

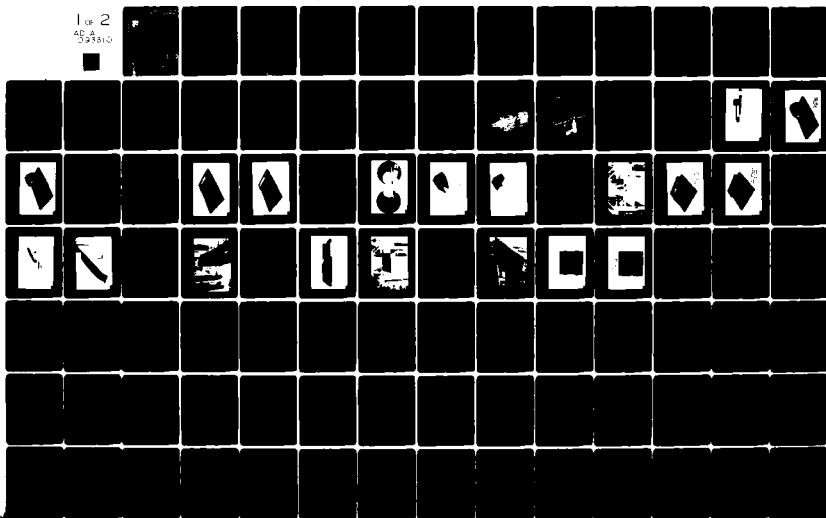
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MATERIALS TESTS OF
SPACE SHUTTLE ALTERNATE FOAMS AND
PROTUBERANCE DEBRIS MODELS

Gerald L. Dommerman

ARO, Inc.

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June 1980

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20. ABSTRACT (Continued)

representative of those expected during launch. Selected results are presented to illustrate the test techniques, photographic coverage, and typical data obtained.

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NOMENCLATURE

ALPI	Indicated sector pitch angle, deg
ALPPB	Sting prebend angle, deg
b	Thin-skin model skin thickness, in.
COLUMN	Streamwise group of thin-skin model thermocouples
CONFIG	Model configuration identification number
CP	Specific heat of thin-skin model material, Btu/lbm-°R
CR	Center of rotation, axial station along the tunnel centerline about which the model rotates in pitch, in.
C1	Laboratory calibrated scale factor used to convert Gardon gage output to heat transfer rate
C2	Correction factor applied to C1 as a function of TGE
DELP	Pressure difference between a model windward wall pressure and the average leeward wall pressure, psia
DTW/DT	Rate of change of model surface temperature with time, °R/sec
E	Gardon gage output, mv
GAGE	Gage identification number
HTT or H(TT)	Heat-transfer coefficient based on TT, $QDOT/(TT-TW)$, Btu/ft ² -sec-°R
ITT	Enthalpy based on tunnel stilling chamber temperature (TT), Btu/lbm
KG	Proportionality constant relating gage output, E, to the output of the gage edge thermocouple, TGE
M	Free-stream Mach number
MACS	Model Attitude Control System
MATERIAL	The model insulation material tested
MODEL	Tested model configuration

MU	Dynamic viscosity based on free-stream static temperature, lbf-sec/ft^2
P	Free-stream static pressure, psia
PHII	Indicated sector roll angle, deg
PT	Tunnel stilling chamber pressure, psia
PW	Model wall pressure, psia
Q	Free-stream dynamic pressure, psia
QDOT	Heat-transfer rate, $\text{Btu/ft}^2\text{-sec}$
QDOT-0	Heat-transfer rate based on 0°F wall temperature, $\text{Btu/ft}^2\text{-sec}$
RE	Free-stream unit Reynolds number, ft^{-1}
RHO	Free-stream density, lbm/ft^3
ROW	Spanwise group of thin-skin model thermocouples
RUN	Data set identification number
SAMPLE	Material specimen identification designation
T	Free-stream static temperature, $^\circ\text{R}$
t	Time, sec
TAP	Pressure orifice identification number
TC	Thermocouple number
TGDEL	Temperature difference from the gage center to its edge, $^\circ\text{R}$
TGE	Measured temperature of gage edge thermocouple, $^\circ\text{R}$
t_1	Time when initial model wall temperature was recorded, sec
TIME	Time of day in Central Time Zone, hours-min-sec
TIMECL	Time of day in Central Time Zone when the model reached tunnel centerline, hours-min-sec

TIMEEXP	Amount of time that the model was exposed to the tunnel flow, sec
TIMEEXPT	Total amount of time that the model was exposed to the tunnel flow, sec
TIMEINJ	Amount of time from model lift-off to tunnel centerline during injection, sec
TS	Material sample temperature, °F
TT	Tunnel stilling chamber temperature, °R
TW	Model surface temperature, °R
TW _i	Initial model surface temperature, °R
V	Free-stream velocity, ft/sec
WA	Wedge angle, the acute angle between the forward wedge surface and the free stream velocity vector, ALPPB - ALPI, deg
ρ	Thin-skin model material density, lbm/ft ³

1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 921E02, Control Number 9E02-00-9, at the request of the ~~National Aeronautics~~ and Space Administration (NASA), Marshall Space Flight Center (MSFC), Huntsville, Alabama, for the Martin Marietta Corporation (Michoud Operations), New Orleans, Louisiana. The Martin Marietta Corporation project monitors were Mr. Walter W. Blake and Mr. Steve C. Copsey, and the NASA/MSFC project monitor was Mr. John Warmbrod. The results were obtained by ARO, Inc., AEDC Group (a Sverdrup Corporation Company), operating contractor for the AEDC, AFSC, Arnold Air Force Station, Tennessee. The overall task consisted of five separate test entries conducted in the von Karman Gas Dynamics Facility (VKF), Tunnels A and C, over the period from October 17, 1979 through May 16, 1980, under ARO Project number V41A/C-A8.

The Shuttle External Tank (ET) is covered with foam insulating materials to prevent ice buildup before launch. If ice were allowed to form, it could separate from the ET and damage orbiter tiles during launch. Portions of the reusable Solid Rocket Boosters (SRB) are also foamed for protection from aerodynamic heating during their suborbital flights. The foam insulation also covers the protuberances which are present on the exterior surface of the ET and SRB such as the Barry Mount, Cable Tray Bracket, Intertank Stringers, etc. This report describes in detail each of the five entries which tested the performance of several different materials and geometries that may be used on the ET and SRB.

The primary test objectives and the test articles tested in each entry are described below:

<u>Entry</u>	<u>Primary Objectives</u>	<u>Test Articles</u>	<u>Tunnel (Test Date)</u>
1	Determine whether significant insulation debris is produced under maximum dynamic pressure conditions	Cable Tray Bracket Barry Mount	Tunnel A 10/17/79
2	Determine whether significant insulation debris is produced under maximum heating rates and corresponding dynamic pressure conditions	Cable Tray Bracket Barry Mount	Tunnel C 10/19/79
3	Determine whether significant insulation debris is produced under maximum dynamic pressure conditions	ET/SRB and Lox Tank Cable Tray Ramps	Tunnel A 1/17/80
4	Evaluate insulating and erosion of several alternate foam materials	Flat panels, shock generator, heater pad	Tunnel C 4/9/80
5	Evaluate insulating and erosion characteristics of materials covering the stringers on the ET intertank structure	Parallel and 10-degree stringers	Tunnel C 5/15/80

All materials were tested by means of the wedge testing technique. This technique involves using a large wedge at various incidence angles to produce the desired local conditions on the wedge that are of primary interest. Additional information about this technique can be found in Reference 1. The debris tests in Tunnel A were conducted at Mach number 2 and free-stream Reynolds numbers of 1.8×10^6 to 3.6×10^6 per foot and a wedge angle of 10 degrees. Tests in Tunnel C were conducted at Mach number 10 and free-stream Reynolds numbers of 0.4×10^6 to 2.2×10^6 per foot and wedge angles ranging from 10 to 25 degrees.

Inquiries to obtain copies of the test data should be directed to Mr. John Warmbrod, NASA/MSFC/ED33, Marshall Space Flight Center, Huntsville, Alabama 35812. A microfilm record has been retained in the VKF at AEDC.

2.0 APPARATUS

2.1 TEST FACILITIES

Tunnels A and C are continuous, closed-circuit, variable density wind tunnels. Tunnel A (Fig. 1) has an automatically driven flexible-plate-type nozzle and a 40- by 40-in. test section. The tunnel can be operated at Mach numbers from 1.5 to 6 at maximum stagnation pressures from 29 to 200 psia, respectively, and stagnation temperatures up to 750°R at Mach number 6. Minimum operating pressures range from about one-tenth to one-twentieth of the maximum at each Mach number. Tunnel C (Fig. 2) is a hypersonic wind tunnel with a Mach number 10 axisymmetric contoured nozzle and a 50-in.-diam test section. The tunnel can be operated continuously over a range of pressure levels from 200 to 2000 psia with air supplied by the VKF main compressor plant. Stagnation temperatures sufficient to avoid air liquefaction in the test section (up to 2260°R) are obtained through the use of a natural gas fired combustion heater in series with an electric resistance heater. The entire tunnel (throat, nozzle, test section, and diffuser) is cooled by integral, external water jackets. Each 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 these tunnels may be found in Ref. 2.

2.2 TEST ARTICLES

All test articles (Figs. 3 through 8) were supplied by the Martin Marietta Corporation. Details of the calibration models are presented in Figs. 9 and 10, and details of the materials samples instrumentation are shown in Figs. 11 and 12. Sketches showing typical model installations are provided in Figure 13.

2.2.1 Support Wedges

A wedge is used in materials testing to reduce the free-stream hypersonic Mach number to the desired supersonic level. Tunnel stagnation conditions are adjusted to produce the desired local flow conditions. Boundary-layer trips spheres were spot welded to the forward surface of each wedge to promote turbulent flow over the sample surfaces. Each

wedge was mounted on a sting which was selected to provide the wedge angles necessary to produce the required flow conditions and to position the samples for adequate photographic coverage.

Entries 1 and 3 in Tunnel A used a non-water-cooled steel wedge provided by the Martin Marietta Corporation to support the test specimens (Fig. 13a). This wedge was 41.5 in. long and 15.0 in. wide with a backstep 17.5 in. aft of the wedge leading edge.

Entries 2 and 5 in Tunnel C used a low-angle water-cooled wedge (Fig. 13b) provided by the VKF to support the test specimens. This wedge has the same dimensions as the wedge of Entries 1 and 3.

Entry 4 in Tunnel C used a high-angle (33.65 deg) water-cooled wedge (Fig. 13c) provided by the VKF. This wedge was 32.5 in. long and 17 in. wide with a backstep 8.5 in. aft of the wedge leading edge. The sting adapters in conjunction with the tunnel pitch mechanism provided the required testing wedge angles.

2.2.2 Debris Samples (Entries 1, 2, and 3)

The protuberances of interest in Entries 1, 2, and 3 were the Cable Tray Bracket/Barry Mount shown in Fig. 3a. The entire protuberance was too large to test full scale because of wind tunnel blockage considerations. Photographs and sketches of the models used to simulate the Cable Tray Bracket and Barry Mount are presented in Figs. 4 through 8.

In Entries 1 and 2, calibration models (Figs. 9a through 9d) of the Barry Mount and Cable Tray Bracket were tested first to measure the flow properties about the protuberance and to select the correct test conditions for testing the material samples. The material samples of the Barry Mount and Cable Tray Bracket were primarily made of BX-250 and PDL-4034. These samples were tested with and without 15 and 30 degree ramps or cones leading the protuberance to determine if these aerodynamic "smoothing" devices were effective in decreasing or eliminating material debris breaking off the protuberance. Examples of the samples tested in Entries 1 and 2 are illustrated in Figure 4 and 5, respectively.

Samples of ET/SRB and LOX Tank Cable Tray Brackets were tested in Entry 3 (Fig. 6). One of the ET/SRB Cable Tray Ramp samples made of BX-250 had a 1/8-in. groove cut across the ramp to simulate the presence of a crack in the foam which might appear on the actual flight article. Likewise, one of the ET/SRB Cable Tray Ramp samples made of PDL-4034 had a 1/16-in. "crack."

2.2.3 Alternate Foam and Intertank Stringer Samples (Entries 4 and 5)

The test articles for Entry 4 (Fig. 7) were basically flat panels of alternate foam materials mounted on an aluminum support plate (Fig. 7a). Eleven different materials were tested, all 24 in. long by 17 in. wide and, depending on the material, between 0.75 in. and 1.5 in. thick. Two samples made of SLA-561 were tested with a shock generator (Fig. 7c), which created a shock across the width of the sample. For samples made of CPR-488 over SLA-561, an electric heater pad was positioned under

the aluminum support plate to preheat the sample backside before testing as a check for material adhesiveness.

The test articles for Entry 5 included (1) a thin-skin heat-transfer calibration model of the ET Intertank Stringers (Figs. 8a and 8b), (2) foamed stringers oriented parallel to the flow (Fig. 8c), (3) foamed stringers oriented 10 degrees to the flow (Fig. 8d), and (4) four additional flat panel alternate foam panels. The Intertank Stringer material samples were made of CPR-488 and CPR-488 over SLA-561.

2.3 TEST INSTRUMENTATION

2.3.1 General

The instrumentation, recording devices, and calibration methods used to measure the primary tunnel and test data parameters are listed in Table 1a, along with the estimated measurement uncertainties. The range and estimated uncertainties for primary parameters that were calculated from measured parameters are listed in Table 1b.

2.3.2 Cameras

A variety of cameras was used to record the testing of the samples. Shadowgraph movies and still photographs were taken to visualize shock wave patterns and flow directions about the protuberance samples. Color motion pictures and color stills were taken to record any changes in the samples as they were tested. A black and white video tape was also made for general coverage during the test.

The cameras were positioned in such a way as to cover the entire aerodynamic surface of the sample and to afford increased perspective. Frame rates of 100 and 400 fps were set for selected cameras in Entries 1, 2, and 3 to record the sizes of debris as it separated from the sample. Grid lines were projected onto the samples in Entries 4 and 5 to show the surface contour as they eroded. Camera setup summaries for all entries are shown in Table 2. All photographic data taken in the test are identified in Table 3.

2.3.3 Calibration Models (Entries 1, 2, and 5)

Barry Mount and Cable Tray Bracket calibration models in Entries 1 and 2 were instrumented with pressure taps to determine the pressure distribution about the protuberances. The locations of the taps are shown on Figs. 9a through 9d.

Thermopile Gardon gages supplied by the VKF were used on the calibration models in Entry 2 to determine the heat-transfer distribution on the protuberances. The thermopile gage utilizes vapor-deposited layers of antimony and bismuth to form a thermopile on the back surface of the sensing foil. The gages were 1/4 in. in diameter with a sensing foil thickness of 0.010 in. The gages were instrumented with Chromel-[®] Alumel[®] thermocouples which provided the gage edge temperature measurement. Gage edge temperatures together with the thermopile output were used to

determine the gage surface temperatures and corresponding gage heat-transfer rate. These data were then used to compute the local heat-transfer coefficient. The Cable Tray Bracket was instrumented with 7 thermopile Gardon gages and the Barry Mount with 8 gages. A sketch showing the general arrangement of the model instrumentation is presented in Fig. 9. Five standard high-temperature Gardon gages were installed in the wedge aft of trip spheres and ahead of the backstep (see Fig. 9e). The gages are 1/4 in. in diameter and had a foil thickness of 0.010 in.

The thin-skin Intertank Stringer calibration models in Entry 5 were instrumented with 60 thermocouples located as shown in Fig. 10. These thermocouples were arranged in rows and columns for online data reduction efficiency and ease of data interpretation. The coordinates and skin thicknesses corresponding to each thermocouple are listed in Table 4.

2.3.4 Materials Samples (Entries 4 and 5)

The alternate foam panels in Entry 4 were each instrumented with three thermocouples (Fig. 11). The Intertank Stringer samples in Entry 5 were instrumented with up to 6 thermocouples. The locations of the thermocouples in the Intertank Stringer samples are shown in Fig. 12.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS

A summary of the nominal free-stream test conditions for each Entry is given below:

ENTRY	M	PT, psia	TT, °R	Q, psia	RE x 10 ⁻⁶ /ft
1	2.00	9.0	650	3.21	1.80
	2.00	12.3	610	4.40	2.66
	2.00	13.0	610	4.64	2.80
	2.00	13.0	650	4.67	2.60
	2.00	15.3	610	5.45	3.30
	2.00	15.3	650	5.45	3.00
	2.00	16.5	610	5.90	3.60
	2.00	17.0	650	6.10	3.40
2	10.02	300	1900	0.46	0.366
	10.05	600	1900	0.92	0.735
3	2.00	14	610	5.00	3.00
	2.00	15	610	5.38	3.25
4	10.10	1750	1900	2.70	2.16
5	10.10	1750	1900	2.70	2.16

A test summary showing the configurations tested and the variables for each is presented in Table 5.

3.2 TEST PROCEDURES

3.2.1 General

In the VKF continuous-flow wind tunnels (A, B, C), the model is mounted on a sting support mechanism in an installation tank directly underneath the tunnel test section. The tank is separated from the tunnel by a pair of fairing doors and a safety door. When closed, the fairing doors, except for a slot for the pitch sector, cover the opening to the tank, and the safety door seals the tunnel from the tank area. After the model is prepared for a data run, the personnel access door to the installation tank is closed, the tank is vented to the tunnel flow, the safety and fairing doors are opened, 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 vented to atmosphere to allow access to the model in preparation for the next run. The sequence is repeated for each configuration change.

Model attitude positioning and data recording were accomplished in one of two ways for each model injection. Either the model attitude was set while in the installation tank before injection and injected at that attitude with data recording taking place manually or automatically at preselected time intervals, or the model was injected using the point-pause and sweep modes of operation under the control of the VKF Model Attitude Control System (MACS). With the MACS, model pitch requirements were entered into the controlling computer prior to the test and model positioning and data recording operations were performed automatically by selecting the list of desired model attitudes and initiating the system.

3.2.2 Test Procedure for Debris Entries (Entries 1, 2, and 3)

The calibration phase of Entry 1 was conducted to find the total pressure required to create an 8.5-psia pressure difference across the Cable Tray Bracket and Barry Mount with a local Mach number of 1.6. This local Mach number required a free-stream Mach number of 2.0 and a 10-degree wedge angle. The Barry Mount and Cable Tray Bracket calibration models were tested at total pressures ranging from 9 to 17 psia. The results indicated that a pressure of 15.3 psia was required to produce the 8.5-psia difference across the model (Fig. 14). The materials samples were then injected into the flow at a 0 wedge angle (to minimize injection loads), pitched to the 10 deg wedge angle, held for 10 sec where the maximum dynamic pressure was experienced, pitched back to 0 wedge angle, and retracted out of the flow.

The calibration phase of Entry 2 was conducted to find the combination of wedge angle and total pressure that resulted in an approximate pressure difference of 2.0 psia across the Barry Mount and Cable Tray Bracket along with heating rates of between 5 and 40 Btu/ft² sec. These conditions were obtained at a total pressure of 300 psia and at a wedge angle of 10 degrees for the Barry Mount and 7.5 degrees for the Cable Tray Bracket. The materials samples were then tested under these conditions for about 20 seconds each.

The LOX Tank and ET/SRB Cable Tray Ramps in Entry 3 were subjected to the dynamic pressure environment at free-stream conditions of Mach number 2.0 and a total pressure of 14.0 psia. These samples were injected into tunnel flow at 0 wedge angle. The MACS pitched it to a 10-degree wedge angle over a 20-second period, held at 10 degrees for 10 sec, pitched back to 0, and retracted just as was done in Entry 1.

3.2.3 Test Procedure for Alternate Foams (Entry 4)

The free-stream flow conditions and wedge angles were known to produce the required heating rates for the alternate foam samples from numerous past tests. Therefore, no calibration was necessary. Each foam panel was clamped onto the wedge and injected into the flow at the desired wedge angle between 10 and 25 degrees for the amount of exposure time required, nominally 60 seconds. Samples which were instrumented with thermocouples were monitored every 2 seconds to record the insulating performance of the material.

Two SLA-561 samples were tested with a shock generator. The shock generator was attached to the wedge and covered the entire span of the sample. Both SLA-561 samples were tested at a 12-degree wedge angle. However, the shock generator angle (Fig. 7c) was 10 degrees for one and 15 degrees for the other.

Before testing, two CPR-488 over SLA-561 samples were preheated by an electric heater pad located between the aluminum support plate of the panel and the wedge. The thermocouples inside the foam were monitored until the temperature of the foam next to the aluminum plate was about 250°F. The heater pad itself was also monitored to avoid overheating it in the process. The samples were injected into the flow and observed for any effect of the preheating on the adhesiveness of the foam.

3.2.4 Test Procedure for Intertank Stringers (Entry 5)

Tunnel operating conditions similar to Entry 4 were established. The thin-skin calibration model was tested in both the parallel and 10-degree configurations at various wedge angles between 10 degrees and 25 degrees. The model was injected and kept on tunnel centerline for 3 seconds, which was long enough to adequately obtain the heating rate distribution over the entire model. A typical plot of this "thermal map" is shown in Fig. 15 for one row.

The foamed stringer samples were then individually tested at pre-selected wedge angles between 10 and 25 degrees for exposure times of between 15 and 75 seconds. Those samples instrumented with thermocouples were monitored every 2 seconds to record the material insulating performance.

3.3 DATA REDUCTION

3.3.1 Pressure Data Reduction

The pressure data obtained during the calibration phases of Entries 1 and 2 were obtained using standard pressure systems and data reduction procedures. The data reduction program calculated the difference between windward pressures and the average base or leeward pressure. This difference was designated DELP.

3.3.2 Gardon Gage Data Reduction

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

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

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

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

The gage wall temperature used in computing the gage heat-transfer coefficient is obtained from two measurements - the output of the gage edge thermocouple (TGE) and the temperature difference (TGDEL) from the gage center to its edge which is proportional to the gage output, E, calculated by

$$TGDEL = (KG)(E) \quad (3)$$

The gage wall temperature is then computed as

$$TW = TGE + 0.75 TGDEL \quad (4)$$

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

The "standard" Gardon gage data reduction procedure was used to compute model local heat-transfer coefficients. The procedure averages five consecutive samples of gage output, E, commencing with the data loop recorded at least one second after the model arrives at tunnel centerline. The average output is then compared to each individual reading used in the average to check for "wild" points. If the individual readings differ from the calculated average by more than ± 2 percent or ± 15 counts, whichever is larger, an asterisk (*) is printed next to the tabulated value of QDOT. The gage edge temperature (TGE) was averaged in the same manner with ± 5 -deg allowable deviation from the average.

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

$$H(TT) = \frac{QDOT}{(TT - TW)} \quad (5)$$

and the "cold wall" ($TW = 0^\circ F$) heating rate was determined by

$$QDOT-0 = [H(TT)] [TT-460] \quad (6)$$

3.3.3 Thin-Skin Data Reduction

The reduction of thin-skin thermocouple data normally involves only the calorimetric heat balance, which, in coefficient form is

$$H(TT) = \rho b CP \frac{DTW/DT}{TT - TW} \quad (7)$$

and the "cold wall" heating rate is calculated using Eq. (6).

Radiation and conduction losses are neglected in this heat balance, and data reduction simply requires evaluation of DTW/DT from the temperature-time data and determination of model material properties. For the present test, radiation effects were negligible. However, conduction effects were potentially significant in several regions of the model. To permit identification of these regions and improve evaluation of the data, the following procedure was used.

Separation of variables and integration of Eq. (7), assuming constant ρ , b , CP and TT yields

$$\frac{H(TT)}{\rho b CP} (t - t_1) = \ln \frac{TT - TW_1}{TT - TW} \quad (8)$$

Since $H(TT)/\rho b CP$ is a constant, plotting $\ln [(TT - TW_1)/(TT - TW)]$ versus time will give a straight line if conduction is negligible. Thus, deviations from a straight line can be interpreted as conduction effects.

The data were evaluated in this manner and, generally, a reasonably linear portion of the curve could be found for all thermocouples. A linear least-squares curve fit of $\ln[(TT - TW_1)/(TT - TW)]$ versus time was applied to the data. The data were reduced starting on centerline. The curve fit extended for a time span which was a function of the heating rate, as shown on the following list.

