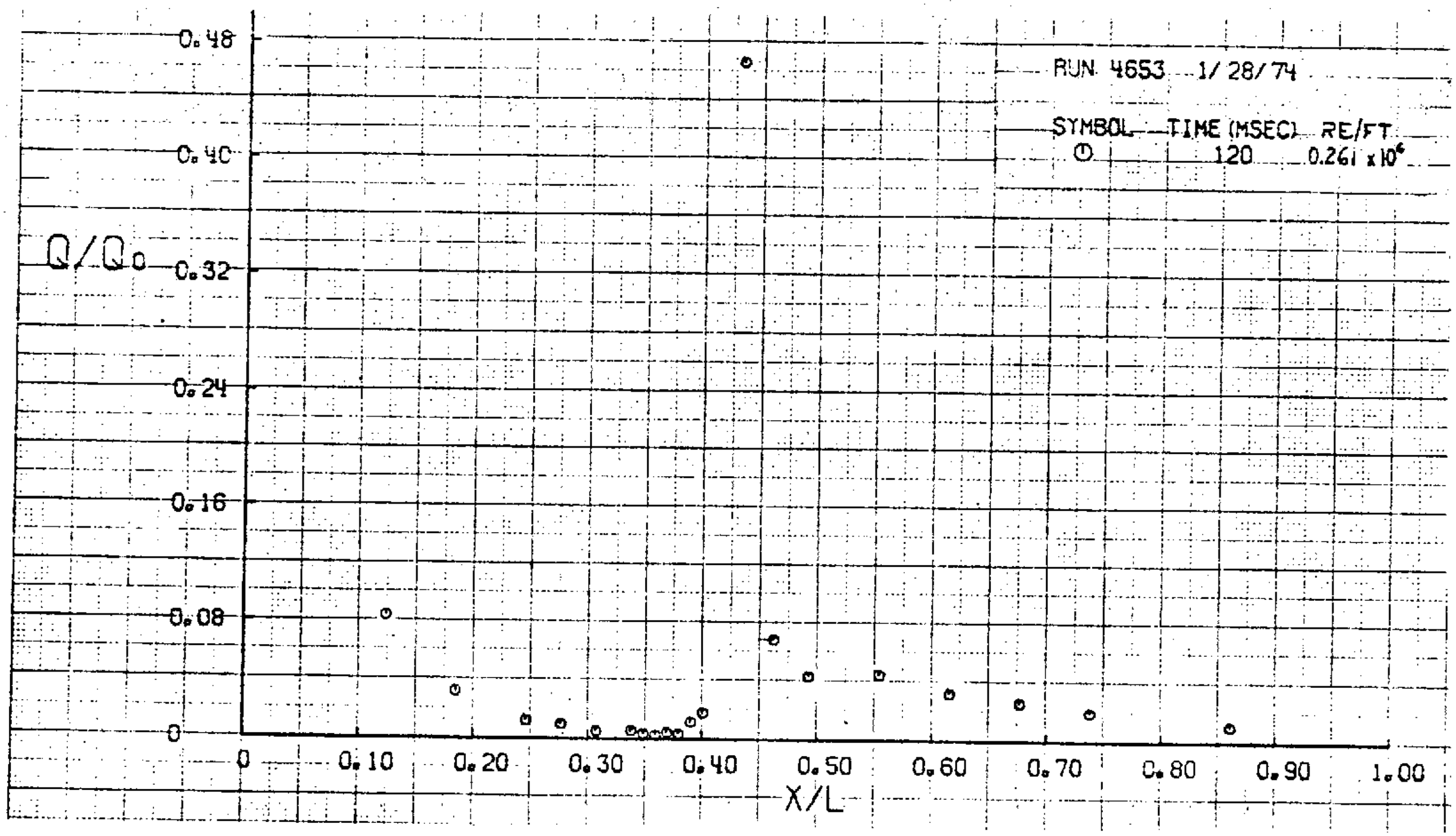
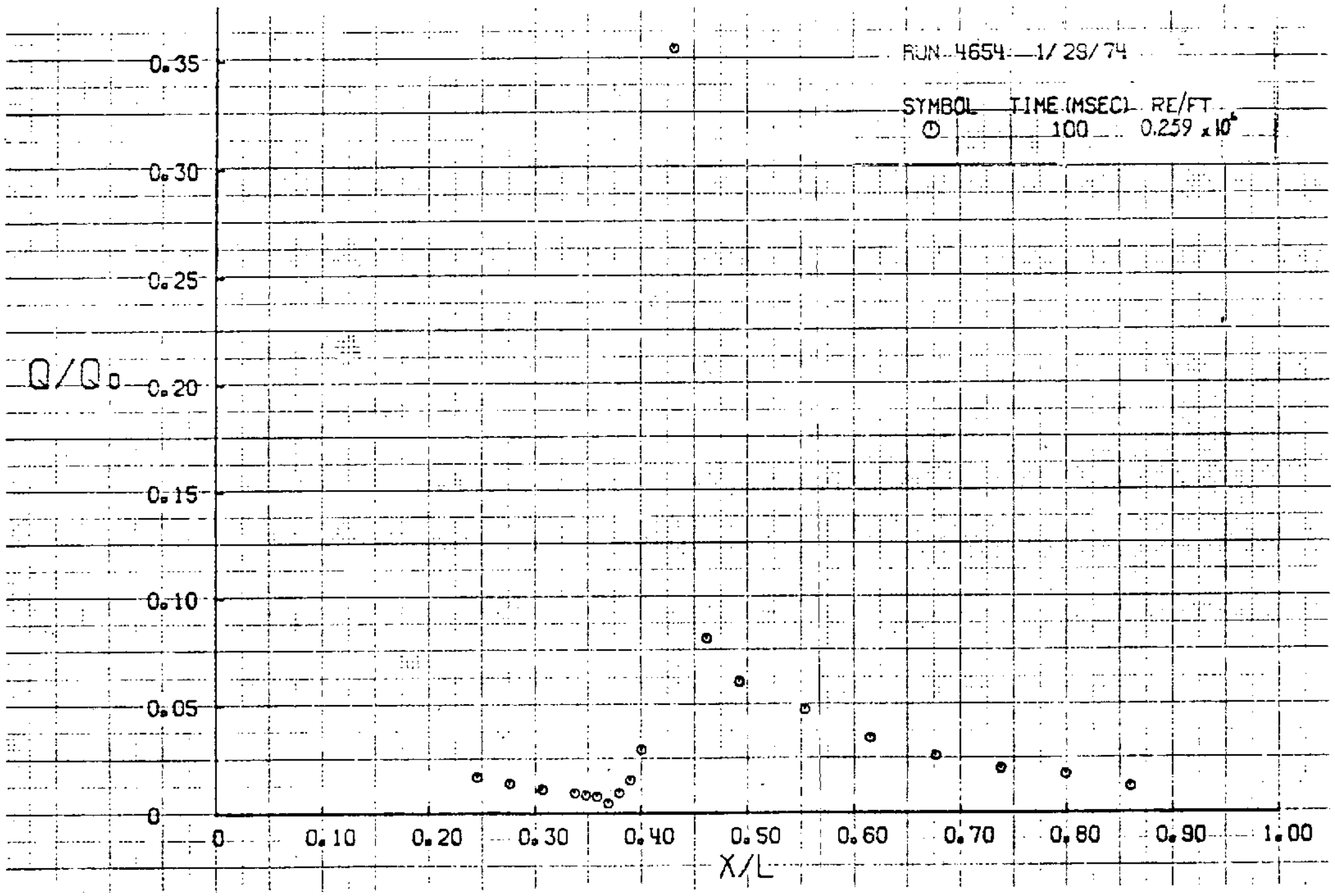
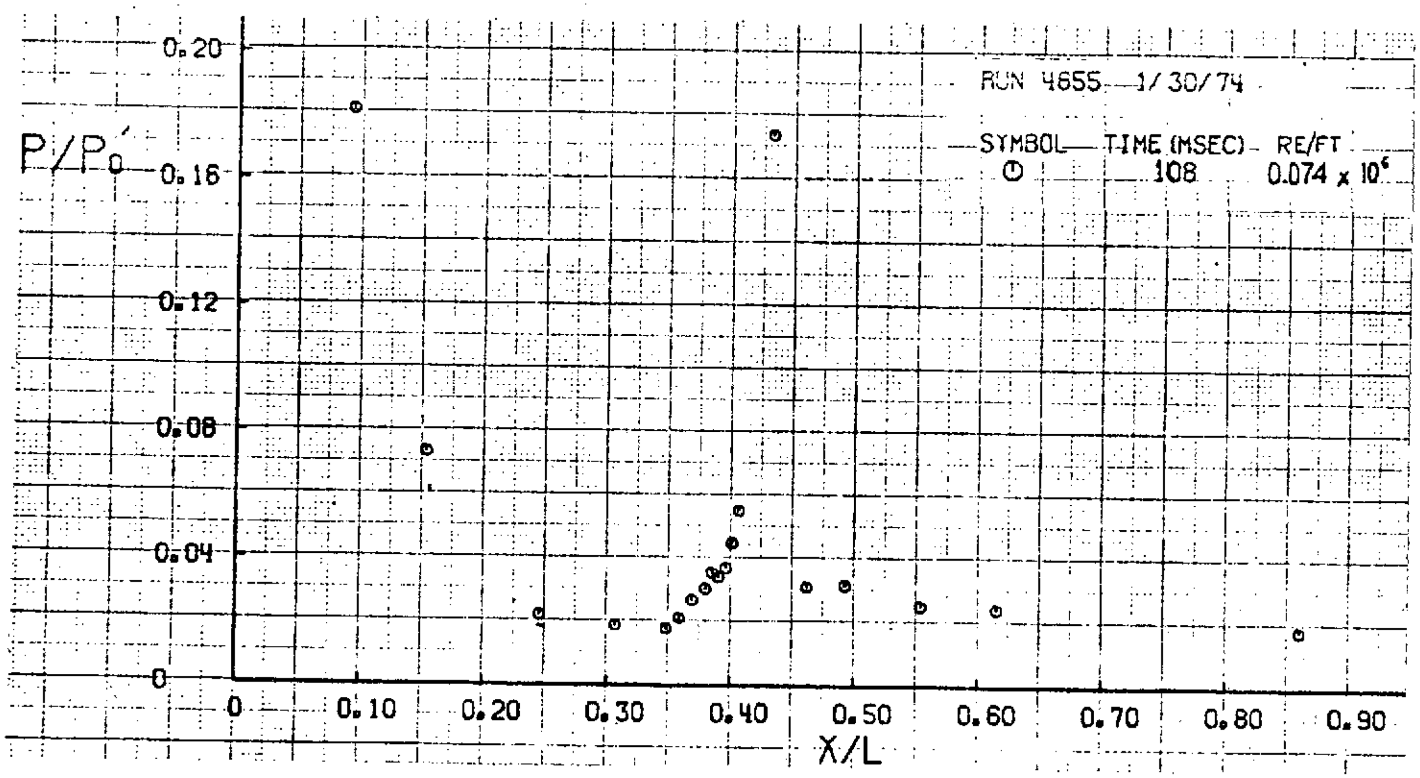


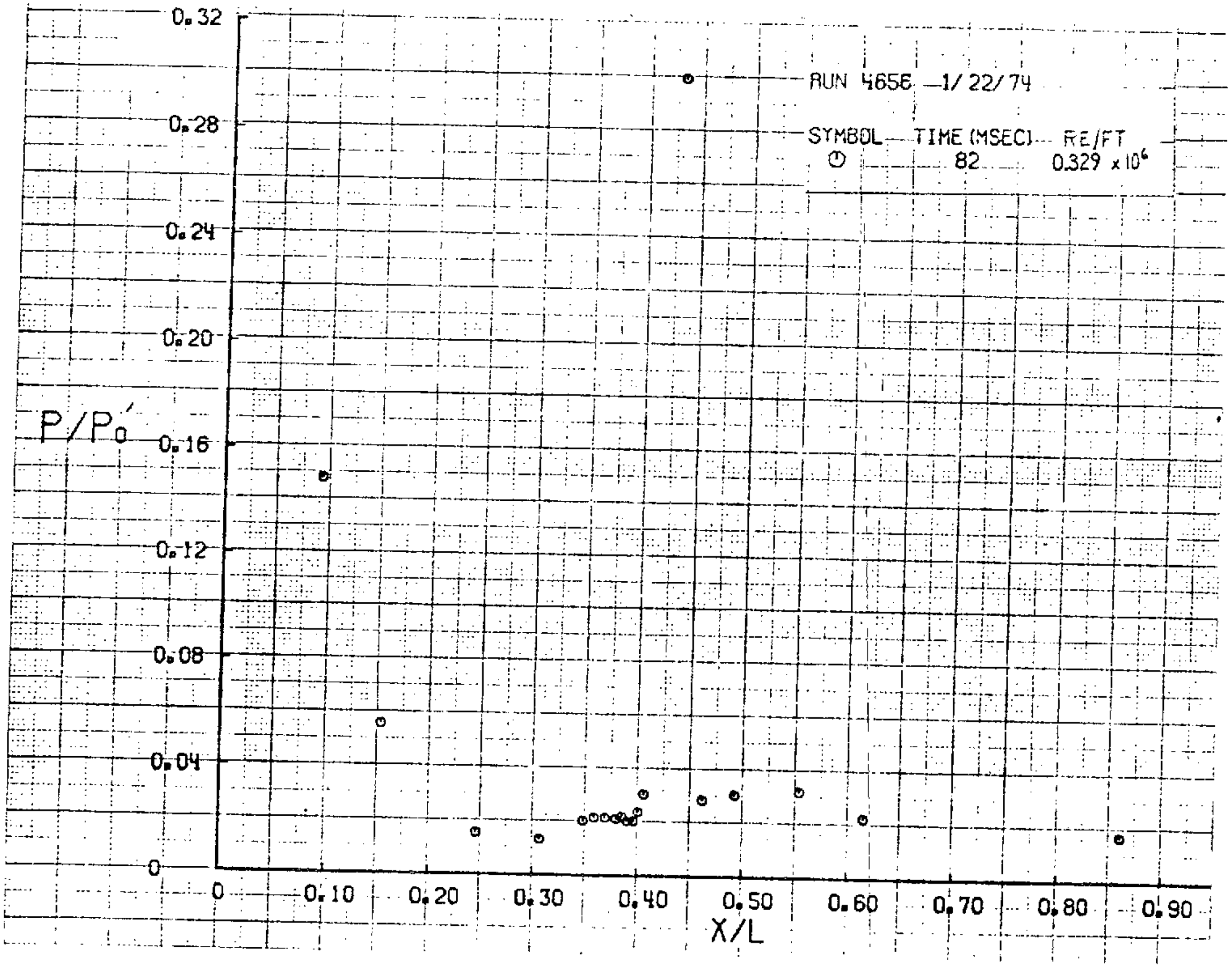
h. $M_\infty \cong 16$, Mated, with Tunnels, with Tie Down
Figure 7. Continued



i. $M_\infty \cong 19$, Mated, with Tunnels, with Tie Down
Figure 7. Concluded



a. $M_\infty \cong 19$, Mated, with Tunnels, with Tie Down
Figure 8. Tank Pressure Distributions