<u>Range</u>	<u>Number of Points</u>	<u>Time Span, sec</u>
$DTW/DT > 32$	5	0.340
$16 < DTW/DT \leq 32$	7	0.476
$8 < DTW/DT \leq 16$	9	0.612
$4 < DTW/DT \leq 8$	13	0.884
$2 < DTW/DT \leq 4$	17	1.156
$1 < DTW/DT \leq 2$	25	1.700
$DTW/DT \leq 1$	41	2.788

In general, the time spans were adequate to keep the evaluation of the right-hand side of Eq. (8) within the linear region. The value of CP is not constant, as assumed, and the relation

$$CP = (2.42278 \times 10^{-4}) + (4.06120 \times 10^{-4})TW \quad (9)$$

$$-(4.67726 \times 10^{-7})TW^2 + (1.94974 \times 10^{-10})TW^3 \text{ Btu/lbm}^\circ\text{R}$$

was used with the computed value of TW at the midpoint of the curve fit to evaluate CP. The maximum variation of CP over any curve fit was less than 0.2 percent. Thus, the assumption of constant CP was reasonable. The value of density used for the 304 stainless steel skin was $\rho = 509.352 - 0.0153594 TW \text{ lbm/ft}^3$, and the skin thickness, b, for each thermocouple is listed in Table 4.

3.4 UNCERTAINTY OF MEASUREMENTS

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

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

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

Estimates of the measured data uncertainties for this test are given in Table 1a. The data uncertainties for the measurements are determined from in-place calibrations through the data recording system and data reduction program.

Propagation of the bias and precision errors of measured data through the calculated data was made in accordance with Ref. 2, and the results are given in Table 1b.

4.0 DATA PACKAGE PRESENTATION

A complete set of all photographic data and tabulated data for each of the five entries in this test has been forwarded to the Martin Marietta Corporation. Photographic data which showed significant testing results and a complete set of tabulated data have been provided to NASA/Marshall Space Flight Center/EP44, Huntsville, Alabama. All test articles for this test have been returned to the Martin Marietta Corporation.

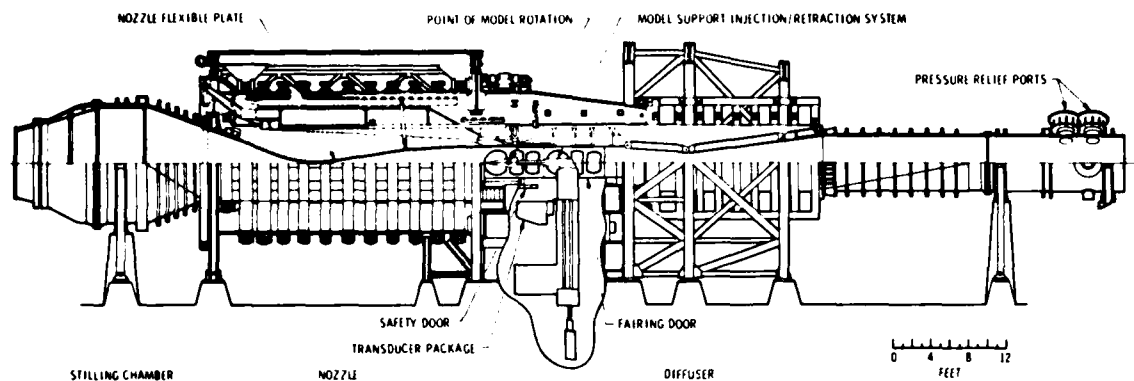
Samples of the tabulated data from the calibration and materials specimen runs are presented in Appendix III. A copy of all data has been retained at AEDC at the VKF.

REFERENCES

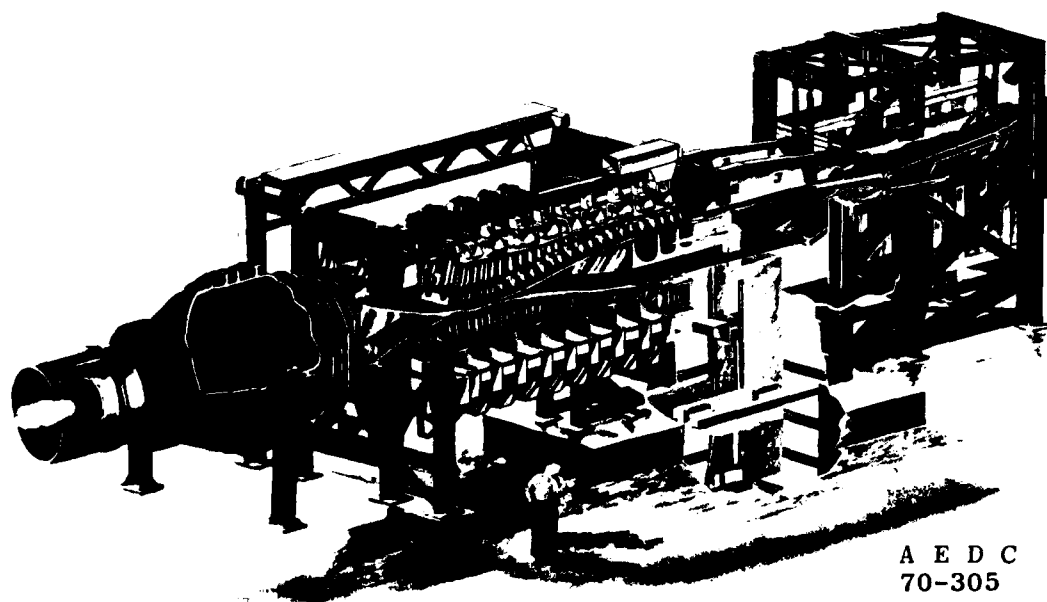
1. Matthews, R. K. and Stallings, D. W. "Materials Testing in the VKF Continuous Flow Wind Tunnels." Presented at AIAA 9th Aerodynamic Testing Conference, Arlington, TX, June 7-9, 1976.
2. Test Facilities Handbook (Eleventh Edition). "Von Kármán Gas Dynamics Facility, Vol. 3." Arnold Engineering Development Center, June 1979.

APPENDIX I

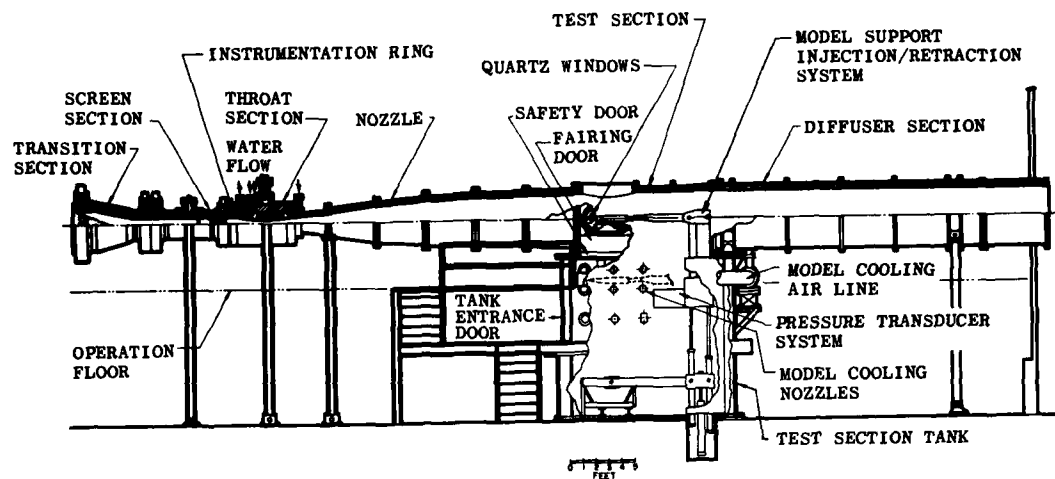
ILLUSTRATIONS



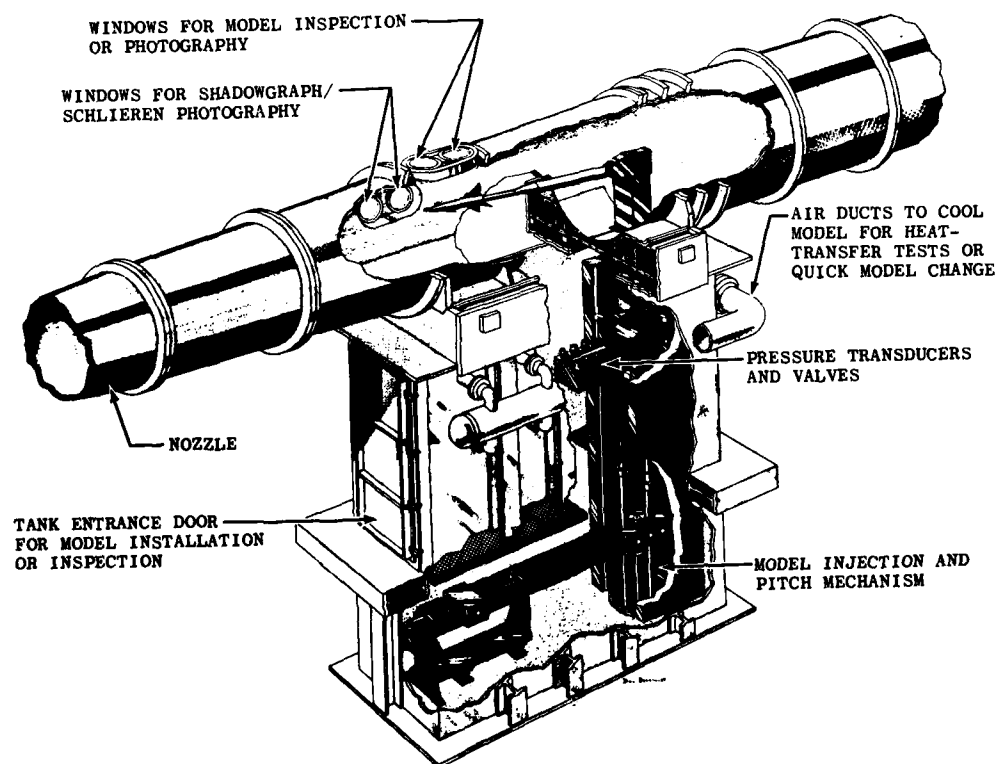
a. Tunnel assembly



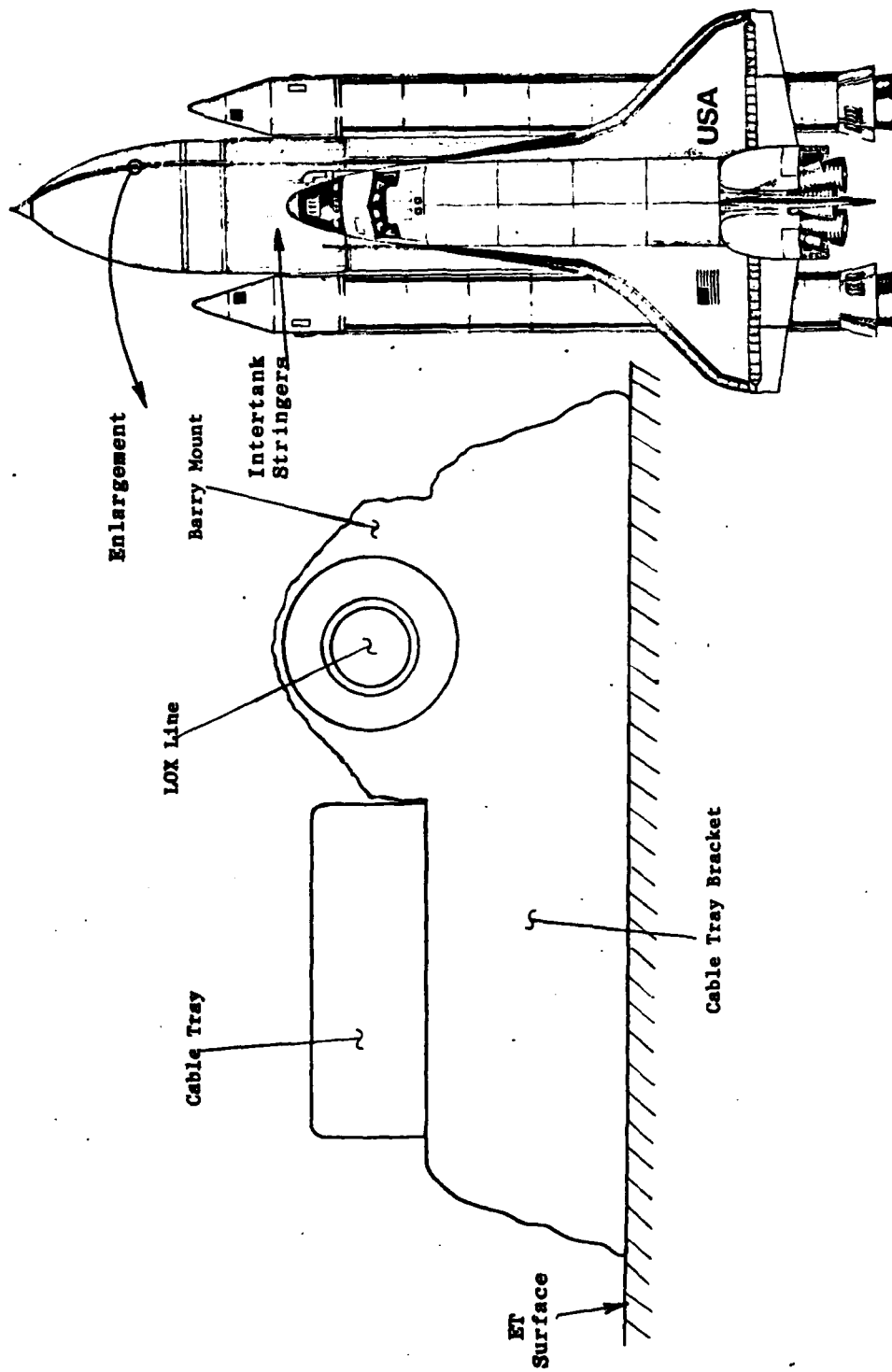
b. Tunnel test section
Fig. 1 Tunnel A



a. Tunnel assembly

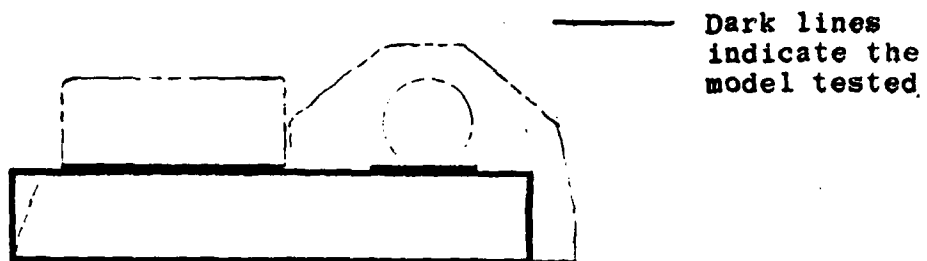


b. Tunnel test section
Fig. 2 Tunnel C

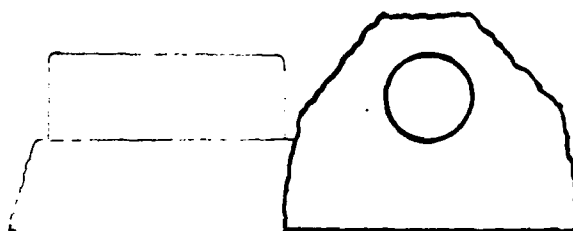


a. General Assembly

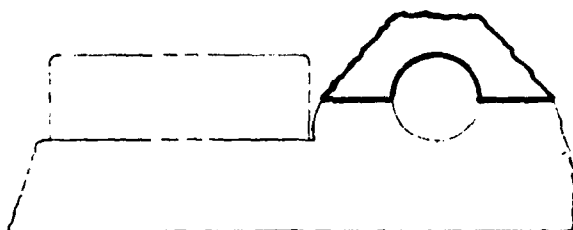
Figure 3. Barry Mount/Cable Tray Bracket Protuberance