b. $M_\infty \cong 16$, Mated, with Tunnels, with Tie Down

Figure 8. Concluded

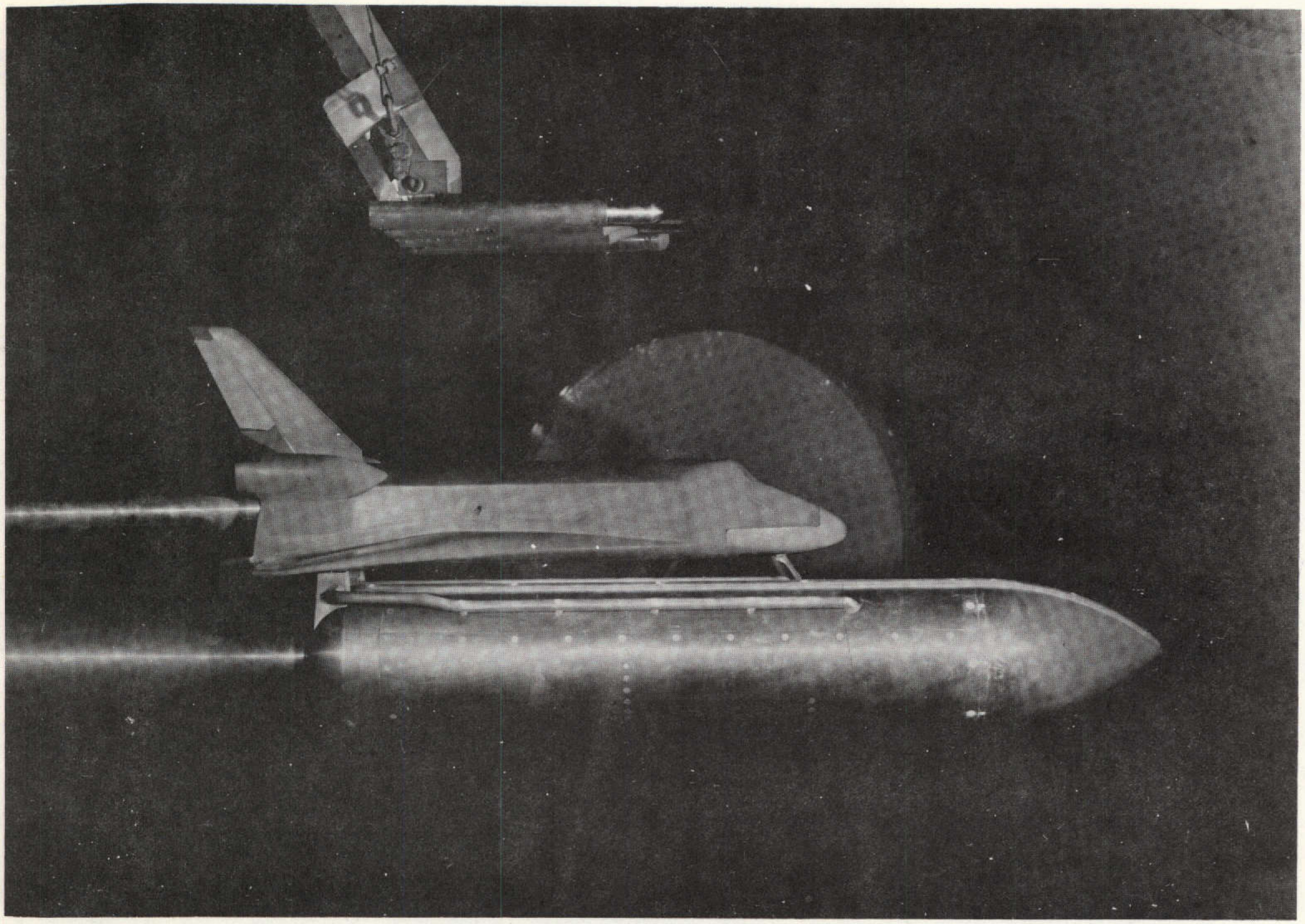


FIGURE 9. ORBITER AND EXTERNAL TANK MATED - SIDE VIEW OF TUNNEL INSTALLATION

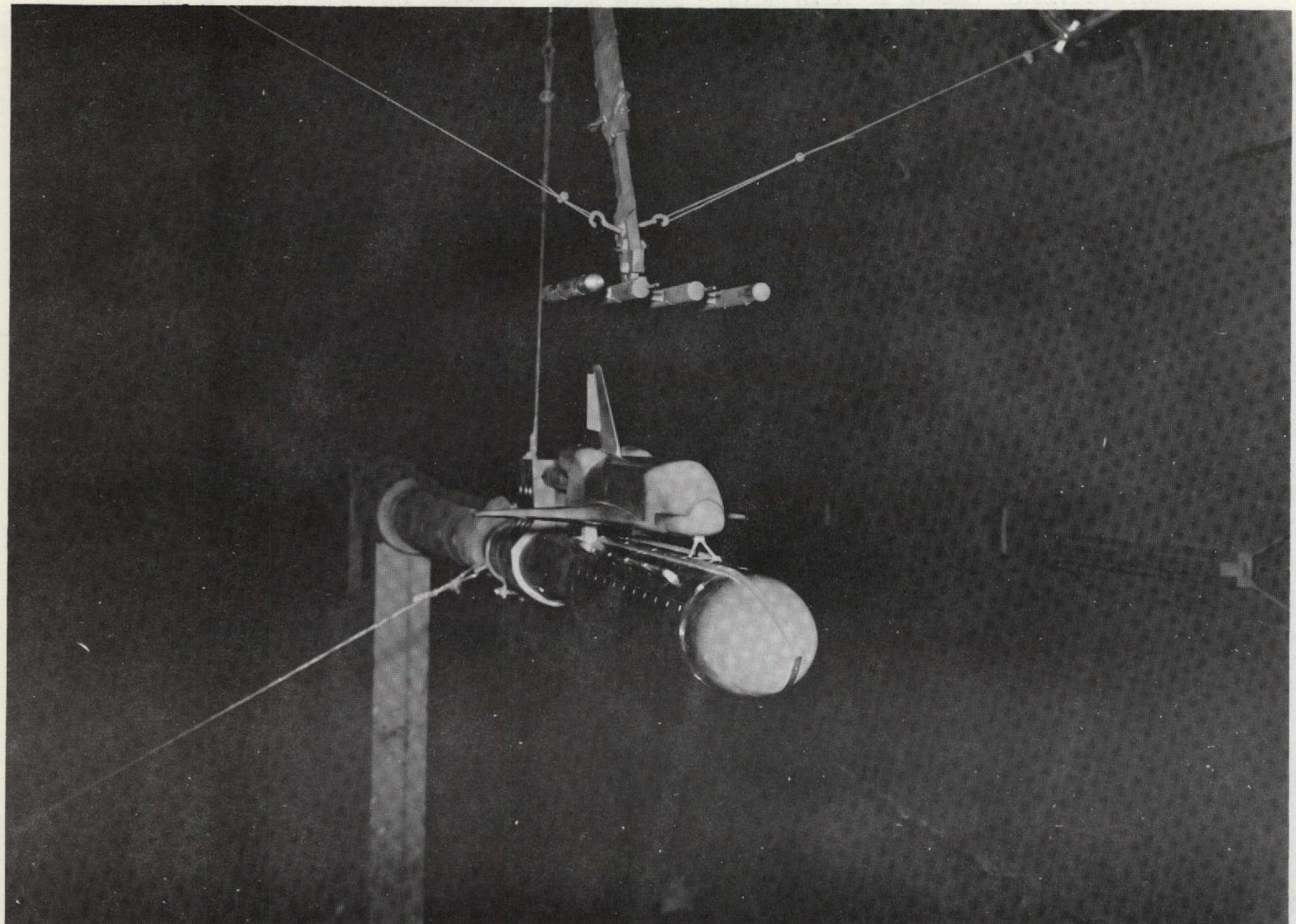


FIGURE 10. ORBITER AND EXTERNAL TANK MATED - 3/4 VIEW OF TUNNEL INSTALLATION

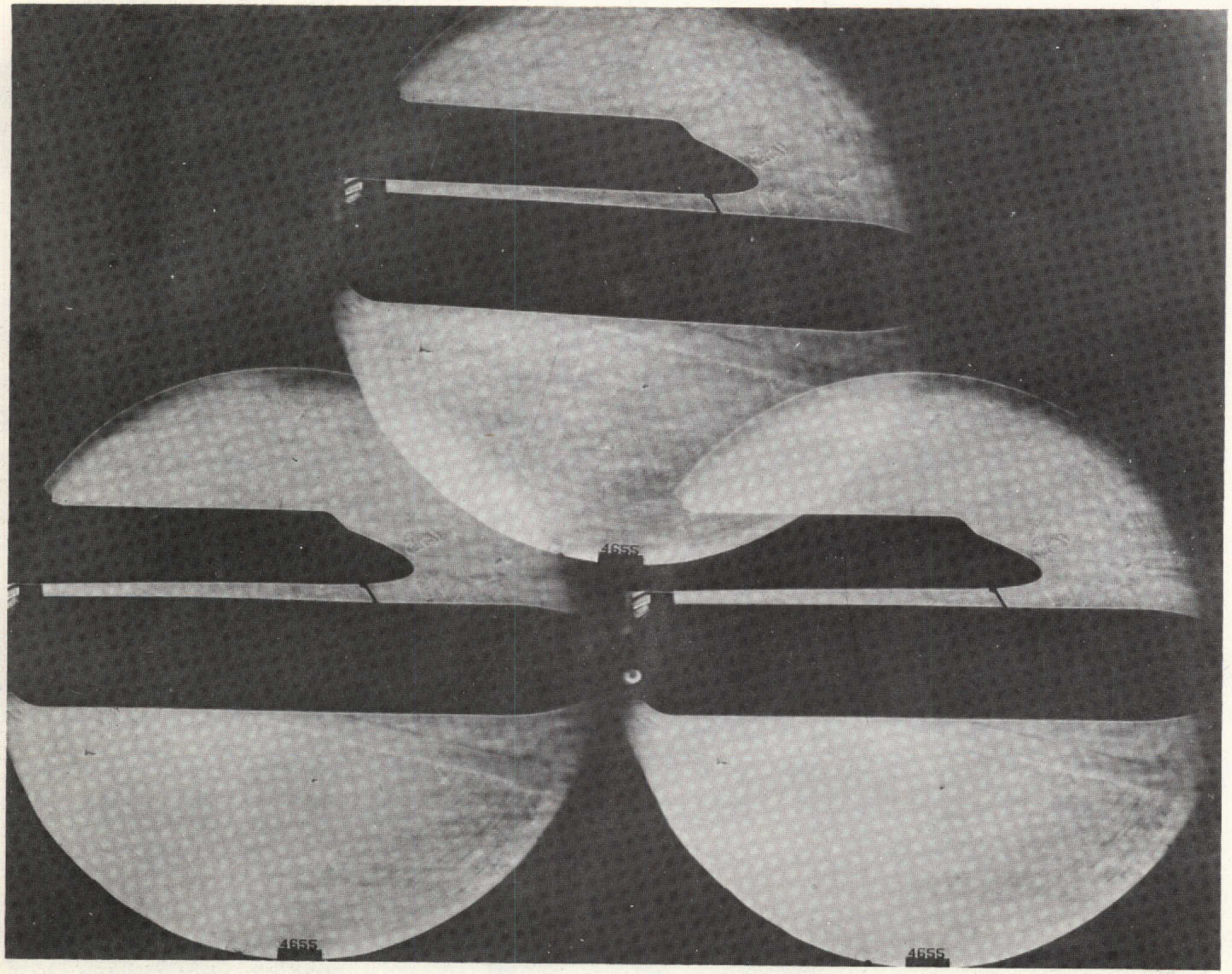


FIGURE 11. RUN 4655 (TARE)

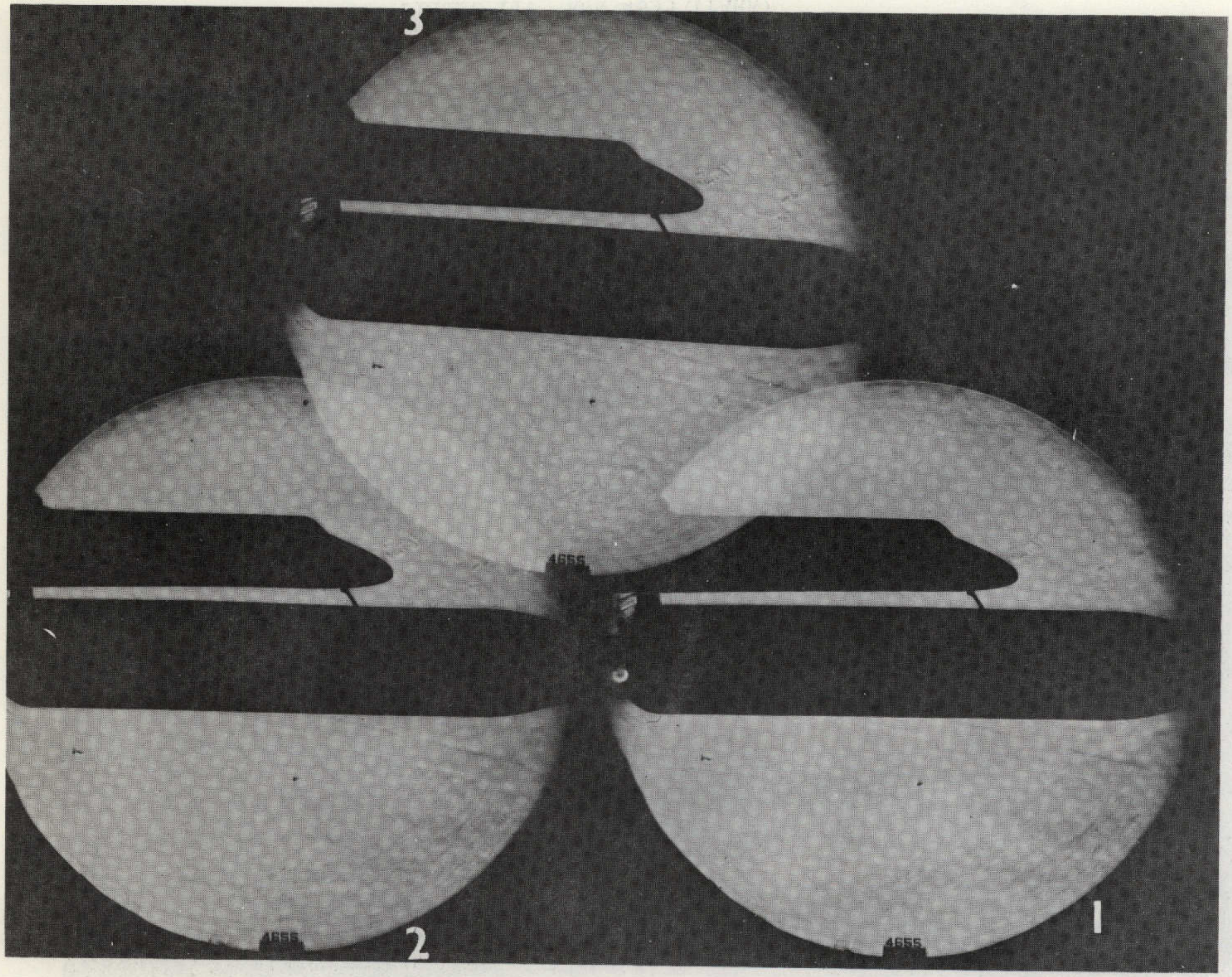


FIGURE 12. RUN 4655 Schlieren at $M_\infty = 19$, $0.070 \times 10^6 < Re/ft < 0.079 \times 10^6$