**Cable Tray Bracket model tested
in Tunnels A and C**

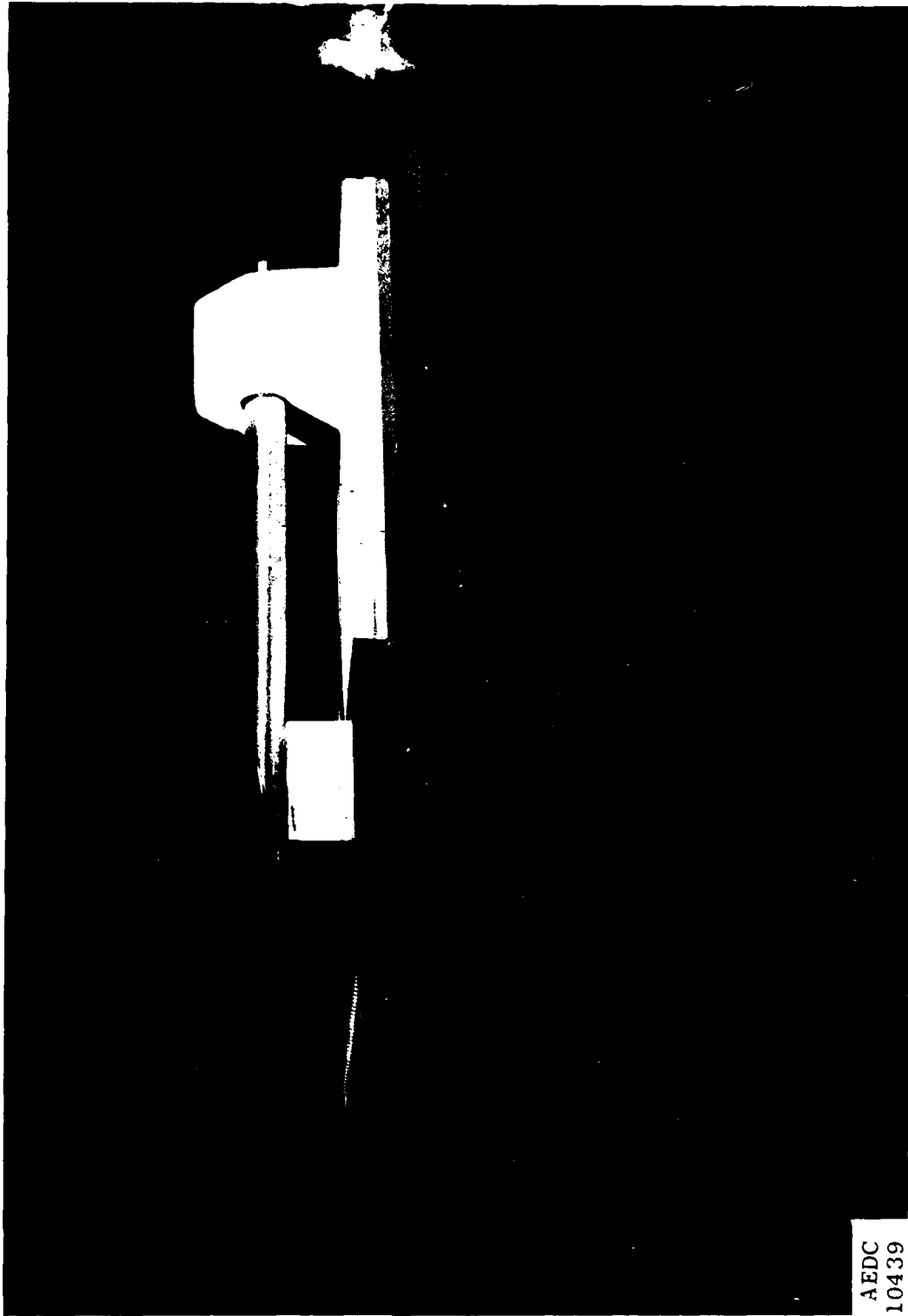


Barry Mount model tested in Tunnel A



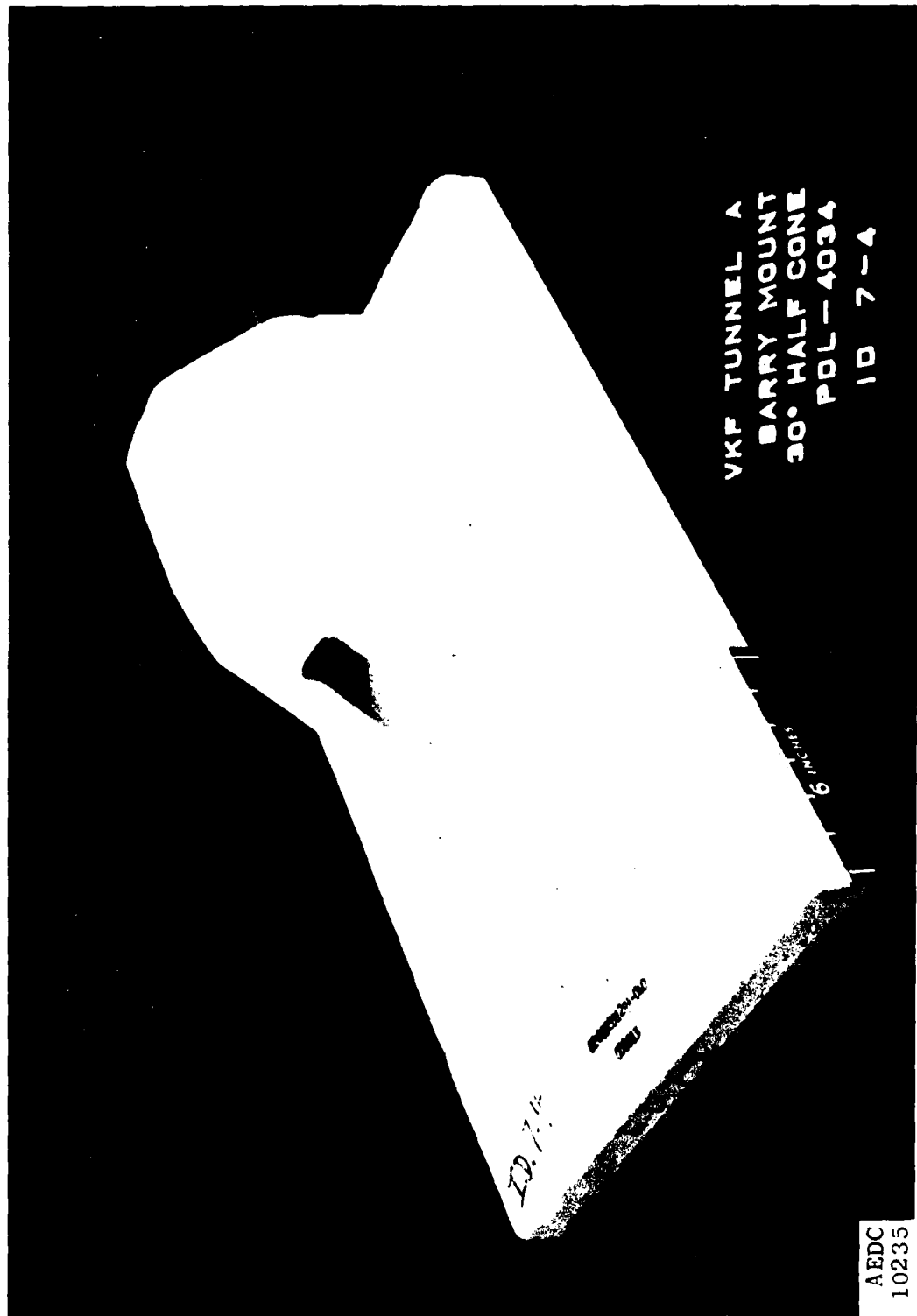
Barry Mount model tested in Tunnel C

**b. Tunnels A and C Models
Figure 3. Concluded**

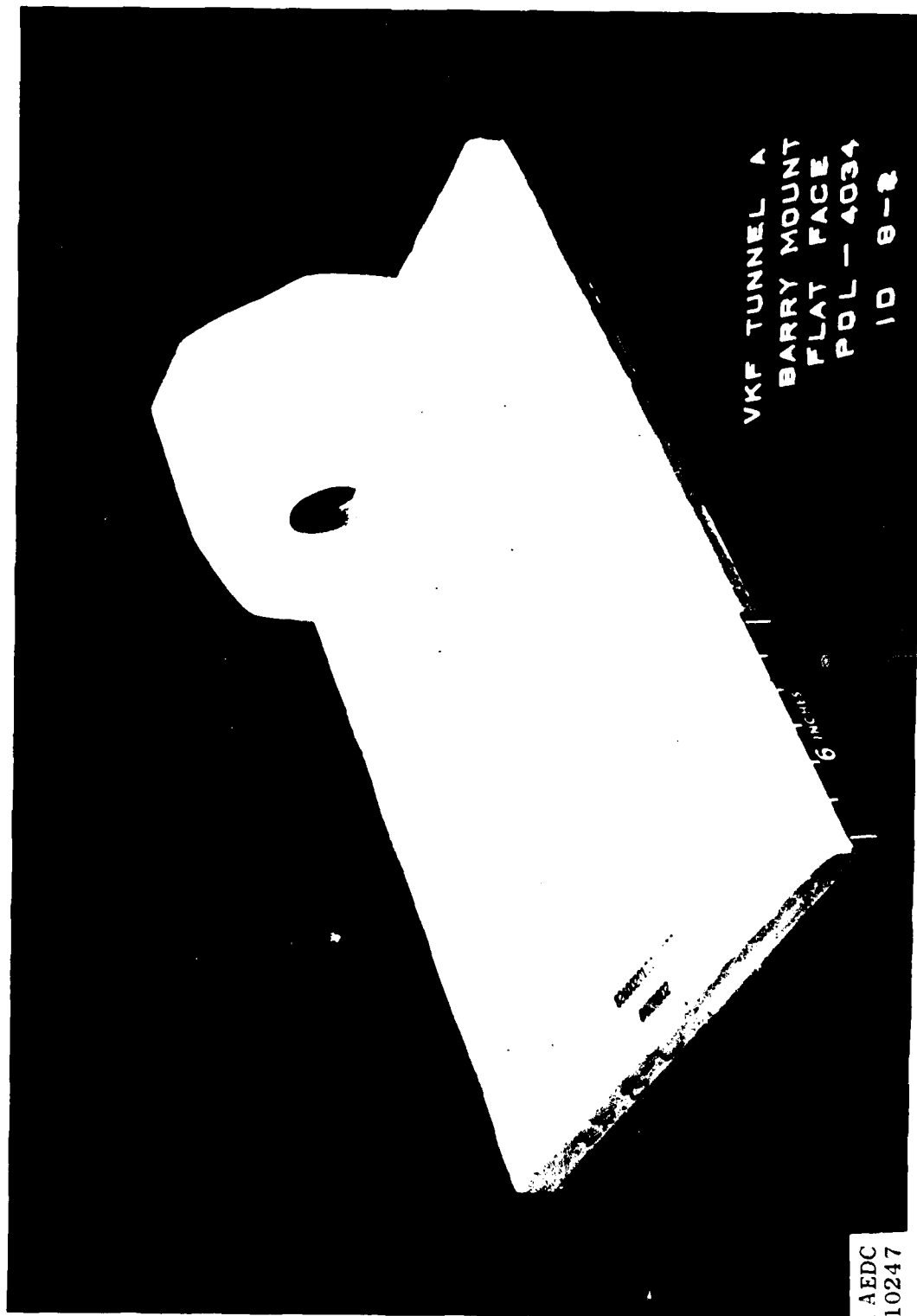


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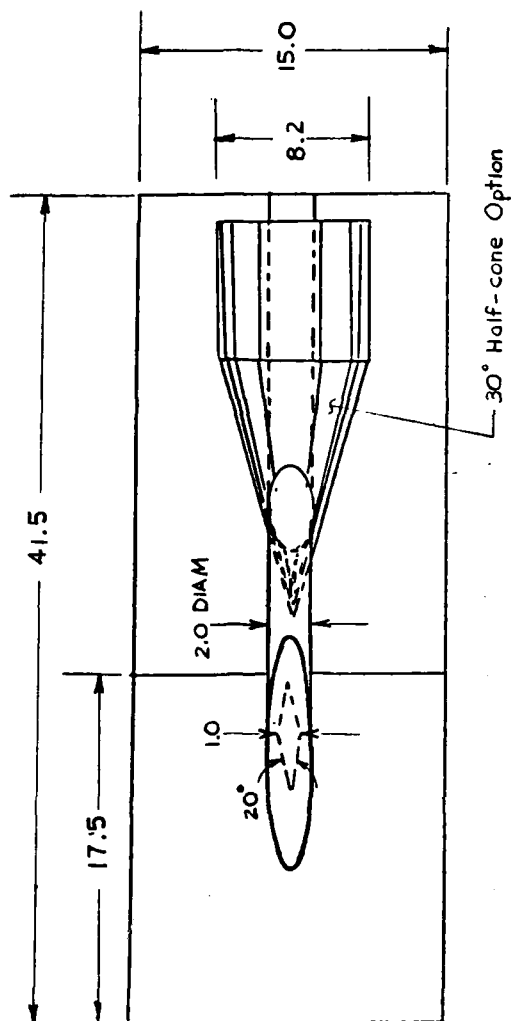
a. Flat face Barry mount sample installed on the wedge
Figure 4. Tunnel A Barry Mount and Cable Tray Bracket Debris Models



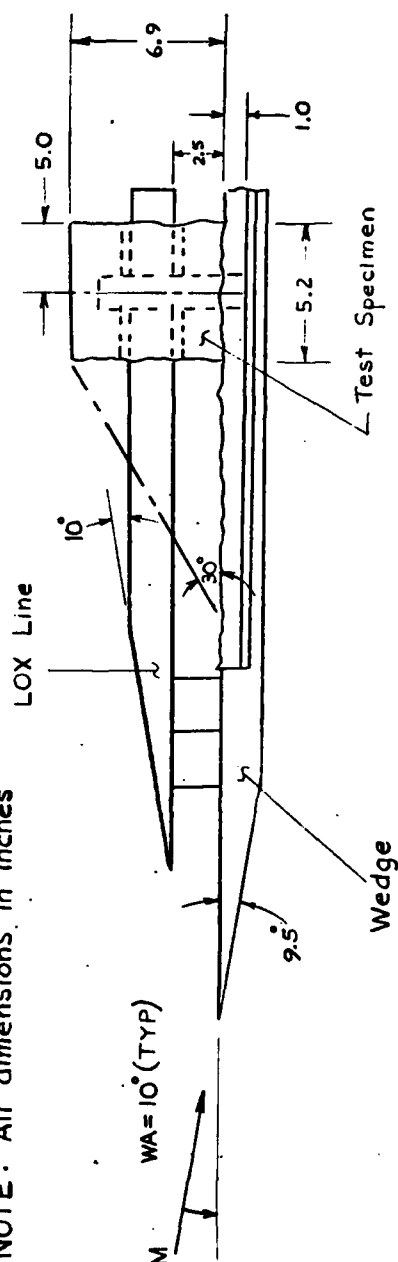
b. Barry mount sample with a 30 degree half-cone
Figure 4. Continued



c. Flat face Barry mount sample
Figure 4. Continued



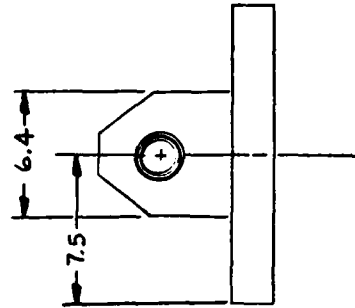
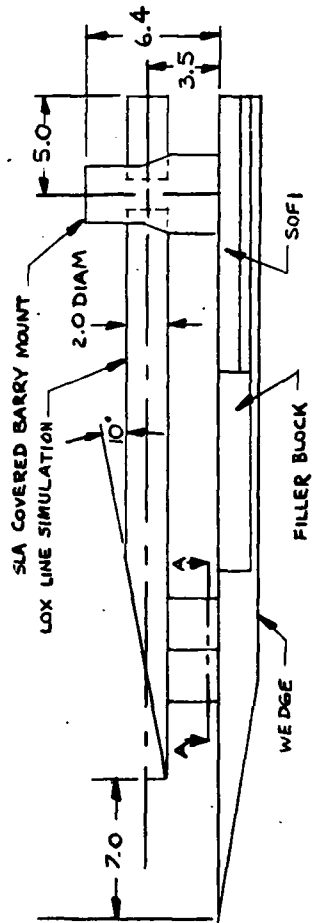
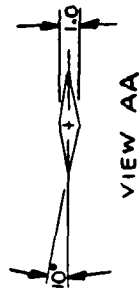
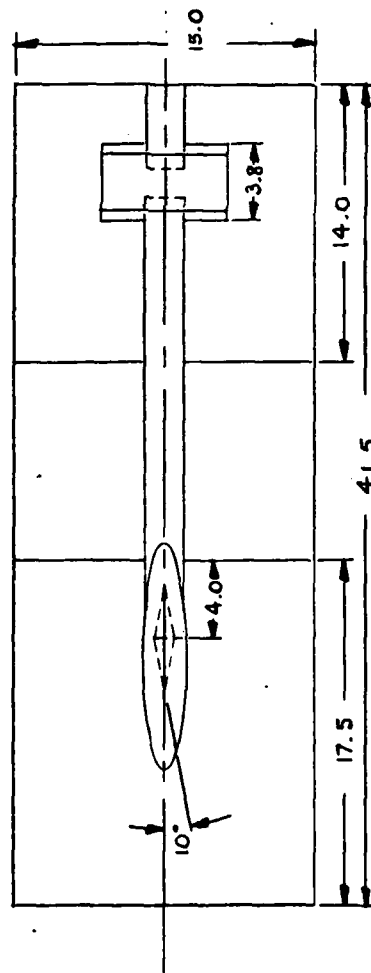
NOTE: All dimensions in inches



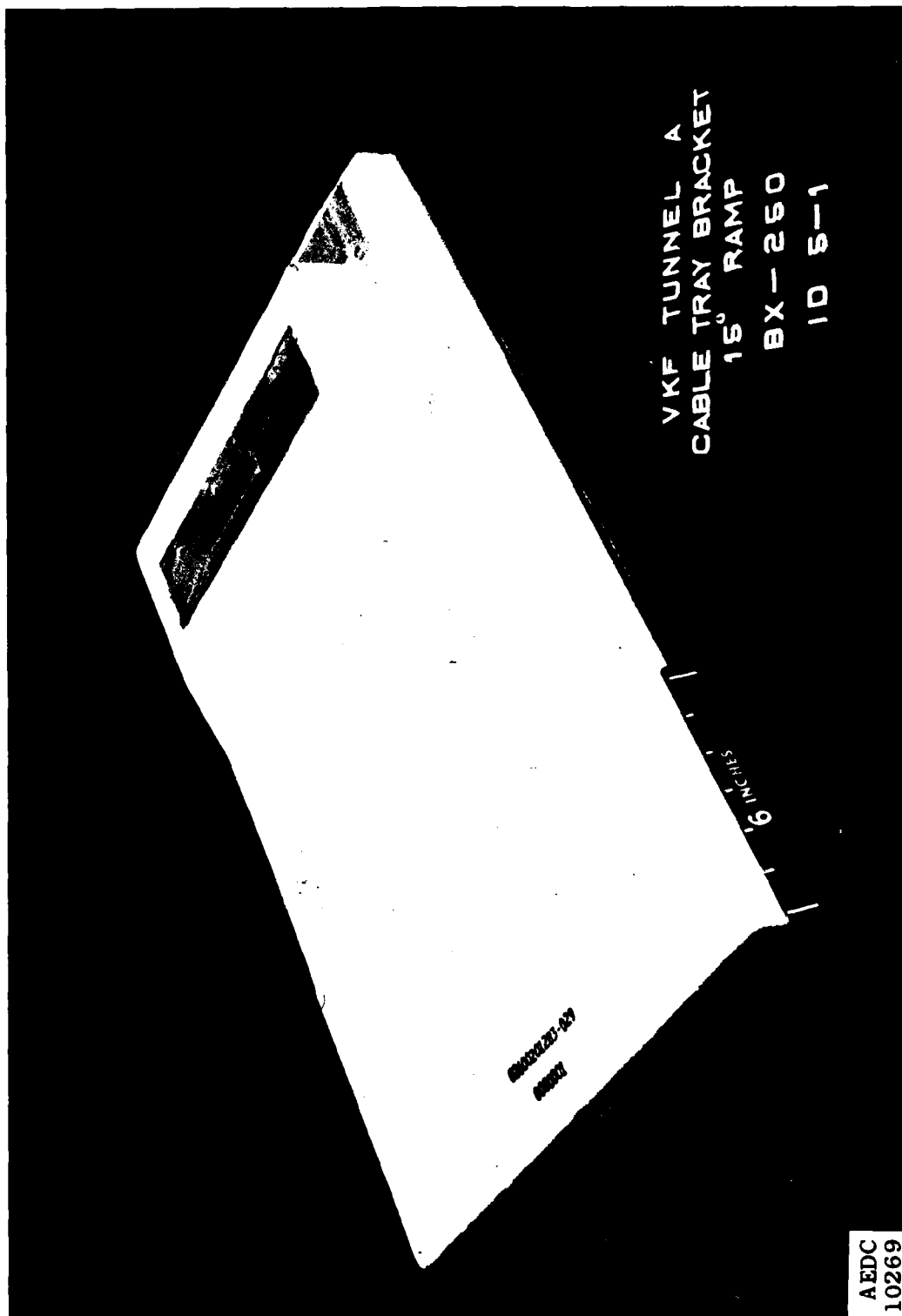
d. Sketch of Barry Mount Model

Figure 4. continued.

NOTE: All dimensions in inches

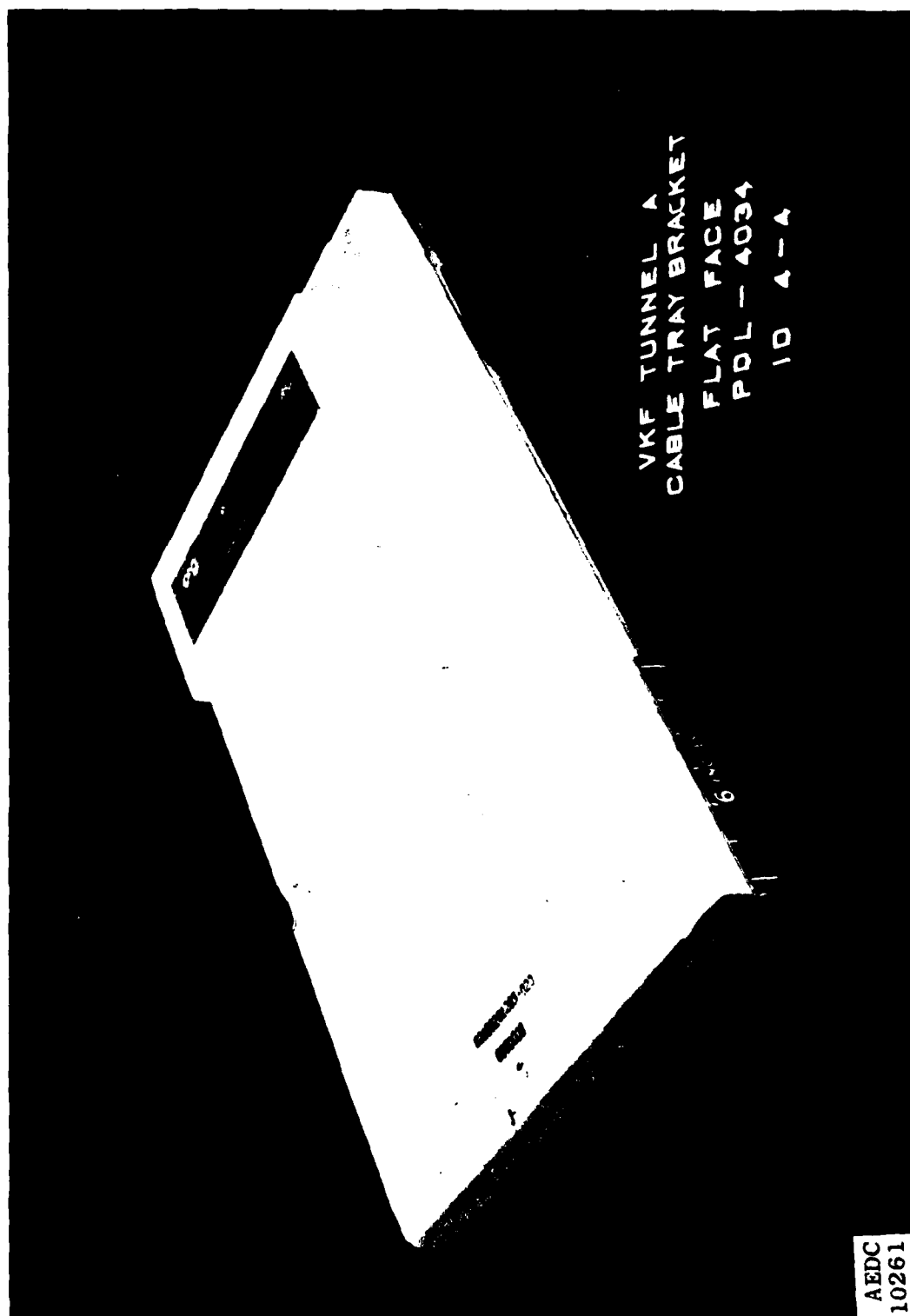


ø. Sketch of the SLA Covered Barry Mount Model (Entry 3)
Figure 4. Continued

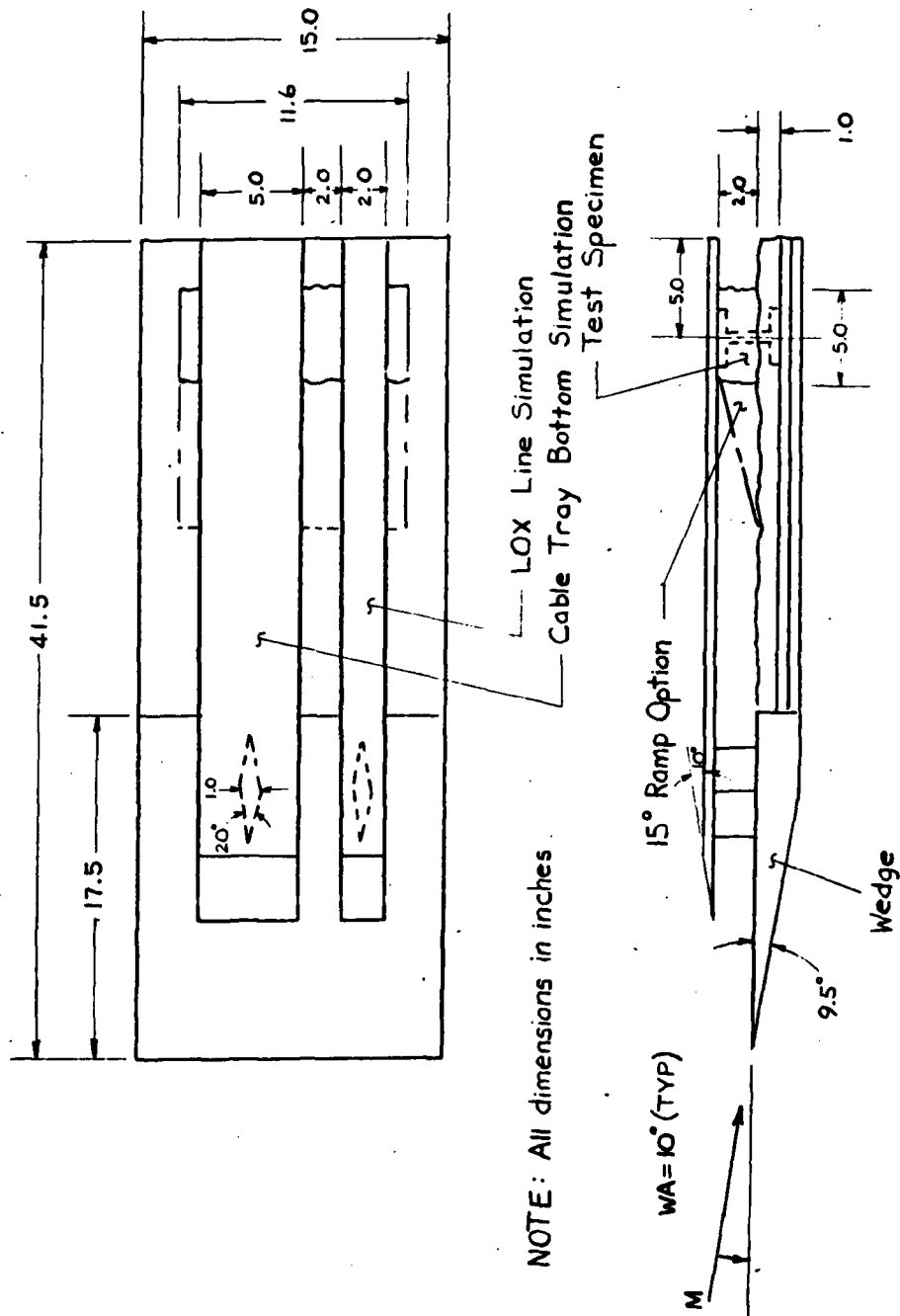


f. Cable tray bracket sample with a 15 degree ramp

Figure 4. Continued



g. Flat face cable tray bracket sample
Figure 4. Continued



h . Sketch of Cable Tray Bracket Model

Figure 4. concluded.

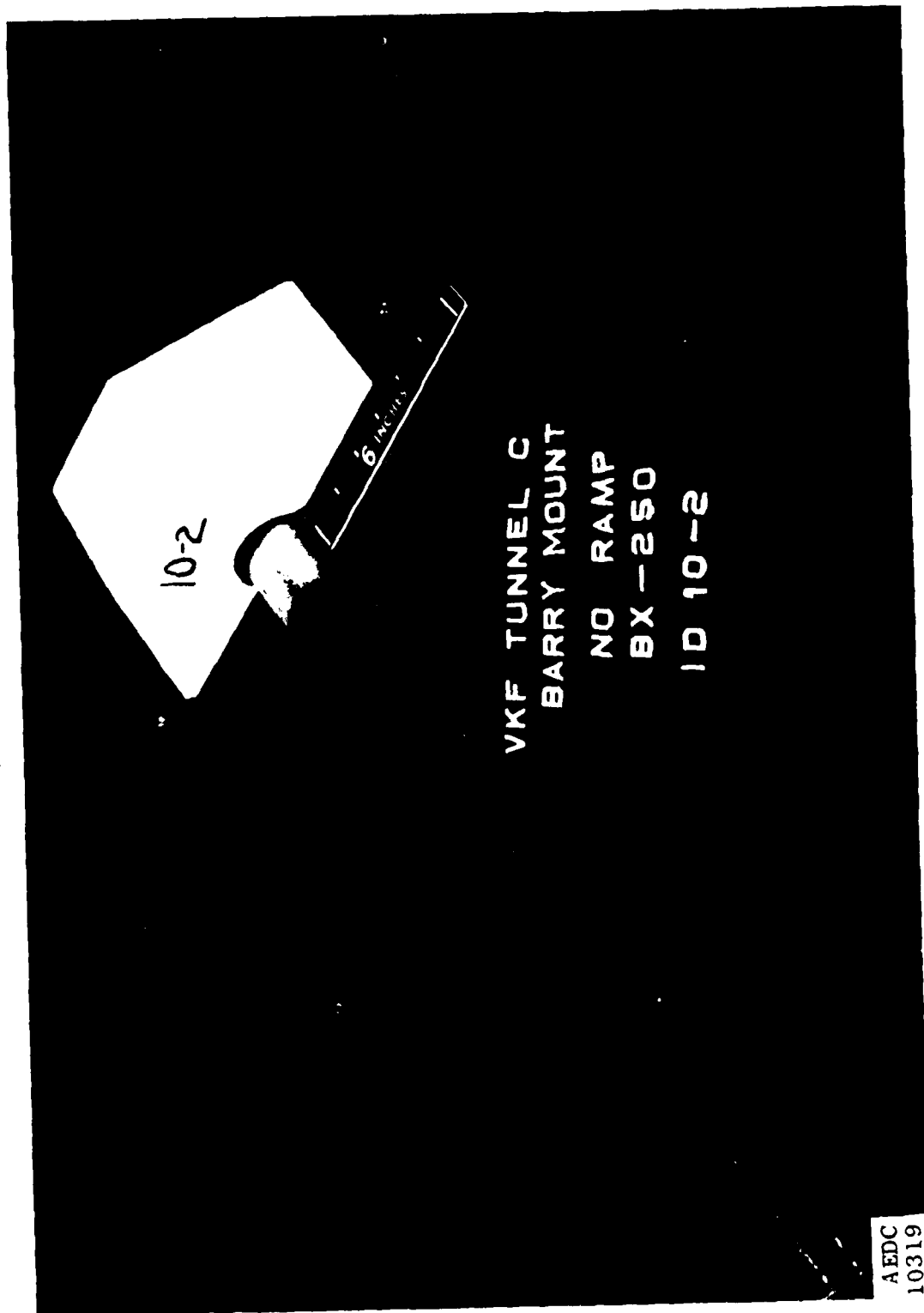


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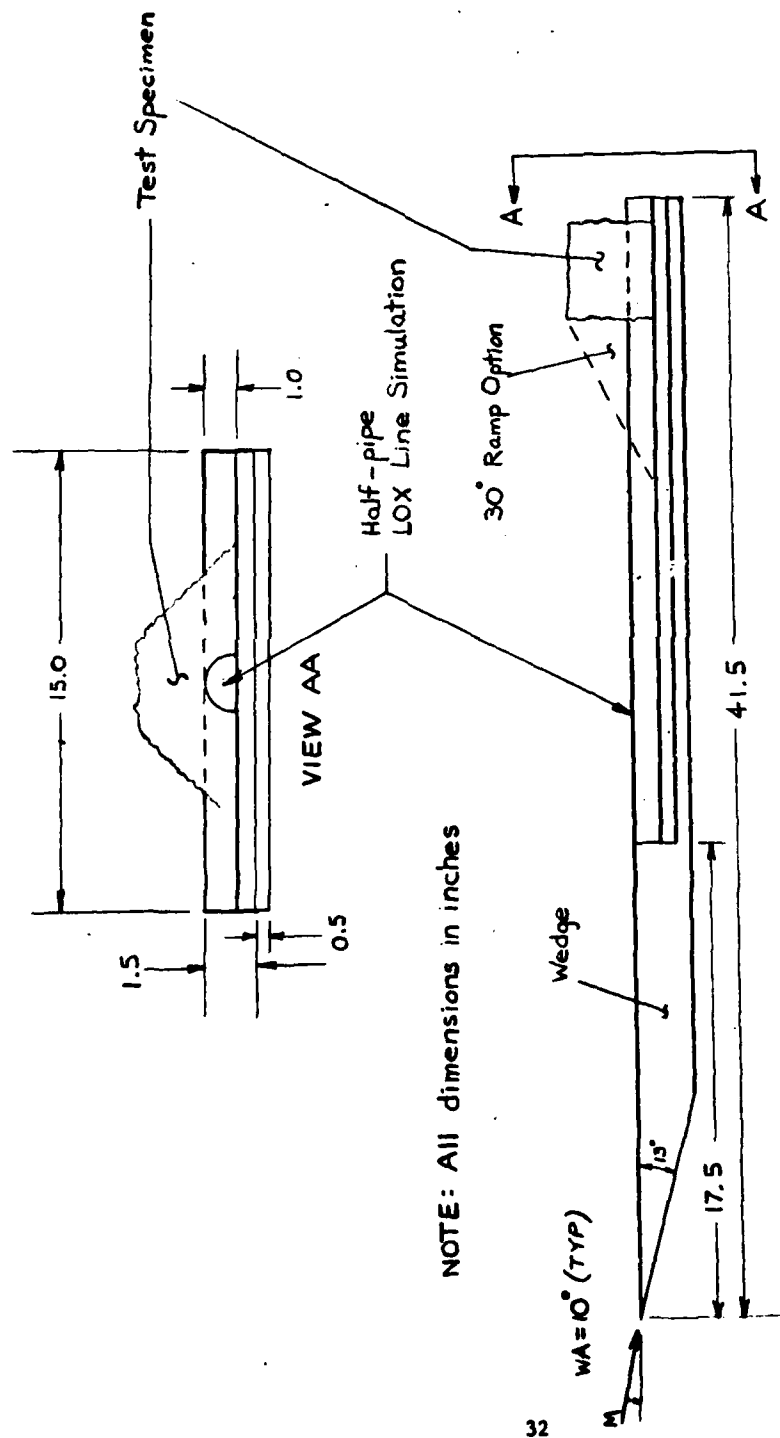
a. Barry mount in Tunnel C
Figure 5. Tunnel C Barry Mount and Cable Tray Bracket Debris Models



b. Barry mount with a 30 degree ramp
Figure 5. Continued

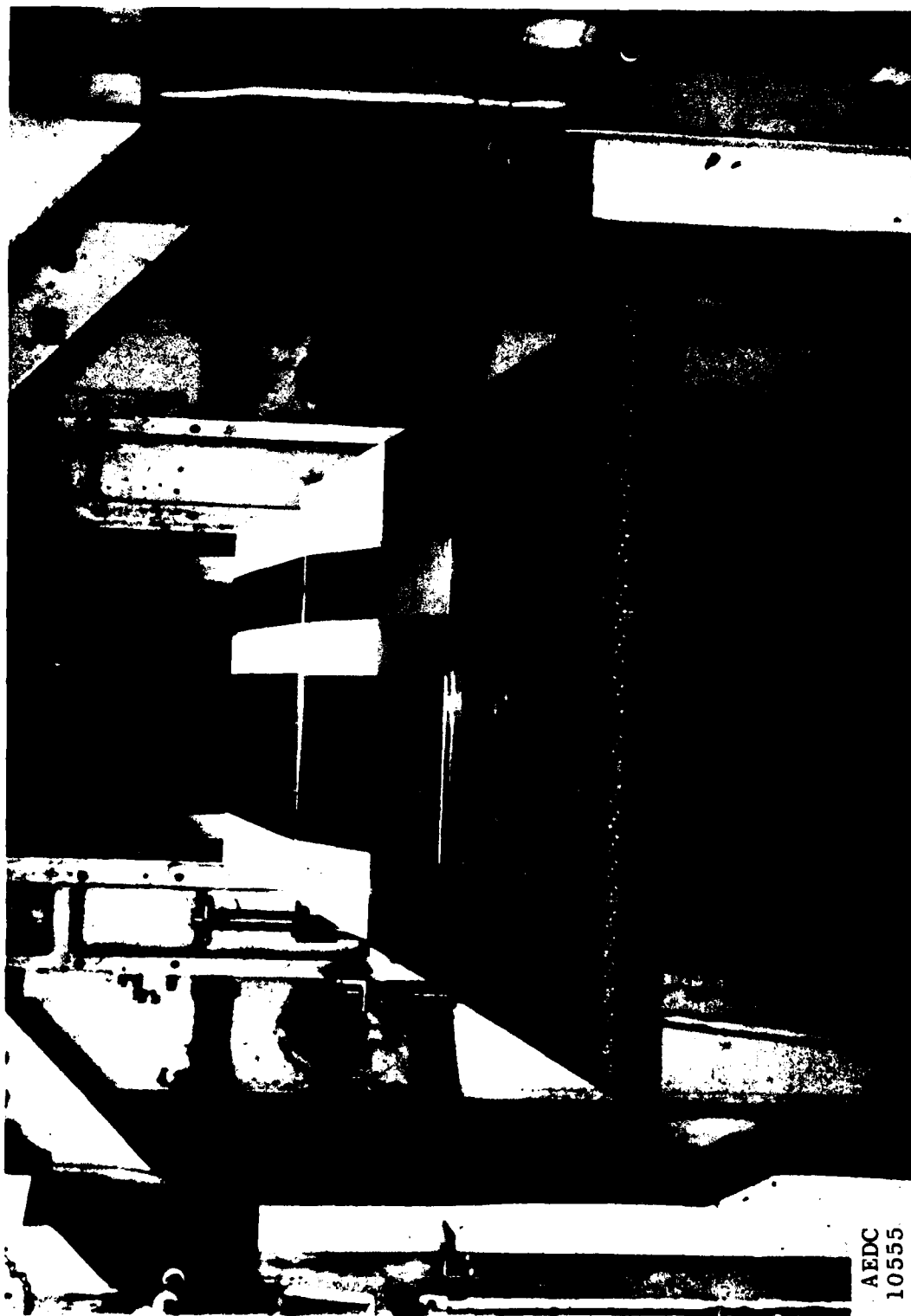


c. Flat face Barry mount sample
Figure 5. Continued



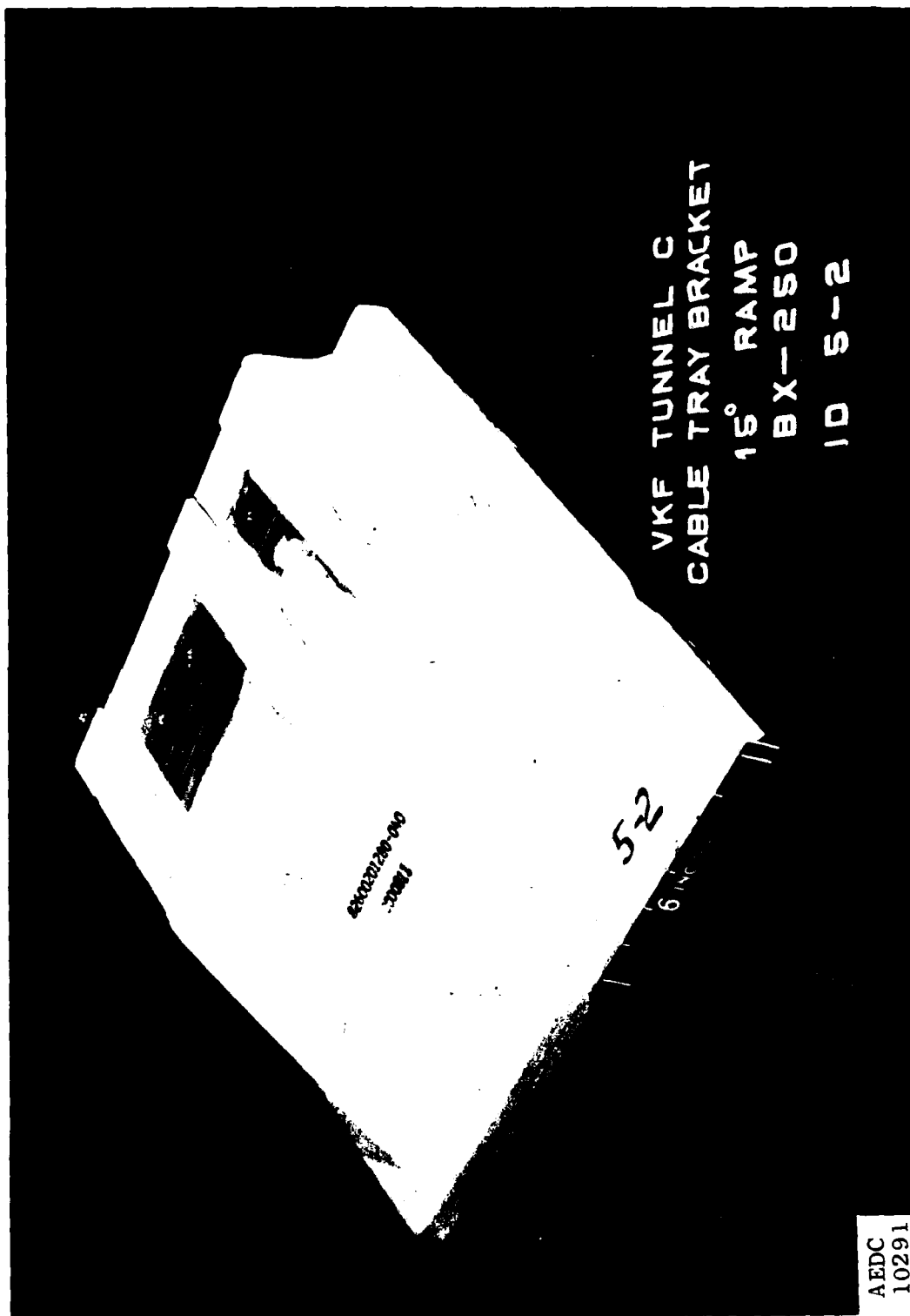
d. Sketch of Barry Mount Model

Figure 5. continued.



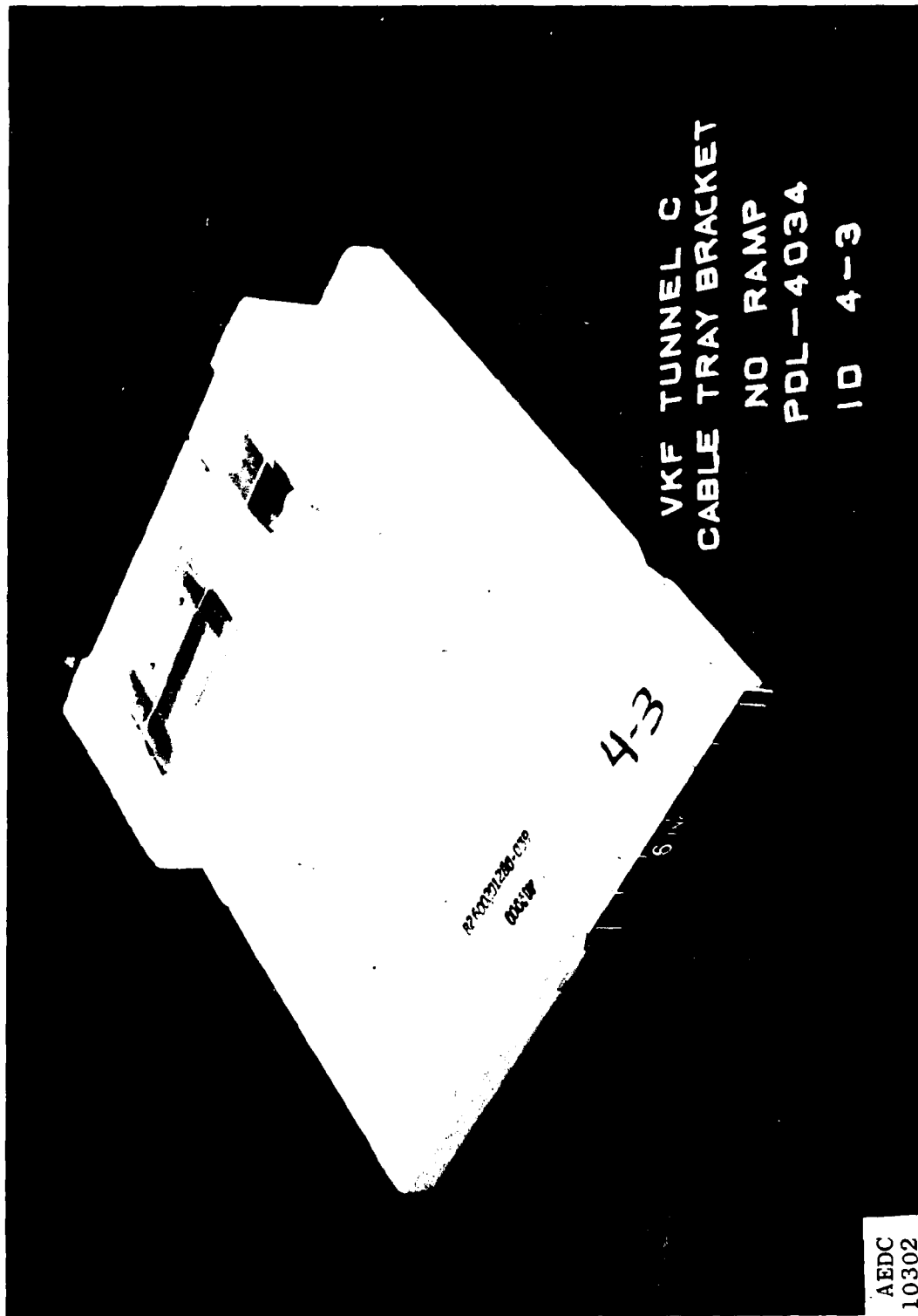
AEDC
10555

e. Cable tray bracket installed on the wedge
Figure 5. Continued

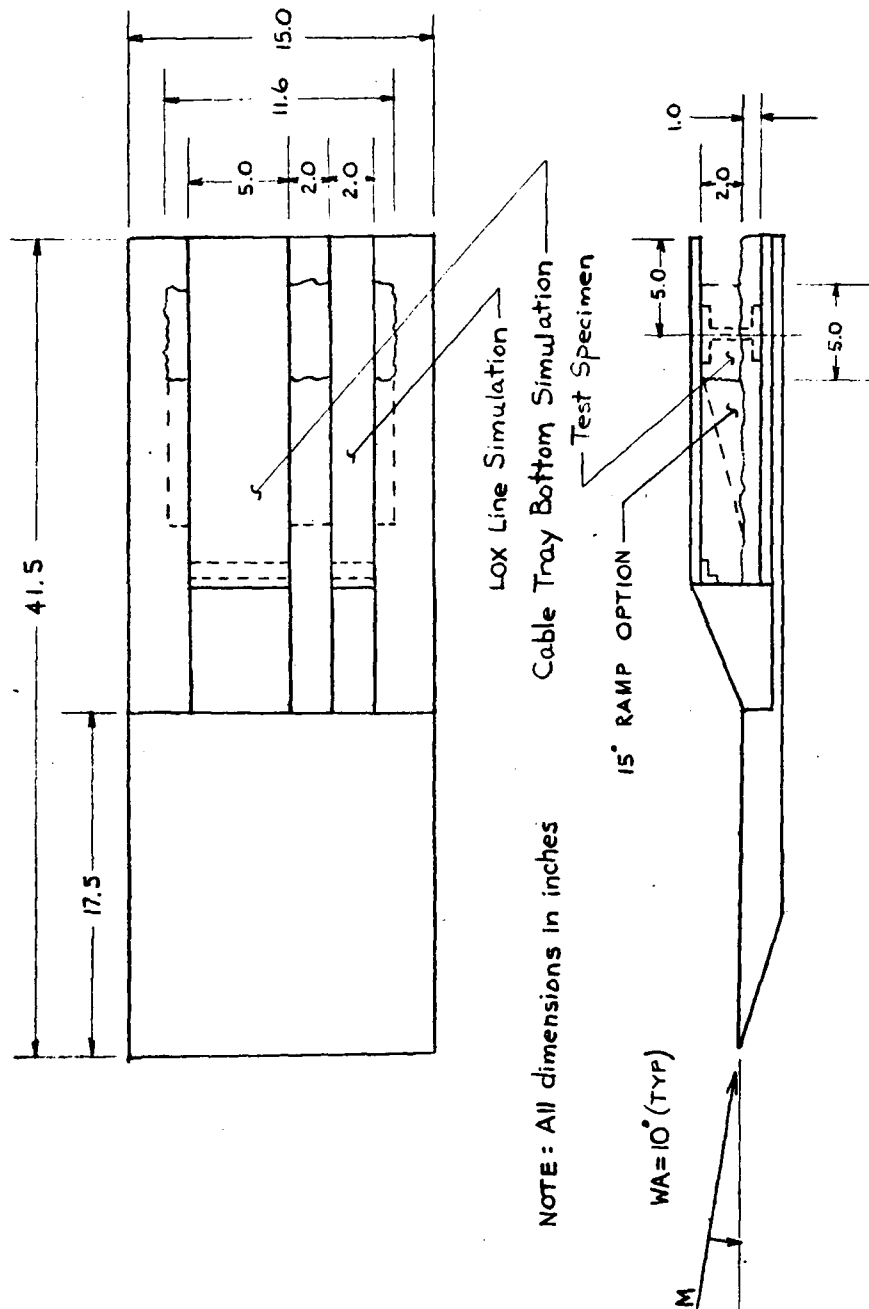


AEDC
10291

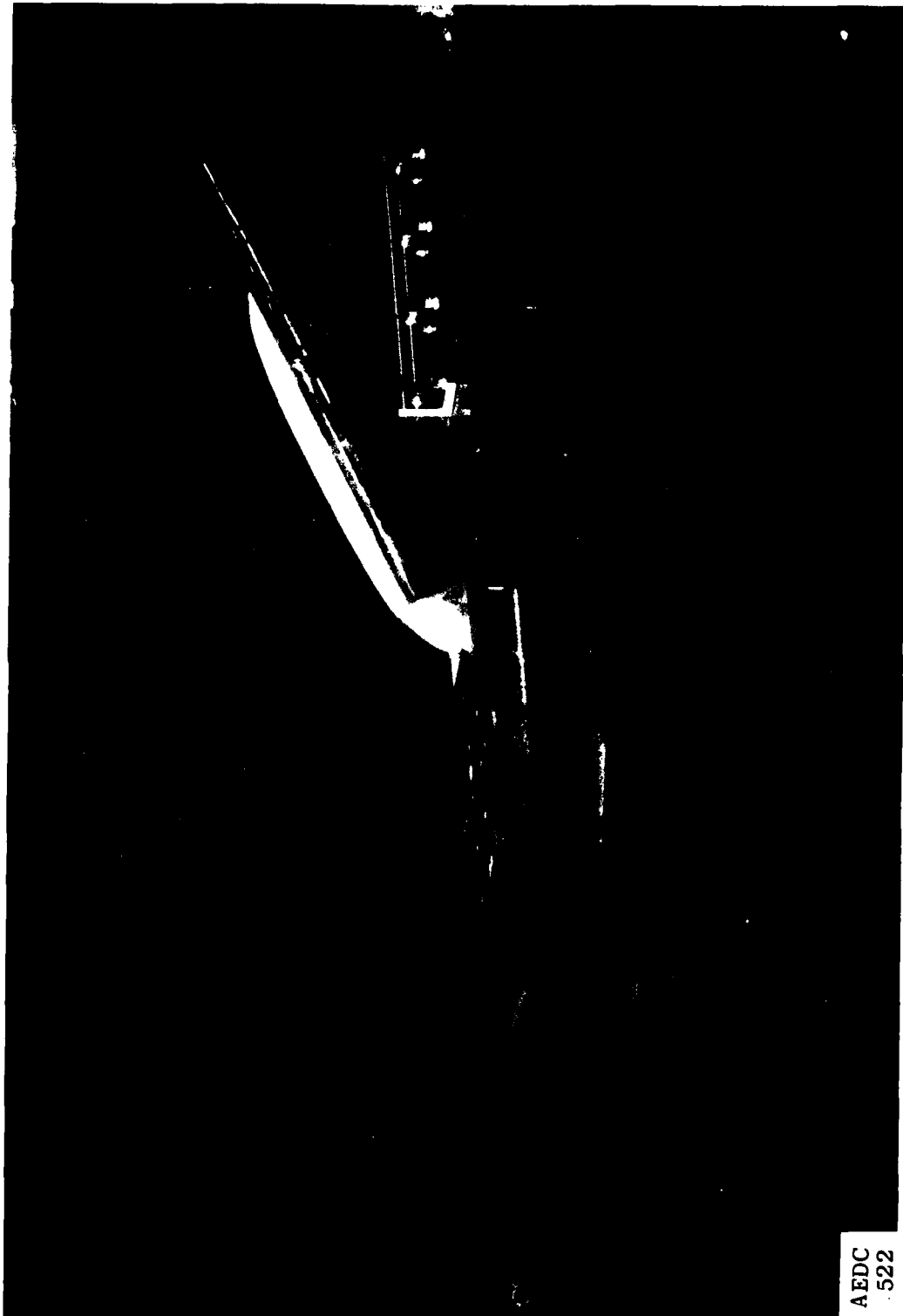
f. Cable tray bracket with a 15 degree ramp
Figure 5. Continued



g. Flat face cable tray bracket
Figure 5. Continued



h. Sketch of Cable Tray Bracket Model
Figure 5. concluded.



a. ET/SRB cable tray ramp installed on the wedge
Figure 6. ET/SRB and LOX Tank Cable Tray Bracket Ramp Models



b. ET/SRB cable tray ramp with a simulated "crack"

Figure 6. Continued

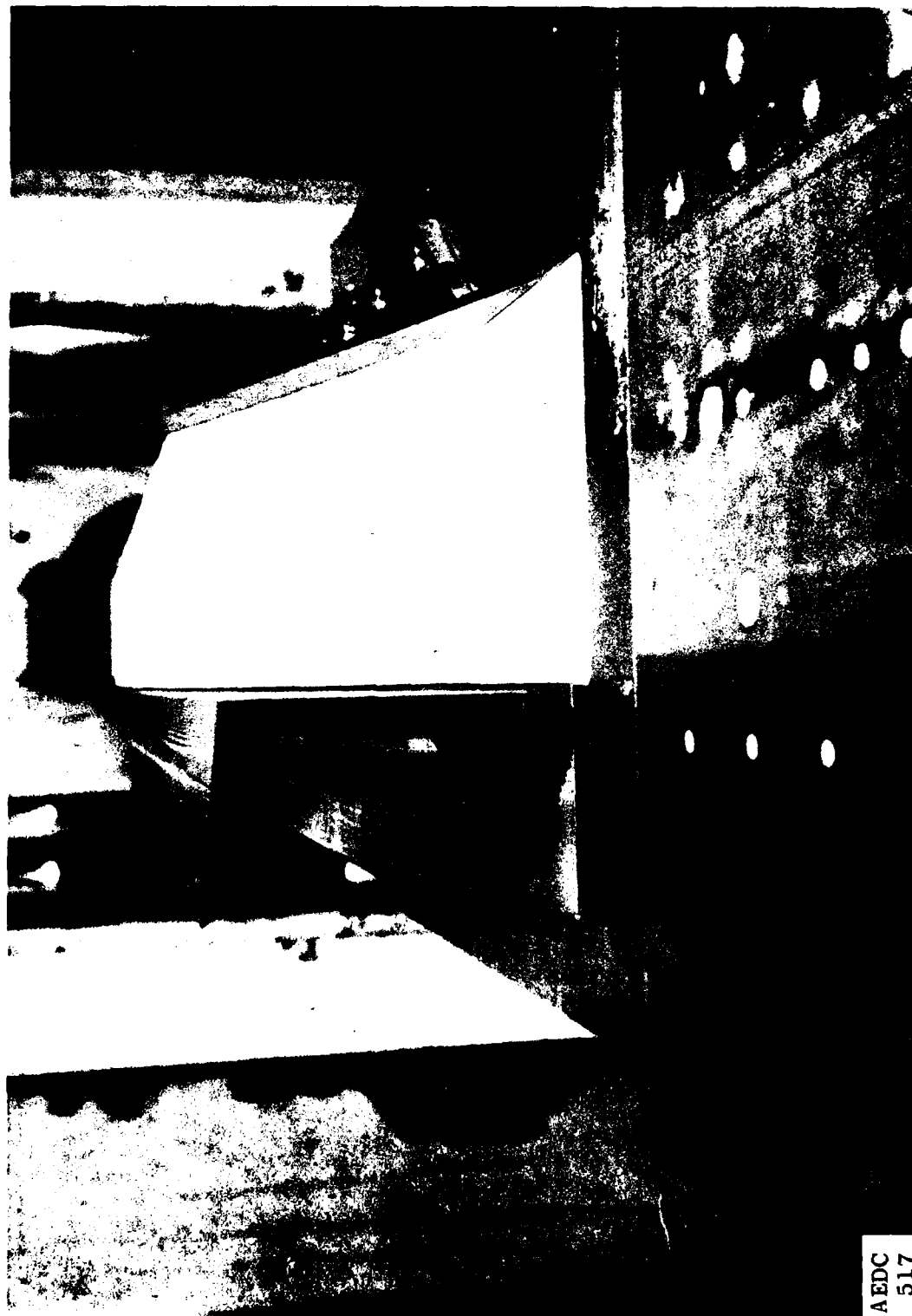
Technical drawing of a cable tray assembly, showing three views: a front view, a side view (VIEW BB), and a top view (VIEW AA).