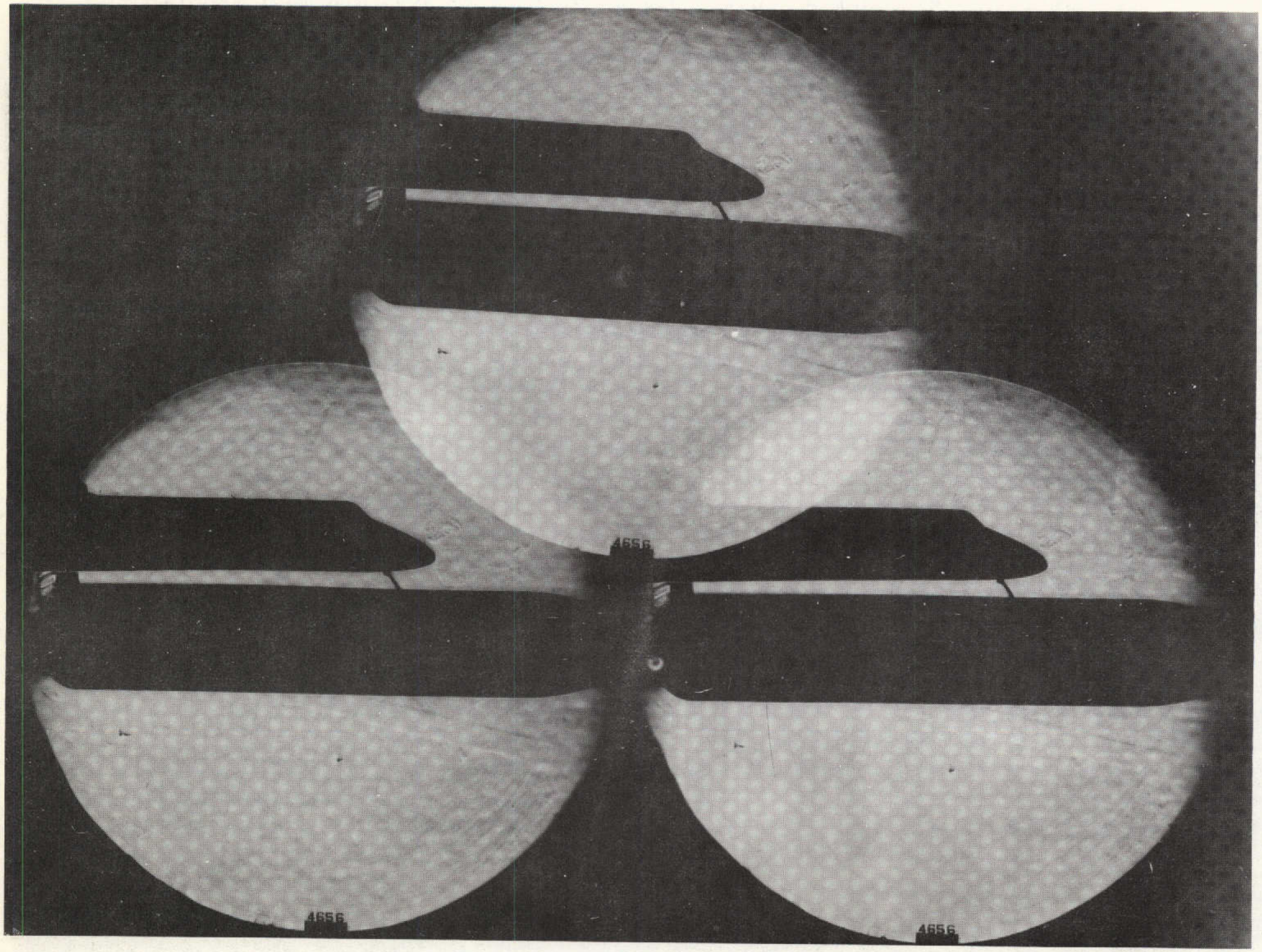


FIGURE 13. RUN 4656 (TARE)

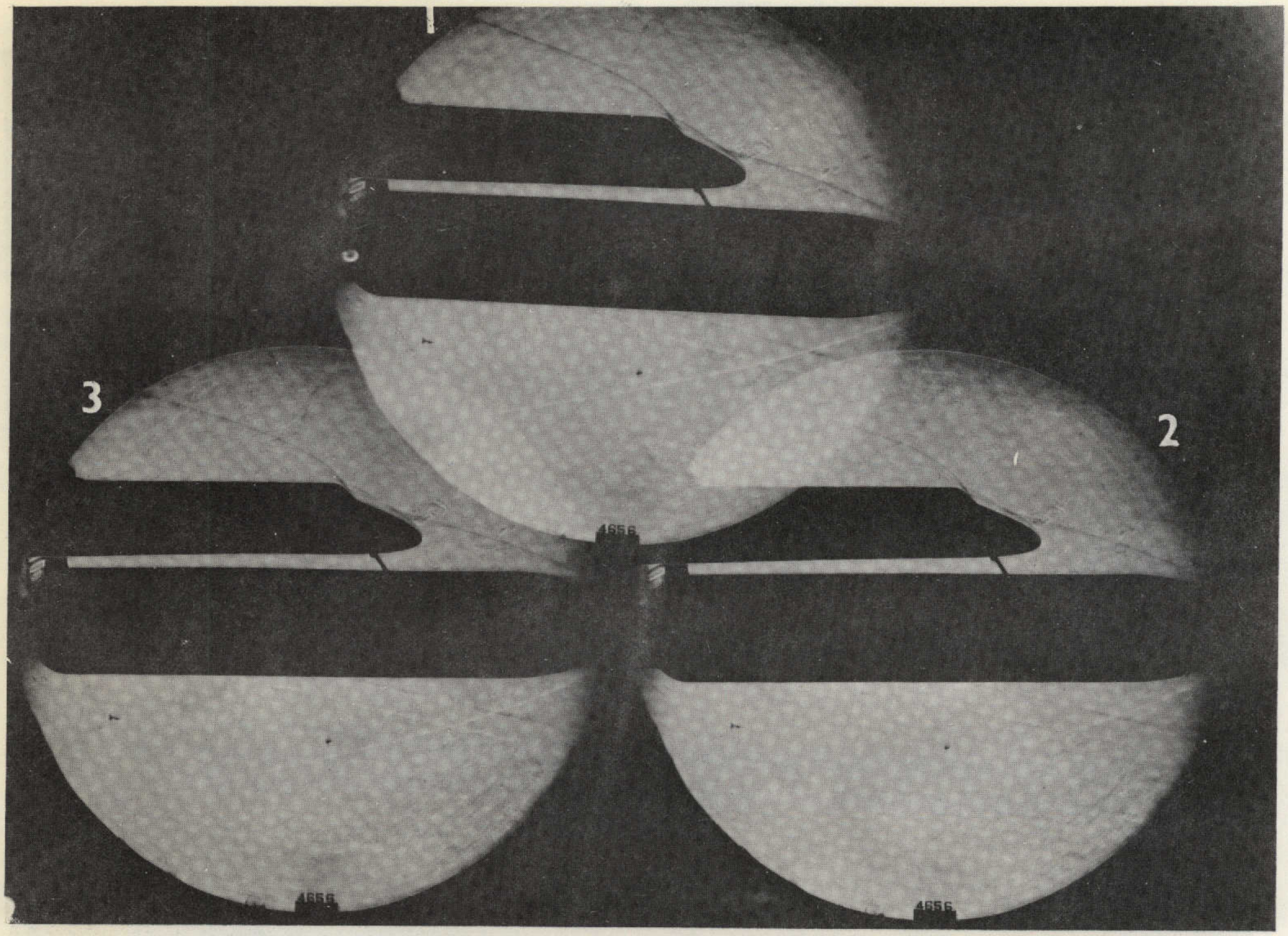


FIGURE 14. RUN 4656 at $M_\infty = 16$, $0.226 \times 10^6 < Re/ft < 0.282 \times 10^6$

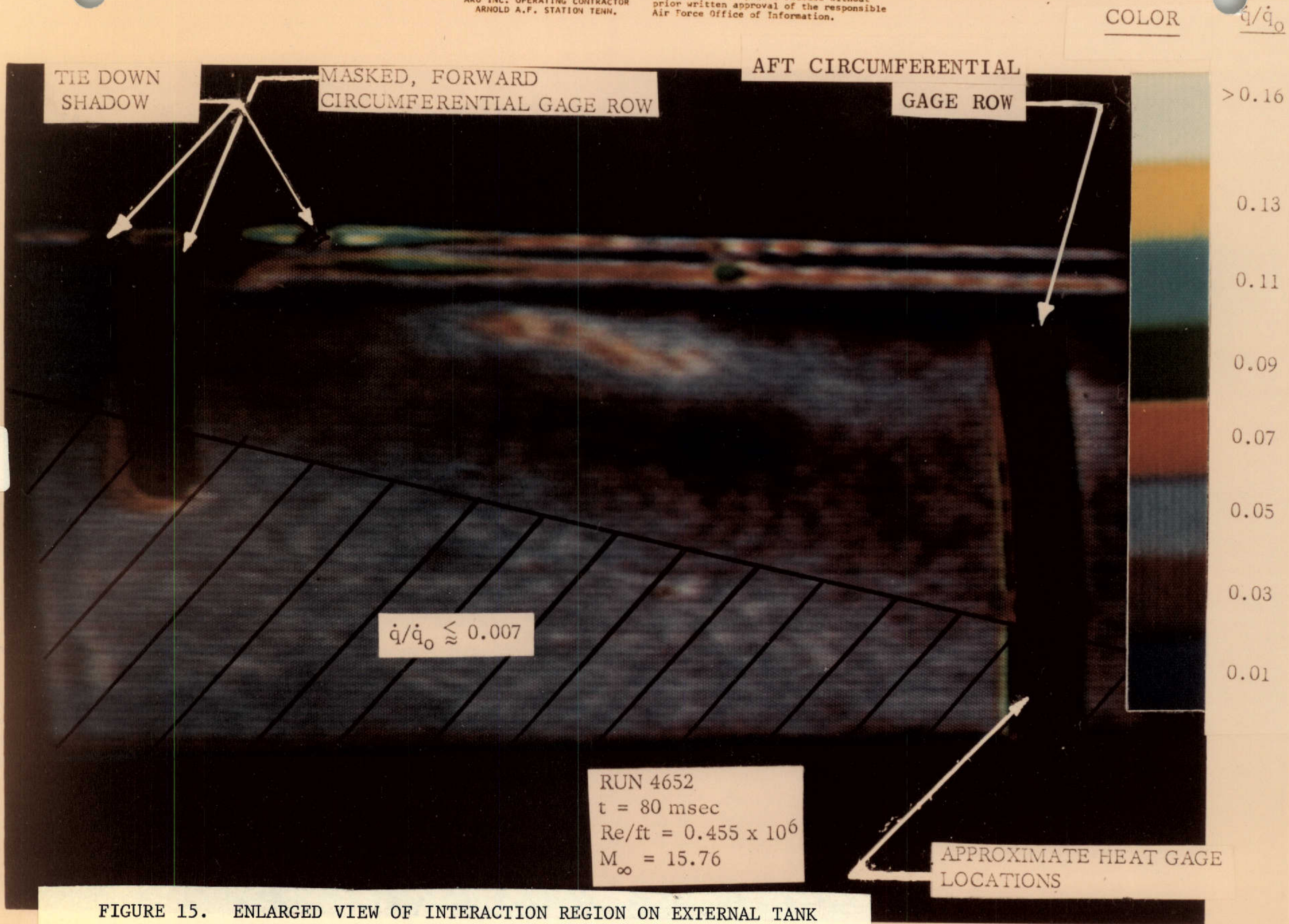


FIGURE 15. ENLARGED VIEW OF INTERACTION REGION ON EXTERNAL TANK USING THERMOGRAPHIC PHOSPHOR PAINT

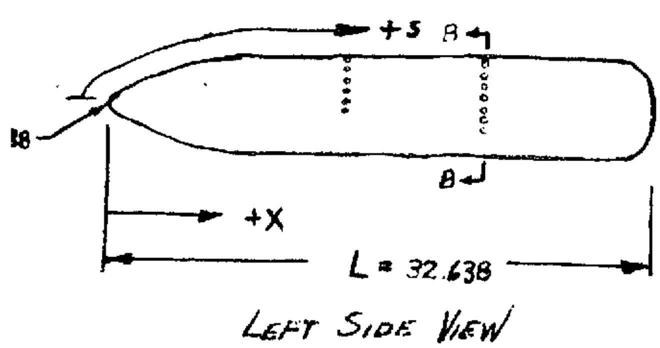
TABLE I. TEST CONDITIONS

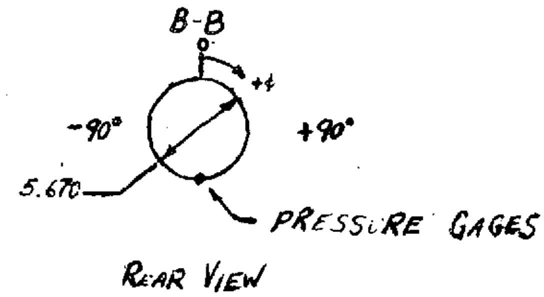
Run No.	Model Configuration	$\approx M_\infty$	$\approx Re/ft \times 10^{-6}$	Optical Data	α, deg	ϕ_s, deg	ϕ', deg
4646	ET only No tunnels	19	0.1	None	0	0.0	0
4647	Mated No tunnels No tie down	19	0.1	None	0	37.5	0
4648	ET only No tunnels	16	0.3	None	0	37.5	0
4649	ET only With tunnels	19	0.1	None	0	37.5	0
4650	Mated With tunnels With tie down	16	0.3	Paint Tare*	0	37.5	0
4651	↓	19	0.1	Paint Tare*	0	37.5	0
4652	↓	16	0.6	Paint Data	0	37.5	0
4653	↓	16	0.3	None	0	37.5	0
4654	↓	19	0.25	None	0	37.5	0
4655	↓	19	0.1	Schlieren Stills	0	0.0	180
4656	↓	16	0.3	Schlieren Stills	0	0.0	180

*A thermographic phosphor paint tare photograph was taken on these runs to determine the possibility of obtaining paint data at these run conditions.

Run 4647 was the only mated run on which the tie down was not used.