Front View: Shows the cable tray with a 10° angle. Dimensions include a total width of 24.0, a depth of 22.0, and a height of 15.0. A section line A-A is indicated.

Side View (VIEW BB): Shows the profile of the cable tray. Dimensions include a total height of 10.0, a width of 5.7, and a depth of 0.50. End plates are shown at the ends.

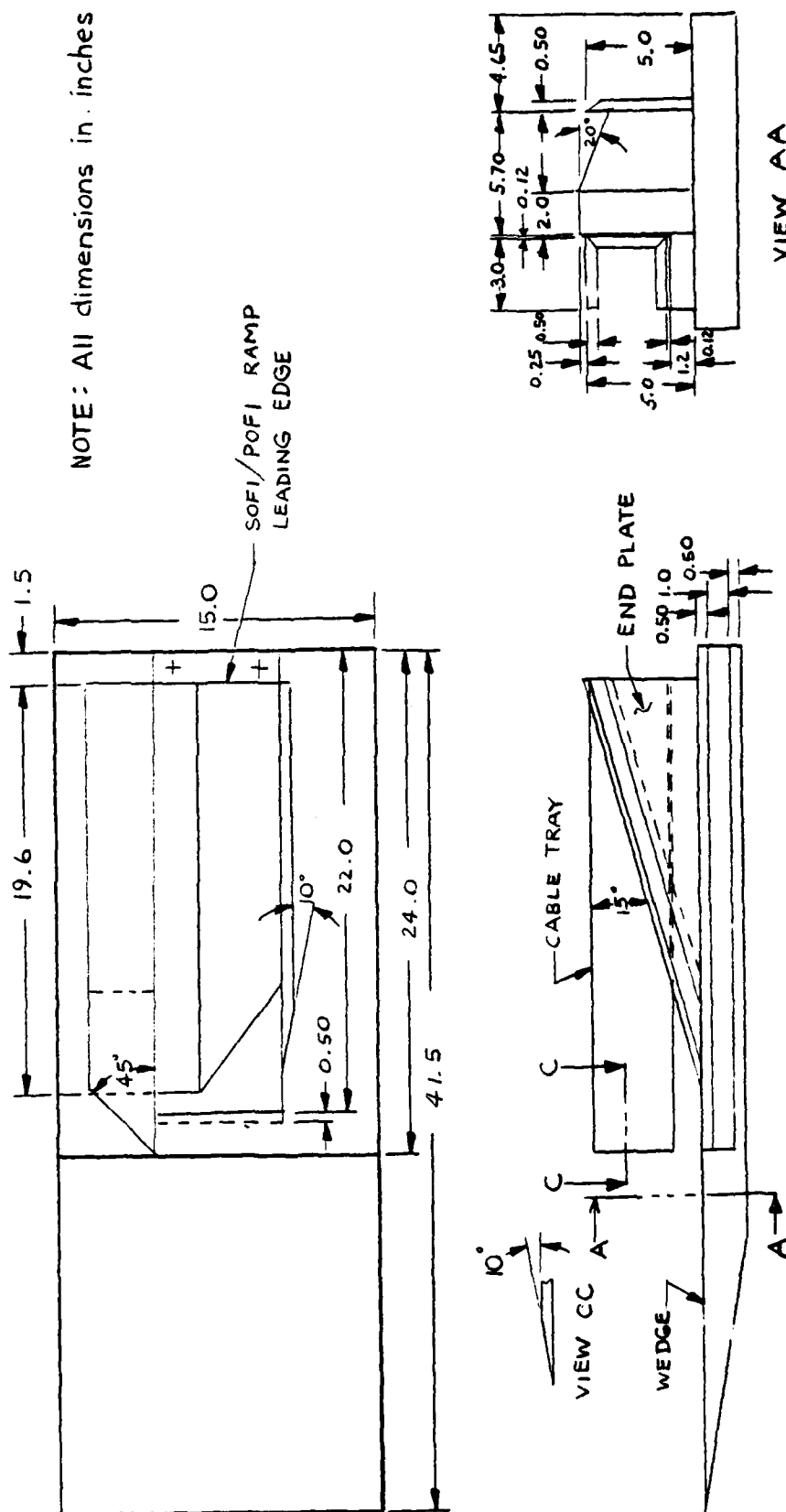
Top View (VIEW AA): Shows the layout of the cable tray. Dimensions include a total length of 41.5, a width of 18.0, and a depth of 0.12. A section line B-B is indicated. The cable tray is labeled "CABLE TRAY". Other components labeled include "SOFI/POFI RAMP", "WEDGE", and "6.0 R".

VIEW AA

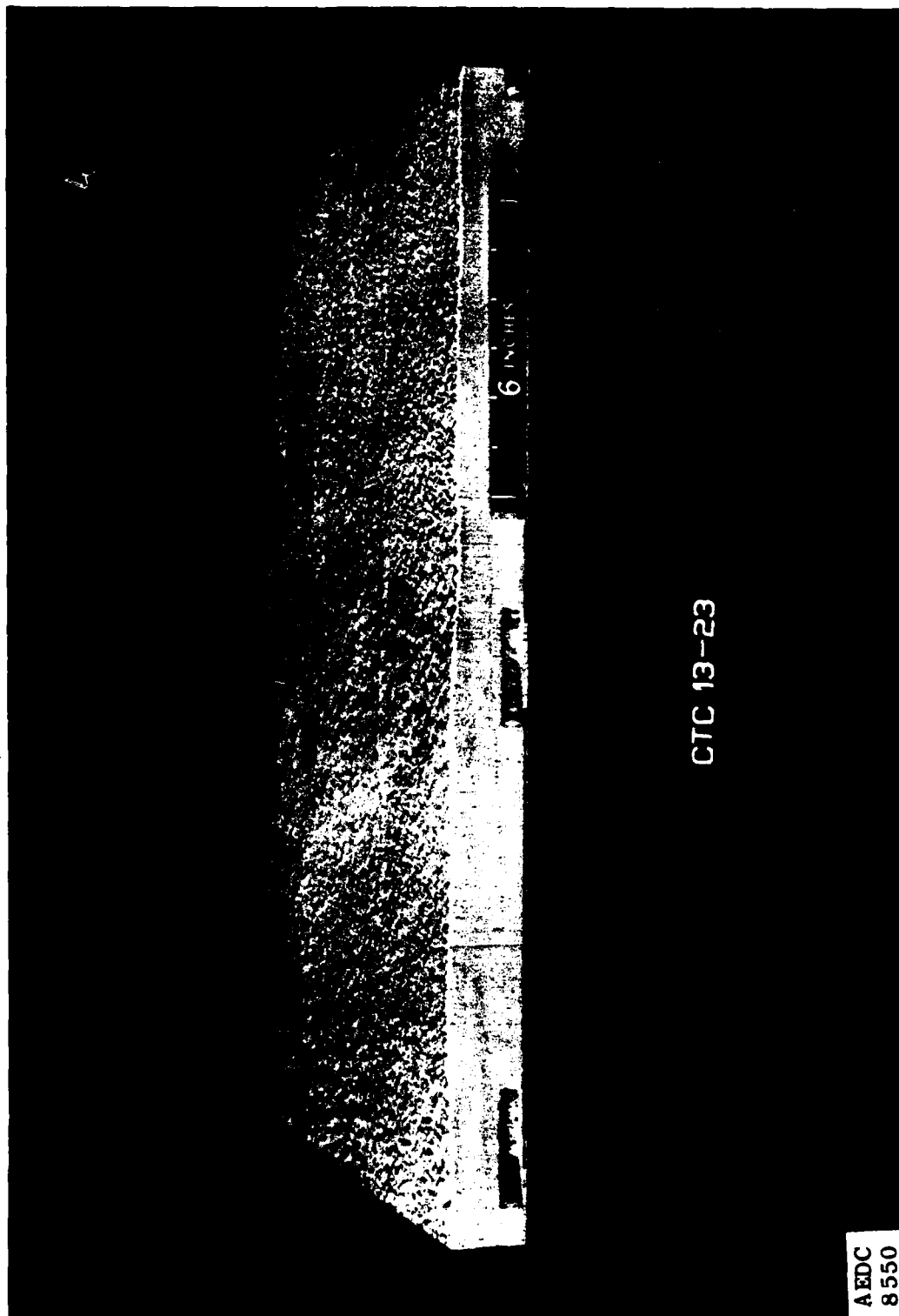


d. LOX tank cable tray ramp, front view
Figure 6. Continued

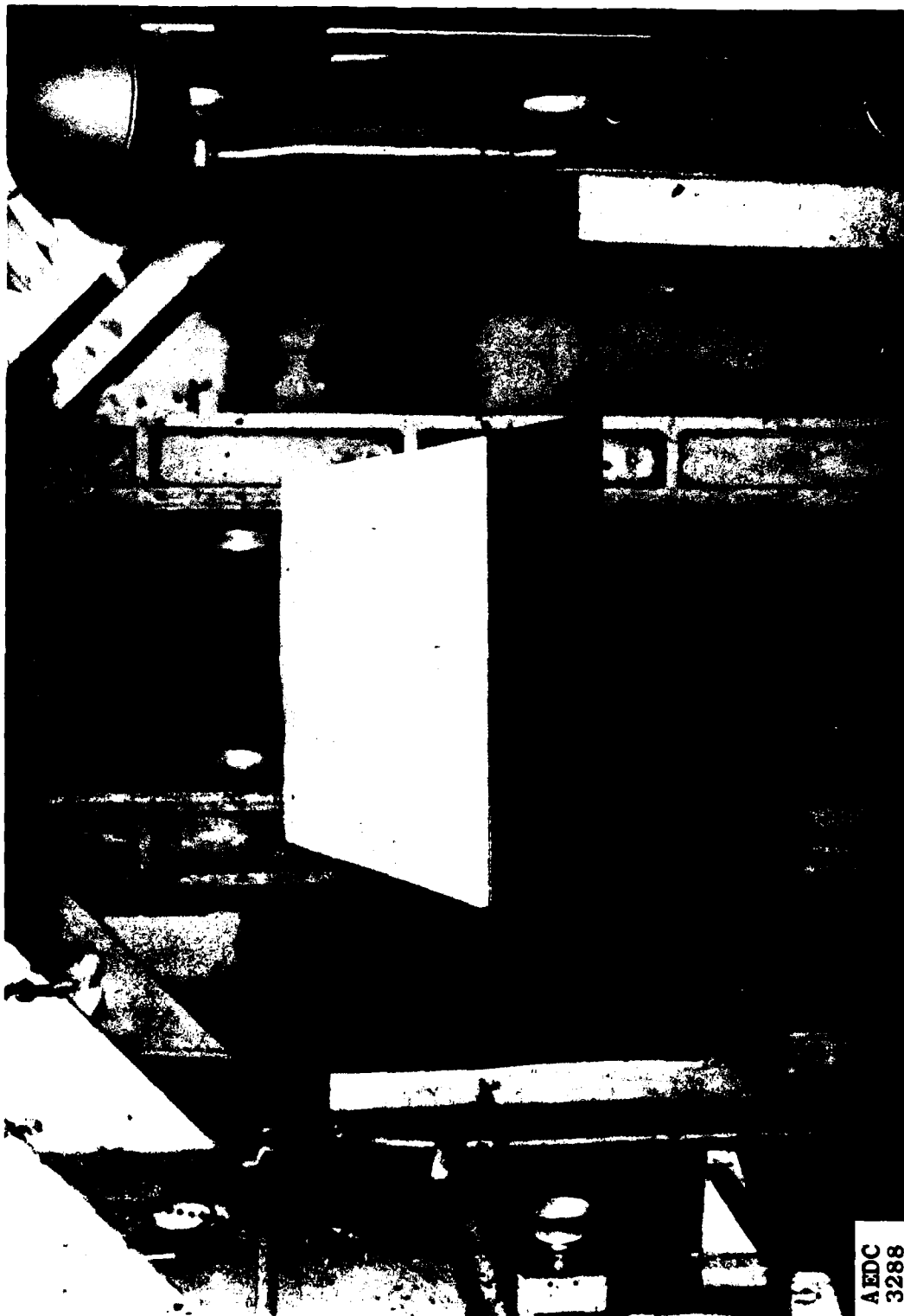
AEDC
517



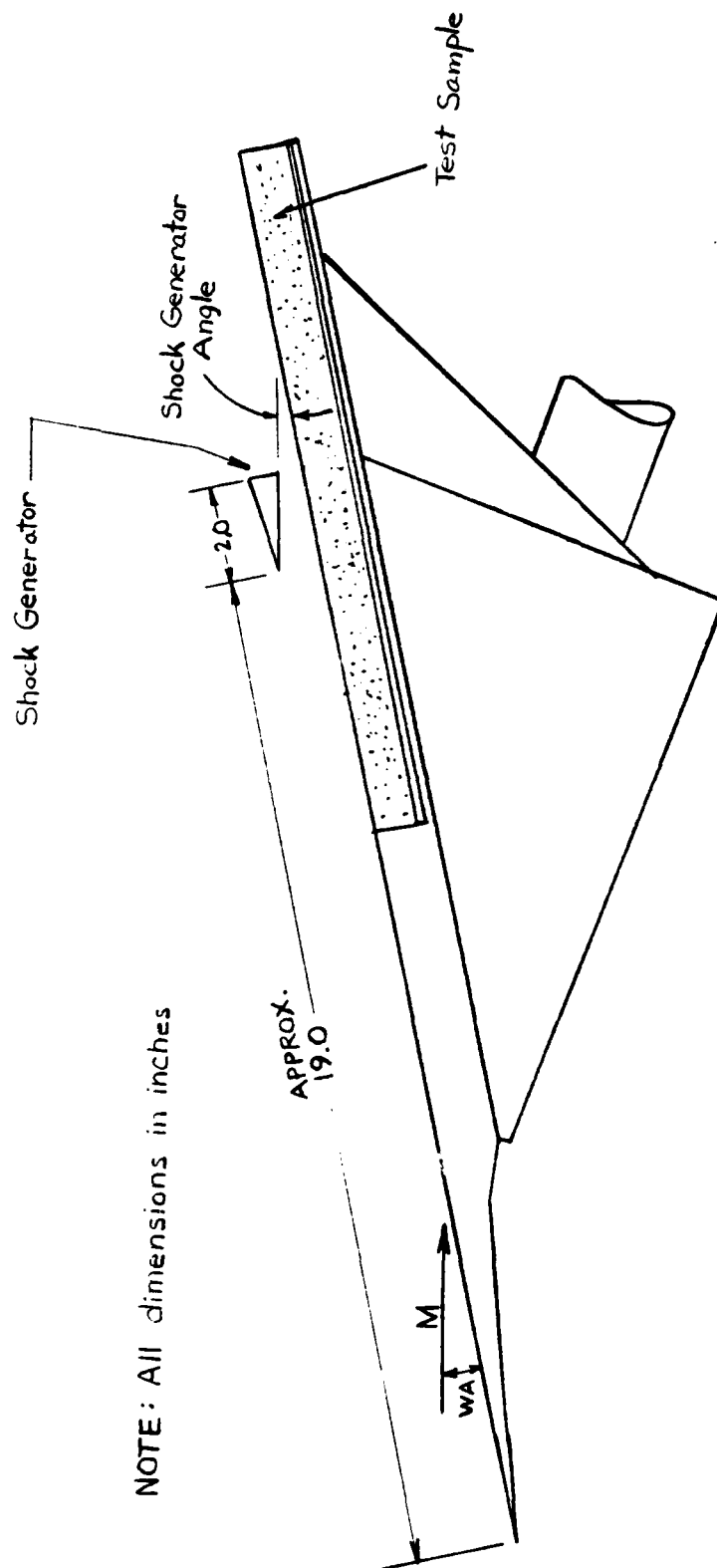
e. Sketch of the LOX Tank Cable Tray Ramp Leading Edge Model
Figure 6. Concluded



a. Typical alternate foam flat panel sample
Figure 7. Alternate Foam Flat Panels



b. Flat panel sample on wedge
Figure 7. Continued



NOTE: All dimensions in inches

c. Shock Generator Positioning

Figure 7. concluded.



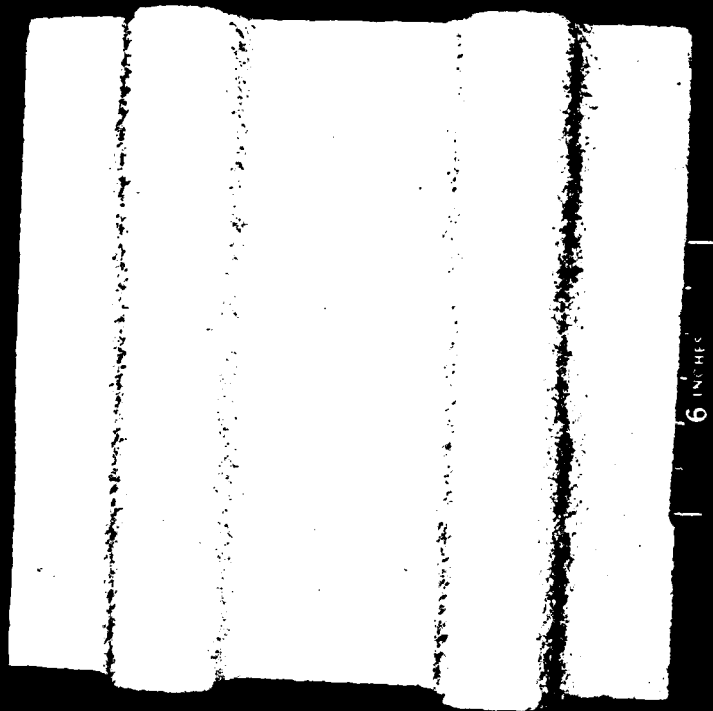
AEDC
4494

a. Thin-skin stringer calibration model on wedge
Figure 8. ET Intertank Stringer Models

PRETEST PICTURE

SAMPLE CTC 15-1

CPR-488
PARALLEL STRINGER



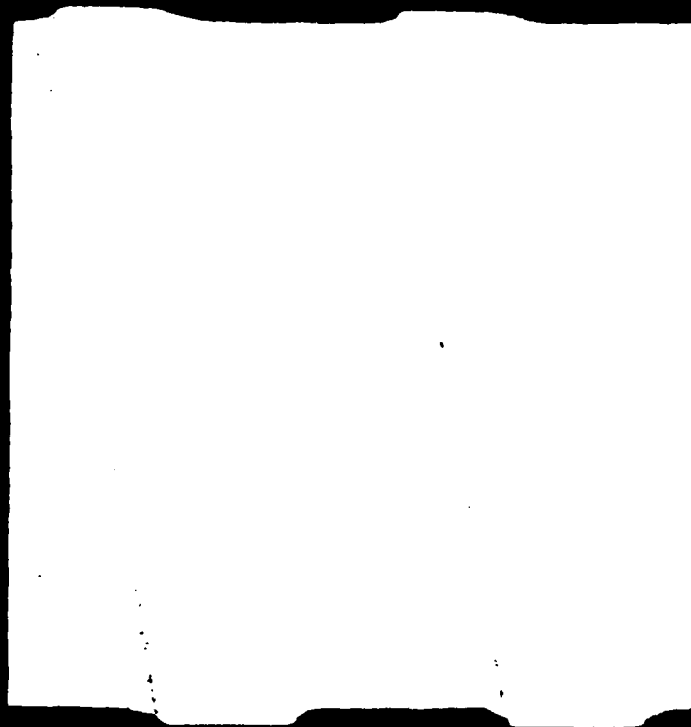
AEDC
45085

b. Parallel stringer sample
Figure 8. Continued

PRETEST PICTURE

SAMPLE CTC 15-16

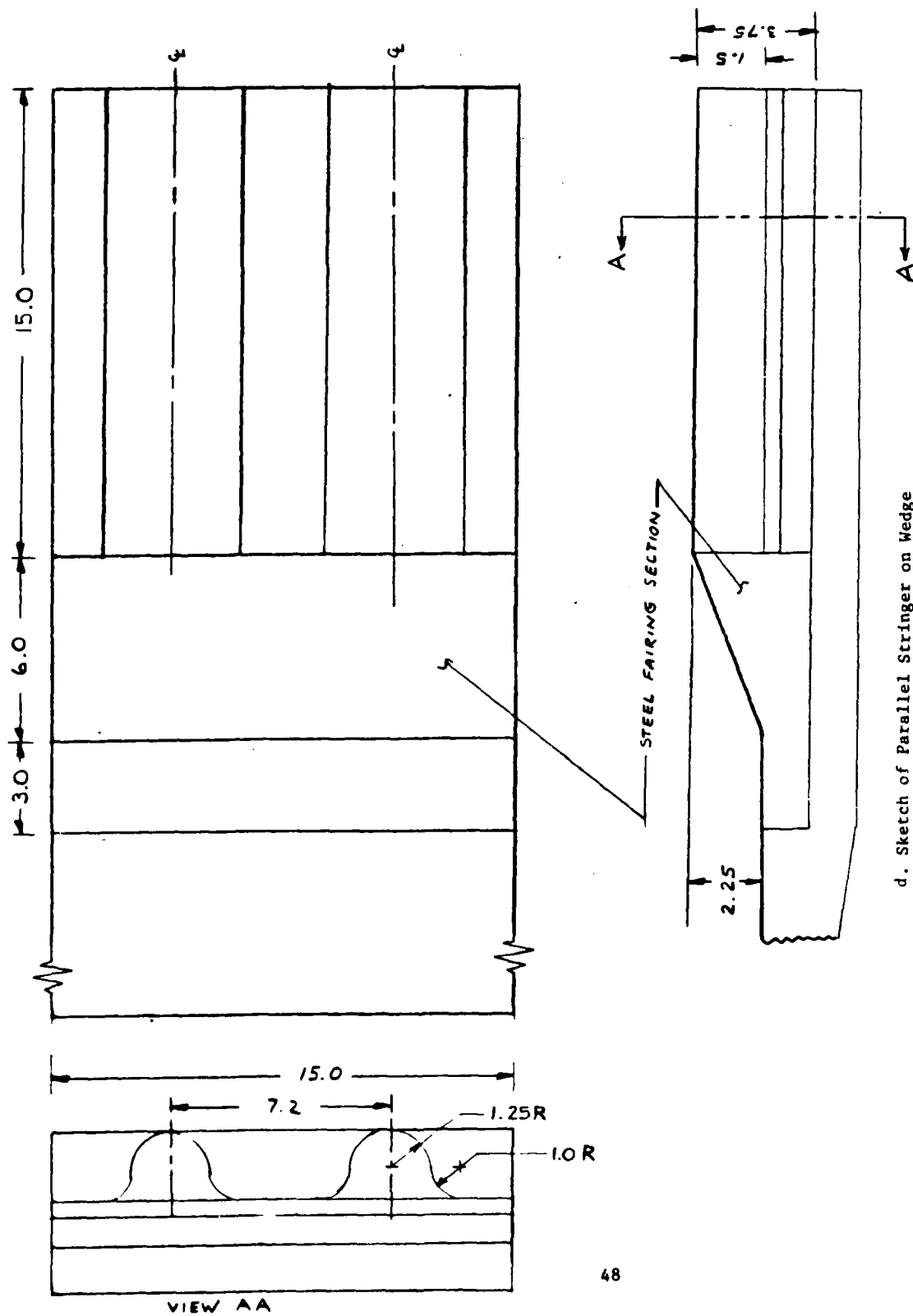
CPR-488/SLA-561
10 DEG STRINGER



AEDC
4514

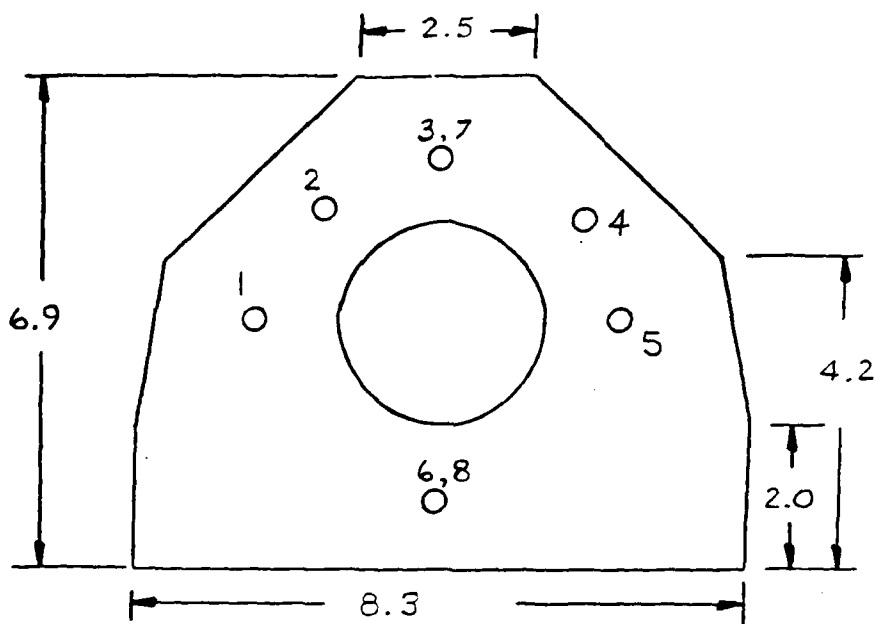
6 INCHES

c. 10 degree Stringer Sample
Figure 6. continued.