TABLE II. GAGE LOCATION





NOTE: ALL DIMENSIONS IN INCHES AND DEGREES

GAGE Heat	GAGE Pressure	X (in.)	X/L	s(in.)	s/r_n	ϕ* (deg)
Q1	P1	0	0	0	0	0
Q2		1.0	0.0306	1.3968	4.85	0
Q3		2.0	0.0613	2.551	8.86	
	P4	3.0	0.0919	3.687	12.80	
Q5		4.0	0.1226	4.750	16.49	
	P6	5.0	0.1532	5.850	20.31	
Q7		6.0	0.1838	6.821	23.68	
Q8	P8	8.02	0.2456	8.887	30.86	
Q9		9.02	0.2763	9.887	34.33	
Q10	P10	10.02	0.3069	10.887	37.80	
Q11		11.02	0.3375	11.887	41.27	
Q12	P12	11.36	0.3481	12.227	42.45	
Q13	P13	11.70	0.3586	12.567	43.64	
Q14	P14	12.05	0.3691	12.917	44.85	
Q15	P15	12.39	0.3797	13.257	46.03	
Q16	P16	12.74	0.3902	13.607	47.25	
Q17	P17	13.08	0.4007	13.947	48.43	
Q18	P18	14.08	0.4314	14.947	51.90	
Q19	P19	15.08	0.4620	15.947	55.37	
Q20	P20	16.08	0.4926	16.947	58.84	
Q21	P21	18.08	0.5539	18.947	65.79	
Q22	P22	20.08	0.615	20.947	72.73	
Q23		22.08	0.677	22.947	79.68	
Q24		24.08	0.738	24.947	86.62	
Q25		26.08	0.799	26.947	93.57	
Q26	P26	28.08	0.860	28.947	100.51	0
Q28		11.19	0.343	12.057	41.86	7
Q29		11.53	0.353	12.697	43.05	7

TABLE II. GAGE LOCATION (Continued)

GAGE						
Heat	Pressure	X (in.)	X/L	s(in.)	s/r_n	ϕ* (deg)
Q30		11.88	0.364	12.747	44.26	7
Q31		12.22	0.374	13.087	45.44	7
Q32		12.56	0.385	13.427	46.62	7
Q33		12.91	0.395	13.777	47.84	7
Q34		10.33	0.317	11.197	38.88	-43
Q35		10.67	0.327	11.537	40.06	-43
Q36		11.02	0.338	11.887	41.27	-43
Q37		11.36	0.348	12.227	42.45	-36
Q38		11.36	0.348	12.227	42.45	-26
Q39		13.25	0.406	14.117	49.02	-36
Q40		↓	↓	↓	↓	-26
Q41		↓	↓	↓	↓	10
Q42		↓	↓	↓	↓	20
Q43		↓	↓	↓	↓	30
Q44		↓	↓	↓	↓	40
Q45		↓	↓	↓	↓	50
Q46		↓	↓	↓	↓	60
Q47		20.08	0.615	20.947	72.73	-36
Q48		↓	↓	↓	↓	-26
Q49		↓	↓	↓	↓	-10
Q50		↓	↓	↓	↓	10
Q51		↓	↓	↓	↓	30
Q52		↓	↓	↓	↓	40
Q53		↓	↓	↓	↓	50
Q54		↓	↓	↓	↓	60
Q55		↓	↓	↓	↓	70
Q56		↓	↓	↓	↓	80
Q57		↓	↓	↓	↓	90
Q58		↓	↓	↓	↓	100
	P15A	12.56	0.3848	13.427	46.62	0
	P16A	12.91	0.3956	13.777	47.84	0
	P17A	13.25	0.406	14.117	49.02	0

*Pressure gages were located on the opposite side of the tank from the heat-transfer-rate gages. On the pressure runs (Runs 4655 and 4656) the tank was rolled 180 deg. putting the ET at ϕ = 180 deg. On the heat-transfer-rate runs (Runs 4646-4654) the ET model was located at ϕ = 0 deg.

APPENDIX

TABULATED SOURCE DATA

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4646

TEST CONDITIONS

ALPHA = 0
PHI$_S$ = 0

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
96	.000560	2.26E-05	64.7	7989	19.93	.156	.120	3558	4534	1.291E 03	33.41	.1598	.289
100	.000509	2.25E-05	59.1	7753	20.23	.146	.115	3482	4292	1.215E 03	29.85	.1582	.271
104	.000512	2.44E-05	54.7	7482	20.29	.147	.116	3443	4023	1.132E 03	27.62	.1515	.276

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P6	P8	P14	P20	P1
96	.0176	.0066	.0050	.0041	.3154
100	.0155	.0061	.0046	.0037	.2939
104	.0156	.0060	.0043	.0038	.2943

PRESSURE DATA (PRESSURE / POP)

TIME	P6	P8	P14	P20	P1
96	.0607	.0227	.0171	.0141	1.0900
100	.0570	.0225	.0169	.0136	1.0840
104	.0570	.0219	.0158	.0140	1.0747

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q17
96	.5747	.4945	.4544	.3843	.3909	.4043	.3976	.3843	.3475
100	.5127	.4456	.4017	.3523	.3527	.3612	.3433	.3463	.3164
104	.4751	.4171	.3895	.3287	.3232	.3356	.3177	.3232	.2983

TIME	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31	Q32	Q33
96	.3208	.3007	.2757	.2807	.2606	.2473	.2043	.4010	.3341	.3742	.3675	.3642
100	.2911	.2753	.2586	.2567	.2388	.2242	.2009	.3672	.2701	.3373	.3304	.3293
104	.2826	.2569	.2293	.2488	.2347	.2155	.1851	.3480	.2845	.3149	.3121	.3121

TIME	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46
96	.3341	.4377	.4243	.4377	.4143	.3876	.2473	.3156	.3222	.3442	.3174	.3158	.3258
100	.2955	.3881	.3683	.3886	.3672	.3403	.2179	.3075	.3062	.3135	.2866	.2851	.2964
104	.2683	.3749	.3651	.3646	.3398	.3177	.1989	.3049	.2762	.2969	.2693	.2679	.2762

TIME	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57
96	.2840	.2840	.2673	.2840	.2506	.2506	.2439	.2339	.2272	.2416
100	.2611	.2611	.2418	.2617	.2235	.2269	.2216	.2089	.2047	.2209
104	.2348	.2472	.2320	.2472	.2141	.2160	.2099	.1989	.1924	.2072

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4646

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / QO)

TIME					Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q17
96					.0172	.0148	.0136	.0115	.0117	.0121	.0116	.0115	.0104
100					.0172	.0149	.0135	.0119	.0118	.0121	.0115	.0116	.0106
104					.0172	.0151	.0141	.0119	.0117	.0121	.0115	.0117	.0108
TIME	Q19	Q20	Q21	Q22	Q23	Q24	Q26		Q29	Q30	Q31	Q32	Q33
96	.0096	.0090	.0083	.0084	.0078	.0074	.0061		.0120	.0100	.0112	.0110	.0109
100	.0097	.0052	.0097	.0086	.0090	.0075	.0067		.0123	.0090	.0113	.0111	.0110
104	.0102	.0093	.0083	.0090	.0085	.0078	.0067		.0126	.0103	.0114	.0113	.0113
TIME	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46
96	.0100	.0131	.0127	.0131	.0124	.0116	.0074	.0094	.0096	.0103	.0095	.0095	.0097
100	.0099	.0130	.0123	.0130	.0123	.0114	.0073	.0103	.0103	.0105	.0096	.0095	.0099
104	.0097	.0136	.0132	.0132	.0123	.0115	.0072	.0110	.0100	.0107	.0097	.0097	.0100
TIME	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57			
96	.0085	.0085	.0080	.0085	.0075	.0075	.0073	.0070	.0068	.0072			
100	.0087	.0087	.0081	.0088	.0075	.0076	.0076	.0070	.0069	.0074			
104	.0085	.0089	.0084	.0089	.0077	.0078	.0076	.0072	.0070	.0075			

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4647

TEST CONDITIONS

ALPHA = 0
PHI$_S$ = 37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
78	.000786	1.97E-05	104.4	9591	18.83	.195	.067	4183	6363	1.863E 03	59.32	.1818	.364
90	.000679	1.74E-05	102.1	9695	19.25	.176	.062	4257	6488	1.902E 03	57.79	.1939	.328
98	.000672	1.67E-05	105.3	9763	19.08	.171	.060	4027	6577	1.929E 03	57.98	.1983	.320
112	.000597	1.49E-05	104.7	9807	19.22	.154	.054	3795	6635	1.947E 03	55.61	.2101	.288
126	.000517	1.46E-05	92.8	9414	19.60	.139	.059	3574	6147	1.793E 03	47.82	.2103	.259

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P6	P8	P10	P14	P20	P1
78	.0233	.0079	.0070	.0058	.0042	.4402
90	.0212	.0073	.0064	.0053	.0039	.4021
98	.0198	.0070	.0063	.0052	.0038	.3900
112	.0180	.0062	.0056	.0046	.0034	.3476
126	.0156	.0055	.0050	.0041	.0029	.3047

PRESSURE DATA (PRESSURE / POP)

TIME	P6	P8	P10	P14	P20	P1
78	.0640	.0217	.0191	.0160	.0116	1.2100
90	.0645	.0221	.0196	.0162	.0119	1.2243
98	.0621	.0218	.0196	.0164	.0120	1.2200
112	.0624	.0216	.0195	.0161	.0117	1.2072
126	.0601	.0211	.0192	.0157	.0110	1.1750

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4647

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
78	.9943	.9182	.8008	.7318	.7215	.7534	.7834	.7533	.7533
90	.9683	.9236	.8095	.7385	.6935	.7455	.7802	.7542	.7513
98	1.0119	.9292	.8077	.7343	.7093	.7622	.7985	.7757	.7770
112	.9566	.8731	.7786	.7063	.6729	.7265	.7730	.7821	.7786
126	*****	.7583	.6834	.6277	.5882	.6444	.6695	.6743	.7221

TIME	Q17	Q18	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31	Q32
78	.8637	3.4319	3.0016	1.9329	1.5783	1.3827	1.0825	.4656	.7571	.6050	.7244	.6146
90	1.0338	3.2122	2.7143	1.8701	1.4737	1.2510	.9652	.3901	.7629	.5779	.6993	.6357
98	1.1365	3.0131	2.6093	1.8534	1.4496	1.2061	.8921	.3508	.7770	.5740	.7190	.6668
112	1.2180	*****	*****	*****	1.3069	1.0455	.7619	.2813	.7508	.5395	.7119	.6776
126	1.1429	*****	*****	*****	1.0759	.8975	.6221	.2200	.6534	.4543	.6378	.5834

TIME	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
78	.7837	.7542	.8015	.7354	.3317	.7711	.6675	.6071	1.2278	.5576	.6406	.6228	.6526
90	.8135	.7801	.7852	.7541	.3208	.7687	.6646	.6117	1.3639	.5779	.6500	.6277	.6395
98	.7462	.7770	.7896	.7475	.3236	.7886	.6784	.6228	1.4543	.5856	.6683	.6405	.6523
112	.9091	.7508	.7619	.7005	.3068	.7564	.6674	.6284	1.5150	.5951	.6562	.6229	.6340
126	.9222	.6550	.6599	.6329	.2678	.6599	.5930	.5867	1.4121	.5643	.5786	.5445	.5629

TIME	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57	Q58
78	.6479	2.1381	2.0997	1.7560	1.8596	2.2165	1.9216	1.3346	.6316	.4345	.3796	.3203
90	.6357	2.0228	1.9361	1.6510	1.7120	2.1095	1.8391	1.3119	.6011	.4251	.3828	.3290
98	.6523	2.0432	1.9549	1.6004	1.6919	2.0505	1.8436	1.3212	.6118	.4227	.3914	.3392
112	.6312	1.8464	1.7240	1.4571	1.5071	*****	1.6538	1.2513	.4004	.3928	.3893	.3365
126	.5451	*****	1.4310	1.1907	1.2103	*****	*****	1.0759	.3491	.3972	.3443	.2965

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4647

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / Q0)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
78	.0169	.0155	.0135	.0123	.0122	.0127	.0132	.0127	.0127
90	.0171	.0160	.0140	.0128	.0120	.0129	.0135	.0131	.0130
98	[illegible]	[illegible]	.0139	.0127	.0122	.0131	.0138	.0134	.0134
112	.0172	.0157	.0140	.0127	.0121	.0131	.0139	.0141	.0140
126	*****	.0159	.0143	.0131	.0123	.0135	.0140	.0141	.0151

TIME	Q17	Q18	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31	Q32
78	.0136	.0579	.0526	.0309	.0266	.0233	.0182	.0078	.0128	.0102	.0122	.0104
90	.0179	.0556	.0470	.0324	.0255	.0216	.0167	.0067	.0132	.0100	.0121	.0110
98	.0196	.0520	.0450	.0320	.0250	.0208	.0154	.0060	.0134	.0099	.0124	.0115
112	.0219	*****	*****	*****	.0235	.0188	.0137	.0050	.0135	.0097	.0128	.0122
126	.0239	*****	*****	*****	.0225	.0188	.0130	.0046	.0137	.0095	.0133	.0122

TIME	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45
78	.0132	.0127	.0135	.0124	.0056	.0130	.0113	.0107	.0207	.0094	.0108	.0105	.0110
90	.0141	.0135	.0135	.0130	.0055	.0133	.0115	.0106	.0236	.0100	.0112	.0109	.0111
98	.0129	.0134	.0136	.0129	.0056	.0136	.0117	.0107	.0251	.0101	.0115	.0110	.0113
112	.0163	.0135	.0137	.0126	.0055	.0136	.0120	.0113	.0272	.0107	.0118	.0112	.0114
126	.0193	.0137	.0138	.0132	.0056	.0138	.0124	.0123	.0295	.0118	.0121	.0114	.0118

TIME	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57	Q58
78	.0109	.0360	.0354	.0296	.0314	.0374	.0324	.0225	.0106	.0073	.0064	.0054
90	.0110	.0350	.0335	.0286	.0296	.0365	.0318	.0227	.0104	.0074	.0066	.0057
98	.0113	.0352	.0337	.0276	.0292	.0354	.0318	.0228	.0106	.0073	.0068	.0058
112	.0113	.0332	.0310	.0262	.0271	*****	.0297	.0225	.0072	.0071	.0070	.0060
126	.0114	*****	.0299	.0249	.0253	*****	*****	.0225	.0073	.0083	.0072	.0062

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1976 PROJECT ENGINEER D.R. HABERMAN

RUN 4648

TEST CONDITIONS

ALPHA = 0.
PHI_S = 37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
89	.001921	7.76E-05	64.7	6408	15.98	.344	.300	2245	3071	8.359E 02	28.46	.0814	.636
97	.001789	6.99E-05	66.8	6518	15.99	.320	.266	2135	3168	8.649E 02	28.74	.0863	.593
100	.001720	6.47E-05	69.4	6646	16.00	.308	.257	2097	3281	8.991E 02	29.69	.0902	.571
105	.001705	6.78E-05	65.7	6462	15.99	.305	.251	2027	3120	8.502E 02	27.42	.0874	.565
109	.001582	6.38E-05	64.8	6460	16.10	.287	.246	1971	3118	8.495E 02	26.56	.0901	.531
121	.001432	5.87E-05	63.7	6424	16.15	.261	.231	1821	3087	8.399E 02	24.95	.0937	.484

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P6	P8	P10	P14	P20	P1
89	.0312	.0107	.0103	.0081	.0066	.5153
97	.0289	.0103	.0098	.0077	.0062	.5010
100	.0279	.0098	.0096	.0074	.0059	.4876
105	.0276	.0098	.0095	.0073	.0059	.4748
109	.0259	.0091	.0089	.0069	.0055	.4542
121	.0239	.0083	.0081	.0062	.0051	.4052

PRESSURE DATA (PRESSURE / POP)

TIME	P6	P8	P10	P14	P20	P1
89	.0490	.0169	.0163	.0128	.0104	.8100
97	.0487	.0173	.0165	.0131	.0105	.8445
100	.0489	.0171	.0168	.0130	.0104	.8535
105	.0489	.0173	.0168	.0130	.0104	.8400
109	.0488	.0171	.0168	.0130	.0104	.8547
121	.0493	.0172	.0168	.0128	.0106	.8379

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4648

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q2	Q3	Q5	Q8	Q9	Q10	Q11	Q12	Q13	Q15	Q16
89	7.2522	4.4651	1.7473	.4010	.3413	.3000	.2887	.2915	.2929	.2675	.2688
97	7.1914	4.3978	1.7321	.4121	.3499	.2989	.2874	.2874	.2961	.2824	.2706
100	7.4221	4.5126	1.6497	.4174	.3563	.3114	.3002	.2969	.3058	.2761	.2791
105	6.6831	4.1408	1.7002	.3891	.3291	.2852	.2701	.2715	.2811	.2550	.2578
109	6.6138	3.9842	1.6203	.3665	.3187	.2762	.2603	.2603	.2709	.2525	.2497
121	6.1140	3.6684	1.4723	.3394	.3394	.2557	.2458	.2396	.2533	.2294	.2371