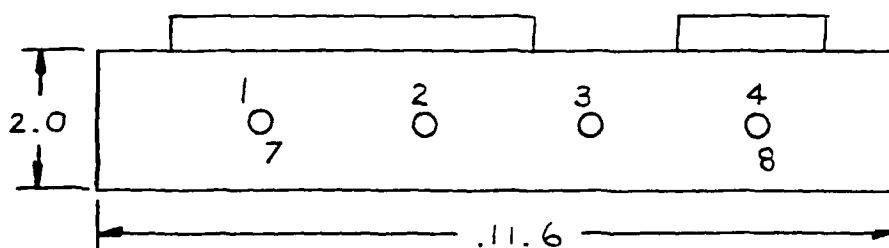
d. Sketch of Parallel Stringer on Wedge

Figure 8. concluded



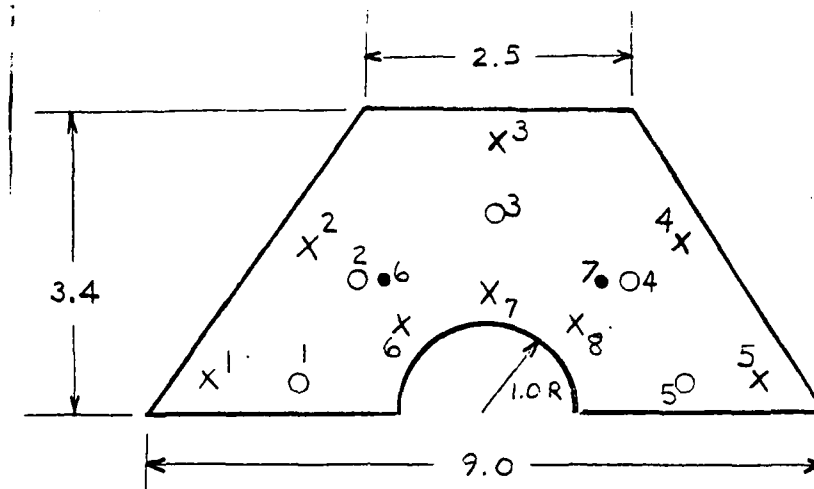
a. Tunnel A Barry Mount

- Notes:
1. All dimensions in inches
 2. Pressure taps 1-6 are windward
 3. Pressure taps 7 and 8 are leeward
 4. $DEL P = P W_{\text{windward}} - P W_{\text{average leeward}}$



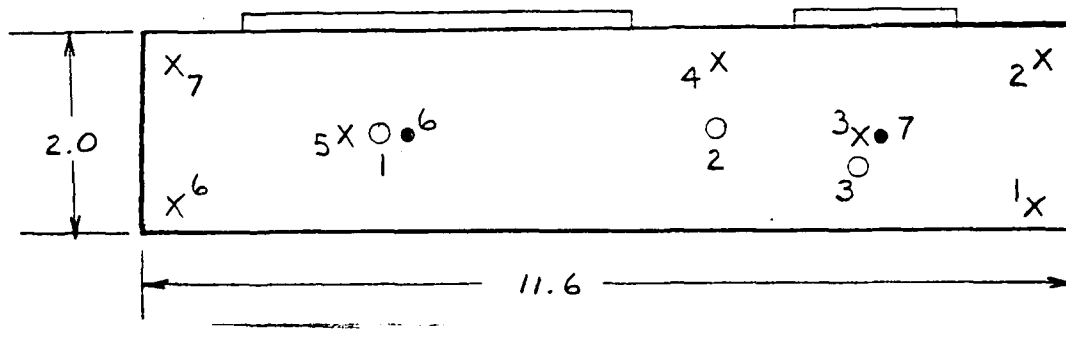
b. Tunnel A Cable Tray Bracket

Figure 9. Debris Calibration Models



c. Tunnel C Barry Mount

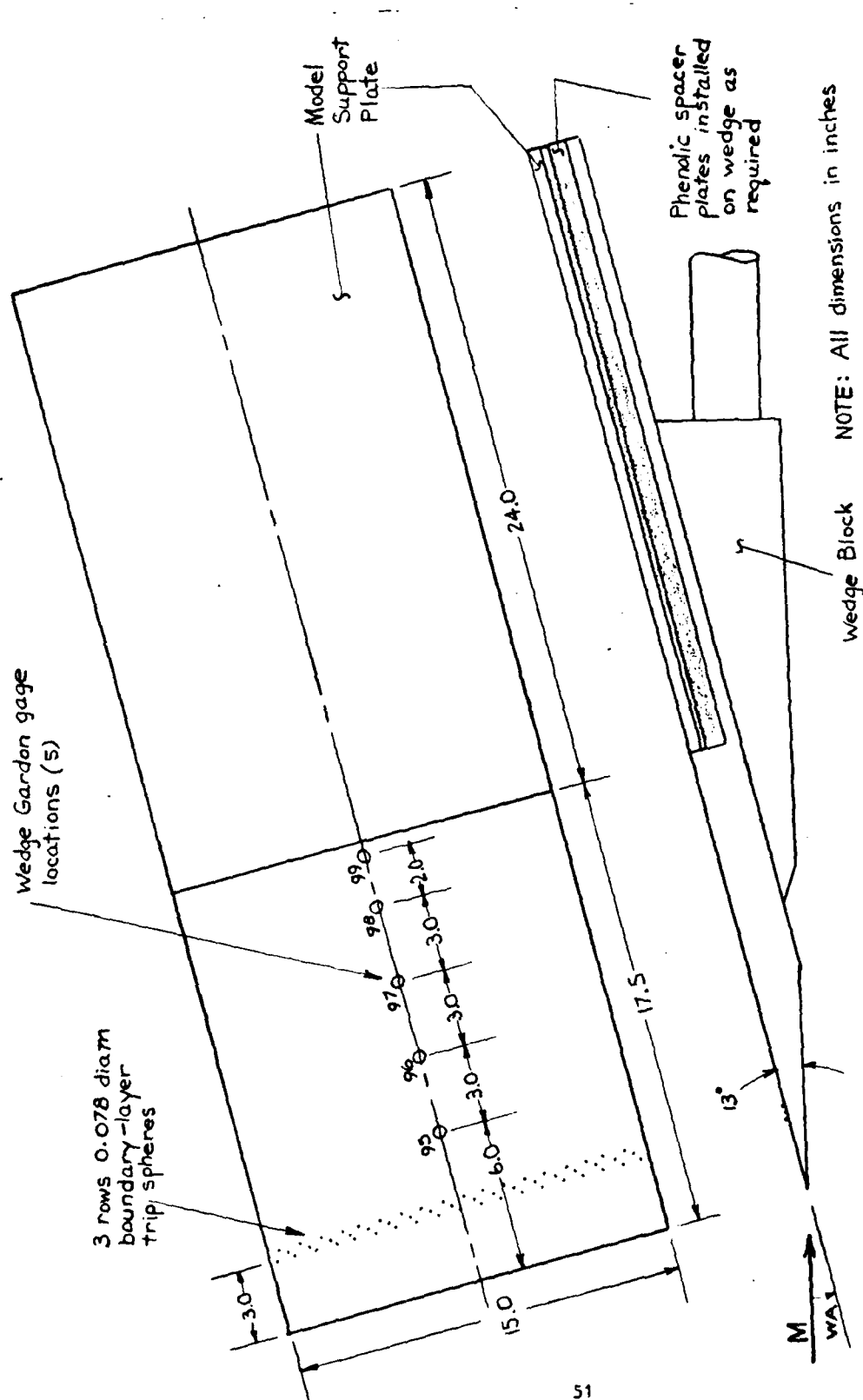
- O Windward pressure tap
- Leeward pressure tap
- X Gardon gage



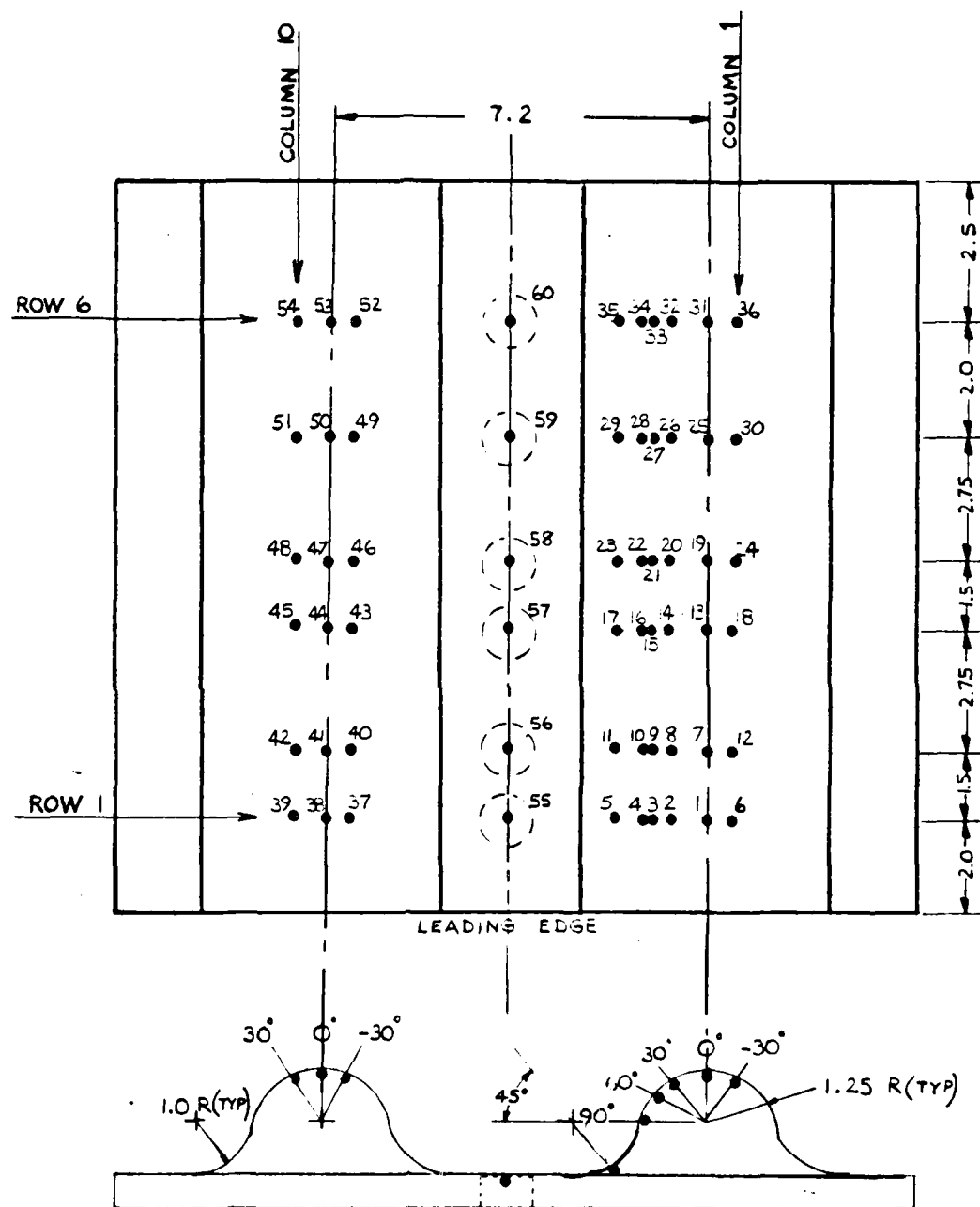
d. Tunnel C Cable Tray Bracket

- Notes:
1. All dimensions in inches
 2. All Gardon gages are windward
 3. $DELP = P_{W_{windward}} - P_{W_{average, leeward}}$

Figure 9. continued.



e. VKF Low-angle Wedge Instrumentation
Figure 9. concluded



NOTE: All dimensions in inches

Figure 10. Thin-skin Stringer Model Instrumentation

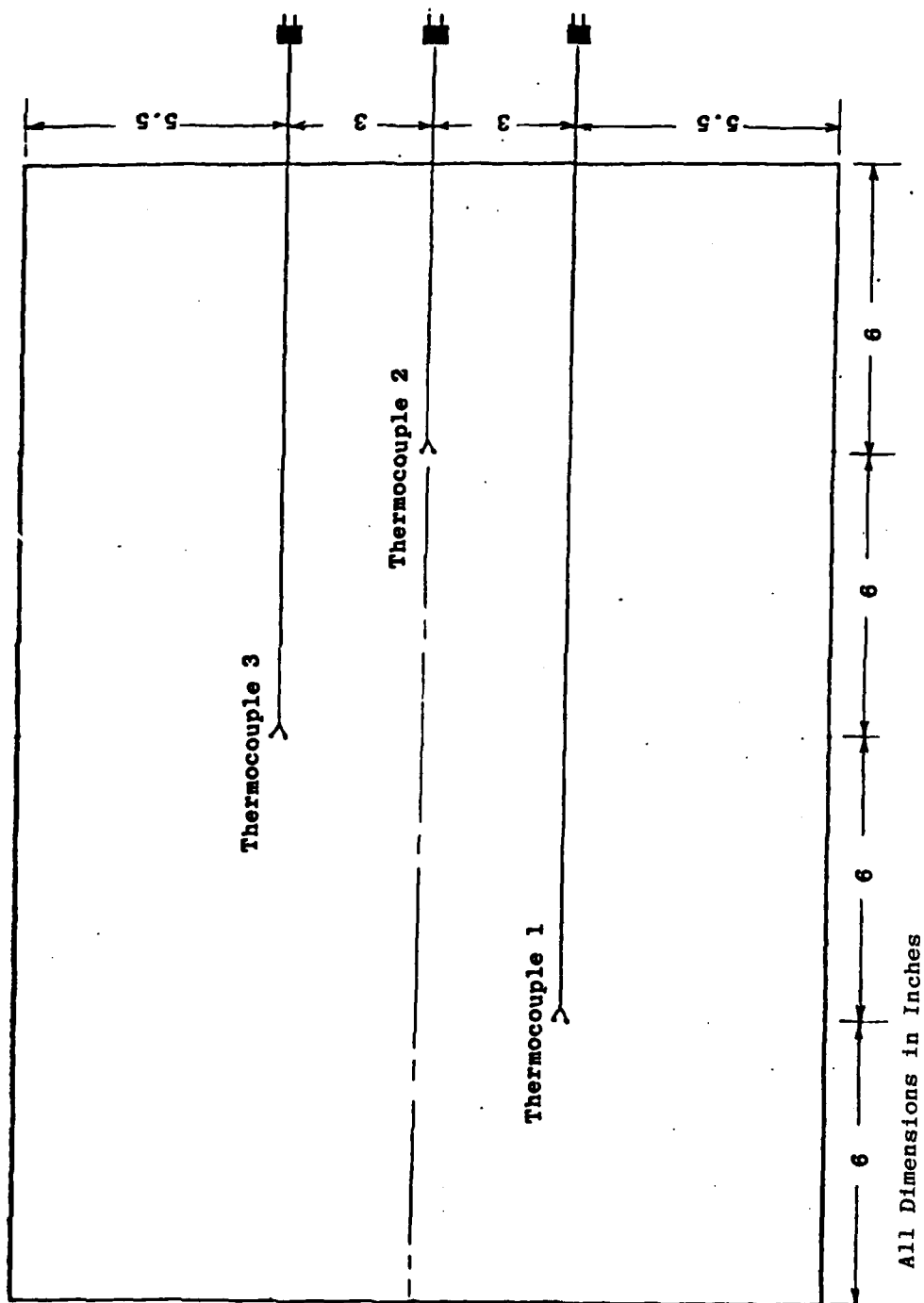
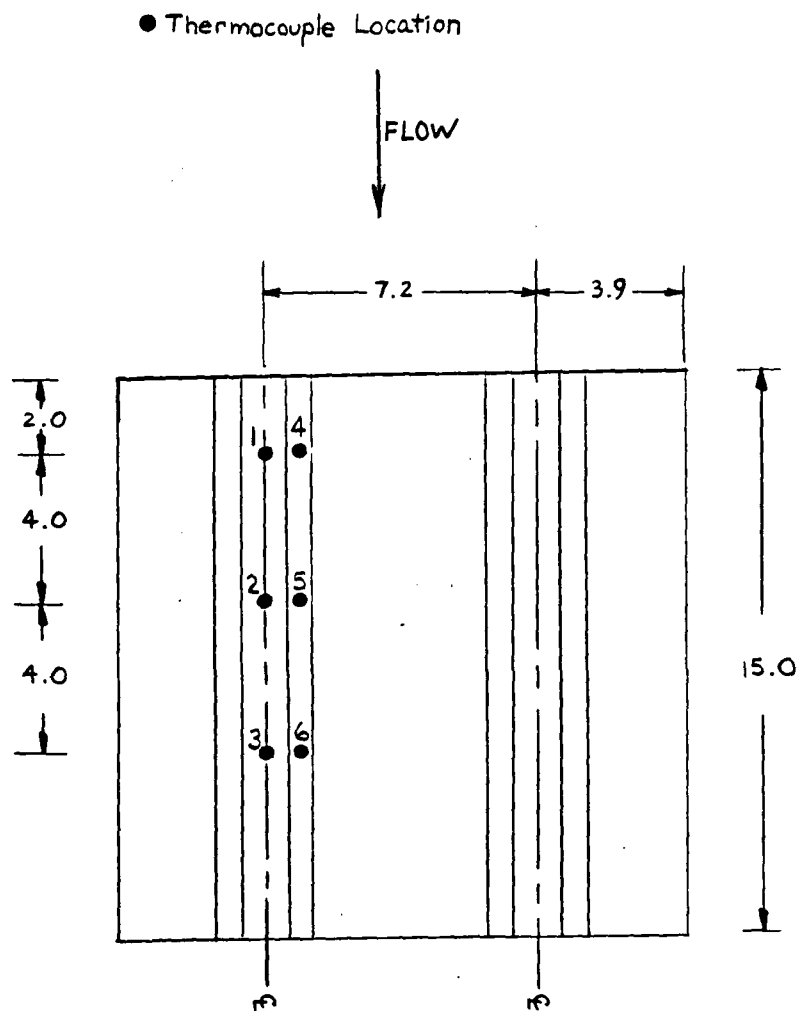
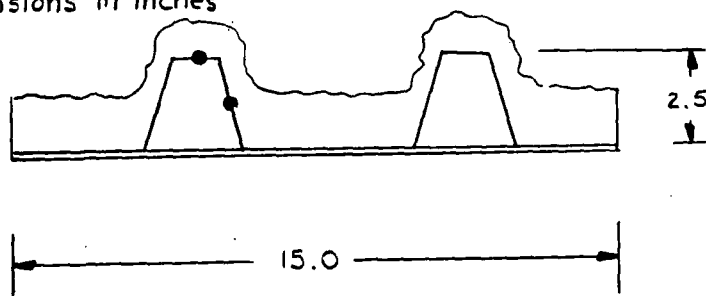


Figure 11. Alternate Foam Sample Thermocouple Locations

All Dimensions in Inches



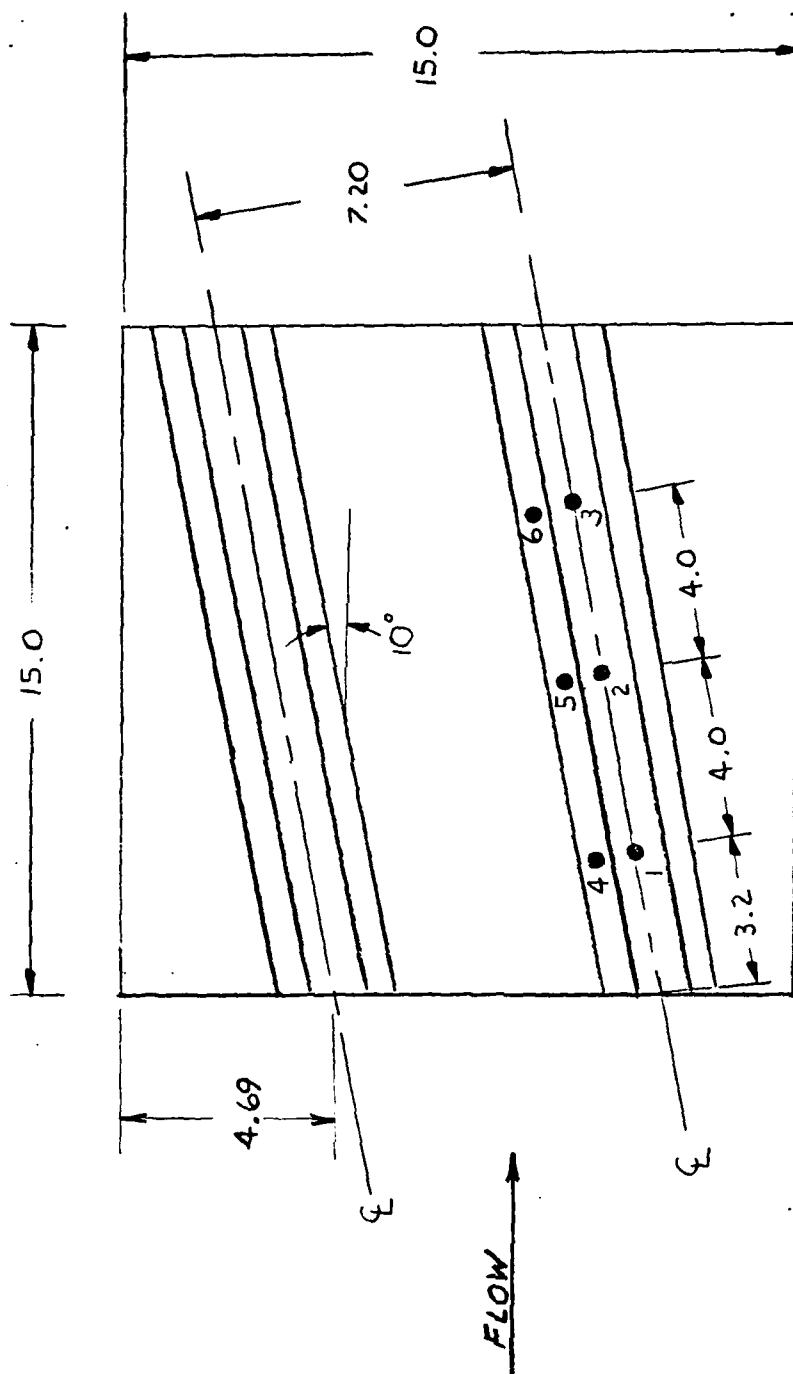
NOTE: All dimensions in inches



a. Parallel Stringer

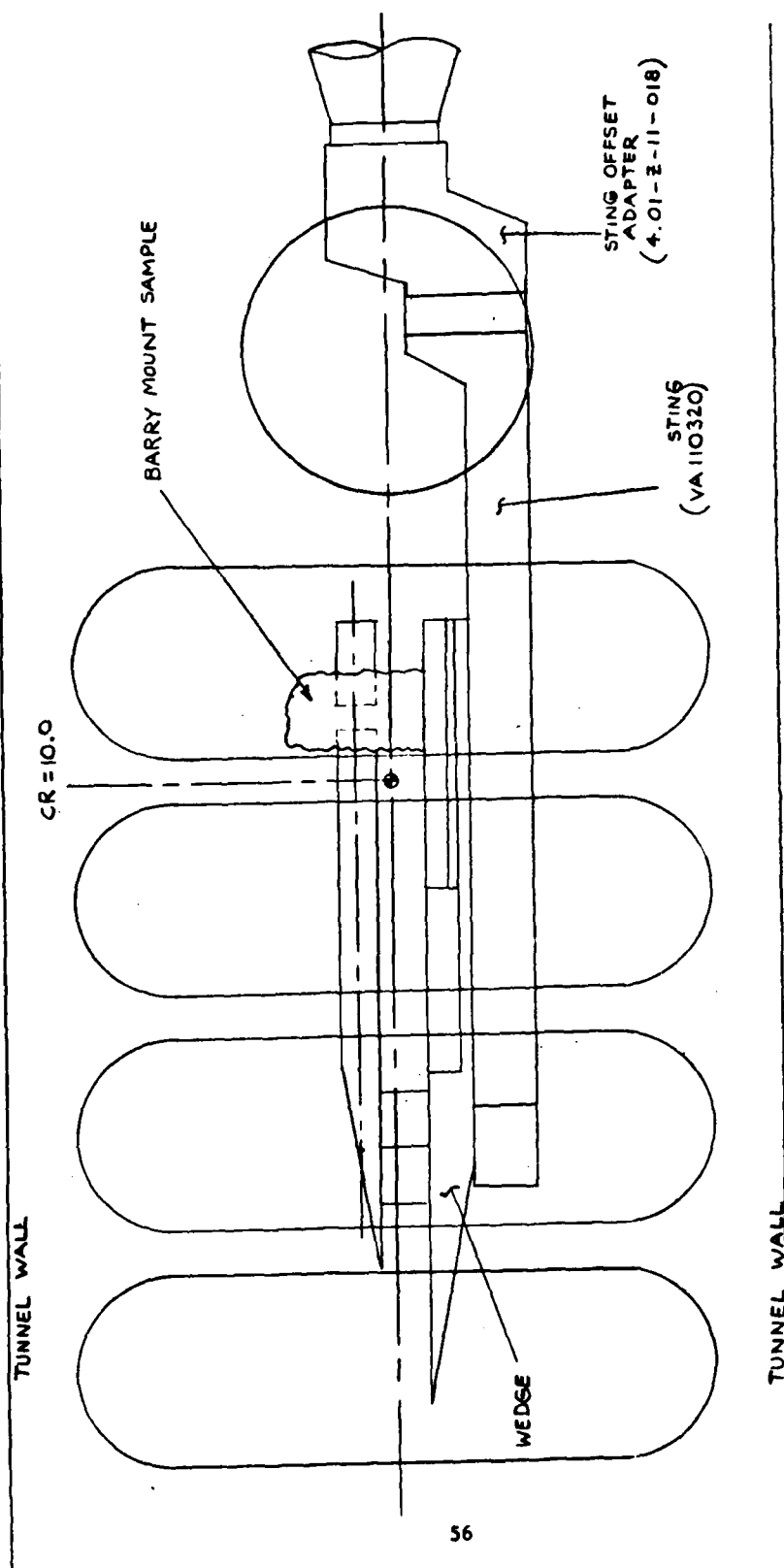
Figure 12. ET Intertank Stringer Sample Thermocouple Locations

● Thermocouple Locations



NOTE: All dimensions in inches

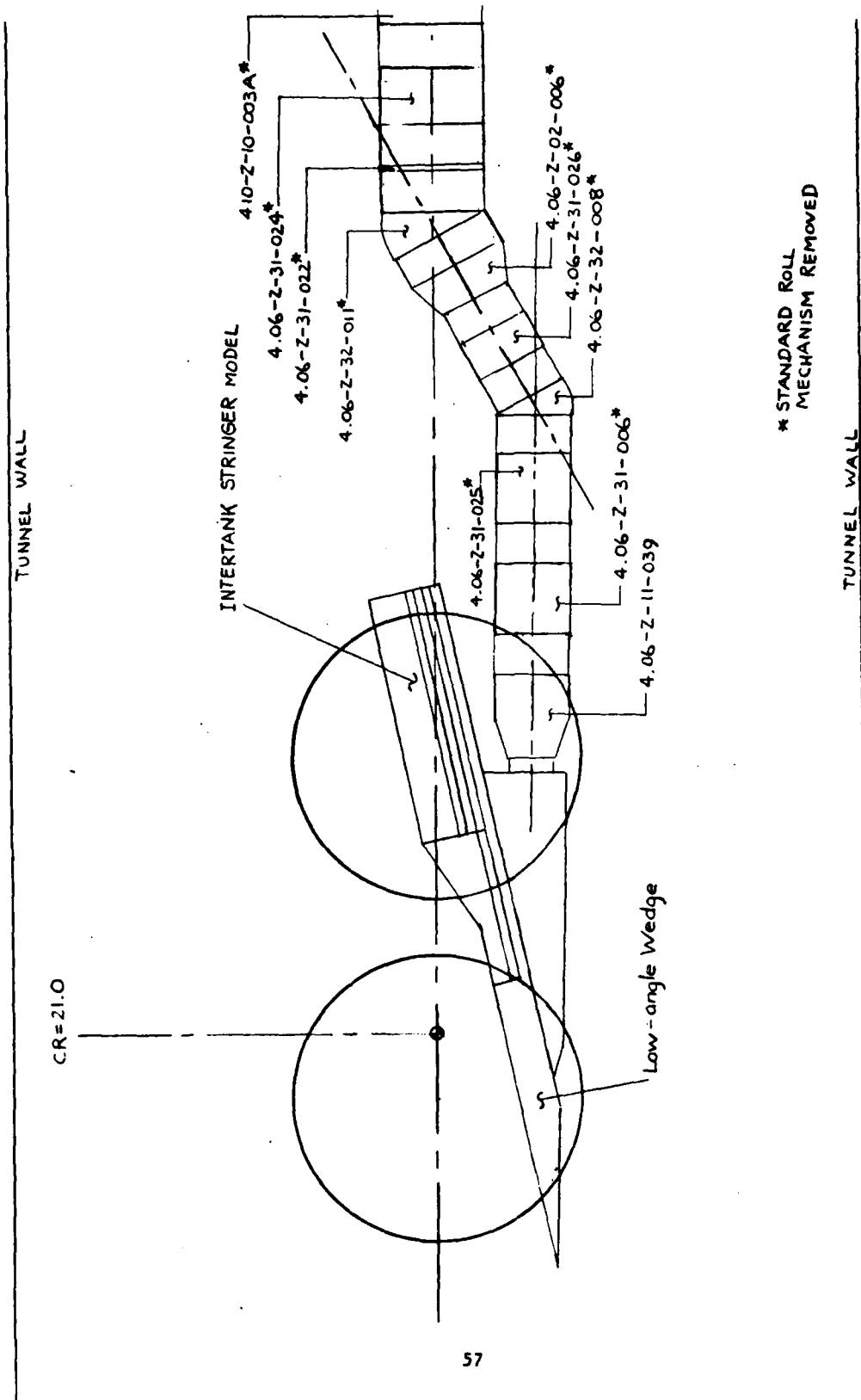
b. 10-degree Stringer
Figure 12. concluded



56

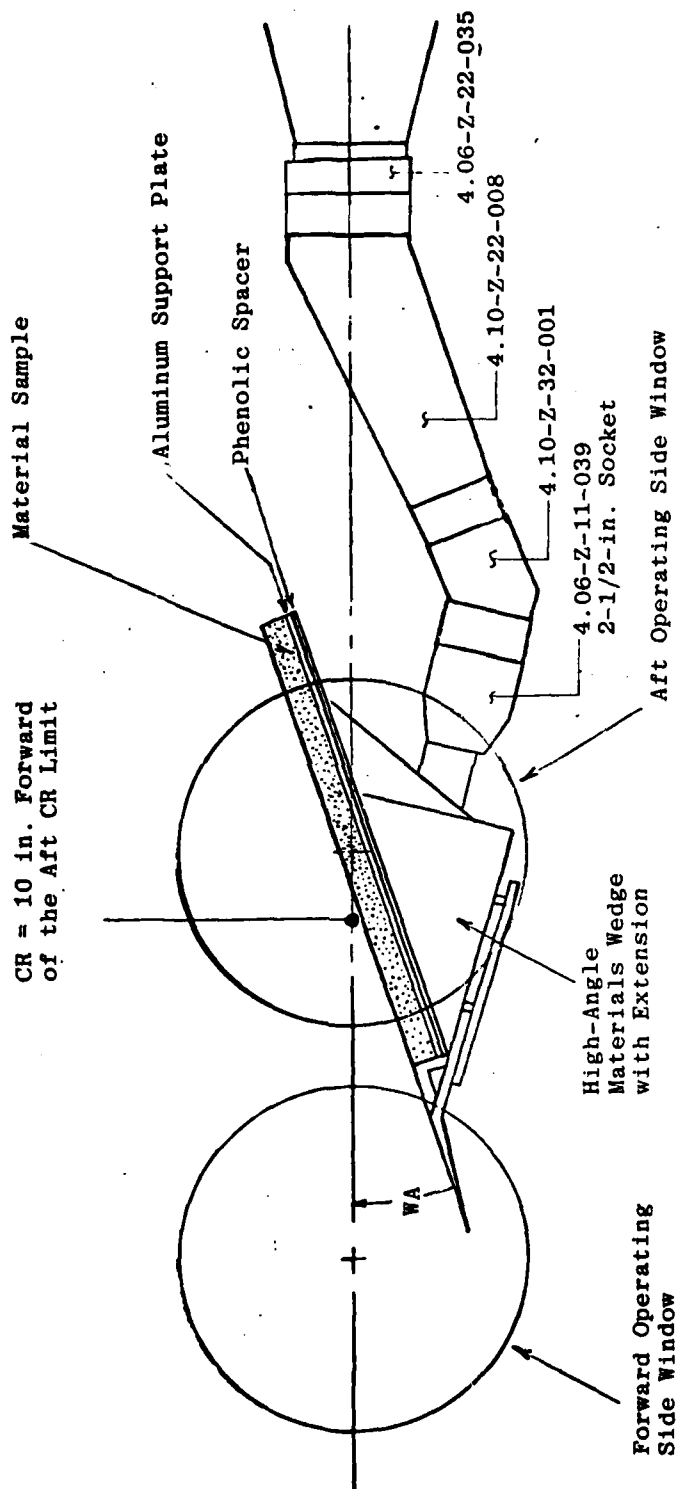
a. Low-angle Wedge in Tunnel A

Figure 13. Installation Sketches

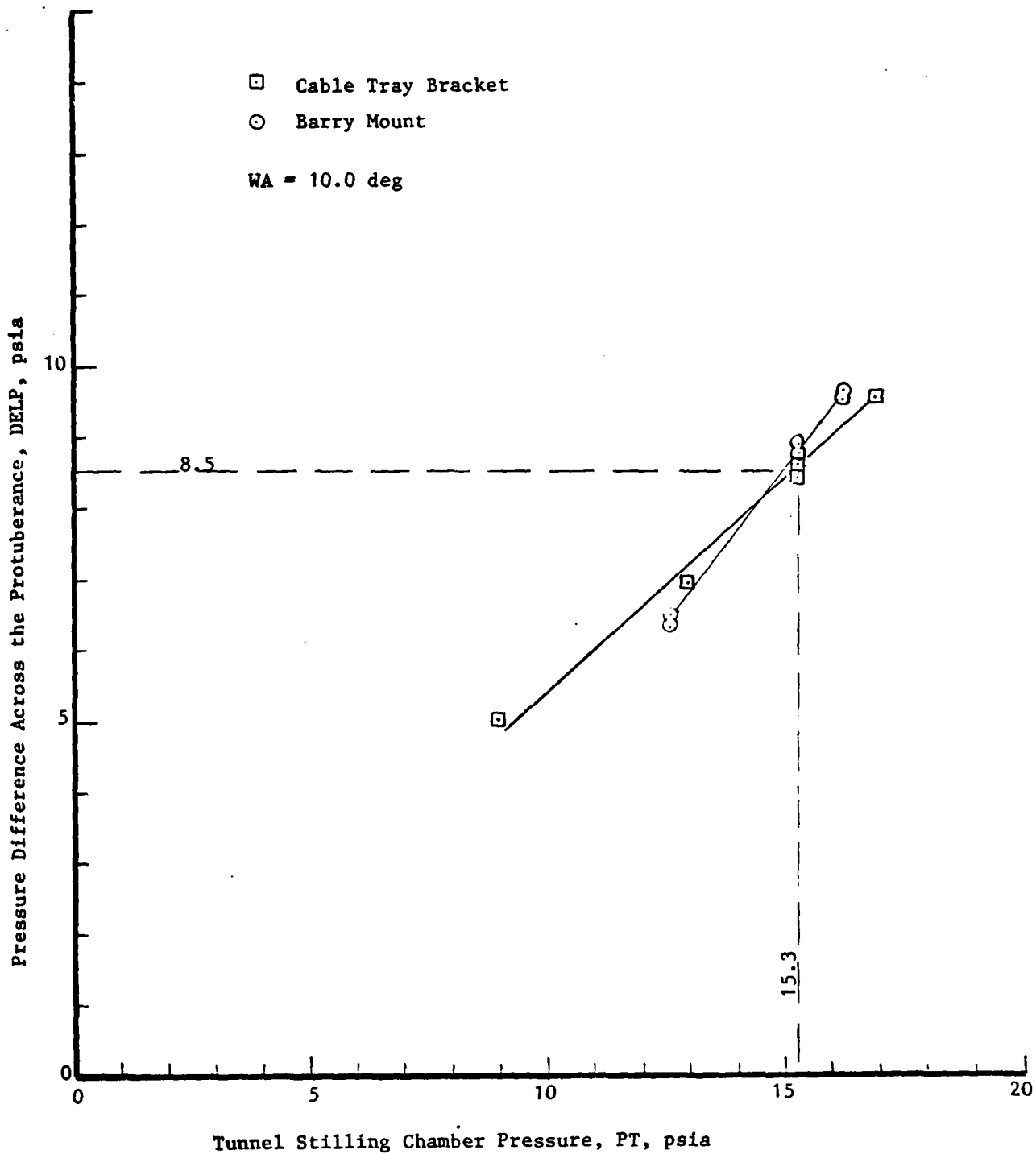


b. Low-angle Wedge in Tunnel C
Figure 13. continued.

Tunnel Wall

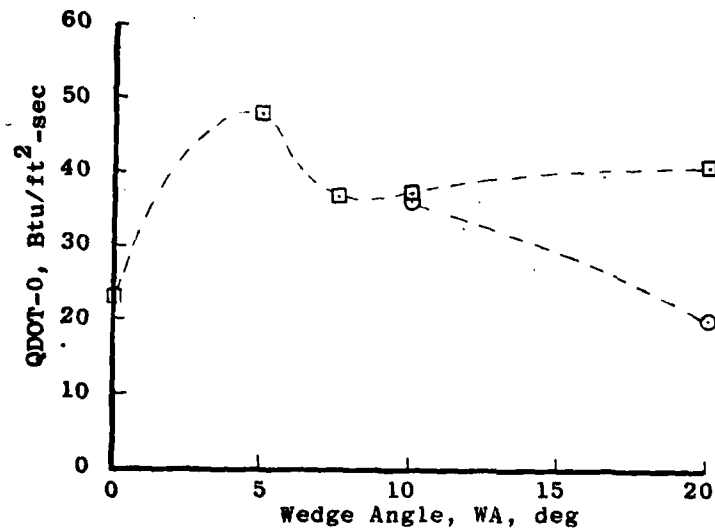
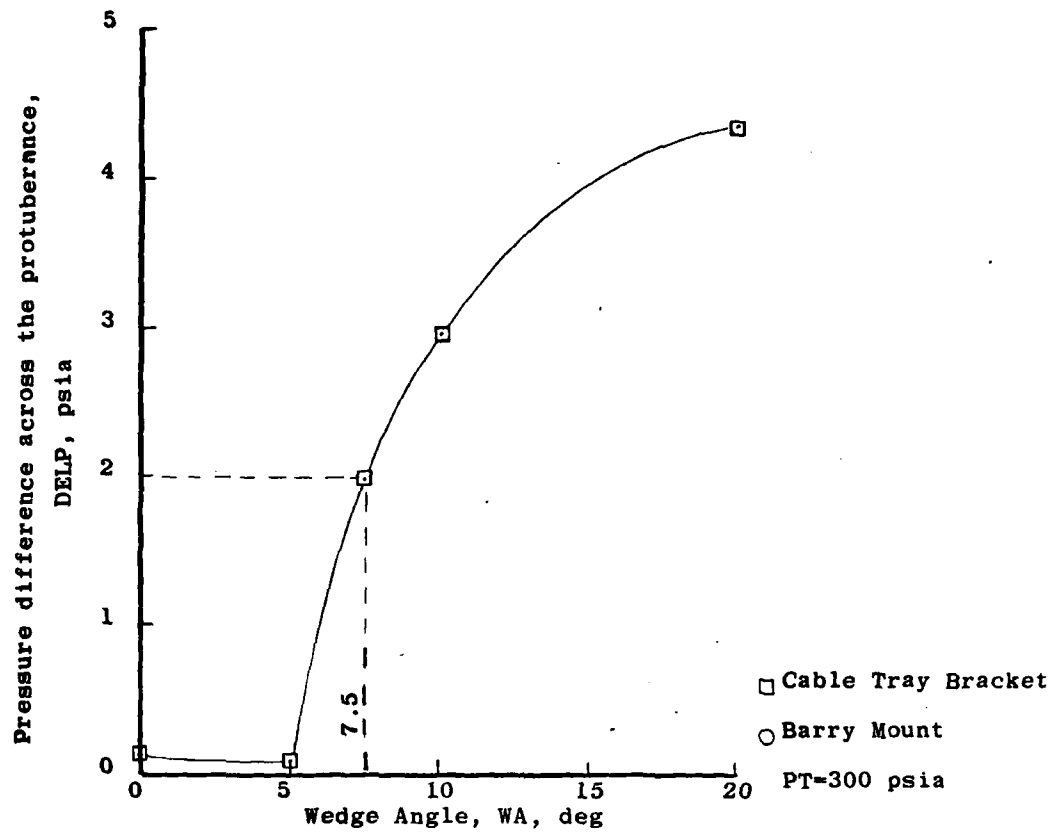


c. High-angle Wedge in Tunnel C
Figure 13. concluded



a. Tunnel A

Figure 14. Typical Debris Model Calibration Results



b. Tunnel C
Figure 14. concluded.

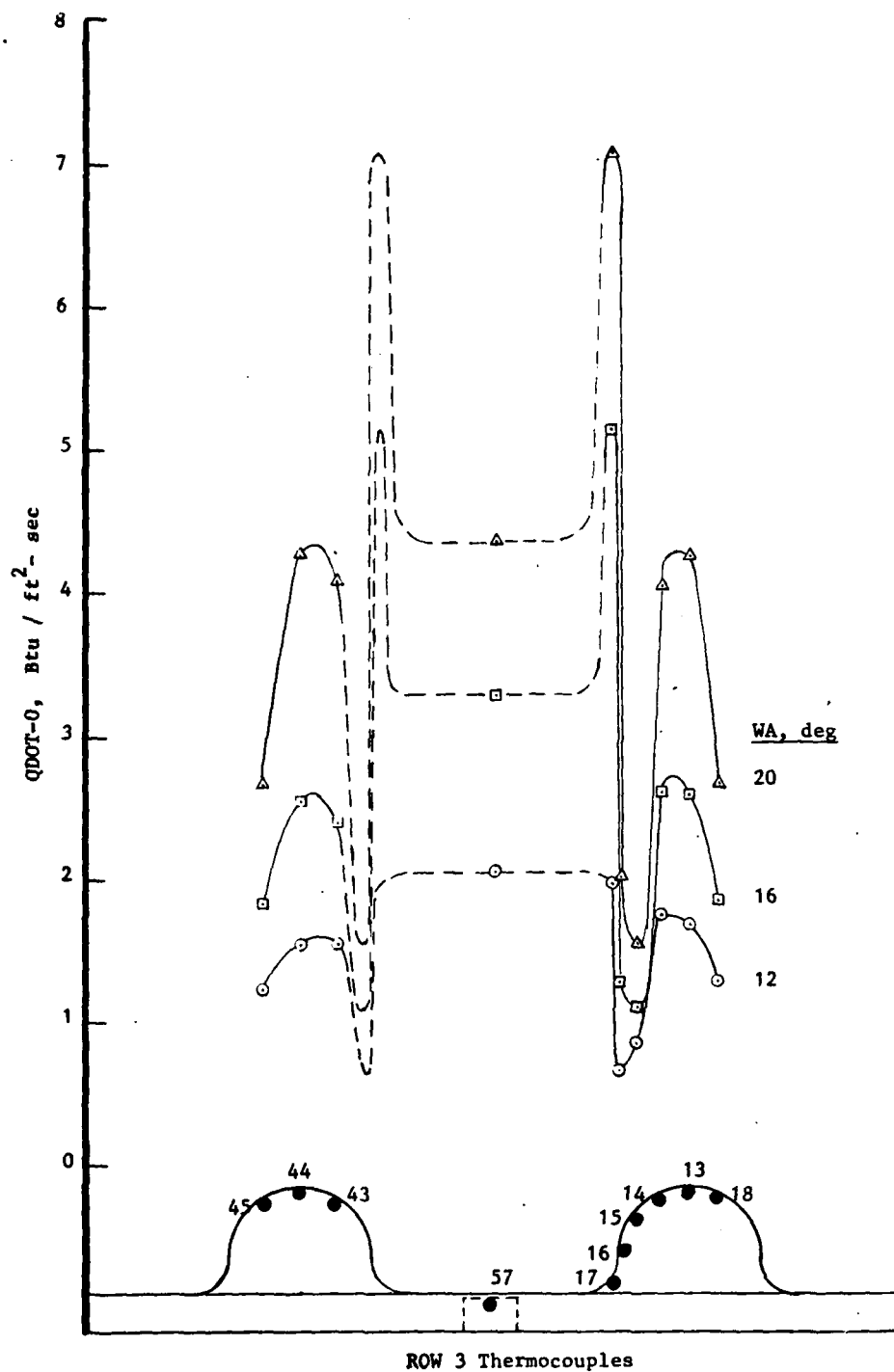


Figure 15. Typical Stringer Model Calibration Results

APPENDIX II

TABLES

TABLE 1. ESTIMATED UNCERTAINTIES
a. Basic Measurements

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT*							Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
	Precision Index $\pm(S)$		Bias $\pm(B)$		Uncertainty $\pm(B + 1.95S)$						
	Percent of Reading	Unit of Measure	Degree of Freedom	Percent of Reading	Unit of Measure	Percent of Reading	Unit of Measure				
STILLING CHAMBER PRESSURE (PT & PTR), psi	0.002 0.002 0.007 0.002	0.002 0.002 0.007 0.002	>30 >30 >30 >30	0.011	0.011	0.015 (0.2%+0.004) (0.2%+0.014) (0.8psi+1.24psi) (0.16%+1.24psi)	<5.5 460 >156.25 500 >500 <2500	Bell & Howell force balance pressure transducer Winchocko variable reluctance pressure transducer	Digital data acquisition system analog-to-digital converter	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory	
TOTAL TEMPERATURE, T_t , °F	1 1	1 1	>30 >30	0.375	2	$\pm(0.375 \pm 2\sigma)$	32 to 530	Chromel-Alumel ^R thermocouple	Doric temperature instrument digital multiplexer	Thermocouple verification of NBS conformity/voltage substitution calibration	
REFERENCE PRESSURE (PREF), microns	25 μ Hg	25 μ Hg	>30	10	(10%+50)	(10%+50)	<1000 μ Hg	Hastings vacuum gage	Digital data acquisition system analog-to-digital converter	Comparison to facility reference gage	
PITCH ANGLE (ALPI) ROLL ANGLE (PHII)	0.025 0.15	0.025 0.15	>30 >30			0.05 0.3	± 15 ± 180	Potentiometer		Heidenhain rotary encoder R02700 Resolution: 0.0006° Overall accuracy: 0.001°	
TIME	5x10 ⁻⁴	5x10 ⁻⁴	>30	Runtime(sec)x10 ⁻⁵	Runtime(sec)x10 ⁻⁵	Runtime(sec)x10 ⁻⁵ + Bunting(sec)x5x10 ⁻⁵	as to 365 days	Syston Donner time code generator	Digital data acquisition system	Instrument lab calibration against Bureau of Standards	
HEAT TRANSFER, QDOT, BTU/ft ² -sec	1.5	0.015	>30 >30	2 2	(0.03 + 2%) 5%	(0.03 + 2%) 5%	1 to 10	Gardon gage	Digital data acquisition system analog-to-digital converter	Radiant heat source and secondary standard	
E _{av}	0.1		>30	0.01	(0.2% + 0.01)	(0.2% + 0.01)		DEC-10/Multiverter Preston amplifier		Millivolt standard, referenced to lab standard	
MODEL PRESSURES, Pw, psia Tunnel A		0.0015	>30	0.15	(0.003 psi + 0.15%)	(0.003 psi + 0.15%)	0-15	Bell & Howell variable capacitance pressure transducer	Digital data acquisition system	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards lab	

*Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD 755356), February 1973.