TIME	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31
89	.2766	.2531	.2460	.2327	.2108	.1992	.1891	.1735	.1580	.3022	.2732	.2730
97	.2673	.2559	.2486	.2357	.2141	.2012	.1926	.1768	.1609	.2989	.2702	.2777
100	.2761	.2675	.2568	.2481	.2227	.2078	.1989	.1841	.1663	.3157	.2791	.2850
105	.2523	.2421	.2372	.2278	.2070	.1911	.1850	.1728	.1549	.2852	.2550	.2633
109	.2430	.2337	.2298	.2178	.2005	.1873	.1772	.1687	.1494	.2765	.2444	.2563
121	.2246	.2246	.2138	.2046	.1897	.1834	.1709	.1650	.1360	.2627	.2332	.2446

TIME	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44
89	.2247	.2730	.2844	.2901	.2929	.1763	.2958	.2576	.2702	.2554	.2560	.2528	.2275
97	.2272	.2745	.2503	.2903	.2961	.1782	.2961	.2529	.2702	.2587	.2587	.2616	.2386
100	.2345	.2820	.2880	.3009	.3028	.1826	.3083	.2598	.2791	.2672	.2685	.2702	.2494
105	.2212	.2566	.2678	.2775	.2819	.1737	.2797	.2413	.2578	.2468	.2455	.2495	.2331
109	.2072	.2462	.2537	.2683	.2683	.1674	.2683	.2337	.2483	.2391	.2391	.2430	.2284
121	.2002	.2422	.2396	.2533	.2556	.1522	.2576	.2196	.2321	.2294	.2316	.2298	.2246

TIME	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57
89	.2531	.2503	.1934	.1977	.1991	.2090	.2121	.2204	.2250	.2090	.2048	.2090
97	.2529	.2486	.1893	.1998	.2041	.2127	.2084	.2185	.2185	.2084	.2056	.2113
100	.2613	.2553	.2019	.2048	.2165	.2197	.2107	.2241	.2256	.2126	.2078	.2182
105	.2386	.2345	.1865	.1892	.1974	.2043	.1913	.2082	.2057	.1974	.1892	.2016
109	.2502	.2258	.1833	.2046	.1980	.1964	.1873	.1953	.1925	.1899	.1936	.1952
121	.2134	.2096	.1747	.1759	.1872	.1909	.1734	.1784	.1901	.1772	.1723	.1822

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4648

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / QO)

TIME	Q2	Q3	Q5	Q8	Q9	Q10	Q11	Q12	Q13	Q15	Q16
89	.2550	.1570	.0628	.0141	.0120	.0105	.0102	.0103	.0103	.0094	.0094
97	.2502	.1530	.0620	.0143	.0121	.0104	.0100	.0100	.0103	.0098	.0094
100	.2500	.1520	.0620	.0141	.0120	.0105	.0101	.0100	.0103	.0093	.0094
105	.2510	.1510	.0620	.0142	.0120	.0104	.0098	.0099	.0102	.0093	.0094
109	.2490	.1500	.0610	.0138	.0120	.0104	.0098	.0098	.0102	.0095	.0094
121	.2450	.1470	.0590	.0136	.0124	.0102	.0098	.0096	.0102	.0092	.0095

TIME	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31
89	.0095	.0089	.0086	.0082	.0074	.0070	.0067	.0061	.0056	.0106	.0096	.0096
97	.0093	.0089	.0086	.0082	.0074	.0070	.0067	.0062	.0056	.0104	.0094	.0097
100	.0093	.0090	.0086	.0084	.0075	.0070	.0067	.0062	.0056	.0106	.0094	.0096
105	.0092	.0088	.0086	.0083	.0076	.0070	.0067	.0063	.0056	.0104	.0093	.0096
109	.0091	.0088	.0086	.0082	.0075	.0070	.0067	.0063	.0056	.0104	.0092	.0096
121	.0090	.0090	.0096	.0082	.0076	.0073	.0068	.0066	.0054	.0105	.0093	.0098

TIME	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44
89	.0079	.0096	.0100	.0102	.0103	.0062	.0104	.0091	.0095	.0090	.0090	.0091	.0080
97	.0079	.0095	.0097	.0101	.0103	.0062	.0103	.0088	.0094	.0090	.0090	.0091	.0083
100	.0079	.0095	.0097	.0101	.0102	.0061	.0104	.0088	.0094	.0090	.0090	.0091	.0084
105	.0081	.0094	.0098	.0101	.0103	.0063	.0102	.0088	.0094	.0090	.0090	.0091	.0085
109	.0078	.0093	.0095	.0101	.0101	.0063	.0101	.0088	.0094	.0090	.0090	.0091	.0086
121	.0080	.0097	.0096	.0102	.0102	.0061	.0103	.0088	.0093	.0092	.0093	.0092	.0090

TIME	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57
89	.0089	.0088	.0068	.0069	.0070	.0073	.0075	.0077	.0079	.0073	.0072	.0073
97	.0088	.0086	.0066	.0069	.0071	.0074	.0072	.0076	.0076	.0072	.0072	.0073
100	.0088	.0086	.0068	.0069	.0073	.0074	.0071	.0075	.0076	.0072	.0070	.0073
105	.0087	.0086	.0068	.0069	.0072	.0074	.0070	.0076	.0075	.0072	.0069	.0073
109	.0094	.0085	.0069	.0077	.0075	.0074	.0070	.0074	.0072	.0072	.0073	.0073
121	.0086	.0084	.0070	.0070	.0075	.0076	.0069	.0071	.0076	.0071	.0069	.0073

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4649

TEST CONDITIONS

ALPHA = 0
PHI_S =37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
70	.000736	2.36E-05	81.6	8517	18.92	.184	.111	3513	5108	1.469E 03	42.98	.1604	.343
86	.000708	2.11E-05	87.4	8917	19.13	.181	.089	3836	5557	1.610E 03	47.81	.1719	.337
94	.000686	2.06E-05	86.8	8886	19.13	.176	.082	3717	5522	1.598E 03	46.69	.1737	.327
102	.000654	1.94E-05	87.9	8899	19.94	.166	.077	3449	5541	1.603E 03	45.54	.1791	.309
112	.000585	1.82E-05	82.6	8790	19.26	.152	.075	3298	5416	1.564E 03	42.22	.1843	.283
130	.000570	1.91E-05	77.9	8449	19.20	.147	.072	3020	5037	1.445E 03	37.62	.1775	.274

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P6	P8	P10	P14	P20	P1
70	.0230	.0072	.0057	.0049	.0039	.3601
86	.0224	.0072	.0057	.0050	.0038	.3577
94	.0216	.0068	.0057	.0048	.0037	.3503
102	.0204	.0065	.0053	.0047	.0036	.3325
112	.0187	.0061	.0049	.0045	.0033	.3054
130	.0181	.0058	.0047	.0043	.0032	.2959

PRESSURE DATA (PRESSURE / POP)

TIME	P6	P8	P10	P14	P20	P1
70	.0670	.0209	.0165	.0144	.0114	1.0500
86	.0665	.0208	.0169	.0147	.0113	1.0600
94	.0660	.0208	.0173	.0148	.0112	1.0700
102	.0660	.0211	.0172	.0151	.0117	1.0756
112	.0660	.0214	.0173	.0158	.0118	1.0800
130	.0660	.0210	.0172	.0156	.0118	1.0800

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4649

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q8	Q9	Q11	Q12	Q13	Q15	Q16
70	.6758	.5158	.3868	.4262	.3884	.3403	.3761
86	.8033	.6503	.4784	.4973	.4623	.4016	.4564
94	.8311	.7057	.5392	.5482	.4482	.4352	.5107
102	.8288	.6967	.5282	.5508	.4554	.4371	.5009
112	.7769	.6733	.5092	.5106	.4332	.4096	.4687
130	.7305	.6081	.4364	.4364	.3837	.3612	.4232

TIME	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31
70	.3758	.3536	.3154	.2923	.2800	.2686	.2611	.2486	.2372	.4972	.3782	.4458
86	.4208	.4112	.3825	.3634	.3347	.3275	.3156	.2917	.2580	.5632	.4426	.4904
94	.4389	.4477	.4015	.3879	.3575	.3455	.3356	.3081	.2921	.5883	.4739	.5483
102	.4554	.4455	.4098	.3825	.3691	.3483	.3301	.3096	.2823	.5874	.4618	.5553
112	.4281	.4065	.3907	.3683	.3427	.3251	.3129	.2913	.2615	.5573	.4318	.5137
130	.3762	.3553	.3461	.3266	.2934	.2784	.2633	.2596	.2302	.5041	.3762	.4514

TIME	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44
70	.3353	.4346	.4513	.5018	.5308	.2364	.3095	.2837	.2407	.3797	.4513	.4556	.4384
86	.4303	.5026	.5977	.5826	.6135	.3060	.3852	.3448	.3273	.4346	.5451	.5307	.4877
94	.4588	.5376	.6387	.5976	.6508	.3222	.4134	.3682	.3411	.4548	.5765	.5369	.4809
102	.4621	.5328	.6152	.6258	.6284	.3279	.4144	.3607	.3370	.4656	.5464	.5350	.4736
112	.4367	.5003	.5685	.5867	.5835	.3082	.3927	.3395	.3338	.4335	.5067	.4733	.4433
130	.3762	.4514	.4853	.5382	.5191	.2840	.3574	.2972	.2821	.3762	.4514	.4800	.4073

TIME	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57
70	.4083	.4298	.1526	.2199	.2020	.2837	.3101	.3441	.3447	.3267	.3382	.3508
86	.4973	.4480	.1915	.2563	.2630	.3365	.3562	.3987	.3873	.3850	.3825	.4016
94	.5089	.5136	.1947	.2720	.2854	.3595	.3712	.4039	.3922	.3829	.3782	.4080
102	.5192	.5123	.2004	.2231	.2823	.3693	.3694	.4014	.3916	.3871	.3821	.4098
112	.4813	.4750	.1942	.2111	.2702	.3462	.3378	.3716	.3673	.3673	.3483	.3884
130	.4364	.4381	.1843	.1969	.2582	.3099	.3066	.3458	.3348	.3410	.3141	.3536

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / QO)

TIME	Q8	Q9	Q11	Q12	Q13	Q15	Q16
70	.0157	.0120	.0090	.0099	.0090	.0079	.0087
86	.0168	.0136	.0100	.0104	.0092	.0084	.0095
94	.0178	.0151	.0115	.0117	.0096	.0093	.0109
102	.0182	.0153	.0116	.0121	.0100	.0096	.0110
112	.0184	.0159	.0121	.0121	.0103	.0097	.0111
130	.0194	.0162	.0116	.0116	.0102	.0096	.0112

TIME	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31
70	.0087	.0082	.0073	.0068	.0065	.0063	.0061	.0058	.0055	.0116	.0088	.0104
86	.0088	.0086	.0080	.0076	.0070	.0068	.0066	.0061	.0054	.0118	.0093	.0103
94	.0094	.0096	.0086	.0083	.0077	.0074	.0072	.0066	.0063	.0126	.0101	.0117
102	.0100	.0098	.0090	.0084	.0081	.0077	.0072	.0068	.0062	.0129	.0101	.0122
112	.0101	.0096	.0093	.0087	.0081	.0077	.0074	.0069	.0062	.0132	.0102	.0122
130	.0100	.0094	.0092	.0087	.0078	.0074	.0070	.0069	.0061	.0134	.0100	.0120

TIME	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44
70	.0078	.0101	.0105	.0117	.0124	.0055	.0072	.0066	.0056	.0088	.0105	.0106	.0102
86	.0090	.0105	.0125	.0122	.0128	.0064	.0081	.0072	.0068	.0091	.0114	.0111	.0102
94	.0098	.0115	.0137	.0128	.0139	.0069	.0089	.0079	.0073	.0097	.0123	.0115	.0103
102	.0101	.0117	.0135	.0137	.0138	.0072	.0091	.0079	.0074	.0102	.0120	.0117	.0104
112	.0103	.0119	.0135	.0139	.0138	.0073	.0093	.0080	.0079	.0103	.0120	.0112	.0105
130	.0100	.0120	.0129	.0143	.0138	.0076	.0095	.0079	.0075	.0100	.0120	.0128	.0108

TIME	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q55	Q56	Q57
70	.0095	.0100	.0036	.0051	.0047	.0066	.0072	.0080	.0080	.0076	.0079	.0082
86	.0104	.0106	.0040	.0054	.0055	.0070	.0074	.0083	.0081	.0081	.0080	.0084
94	.0109	.0110	.0042	.0058	.0061	.0077	.0080	.0087	.0084	.0082	.0081	.0087
102	.0114	.0113	.0044	.0049	.0062	.0081	.0081	.0088	.0086	.0085	.0084	.0090
112	.0114	.0113	.0046	.0050	.0064	.0082	.0080	.0088	.0087	.0087	.0083	.0092
130	.0116	.0116	.0049	.0052	.0069	.0082	.0081	.0092	.0089	.0091	.0084	.0094

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4650

TEST CONDITIONS

ALPHA = 0
PHI_S =37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
78	.002849	1.12E-04	66.4	6443	15.86	.502	.424	3096	3095	8.454E 02	34.90	.0679	.929
84	.002579	9.23E-05	73.0	6754	15.86	.454	.333	2925	3371	9.290E 02	37.61	.0759	.842
90	.002421	8.53E-05	74.2	6814	15.87	.427	.305	2792	3426	9.455E 02	37.31	.0791	.791
96	.002377	7.60E-05	81.7	7083	15.72	.411	.257	2665	3676	1.022E 03	40.75	.0852	.762
102	.002164	6.83E-05	82.8	7158	15.78	.377	.230	2529	3748	1.044E 03	40.05	.0900	.700
114	.002062	6.12E-05	87.9	7300	15.62	.352	.158	2296	3887	1.086E 03	40.58	.0953	.653

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P4	P6	P8	P14	P20
78	.1122	.0369	.0126	.0105	.0086
84	.1046	.0337	.0120	.0099	.0081
90	.0977	.0326	.0116	.0097	.0079
96	.0945	.0319	.0114	.0095	.0077
102	.0882	.0304	.0105	.0087	.0070
114	.0823	.0283	.0100	.0082	.0065

PRESSURE DATA (PRESSURE / POP)

TIME	P4	P6	P8	P14	P20
78	.1207	.0397	.0136	.0113	.0092
84	.1243	.0400	.0142	.0118	.0096
90	.1235	.0412	.0147	.0122	.0099
96	.1240	.0418	.0150	.0125	.0101
102	.1260	.0435	.0150	.0124	.0100
114	.1260	.0433	.0153	.0125	.0099

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4650

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q1	Q2	Q3	Q5	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
78	38.2432	10.6366	7.9928	3.0250	.4038	.3134	.1676	.1353	.1326	.1539	.2050	.2414
84	40.0504	10.1536	8.4723	3.1025	.4419	.3573	.1764	.1692	.1448	.1523	.2125	.2482
90	39.5451	9.6997	8.3547	3.0965	.4605	.3696	.1761	.1791	.1462	.1418	.2071	.2388
96	43.1925	10.1054	9.0867	3.3821	.5100	.4132	.1948	.2133	.1622	.1426	.2241	.2567
102	42.5487	9.9039	9.0893	3.3344	.5918	.4005	.1923	.2219	.1658	.1282	.2100	.2691
114	44.0339	10.0154	9.0862	3.4269	.5073	.4058	.1977	.2529	.1644	.0965	.1887	*****

TIME	Q16	Q17	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30	Q31
78	.4232	.6527	2.1371	1.2107	1.1333	1.0668	.8869	.6609	.4342	.2208	.2455	.2648
84	.4325	.7370	2.6136	1.3989	1.4143	1.1976	.9706	.7296	.4588	.2068	.2651	.3054
90	.4328	.7388	2.6115	1.4793	1.5236	1.2470	.9651	.7126	.4568	.1940	.2441	.2985
96	.4859	.8174	2.9338	1.7073	1.7171	1.3626	1.0498	.7868	.4806	.2119	.2377	.3328
102	.4686	.8091	2.5225	1.7531	1.7023	1.3151	.9893	.7612	.4560	.2123	.2058	.3204
114	.4830	.8360	2.5981	1.8263	1.7765	1.2946	.9659	.7102	.4363	.2110	.1778	.2942

TIME	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44
78	.4211	.5830	.2845	.2647	.2005	.0924	.1393	.0970	.3684	.9240	.3447	.2765	.2919
84	.4590	.6844	.3253	.3046	.2670	.0921	.1546	.0944	.3225	.9890	.3610	.2863	.3081
90	.4365	.6678	.3320	.3208	.2869	.1015	.1533	.0888	.2574	.9599	.3418	.2726	.2817
96	.4629	.7096	.3708	.3647	.3201	.1256	.1699	.0970	.2282	.9902	.3854	.2934	.2995
102	.4196	.6873	.3705	.3645	.3204	.1251	.1744	.0941	.2023	.9460	.3746	.2864	.2864
114	.3653	.6735	.3795	.3774	.3409	.1299	.1757	.0990	.1867	.8724	.3929	.2914	.2658

TIME	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57
78	.2072	.1423	3.3181	.6453	.7093	.6656	.7902	1.3597	1.4580	.7438	.4179	.2122	.5070
84	.1880	.1589	3.3093	.5393	.7311	.8010	.8649	1.4854	1.5460	.8011	.4776	.2548	.5331
90	.1689	.1623	3.0592	.6025	.6976	.8394	.8792	1.4895	1.5035	.8021	.5084	.2761	.5067
96	.1711	.1907	3.1579	.6253	.7416	.9413	.9587	1.6297	1.6340	.8686	.5534	.3174	.5175
102	.1622	.1963	2.9239	.6144	.7210	.9413	.9413	1.5067	1.5386	.8393	.5426	.3143	.4866
114	.1657	.2110	2.7616	.6005	.7433	.9749	.9858	1.5013	1.5060	.8320	.5438	.3166	.4627

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4650

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / QO)

TIME	Q1	Q2	Q3	Q5			Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
78	1.0958	.3048	.2287	.0967			.0116	.0090	.0048	.0039	.0038	.0044	.0059	.0069
84	1.0650	.2700	.2253	.0825			.0117	.0095	.0047	.0045	.0038	.0041	.0055	.0066
90	1.0400	.2600	.2240	.0830			.0123	.0099	.0047	.0048	.0039	.0038	.0055	.0064
96	1.0600	.2480	.2230	.0830			.0125	.0101	.0048	.0052	.0040	.0035	.0055	.0063
102	1.0623	.2473	.2219	.0832			.0125	.0100	.0048	.0055	.0041	.0032	.0052	.0067
114	1.0850	.2468	.2239	.0844			.0125	.0100	.0049	.0062	.0041	.0024	.0046	*****

TIME	Q16	Q17	Q19	Q20	Q21	Q22	Q23	Q24	Q26		Q29	Q30	Q31
78	.0121	.0190	.0612	.0347	.0325	.0288	.0255	.0189	.0124		.0063	.0070	.0076
84	.0115	.0188	.0695	.0372	.0376	.0318	.0258	.0194	.0122		.0055	.0071	.0081
90	.0116	.0198	.0700	.0397	.0408	.0334	.0259	.0191	.0122		.0052	.0065	.0080
96	.0119	.0201	.0720	.0419	.0421	.0334	.0258	.0193	.0118		.0052	.0058	.0082
102	.0117	.0202	.0630	.0438	.0425	.0328	.0247	.0190	.0114		.0053	.0051	.0080
114	.0119	.0206	.0640	.0450	.0438	.0319	.0238	.0175	.0107		.0052	.0044	.0072

TIME	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44
78	.0121	.0167	.0092	.0076	.0057	.0026	.0040	.0028	.0106	.0265	.0099	.0079	.0084
84	.0122	.0182	.0086	.0081	.0071	.0024	.0041	.0025	.0086	.0263	.0096	.0077	.0082
90	.0117	.0179	.0089	.0086	.0077	.0027	.0041	.0024	.0069	.0257	.0092	.0073	.0076
96	.0114	.0174	.0091	.0089	.0079	.0031	.0042	.0024	.0056	.0243	.0095	.0072	.0073
102	.0105	.0172	.0092	.0091	.0080	.0031	.0044	.0023	.0050	.0236	.0094	.0072	.0072
114	.0090	.0166	.0094	.0093	.0084	.0032	.0043	.0024	.0046	.0215	.0097	.0072	.0065

TIME	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56	Q57
78	.0059	.0041	.0951	.0185	.0203	.0191	.0226	.0390	.0418	.0213	.0120	.0061	.0145
84	.0050	.0042	.0880	.0170	.0194	.0213	.0230	.0395	.0411	.0213	.0127	.0068	.0142
90	.0045	.0044	.0820	.0161	.0187	.0225	.0236	.0399	.0403	.0215	.0136	.0074	.0136
96	.0042	.0047	.0775	.0153	.0182	.0231	.0235	.0400	.0401	.0213	.0136	.0078	.0127
102	.0040	.0049	.0730	.0153	.0180	.0235	.0235	.0376	.0384	.0210	.0135	.0078	.0122
114	.0041	.0052	.0680	.0148	.0183	.0240	.0243	.0370	.0371	.0205	.0134	.0078	.0114

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4651

TEST CONDITIONS

ALPHA = 0
PHI_S =37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
66	.000816	2.32E-05	91.9	8947	18.73	.200	.088	3837	5594	1.621E 03	50.73	.1642	.373
70	.000828	2.23E-05	96.8	9178	18.72	.203	.083	3996	5865	1.706E 03	54.39	.1686	.378
90	.000717	1.82E-05	102.7	9560	18.92	.180	.066	3935	6326	1.850E 03	56.45	.1887	.335
100	.000597	1.48E-05	105.2	9790	19.15	.153	.059	3690	6615	1.940E 03	55.17	.2105	.286
140	.000548	1.39E-05	102.7	9570	18.94	.137	.053	3070	6349	1.854E 03	49.51	.2160	.256

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P8	P14	P20
66	.0076	.0055	.0040
70	.0077	.0056	.0041
90	.0078	.0051	.0037
100	.0062	.0044	.0032
140	.0051	.0037	.0027

PRESSURE DATA (PRESSURE / POP)

TIME	P8	P14	P20
66	.0202	.0148	.0108
70	.0204	.0148	.0108
90	.0208	.0152	.0110
100	.0218	.0153	.0111
140	.0201	.0146	.0105

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4651

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
65	.7652	.6493	.5261	.4819	.4718	.4397	.3398	.3592
70	.8407	.6799	.5711	.5113	.5275	.4952	.3934	.3745
90	.9437	.7554	.6266	.5979	.6154	.5835	.4629	.4441
100	.9263	.7614	.6234	.8276	.6166	.6164	.4800	.4827
140	.8565	.7696	.6089	.5693	.5644	.6089	.5297	.5099

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26		Q29	Q30
66	.5818	1.3314	13.0295	3.1670	2.4875	1.5617	1.1464	.8180	.5602	.2841		.5610	.4876
70	.6501	1.4503	13.3832	3.4049	2.6470	1.6861	1.1890	.8466	.5970	.2882		.6154	.5502
90	.7006	1.5421	11.9119	3.4437	2.5574	1.5311	1.0726	.7000	.5024	.2371		.6770	.6210
100	.6832	1.5415	10.6868	3.2932	2.3909	1.4547	.9726	.6130	.4421	.2097		.6785	.6207
140	.7079	1.4913	*****	2.7906	1.8516	1.0837	.7371	.4555	.3095	.1238		.6530	.5842

TIME	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
66	.3682	.3927	.7660	.5643	.5683	.6189	.3359	.3862	.2599	.3500	1.4482	.7622	.4362
70	.4135	.4218	.8267	.6077	.6249	.6578	.3534	.4133	.2898	.3769	1.5806	.8267	.4694
90	.5024	.4778	.9239	.6775	.6718	.7524	.4262	.4516	.3105	.4178	1.7040	.9033	.5130
100	.5241	.4774	.8807	.6681	.6621	.7094	.4093	.4579	.3200	.4035	1.6077	.8633	.5128
140	.5644	.5258	.9109	.6331	.6436	.7844	.4027	.4604	.3366	.4246	1.5991	.8888	.5149

TIME	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
66	.3196	.3615	.4495	1.6194	.8253	.7710	.9435	1.3290	1.6243	1.4000	.9884	.7203	.4920
70	.3526	.4025	.4761	1.5675	.8964	.8103	.9875	1.3923	1.7153	1.4830	1.0605	.7629	.5214
90	.4065	.4723	.5726	1.4904	.9484	.7703	.9727	1.3348	1.7218	1.4114	1.0535	.7396	.5047
100	.4193	.4800	.5628	1.3462	.9324	.7073	.8619	1.2766	1.6136	1.3517	.9912	.7352	.4934
140	.4455	.4951	.5594	1.0840	.8134	.5792	.7232	1.0061	1.3063	1.1634	.8531	.6244	.4165

TIME	Q57
66	.3987
70	.4231
90	.4178
100	.4028
140	.3763

RUN 4651

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4651

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / QO)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
66	.0151	.0128	.0104	.0095	.0093	.0087	.0067	.0071
70	.0155	.0125	.0105	.0094	.0097	.0091	.0072	.0069
90	.0167	.0134	.0111	.0106	.0109	.0103	.0082	.0079
100	.0168	.0138	.0113	.0150	.0112	.0112	.0087	.0087
140	.0173	.0155	.0123	.0115	.0114	.0123	.0107	.0103

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30
66	.0115	.0262	.2569	.0624	.0490	.0308	.0226	.0161	.0110	.0056	.0111	.0096
70	.0120	.0267	.2461	.0626	.0487	.0310	.0219	.0156	.0110	.0053	.0113	.0101
90	.0124	.0273	.2110	.0610	.0453	.0271	.0190	.0124	.0089	.0042	.0120	.0110
100	.0124	.0279	.1937	.0597	.0433	.0264	.0176	.0111	.0080	.0038	.0123	.0113
140	.0143	.0301	*****	.0564	.0374	.0219	.0149	.0092	.0063	.0025	.0132	.0118

TIME	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
66	.0073	.0077	.0151	.0111	.0112	.0122	.0066	.0076	.0051	.0069	.0285	.0150	.0086
70	.0076	.0078	.0152	.0112	.0115	.0121	.0065	.0076	.0053	.0069	.0291	.0152	.0086
90	.0089	.0085	.0164	.0120	.0119	.0133	.0075	.0080	.0055	.0074	.0302	.0160	.0091
100	.0095	.0087	.0160	.0121	.0120	.0129	.0074	.0083	.0058	.0073	.0291	.0156	.0093
140	.0114	.0106	.0184	.0128	.0130	.0158	.0081	.0093	.0068	.0086	.0323	.0180	.0104

TIME	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
66	.0063	.0071	.0089	.0319	.0163	.0152	.0186	.0262	.0320	.0276	.0195	.0142	.0097
70	.0065	.0074	.0088	.0307	.0165	.0149	.0182	.0256	.0315	.0273	.0195	.0140	.0096
90	.0072	.0084	.0101	.0264	.0168	.0136	.0172	.0236	.0305	.0250	.0187	.0131	.0089
100	.0076	.0087	.0102	.0244	.0169	.0128	.0156	.0231	.0292	.0245	.0180	.0133	.0089
140	.0090	.0100	.0113	.0219	.0164	.0117	.0146	.0203	.0264	.0235	.0172	.0126	.0084

TIME	Q57
66	.0079
70	.0078
90	.0074
100	.0073
140	.0076

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4652

TEST CONDITIONS

ALPHA = 0
PHI_S=37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
72	.004850	1.78E-04	71.3	6648	15.80	.847	.646	5024	3253	9.003E 02	49.32	.0544	1.570
75	.004745	1.65E-04	75.2	6807	15.75	.824	.581	4925	3397	9.439E 02	51.72	.0569	1.527
78	.004568	1.51E-04	79.2	6979	15.73	.791	.518	4836	3555	9.922E 02	54.56	.0604	1.468
80	.004330	1.36E-04	83.4	7173	15.76	.753	.455	4774	3737	1.048E 03	56.89	.0639	1.397
90	.003709	1.13E-04	85.5	7307	15.85	.652	.365	4369	3869	1.087E 03	55.37	.0701	1.211
120	.002754	7.80E-05	92.2	7587	15.85	.484	.250	3434	4154	1.172E 03	51.80	.0843	.899

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P4	P6	P8	P14	P20
72	.2066	.0973	.0196	.0169	.0141
75	.2018	.0952	.0194	.0166	.0136
78	.1943	.0930	.0191	.0165	.0137
80	.1866	.0903	.0184	.0160	.0134
90	.1674	.0830	.0167	.0141	.0116
120	.1284	.0695	.0128	.0106	.0087

PRESSURE DATA (PRESSURE / POP)

TIME	P4	P6	P8	P14	P20
72	.1316	.0620	.0125	.0108	.0089
75	.1322	.0624	.0127	.0109	.0089
78	.1323	.0633	.0130	.0112	.0093
80	.1336	.0647	.0132	.0115	.0096
90	.1382	.0686	.0138	.0116	.0096
120	.1427	.0772	.0142	.0118	.0096

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4652

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q1	Q2	Q3	Q5		Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
72	57.6773	20.2725	11.6467	4.5778		.5721	.4587	.4044	.1874	.1716	.3756	.4575	.2701
75	62.1331	21.0743	12.6429	5.4305		.6070	.4913	.4165	.1991	.1733	.3086	.4198	.2605
78	65.2174	21.3002	13.4458	5.6200		.6438	.5293	.4501	.2125	.1815	.2834	.4111	.2745
80	65.5251	20.9230	13.7468	5.8029		.6770	.5575	.4693	.2372	.1849	.2714	.3987	.2889
90	62.5450	19.3375	13.0172	5.3153		.6798	.5592	.4415	.2439	.1772	.1919	.2264	.2925
120	57.2346	13.9881	11.5546	4.4545		.6216	.5041	.4662	.2606	.1600	.2009	.2108	.2383

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26		Q29	Q30
72	.9716	1.0837	33.8244	3.1327	1.2439	1.5310	.7791	.8576	.9764	.8047		.3305	.4344
75	.8595	1.1226	30.5309	2.9314	1.3465	1.5233	.7979	.9671	1.1182	.8760		.3155	.3846
78	.7912	1.1513	29.7917	3.0622	1.5601	1.5475	.9645	1.1484	1.2718	.9335		.3092	.3354
80	.7737	1.1727	29.6851	3.2505	1.6853	1.7025	1.0978	1.3107	1.3133	.9887		.3145	.3584
90	.5118	.9011	29.7778	3.0391	1.7441	1.8089	1.3245	1.4922	1.2734	.8730		.2654	.2748
120	.5348	.7618	22.5820	3.0938	1.9475	2.2013	1.5760	1.3985	1.0618	.5709		.2327	.2335

TIME	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
72	.5129	.9396	.7130	.4093	.3551	.2967	.0542	.2953	.2022	.9368	1.7262	.6263	.5812
75	.5275	.8961	.7334	.4161	.4059	.3310	.0672	.2822	.1851	.8629	1.7052	.5887	.5707
78	.5511	.8954	.8021	.4932	.4338	.3768	.0775	.3022	.1801	.8411	1.7351	.6057	.5960
80	.5689	.8639	.8729	.5145	.4608	.3893	.0836	.2984	.1792	.8027	1.7522	.6315	.6057
90	.5094	.6423	.8598	.4864	.4804	.3840	.0947	.2602	.1541	.5792	1.5139	.5226	.5427
120	.4126	.5401	.8507	.4615	.4735	.3776	.1122	.2164	.1243	.2981	1.3053	.4536	.4168

TIME	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
72	.4804	.4210	.3058	5.5859	1.6078	1.1561	1.3985	1.1724	2.8189	2.3112	1.2285	.6165	.3058
75	.4578	.4133	.2921	5.8837	1.7262	1.3738	1.4068	1.2158	2.9202	2.4688	1.3033	.6931	.3243
78	.4681	.4119	.2776	6.2188	1.4968	1.4405	1.4350	1.2897	3.0216	2.5548	1.3674	.7366	.3492
80	.4407	.4086	.2766	6.3302	1.3995	1.4848	1.4678	1.3270	2.9929	2.5901	1.4052	.7737	.3669
90	.4162	.3680	.2367	5.7582	1.2990	1.3746	1.3091	1.4145	2.7078	2.5959	1.3225	.7463	.3851
120	.4090	.2648	.2091	4.4545	1.0472	1.1240	1.2618	1.2949	2.1125	2.1061	1.0929	.6628	.3626

TIME	Q57
72	.6510
75	.7008
78	.7743
80	.8416
90	.8360
120	.6992

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA CREITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4652

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / Q0)

TIME	Q1	Q2	Q3	Q5	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
72	1.1695	.4111	.2452	.0928	.0116	.0093	.0082	.0038	.0035	.0076	.0093	.0055
75	1.2014	.4275	.2445	.1050	.0117	.0095	.0081	.0038	.0033	.0060	.0081	.0050
78	1.1953	.3904	.2464	.1030	.0118	.0097	.0083	.0039	.0033	.0052	.0075	.0050
80	1.1516	.3678	.2416	.1020	.0119	.0098	.0082	.0042	.0032	.0048	.0070	.0051
90	1.1300	.3493	.2459	.0960	.0123	.0101	.0080	.0044	.0032	.0035	.0041	.0053
120	1.1050	.2701	.2231	.0860	.0120	.0097	.0090	.0052	.0031	.0039	.0041	.0046

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30
72	.0197	.0220	.5858	.0635	.0252	.0310	.0158	.0174	.0198	.0163	.0067	.0088
75	.0166	.0217	.5953	.0567	.0260	.0295	.0154	.0187	.0216	.0169	.0061	.0074
78	.0145	.0211	.5460	.0561	.0286	.0284	.0177	.0210	.0233	.0171	.0057	.0071
80	.0136	.0206	.5218	.0571	.0296	.0299	.0193	.0230	.0231	.0174	.0055	.0063
90	.0092	.0163	.5198	.0549	.0315	.0327	.0239	.0270	.0230	.0158	.0048	.0050
120	.0103	.0147	.4360	.0597	.0376	.0425	.0304	.0270	.0205	.0110	.0045	.0045

TIME	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
72	.0104	.0191	.0145	.0083	.0072	.0060	.0011	.0060	.0041	.0190	.0350	.0127	.0118
75	.0102	.0173	.0142	.0080	.0078	.0064	.0013	.0055	.0036	.0167	.0330	.0114	.0110
78	.0101	.0164	.0147	.0090	.0079	.0069	.0014	.0055	.0033	.0154	.0318	.0111	.0109
80	.0100	.0152	.0153	.0090	.0081	.0068	.0015	.0052	.0031	.0141	.0308	.0111	.0106
90	.0092	.0116	.0155	.0088	.0087	.0069	.0017	.0047	.0028	.0105	.0273	.0094	.0098
120	.0080	.0112	.0144	.0089	.0091	.0073	.0022	.0042	.0024	.0058	.0252	.0088	.0080

TIME	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
72	.0097	.0085	.0062	.1133	.0326	.0234	.0284	.0238	.0572	.0469	.0249	.0125	.0062
75	.0089	.0080	.0056	.1138	.0334	.0266	.0272	.0235	.0565	.0477	.0252	.0134	.0063
78	.0086	.0075	.0051	.1140	.0274	.0264	.0263	.0236	.0554	.0468	.0251	.0135	.0064
80	.0081	.0072	.0048	.1113	.0246	.0261	.0258	.0233	.0526	.0455	.0247	.0136	.0064
90	.0075	.0066	.0043	.1040	.0235	.0248	.0236	.0255	.0489	.0469	.0239	.0135	.0070
120	.0079	.0051	.0040	.0860	.0202	.0217	.0244	.0250	.0408	.0407	.0211	.0128	.0070

TIME	Q57
72	.0132
75	.0136
78	.0142
80	.0148
90	.0151
120	.0135

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4653

TEST CONDITIONS

ALPHA = 0
PHI_S=37.50

H=0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
104	.002090	8.26E-05	66.1	6577	16.23	.385	.320	2730	3214	8.603E 02	32.28	.0796	.714
110	.001920	7.41E-05	67.7	6675	16.27	.356	.284	2595	3301	9.065E 02	32.24	.0844	.660
120	.001916	7.05E-05	71.0	6745	16.05	.346	.261	2396	3366	9.260E 02	32.68	.0868	.641
125	.001882	6.76E-05	72.7	6797	15.99	.337	.246	2308	3414	9.405E 02	33.32	.0899	.624
128	.001799	6.17E-05	76.2	6955	15.99	.322	.219	2253	3559	9.847E 02	34.45	.0944	.597

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P4	P6	P8	P14	P20
104	.1075	.0535	.0109	.0087	.0071
110	.0971	.0488	.0102	.0083	.0067
120	.0990	.0484	.0099	.0079	.0063
125	.0994	.0499	.0096	.0076	.0061
128	.0964	.0494	.0093	.0074	.0059

PRESSURE DATA (PRESSURE / POP)

TIME	P4	P6	P8	P14	P20
104	.1506	.0750	.0153	.0122	.0099
110	.1472	.0740	.0154	.0125	.0102
120	.1545	.0756	.0154	.0123	.0098
125	.1592	.0800	.0153	.0122	.0097
128	.1616	.0829	.0156	.0124	.0099

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA251-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4653

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q1	Q2	Q3	Q5		Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
104	36.8013	9.2253	7.4766	2.7681		.4116	.3325	.1711	.1707	.1192	.1098	.1646	.1385
110	36.7585	9.0606	7.6037	2.7085		.4111	.3241	.1709	.1757	.1225	.1098	.1596	.1319
120	38.0468	9.0836	7.8094	2.7611		.4117	.3312	.1732	.1862	.1245	.0980	.1536	.1251
125	39.0735	9.1989	7.8126	2.8554		.4229	.3432	.1760	.1932	.1283	.0973	.1599	.1266
128	40.3122	8.9947	8.2347	2.9287		.4341	.3569	.1827	.2075	.1340	.0999	.1688	.1309

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26		Q29	Q30
104	.3874	.5718	17.3408	2.1306	1.3235	1.4042	1.0911	.8845	.6908	.3825		.1403	.0854
110	.3818	.5655	16.0601	2.1603	1.3784	1.4463	1.0933	.8625	.6638	.3666		.1392	.0803
120	.3923	.5947	15.2856	2.2380	1.4262	1.4605	1.0596	.8553	.6433	.3643		.1389	.0721
125	.4032	.6265	15.3616	2.2939	1.4995	1.4662	1.0996	.8664	.6731	.3654		.1443	.0666
128	.4099	.6615	15.6596	2.3946	1.5849	1.5112	1.1167	.8958	.7063	.3782		.1516	.0643

TIME	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
104	.2841	.3809	.6004	.2997	.2808	.1775	.0366	.1420	.0767	.1969	.8346	.3164	.2582
110	.2757	.3482	.5804	.2966	.2837	.1692	.0413	.1403	.0748	.1967	.8093	.3163	.2563
120	.2696	.3170	.5620	.2941	.2892	.1748	.0425	.1405	.0745	.1699	.7809	.3088	.2524
125	.2693	.3199	.5669	.2951	.2966	.1733	.0437	.1444	.0760	.1632	.7902	.3070	.2599
128	.2774	.3308	.5777	.3032	.3066	.1797	.0452	.1482	.0786	.1636	.7959	.3103	.2687

TIME	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
104	.2615	.1711	.1542	2.8246	.5577	.6166	.7877	.7671	1.4163	1.3969	.7263	.4395	.2437
110	.2499	.1661	.1532	2.7085	.5492	.6094	.7868	.7910	1.3446	1.3589	.7094	.4374	.2402
120	.2353	.1601	.1537	2.5660	.5424	.6108	.7989	.8267	1.3491	1.3070	.6895	.4313	.2418
125	.2333	.1616	.1616	2.4835	.5498	.6256	.7921	.8564	1.3752	1.3063	.6898	.4347	.2466
128	.2377	.1676	.1688	2.5497	.5651	.6478	.8137	.8958	1.3926	1.3383	.7063	.4511	.2550

TIME	Q57
104	.4681
110	.4419
120	.4215
125	.3967
128	.4129

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST　　VA291-21FA　　JANUARY 1974　　PROJECT ENGINEER D.R. HABERMAN

RUN 4653

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / Q0)

TIME	Q1	Q2	Q3	Q5	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
104	1.1400	.2458	.2316	.0857	.0127	.0103	.0053	.0053	.0037	.0034	.0051	.0043
110	1.1400	.2410	.2360	.0840	.0127	.0101	.0053	.0054	.0038	.0034	.0050	.0041
120	1.1650	.2780	.2390	.0845	.0126	.0101	.0053	.0057	.0038	.0030	.0047	.0038
125	1.1726	.2761	.2345	.0857	.0127	.0103	.0053	.0058	.0038	.0029	.0048	.0038
128	1.1700	.2611	.2390	.0850	.0126	.0104	.0053	.0060	.0039	.0029	.0049	.0038

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q26	Q29	Q30
104	.0120	.0177	.5372	.0660	.0410	.0435	.0338	.0274	.0214	.0118	.0043	.0026
110	.0118	.0175	.4981	.0670	.0427	.0449	.0339	.0268	.0206	.0114	.0043	.0025
120	.0120	.0182	.4678	.0685	.0436	.0447	.0324	.0262	.0197	.0112	.0042	.0022
125	.0121	.0188	.4610	.0688	.0450	.0440	.0330	.0260	.0202	.0110	.0043	.0020
128	.0119	.0192	.4545	.0695	.0460	.0439	.0324	.0260	.0205	.0110	.0044	.0019

TIME	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43
104	.0088	.0118	.0186	.0093	.0087	.0055	.0011	.0044	.0024	.0061	.0259	.0098	.0080
110	.0085	.0108	.0190	.0092	.0088	.0052	.0013	.0044	.0023	.0058	.0251	.0098	.0079
120	.0082	.0097	.0172	.0090	.0088	.0054	.0013	.0043	.0023	.0052	.0239	.0095	.0077
125	.0081	.0096	.0170	.0089	.0089	.0052	.0013	.0043	.0023	.0049	.0237	.0092	.0078
128	.0081	.0096	.0168	.0088	.0089	.0052	.0013	.0043	.0023	.0047	.0231	.0090	.0078

TIME	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
104	.0081	.0053	.0048	.0875	.0173	.0191	.0244	.0238	.0439	.0433	.0225	.0136	.0076
110	.0077	.0051	.0047	.0840	.0170	.0189	.0244	.0245	.0417	.0421	.0220	.0136	.0074
120	.0072	.0049	.0047	.0785	.0166	.0187	.0245	.0253	.0413	.0400	.0211	.0132	.0074
125	.0070	.0049	.0049	.0745	.0165	.0188	.0238	.0257	.0413	.0392	.0207	.0130	.0074
128	.0069	.0049	.0049	.0740	.0164	.0188	.0236	.0260	.0404	.0388	.0205	.0131	.0074

TIME	Q57
104	.0145
110	.0137
120	.0129
125	.0119
128	.0120

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4654

TEST CONDITIONS

ALPHA = 0
PHI$_S$ =37.50

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
100	.001748	6.09E-05	74.9	8556	19.83	.481	.259	10525	5056	1.481E 03	70.16	.0999	.896
110	.001770	5.58E-05	82.8	8860	19.54	.473	.233	10108	5407	1.588E 03	75.96	.1055	.881
120	.001745	5.13E-05	88.8	9106	19.38	.459	.205	9831	5697	1.678E 03	80.10	.1110	.855
130	.001677	4.51E-05	97.2	9466	19.26	.435	.171	9567	6134	1.813E 03	85.78	.1197	.812
160	.001573	3.96E-05	103.7	9685	19.08	.401	.160	8762	6417	1.899E 03	86.98	.1284	.747

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P4	P6	P8	P14	P20
100	.1166	.0477	.0145	.0109	.0078
110	.1160	.0475	.0140	.0105	.0076
120	.1089	.0460	.0137	.0103	.0075
130	.1051	.0446	.0130	.0096	.0069
160	.0973	.0418	.0119	.0089	.0064

PRESSURE DATA (PRESSURE / POP)

TIME	P4	P6	P8	P14	P20
100	.1300	.0533	.0162	.0122	.0087
110	.1317	.0539	.0160	.0119	.0086
120	.1273	.0538	.0160	.0120	.0088
130	.1295	.0549	.0160	.0118	.0085
160	.1302	.0560	.0160	.0119	.0085

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4654

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q15
100	1.1795	.9670	.7854	.6774	.5963	.5609	.6752
110	1.2534	1.0494	.8695	.7520	.6966	.6457	.7140
120	1.3015	1.0797	.8731	.7966	.7568	.7153	.7235
130	1.4068	1.1886	.9808	.8761	.8080	.7977	.7634
160	1.3916	1.1344	.9481	.8705	.8068	.8430	.7741

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q29
100	1.0784	2.0766	24.9809	5.6826	4.2795	3.3675	2.4414	1.8669	1.4363	1.2503	.8482	.8000
110	1.1397	2.2541	24.3074	5.9249	4.5471	3.5532	2.5599	1.8990	1.4053	1.2961	.8816	.8728
120	1.1214	2.3375	24.1099	6.1424	4.5753	3.4869	2.5551	1.9080	1.3937	1.2495	.8598	.9659
130	1.1409	2.4088	23.2698	6.5186	4.9382	3.4569	2.6294	1.9410	1.4298	1.2689	.8460	1.0348
160	1.0488	2.2077	21.7444	5.9181	4.3996	3.3812	2.4120	1.7641	1.3568	1.1674	.7171	1.1133

TIME	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42
100	.6162	.5682	.8337	1.3789	.8559	.8232	.8349	.3854	.5050	.3546	.5602	2.1956	1.0348
110	.6892	.6229	.9086	1.4889	.9826	.9077	.9346	.4402	.5992	.4096	.5626	2.3396	1.1541
120	.7110	.6607	.8722	1.4975	1.0122	.9551	.9673	.4597	.6016	.4446	.6111	2.4044	1.2317
130	.7849	.7034	.9176	1.4983	1.0443	1.1666	1.0098	.5195	.6523	.4585	.6320	2.5298	1.2985
160	.8350	.7393	.8698	1.4177	1.0375	1.0212	1.0606	.5081	.6610	.4720	.6007	2.4304	1.2634

TIME	Q43	Q44	Q45	Q46	Q47	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
100	.7594	.5199	.5746	.6489	4.1469	1.7954	1.9176	2.5256	3.3731	2.8062	1.9574	1.1997	.7787
110	.7824	.5278	.6048	.7167	4.1542	1.7944	1.9668	2.5555	3.2794	2.7020	2.0087	1.2534	.7955
120	.8162	.5447	.6424	.7448	3.9525	1.7604	2.0024	2.6787	3.3156	2.9084	2.0706	1.2736	.8466
130	.8377	.5759	.7043	.8131	3.6498	1.7511	2.0658	2.7876	3.3369	2.8225	2.0792	1.2959	.8463
160	.8456	.5943	.7520	.8785	3.4831	1.6146	2.0023	2.6025	3.2223	2.6868	2.0421	1.2822	.8487

TIME	Q57	Q58
100	.7717	.4877
110	.7697	.4916
120	.7667	.4742
130	.7849	.4608
160	.7373	.4700

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / Q0)

TIME	Q8	Q9	Q10	Q11	Q12	Q13	Q15
100	.0168	.0138	.0112	.0097	.0085	.0080	.0096
110	.0165	.0138	.0116	.0099	.0092	.0085	.0094
120	.0162	.0135	.0109	.0099	.0094	.0089	.0090
130	.0164	.0139	.0116	.0102	.0094	.0093	.0089
160	.0160	.0130	.0109	.0100	.0093	.0097	.0089

TIME	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q29
100	.0159	.0296	.3561	.0810	.0610	.0480	.0348	.0266	.0205	.0178	.0121	.0116
110	.0150	.0297	.3200	.0780	.0599	.0468	.0337	.0250	.0185	.0171	.0116	.0115
120	.0140	.0292	.3010	.0767	.0571	.0435	.0331	.0238	.0174	.0156	.0107	.0121
130	.0133	.0281	.2713	.0760	.0576	.0403	.0307	.0226	.0167	.0148	.0099	.0121
160	.0121	.0254	.2500	.0669	.0506	.0389	.0277	.0203	.0156	.0134	.0082	.0128

TIME	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42
100	.0088	.0081	.0119	.0197	.0122	.0117	.0119	.0055	.0072	.0051	.0080	.0313	.0147
110	.0091	.0082	.0120	.0196	.0129	.0120	.0123	.0058	.0079	.0054	.0076	.0308	.0152
120	.0089	.0082	.0109	.0187	.0126	.0119	.0121	.0057	.0075	.0056	.0076	.0300	.0154
130	.0091	.0082	.0107	.0175	.0122	.0136	.0118	.0061	.0076	.0053	.0076	.0295	.0151
160	.0096	.0085	.0100	.0163	.0119	.0117	.0122	.0059	.0076	.0054	.0069	.0279	.0145

TIME	Q43	Q44	Q45	Q46	Q47	Q49	Q50	Q51	Q52	Q53	Q54	Q55	Q56
100	.0108	.0074	.0082	.0092	.0591	.0256	.0273	.0360	.0481	.0400	.0279	.0171	.0111
110	.0103	.0069	.0080	.0094	.0547	.0736	.0259	.0336	.0432	.0356	.0264	.0165	.0105
120	.0102	.0068	.0090	.0093	.0493	.0220	.0250	.0336	.0416	.0363	.0259	.0159	.0106
130	.0098	.0067	.0082	.0095	.0425	.0206	.0261	.0325	.0389	.0329	.0242	.0151	.0099
160	.0097	.0068	.0086	.0101	.0400	.0186	.0230	.0299	.0370	.0309	.0235	.0147	.0098

TIME	Q57	Q58
100	.0110	.0070
110	.0101	.0065
120	.0096	.0059
130	.0091	.0054
160	.0085	.0054

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1974   PROJECT ENGINEER D.R. HABERMAN

RUN 4655

TEST CONDITIONS

ALPHA = 0
PHI_S = 0

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
92	.000692	1.97E-05	91.7	9218	19.30	.181	.079	4150	5905	1.720E 03	51.78	.1797	.337
96	.000663	1.94E-05	89.2	9111	19.35	.174	.077	3985	5780	1.680E 03	49.36	.1805	.324
108	.000663	1.93E-05	89.7	9052	19.17	.170	.074	3721	5715	1.658E 03	48.13	.1807	.318
120	.000619	1.79E-05	90.4	9093	19.18	.159	.070	3525	5766	1.674E 03	47.06	.1880	.297
128	.000599	1.69E-05	92.4	9142	19.08	.153	.065	3323	5827	1.692E 03	46.68	.1936	.285

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P4	P6	P8	P10	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
92	.0614	.0249	.0076	.0065	.0062	.0075	.0094	.0105	.0116	.0151	.0602	.0105	.0111	.0088
96	.0600	.0244	.0074	.0063	.0061	.0073	.0091	.0102	.0113	.0148	.0575	.0104	.0107	.0083
108	.0578	.0235	.0071	.0060	.0057	.0068	.0086	.0097	.0109	.0144	.0554	.0100	.0101	.0080
120	.0532	.0216	.0065	.0055	.0052	.0061	.0078	.0092	.0102	.0136	.0496	.0090	.0092	.0073
128	.0492	.0200	.0061	.0052	.0048	.0056	.0073	.0086	.0098	.0131	.0456	.0084	.0084	.0067

TIME	P22	P26	P15A	P16A	P17A	P1
92	.0087	.0066	.0135	.0128	.0189	.3740
96	.0082	.0062	.0128	.0123	.0183	.3564
108	.0078	.0057	.0113	.0118	.0177	.3371
120	.0071	.0052	.0103	.0113	.0167	.3142
128	.0067	.0049	.0098	.0107	.0157	.2854

PRESSURE DATA (PRESSURE / POP)

TIME	P4	P6	P8	P10	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
92	.1824	.0741	.0225	.0192	.0184	.0223	.0279	.0312	.0344	.0448	.1788	.0313	.0331	.0260
96	.1853	.0754	.0228	.0196	.0187	.0224	.0282	.0315	.0348	.0458	.1774	.0323	.0332	.0258
108	.1818	.0739	.0222	.0190	.0180	.0213	.0271	.0307	.0344	.0452	.1745	.0314	.0319	.0253
120	.1791	.0728	.0218	.0187	.0175	.0205	.0264	.0309	.0345	.0459	.1670	.0304	.0310	.0245
128	.1728	.0702	.0213	.0183	.0170	.0197	.0255	.0302	.0343	.0461	.1601	.0295	.0296	.0237

TIME	P22	P26	P15A	P16A	P17A	P1
92	.0258	.0196	.0402	.0382	.0560	1.1115
96	.0255	.0193	.0395	.0380	.0565	1.1006
108	.0244	.0180	.0356	.0373	.0556	1.0613
120	.0240	.0174	.0349	.0380	.0563	1.0581
128	.0236	.0172	.0346	.0377	.0552	1.0032

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4655

HEAT-TRANSFER DATA

HEAT-TRANSFER RATE (BTU/FT2-SEC)

TIME	Q8	Q9	Q11	Q12	Q13	Q15	Q16	Q17
92	.9397	.8208	.6811	.5778	.6567	.6292	.6377	.6085
96	.8867	.7693	.6355	.5425	.6219	.5853	.5935	.5711
108	.8749	.7469	.6278	.5345	.6011	.5697	.5790	.5556
120	.8540	.7429	.6149	.5341	.6055	.5631	.5705	.5448
128	.8265	.7142	.5874	.5071	.5585	.5303	.5390	.5235

TIME	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q33	Q34	Q35	Q36	Q37	Q38
92	.5395	.5160	.4690	.4480	.4072	.3788	.3208	.6218	.6598	.6979	.6255	.3690	.6672
96	.4891	.4650	.4411	.3993	.3731	.3399	.2848	.5658	.6463	.6648	.6170	.3381	.6277
108	.4790	.4572	.4101	.3912	.3560	.3138	.2710	.5659	.6223	.6701	.6271	.3452	.6343
120	.4790	.4438	.4077	.3876	.3596	.3175	.2845	.5687	.6032	.6506	.6333	.3344	.6264
128	.4571	.4279	.3906	.3690	.3455	.3060	.2666	.5273	.6066	.6705	.5655	.3263	.5813

TIME	Q39	Q40	Q41	Q42	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58
92	.5812	.5804	.5578	.5682	.4228	.4368	.4164	.4388	.3562	.3260	.3626	.4573
96	.5540	.5590	.5327	.5327	.3669	.3850	.3751	.3969	.3258	.2947	.3159	.4442
108	.5588	.5519	.5268	.5391	.3728	.3921	.3765	.3960	.3428	.3085	.3827	.4611
120	.5487	.5475	.5223	.5179	.3731	.3775	.3707	.3859	.3666	.3216	.3555	.4521
128	.5179	.5155	.5030	.5063	.3571	.3791	.3752	.4017	.3622	.3229	.3786	.4388

NASA ORBITER/TANK HEATING TEST VA291-21FA JANUARY 1974 PROJECT ENGINEER D.R. HABERMAN

RUN 4455

HEAT-TRANSFER DATA

HEAT TRANSFER DATA (Q / QO)

TIME	Q8	Q9	Q11	Q12	Q13	Q15	Q16	Q17
92	.0181	.0159	.0132	.0112	.0127	.0122	.0123	.0118
96	.0180	.0156	.0129	.0110	.0126	.0119	.0120	.0116
108	.0182	.0155	.0130	.0111	.0125	.0118	.0120	.0115
120	.0181	.0158	.0131	.0113	.0129	.0120	.0121	.0116
128	.0177	.0153	.0126	.0109	.0120	.0114	.0115	.0112

TIME	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q33	Q34	Q35	Q36	Q37	Q38
92	.0104	.0100	.0091	.0087	.0079	.0073	.0062	.0120	.0127	.0135	.0121	.0071	.0129
96	.0099	.0094	.0089	.0081	.0076	.0069	.0058	.0115	.0131	.0135	.0125	.0068	.0127
108	.0100	.0095	.0085	.0081	.0074	.0065	.0056	.0118	.0129	.0139	.0130	.0072	.0132
120	.0102	.0094	.0087	.0082	.0076	.0067	.0060	.0117	.0128	.0138	.0135	.0071	.0133
128	.0098	.0092	.0084	.0079	.0074	.0065	.0057	.0113	.0130	.0133	.0121	.0070	.0125

TIME	Q39	Q40	Q41	Q42	Q51	Q52	Q53	Q54	Q55	Q56	Q57	Q58
92	.0112	.0112	.0108	.0110	.0082	.0084	.0080	.0095	.0068	.0063	.0070	.0088
96	.0112	.0113	.0108	.0108	.0074	.0078	.0076	.0080	.0066	.0060	.0064	.0090
108	.0116	.0115	.0109	.0112	.0077	.0081	.0078	.0082	.0071	.0064	.0080	.0096
120	.0117	.0116	.0111	.0110	.0079	.0080	.0079	.0082	.0073	.0068	.0076	.0096
128	.0111	.0110	.0108	.0108	.0076	.0081	.0080	.0086	.0073	.0069	.0081	.0094

AEDC (ARO, INC.) ARNOLD AFS, TENN. 37389
VON KARMAN GAS DYNAMICS FACILITY
HYPERVELOCITY WIND TUNNEL F

NASA ORBITER/TANK HEATING TEST   VA291-21FA   JANUARY 1976   PROJECT ENGINEER D.R. HABERMAN

RUN 4656

TEST CONDITIONS

ALPHA = 0
PHI_S = 0

Q-0, ST-0 BASED ON .500 INCH RADIUS
MODEL LENGTH = 32.638

TIME MSEC	P-INF PSIA	RHO-INF LBM/FT3	T-INF DEG R	U-INF FT/SEC	M-INF	Q-INF PSIA	RE/FT X10-6	PO PSIA	TO DEG R	HO BTU/LBM	QO- BTU/ FT2-SEC	ST-0	POP PSIA
76	.002666	9.74E-05	71.5	6757	16.03	.479	.359	3229	3369	9.294E 02	38.66	.0739	.889
82	.002632	9.21E-05	74.7	6846	15.89	.465	.329	3057	3453	9.545E 02	39.90	.0771	.863
87	.002546	8.69E-05	76.5	6913	15.85	.448	.306	2940	3516	9.734E 02	40.08	.0795	.830
96	.002484	8.39E-05	77.3	6899	15.74	.431	.282	2739	3506	9.697E 02	39.13	.0809	.798
102	.002439	7.71E-05	82.6	7076	15.62	.416	.257	2618	3671	1.020E 03	40.92	.0846	.772
110	.002352	7.03E-05	87.4	7222	15.50	.395	.226	2449	3812	1.063E 03	41.92	.0889	.733

PRESSURE DATA

PRESSURE DATA (PSIA)

TIME	P4	P6	P8	P10	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
76	.1266	.0482	.0137	.0117	.0179	.0189	.0190	.0186	.0184	.0212	.2671	.0248	.0272	.0290
82	.1295	.0485	.0136	.0116	.0178	.0189	.0189	.0184	.0179	.0209	.2593	.0249	.0267	.0281
87	.1257	.0472	.0132	.0112	.0169	.0180	.0182	.0178	.0176	.0203	.2449	.0239	.0257	.0271
96	.1230	.0464	.0130	.0110	.0165	.0177	.0179	.0175	.0170	.0200	.2402	.0239	.0255	.0266
102	.1195	.0453	.0127	.0108	.0162	.0173	.0177	.0173	.0167	.0198	.2319	.0228	.0245	.0257
110	.1121	.0430	.0121	.0102	.0149	.0161	.0165	.0161	.0158	.0189	.2040	.0712	.0231	.0239

TIME	P22	P26	P15A	P16A	P17A	P1
76	.0201	.0152	.0194	.0187	.0266	.8340
82	.0196	.0149	.0193	.0178	.0267	.8330
87	.0188	.0139	.0191	.0177	.0259	.8028
96	.0185	.0131	.0188	.0172	.0262	.7782
102	.0182	.0127	.0184	.0167	.0256	.7629
110	.0172	.0129	.0182	.0163	.0248	.7303

PRESSURE DATA (PRESSURE / POP)

TIME	P4	P6	P8	P10	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
76	.1425	.0542	.0154	.0131	.0201	.0212	.0214	.0209	.0207	.0238	.3006	.0279	.0306	.0326
82	.1499	.0562	.0158	.0135	.0207	.0219	.0219	.0213	.0207	.0242	.3045	.0288	.0310	.0326
87	.1514	.0568	.0160	.0135	.0204	.0217	.0220	.0216	.0212	.0245	.2949	.0287	.0310	.0326
96	.1541	.0581	.0163	.0138	.0207	.0221	.0225	.0219	.0213	.0250	.3008	.0299	.0319	.0333
102	.1547	.0586	.0165	.0139	.0209	.0224	.0229	.0226	.0216	.0257	.3002	.0295	.0317	.0333
110	.1528	.0587	.0164	.0138	.0203	.0219	.0225	.0220	.0215	.0258	.2782	.0289	.0315	.0326

TIME	P22	P26	P15A	P16A	P17A	P1
76	.0226	.0171	.0219	.0211	.0300	.9385
82	.0227	.0172	.0224	.0207	.0309	.9653
87	.0226	.0167	.0230	.0213	.0312	.9668
96	.0232	.0165	.0235	.0215	.0328	.9746
102	.0236	.0164	.0239	.0216	.0331	.9876
110	.0234	.0163	.0248	.0222	.0338	.9957