TABLE I. Continued
a. Concluded

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT*							Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
	Precision Index		Bias		Uncertainty						
	Percent of Reading	Unit of Measurement	Degree of Freedom	Percent of Reading	Unit of Measurement	Percent of Reading	Unit of Measurement				
TEMPERATURE, TCE, T ₁₇ , T ₂₅ , T ₃₀	1		30	3/8%	0.75	2.75 (3/8%+2.0°F)	-75 to 200	THERMOCOUPLE CuCu			
	1		30	3/8%	2	1.4 (3/8%+2.0°F)	200 to 700				
	1		30	3/8%			32 to 530				CrAl
	1		30	3/8%	2	1.4 (3/8%+2.0°F)	530 to 2300				IC
b. in.	0+		30	3/8%			32 to 530	Supplied by Martin			
CP, BTU/lbm-°R	0+		30	3.0		3.0	530 to 1400	Supplied by Martin			
1. lbm/in. ³	0+		30	5.0		5.0		Supplied by Martin			
	0+		30	1.0		1.0		Supplied by Martin			

*Thompson, J. W. and Abernethy, R. B. et al. "Handbook Uncertainty in Gas Turbine Measurements." AEDC-TR-73-5 (AD 755356), February 1973.
Assumed to be zero

TABLE 1. Concluded
b. Calculated Parameters

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT*								Range
	Precision Index $\pm (S)$			Bias $\pm (B)$			Uncertainty $\pm (B + 1.95S)$		
	Percent of Reading	Unit of Measure	Degree of Freedom	Percent of Reading	Unit of Measure	Percent of Reading	Unit of Measure		
DELP, psia		0.002 0.003	30 30	0.2 0.3				(0.2% + 0.004) (0.3% + 0.006)	Tunnel A Tunnel C DELP 1 psia
H(TT), BTU/ft ² -sec-°R Gardon Gage Results	2.0		30	2.0				6.0	
H(TT), BTU/ft ² -sec-°R Thin Skin Results	0.6		30	5.8				7.0	
M		0.008 0.007 0.008 0.004	30 30 30 30		0 ⁺ 0 ⁺ 0 ⁺ 0 ⁺			0.016 0.014 0.012 0.008	2.0 10.02 10.05 10.11
QDOT-0, BTU/ft ² -sec Gardon Gage Results	2.0		30	2.0				6.0	
QDOT-0, BTU/ft ² -sec Thin Skin Results	1.1		30	5.8				8.0	
TW, °R Gardon Gage Results	0.2		30	0.4				0.8	All
WA, deg		0.05	30		0 ⁺			0.10	All

^aSherethy, R. B. et al. and Thompson, J. W. "Handbook Uncertainty in Gas Turbine Measurements." AD-75-358 (AD 755358), February 1973. Assumed to be zero

TABLE 2. CAMERA SETUP SUMMARIES

a. Entry 1

	Camera Type	Frame Rate	Camera Location	Sample View
Camera 1	Milliken 16mm color movie	400	Operating Side No. 3 window	* Left oblique view of sample on centerline
Camera 2	Mitchell 16mm color movie	100	Operating Side No. 4 window	Left side view of sample on centerline
Camera 3	Mitchell 16mm color movie	100	Non-operating Side No. 4 window	Right side view of sample on centerline
Camera 4	Sony black/white videocamera	N/A	Non-operating Side No. 4 window	Right side view of sample on centerline
Camera 5	Hycam shadowgraph movies	100	Operating Side Aft windows	Left side view of sample on centerline
Camera 6	Varitron shadowgraph stills	1 per 5 sec	Operating Side Forward windows	Left side view of forward portion of wedge

* "left" and "right" based on view from downstream
of test section looking toward throat

+ operating side ~ right non-operating side ~ left

TABLE 2. continued.
b. Entry 2

	Camera Type	Frame Rate	Camera Location	Sample View
Camera 1	Milliken 16mm color movies	400	Top No. 2 window of 3-port window	Top view of sample
Camera 2	Mitchell 16mm color movie	400	Operating Side Aft window	Left side view of sample on centerline
Camera 3	Mitchell 16mm color movie	400	Non-operating Side Aft window	Right side view of sample on centerline
Camera 4	Hycam shadowgraph movie	100	Operating Side Aft window	Left side view of sample on centerline
Camera 5	Sony black/white videocamera	N/A	Top No. 2 window of 3-port window	Top view of sample

TABLE 2. continued.

c. Entry 3

	Camera Type	Frame Rate	Camera Location	Sample View
Camera 1	Milliken 16mm color movies	100	Operating Side No. 3 window	Left side view of sample in full forward position on centerline
Camera 2	Milliken 16mm color movies	400	Operating Side No. 4 window	Left side view of rear of sample in full forward position on centerline
Camera 3	Mitchell 16mm color movies	100	Operating Side No. 5 window	Left side view of model passing through the tunnel wall opening
Camera 4	Sony black/white videocamera	N/A	Non-operating Side No. 3 window	Right side view of sample in full forward position on centerline
Camera 5	Varitron shadowgraph still	2 per run 0 and 10 sec	Operating Side Aft windows	Right side view of sample and wedge in full forward position on centerline

TABLE 2, continued.

d. Entry 4

	Camera Type	Frame Rate	Camera Location	Sample View
Camera 1	Varitron 70mm color still	Approx. 1 every 3.5 sec	Top forward window of 2-port window	Top view of sample showing surface contour using grid line projection technique
Camera 2	Milliken 16mm color movie	24	Top forward window of 2-port window	Top view of sample showing surface contour using grid line projection technique
Camera 3	Milliken 16mm color movie	24	Forward Operating Side window	Oblique view of sample on centerline
Camera 4	Sony black/white videocamera	N/A	Top forward window of 2-port window	Same as Cameras 1 and 2
Camera 5	Varitron still shadowgraph	Approx. 1 every 10 sec	Forward Operating Side window	Side view shadowgraph of forward portion of wedge
Camera 6	Varitron still shadowgraph	Approx. 1 every 10 sec	Aft Operating Side window	Side view shadowgraph of sample and aft portion of wedge

Hycam high-speed black and white shadowgraph movie camera was available in the same position and same view as Camera 6 This was set for 1000 frames/sec but it was not used.

TABLE 2. concluded.
e. Entry 5

	Camera Type	Frame Rate	Camera Location	Sample View
Camera 1	Varitron 70mm color still	1 per 4 sec	Top forward window of 2-port window	Top view of sample on centerline with projected grid lines
Camera 2	Milliken 16mm color movie	24	Top forward window of 2-port window	Top view of sample on centerline with projected grid lines
Camera 3	Hycam shadowgraph movies*	1000	Operating Side Forward window	Left side view of forward portion of sample on centerline
Camera 4	Hycam shadowgraph movies*	1000	Operating Side Aft window	Left side view of aft portion of sample on centerline
Camera 5	Sony black/white videocamera	N/A	Top forward window of 2-port window	Top view of sample
Camera 6	Varitron shadowgraph still	1 per 10 sec	Operating Side Forward window	Left side view of forward portion of wedge on centerline
Camera 7	Varitron shadowgraph still	1 per 10 sec	Operating Side Aft window	Left side view of sample and aft portion of wedge on centerline

*Hycam high-speed black and white shadowgraph cameras were available but were not used.

TABLE 3. FILM LOGS

a. Entry 1

MODEL I.D.	RUN	DEBRIS ✓	STILL PHOTOGRAPHS I.D. No.			MOVIES I.D. No.		
			PRETEST	POSTTEST	INSTL.	CAMERA 1	CAMERA 2	CAMERA 3
						400 FPS	100 FPS	100 FPS
1-1	1							
	2						4713	
	3						4713	
	4						4713	
2-1	5				10431		4713	
	6						4713	
	7						4713	
3-1	8		10271-72	10467		4692	4705	4709
3-2	9		10276-77	10468		4693	4705	4709
3-3	10		10273-75	10469		4694	4679	4686
3-4			10278-79					
4-1	11	✓	10254-55	10473, 97, 98	10433	4670	4679	4686
4-2	12		10256-57	10474		4695	4680	4687
4-3	13	✓	10258-60	10475, 499-501		4672	4680	4687
4-4	17		10261-62 10436-37	10476		4699	4707	4711
5-1	14		10269-70	10470	10434	4696	4706	4710
5-2			10267-68					
6-1	15		10263-64	10471		4697	4706	4710
6-2	16		10265-66	10472		4698	4707	4711
7-1	18		10228-29	10484	10435	4700	4708	4712
7-2	19		10230-31	10485		4701	4708	4712
7-3			10232-34					
7-4	20		10235-36	10486		4702	4681	4688
8-1	21	✓	10245-46	10477, 87-88		4691	4681	4688
8-2	22	✓	10247-48	10478, 89-90		4673	4682	4671
8-3	23	✓	10249-50, 53	10479, 91-92		4674	4682	4671
8-4	27/28	✓	10251-52	10480, 93-94	10438-41	4676/4678	4684/4685	/4690
9-1	24		10237-38	10483		4703	4683	4689
9-2			10239-40					
10-1	25	✓	10241-42	10481, 95-96		4675	4683	4689
10-2	26		10243-44	10482		4704	4684	
			OPERATING CAMERAS 1	SIDE AND 2	→ 10432			

TABLE 3. continued.

b. Entry 2 Calibration Models

[illegible]

c. Entry 2 Materials Samples

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TABLE 3. continued.

d. Entry 3 Still Photographs

RUN	MODEL	MATERIAL	PRETEST PHOTO NO.	POSTTEST PHOTO NO.	INSTL. PHOTO NO.
302	ET/SRB CABLE TRAY RAMP SAMPLE 1	BX-250	446 447	582 583	
301	SAMPLE 2		448 449	584 585	
303	SAMPLE 3		450 451	586 587	
304	↓ SAMPLE 4 1/16" CRACK	↓	452 453	588 589	
305	ET/SRB CABLE TRAY RAMP SAMPLE 1	PDL-4034	456 457	592 593	
306	SAMPLE 2		458 459	594 595	
307	SAMPLE 3		460 461	596 597	
308	↓ SAMPLE 4 1/8" CRACK	↓	454 455	590 591	521 522 523 524
309	LOX TANK CABLE TRAY RAMP SAMPLE 1	BX-250	430 431	604 605	514 515 517 518
310	SAMPLE 2		432 433	606 607	
311	SAMPLE 3		434 435	608 609	
	↓ SAMPLE 4	↓	436 437		
312	LOX TANK CABLE TRAY RAMP SAMPLE 1	PDL-4034	438 439	602 603	
313	SAMPLE 2		440 441	600 601	
314	SAMPLE 3		442 443	598 599	
	↓ SAMPLE 4	↓	444 445		
315	BARRY MOUNT SAMPLE 1	SLA-561	462 463 465	610 611	
316	BARRY MOUNT SAMPLE 2	SLA-561	464 466	612 613	516 519 520
	CAMERA SETUP OPERATING SIDE				488 489
	CAMERA SETUP NON-OPERATING SIDE				490
302 - 316	SHADOWGRAPH		ROLL NUMBER	0860	

TABLE 3. continued.

e. Entry 3 Motion Pictures

RUN	MODEL	MATERIAL	CAMERA 1	CAMERA 2	CAMERA 3
			REEL I.D. NO.	REEL I.D. NO.	REEL I.D. NO.
			100 FPS	400 FPS	100 FPS
302	ET/SRB CABLE TRAY RAMP SAMPLE 1	BX-250	4743	4750	4742
301	SAMPLE 2		4743	4749	4742
303	SAMPLE 3		4743	4751	4742
304	SAMPLE 4 1/16" CRACK		4744	4752	4742
305	ET/SRB CABLE TRAY RAMP SAMPLE 1	PDL-4034	4744	4753	4742
306	SAMPLE 2		4744	4754	4742
307	SAMPLE 3		4745	4755	4742
308	SAMPLE 4 1/8" CRACK		4745	4756	4742
309	LOX TANK CABLE TRAY RAMP SAMPLE 1	BX-250	4745	4757	4742
310	SAMPLE 2		4746	4758	4742
311	SAMPLE 3		4746	4759	4742
	SAMPLE 4				
312	LOX TANK CABLE TRAY RAMP SAMPLE 1	PDL-4034	4746	4760	4742
313	SAMPLE 2		4747	4761	4742
314	SAMPLE 3		4747	4762	4742
	SAMPLE 4				
315	BARRY MOUNT SAMPLE 1	SLA-561	4747	4763	4742
316	BARRY MOUNT SAMPLE 2	SLA-561	4748	4764	4742
301- 316	VIDEOTAPE				

TABLE 3. continued.

f. Entry 4 Pretest and Posttest Photographs

RUN	SAMPLE	MATERIAL	PRETEST Photo No.	POSTTEST Photo No.
401	CTC13-01	NCFI-25-13	8530	3281 3292
402	CTC13-02		8533	3285 3320
403	CTC13-03		85211	3276 3314
	CTC13-04	↓	8522 3288 3289	
404	CTC13-05	FSC-76-1-29	8543	3271 3317
405	CTC13-06		8546	3272 3316
406	CTC13-07		8542	3270 3305
	CTC13-08	↓	8544	
407	CTC13-09	TU-333	8527 8529	3267 3319
408	CTC13-10		8531 8532	3282 3304
409	CTC13-11		8525	3263 3307
	CTC13-12	↓	8528	
410	CTC13-13	TU-2006-21B	8549	3264 3306
411	CTC13-14		8539	3268 3318
431	CTC13-15		8547	3283 3315
	CTC13-16	↓	8540	
412	CTC13-17	CPRX-90-96-2	8536	3261 3295
413	CTC13-18		8535	3262 3294
414	CTC13-19		8538	3273 3297
426	CTC13-20	↓	8534 8551	3279 3303
415	CTC13-21	PDL-500-2.5	8541	3274 3296
416	CTC13-22		8537	3277 3299
417	CTC13-23		8548 8550 8552	3269 3287
427	CTC13-24	↓	8545	3275 3312
420	CTC13-27	COOK G325	3098	3260 3309
422	CTC13-28	SLA w/shock gen.	3094	3258 3311
423	CTC13-29	↓	3092	3265 3301
430	CTC13-30	QUELFLAM SS624	3096	3286 3313
421	CTC13-31		3099	3293 3308
	CTC13-32	↓	3097	
424	CTC13-33	CPR/SLA heated	3095	3266 3300
	CTC13-34		3093	
425	CTC13-36	↓	3090	3259 3310

f. Concluded

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TABLE 3. continued.

g. Entry 4 Motion Pictures and Videotape

RUN	Film Reel or Roll I.D. No.					
	Camera 1	Camera 2	Camera 3	Camera 4	Camera 5	Camera 6
401	0352	04784	04785	Videotape	0549	0492
402						
403						
404						
405						
406						
407		↓	↓			
408		04783	04782			
409						
410						
411						
412						
413						
414		↓				
415		04780				
416		04780	↓			
417			04779			
418						
419						
420						
421						
422	↓	04780				
423	0835					
424						
425						
426			↓			
427			04778			
428		↓				
429		04781				
430		↓				
431	↓	↓	↓	↓	↓	↓

h. Entry 5 Pretest and Posttest Photographs

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TABLE 3. concluded.

1. Entry 5 Motion Pictures and Videotape

RUN	Film Reel or Roll I.D. No.				
	CAMERA 1	CAMERA 2	CAMERA 5	CAMERA 6	CAMERA 7
501			Videotape	0073	0163
502					
503					
504					
505	0291	4659			
506					
507	0291	4659			
508	0291	4659			
509	0291	4659			
510	0291	4659			
511	0291	4659			
512					
513					
514	0291	4659			
515					
516					
517					
518					
519					
520					
521					
522		↓			
523		4659			
524		4660			
525		↓			
526					
527		↓			
528	↓	↓		↓	↓
529	0291	4660	↓	0073	0163

TABLE 4.

ET INTERTANK STRINGER THIN-SKIN THERMOCOUPLE
LOCATIONS AND SKIN THICKNESSES

Thermocouple No.	ROW	COLUMN	Skin Thickness, in.	Thermocouple No.	ROW	COLUMN	Skin Thickness, in.
1	1	2	0.040	31	6	2	0.040
2	1	3	0.040	32	6	3	0.040
3	1	4	0.040	33	6	4	0.040
4	1	5	0.040	34	6	5	0.040
5	1	6	0.040	35	6	6	0.040
6	1	1	0.040	36	6	1	0.040
7	2	2	0.040	37	1	8	0.040
8	2	3	0.040	38	1	9	0.040
9	2	4	0.040	39	1	10	0.040
10	2	5	0.040	40	2	8	0.040
11	2	6	0.040	41	2	9	0.040
12	2	1	0.040	42	2	10	0.040
13	3	2	0.040	43	3	8	0.040
14	3	3	0.040	44	3	9	0.040
15	3	4	0.040	45	3	10	0.040
16	3	5	0.040	46	4	8	0.040
17	3	6	0.040	47	4	9	0.040
18	3	1	0.040	48	4	10	0.040
19	4	2	0.040	49	5	8	0.040
20	4	3	0.040	50	5	9	0.040
21	4	4	0.040	51	5	10	0.040
22	4	5	0.040	52	6	8	0.040
23	4	6	0.040	53	6	9	0.040
24	4	1	0.040	54	6	10	0.040
25	5	2	0.040	55	1	7	0.031
26	5	3	0.040	56	2	7	0.033
27	5	4	0.040	57	3	7	0.033
28	5	5	0.040	58	4	7	0.033
29	5	6	0.040	59	5	7	0.031
30	5	1	0.040	60	6	7	0.033

TABLE 5. TEST SUMMARY

a. Total Project

ENTRY (Date)	M	MODEL or MATERIAL	RUN NUMBERS	REFER TO TABLE NO.
1	2.0	CABLE TRAY BRACKET CALIB.	1-4	5b
(10/17/79)	↓	BARRY MOUNT CALIBRATION	5-7	5b
	↓	CABLE TRAY BRACKET MATERIALS	8-17	5c
	↓	BARRY MOUNT MATERIALS	18-28	5c
2	10.02	CABLE TRAY BRACKET CALIBRATION	10-21	5d
(10/19/79)	↓	BARRY MOUNT CALIBRATION	28-31	5d
	10.05	BARRY MOUNT CALIBRATION	1-6	5d
	↓	CABLE TRAY BRACKET CALIB.	7-9	5d
	10.02	CABLE TRAY BRACKET MATERIALS	22-27	5e
	↓	BARRY MOUNT MATERIALS	32-39	5e
3	2.0	ET/SRE CABLE TRAY RAMPS	301-308	5f
(1/17/80)	↓	LOX TANK CABLE TRAY RAMPS	309-314	5f
	↓	BARRY MOUNTS	315, 316	5f
4	10.0	NCFI-25-13	401-403	5g
(4/5/80)	↓	FSC-76-1-29	404-406	5g
		TU-333	407-409	5g
		TU-2006-21B	410 411 431	5g
		CPRX-90-96-2	412-414 426	5g
		PDL-500-2.5	415-417 427	5g
		COOK G325	420	5g
		SLA-561 with shock generator	422 423	5g
		QUELFLAM S3624	421 430	5g
		CPR-488/SLA-561 heat pad	424 425	5g
		CPR-488 Binks-machined	418 428	5g
	↓	CPR-488 Binks-net	419 429	5g
5	10.10	PARALLEL STRINGER CALIBRATION	501-506	5h
(5/15/80)		10° STRINGER CALIBRATION	507-513	5h
		PARALLEL STRINGER MATERIALS	514-518 524	5h
		10° STRINGER MATERIALS	519-523 525	5h
		FLAT PANELS	526-529	5h

b. Entry 1 Calibration

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c. Entry 1 Materials

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d. Entry 2 Calibration

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e. Entry 2 Materials

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TABLE 5. continued.

f. Entry 3

RUN	MODEL	MATERIAL	WEDGE ANGLE	M	PT	TT
302	ET/SRB CABLE TRAY RAMP SAMPLE 1	BX-250	MACS	2.0	14.0	610
301	↓ SAMPLE 2	↓	↓	↓	↓	↓
303	↓ SAMPLE 3	↓	↓	↓	↓	↓
304	↓ SAMPLE 4 1/16" CRACK	↓	↓	↓	↓	↓
305	ET/SRB CABLE TRAY RAMP SAMPLE 1	PDL-4034	MACS	2.0	14.0	610
306	↓ SAMPLE 2	↓	↓	↓	↓	↓
307	↓ SAMPLE 3	↓	↓	↓	↓	↓
308	↓ SAMPLE 4 1/8" CRACK	↓	↓	↓	↓	↓
309	LOX TANK CABLE TRAY RAMP SAMPLE 1	BX-250	MACS	2.0	14.0	610
310	↓ SAMPLE 2	↓	↓	↓	↓	↓
311	↓ SAMPLE 3	↓	↓	↓	↓	↓
	↓ SAMPLE 4	↓	↓	↓	↓	↓
312	LOX TANK CABLE TRAY RAMP SAMPLE 1	PDL-4034	MACS	2.0	14.0	610
313	↓ SAMPLE 2	↓	↓	↓	↓	↓
314	↓ SAMPLE 3	↓	↓	↓	↓	↓
	↓ SAMPLE 4	↓	↓	↓	↓	↓
315	BARRY MOUNT SAMPLE 1	SLA-561	MACS	2.0	15.0	610
316	BARRY MOUNT SAMPLE 2	SLA-561	MACS	2.0	15.0	610

TABLE 5. continued.

g. Entry 4 Alternate Foams

RUN	SAMPLE	MATERIAL	WEDGE ANGLE deg	M	PT psia	TT °F
401	CTC13-01	NCFI-25-13	10.0	10.0	1800	1440
402	CTC13-02		15.0			
403	CTC13-03		20.0			
	CTC13-04	↓				
404	CTC13-05	FSC-76-1-29	10.0			
405	CTC13-06		15.0			
406	CTC13-07		20.0			
	CTC13-08	↓				
407	CTC13-09	TU-333	10.0			
408	CTC13-10		15.0			
409	CTC13-11		20.0			
	CTC13-12	↓				
410	CTC13-13	TU-2006-21B	10.0			
411	CTC13-14		15.0			
431	CTC13-15		20.0			
	CTC13-16	↓				
412	CTC13-17	CPRX-90-96-2	10.0			
413	CTC13-18		15.0			
414	CTC13-19		20.0			
426	CTC13-20	↓	25.0			
415	CTC13-21	PDL-500-2.5	10.0			
416	CTC13-22		15.0			
417	CTC13-23		20.0			
427	CTC13-24	↓	25.0			
420	CTC13-27	COOK G325	15.0			
422	CTC13-28	SLA w/shock gen. 10°	12.0			
423	CTC13-29	SLA w/shock gen. 15°	12.0			
430	CTC13-30	QUELFLAM SS624	10.0			
421	CTC13-31		15.0			
	CTC13-32	↓				
424	CTC13-33	CPR/SLA heated	20.0			
	CTC13-34					
425	CTC13-36	↓	20.0	Y	Y	Y

g. Concluded

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TABLE 5. concluded

h. Entry 5

RUN	MODEL	MATERIAL	WEDGE ANGLE deg	M	PT psia	TT °F
501	THIN-SKIN PARALLEL STRINGERS	304 STAINLESS STEEL	10.0	10.10	1800	1440
502			12.0			
503			16.0			
504			20.0			
505			25.0			
506	↓		20.0			
507	THIN-SKIN 10 DEG STRINGERS		10.0			
508			12.0			
509			16.0			
510			20.0			
511			25.0			
512			20.0			
513	↓	↓	10.0			
514	PARALLEL STRINGERS	CPR-488	12.0			
515			16.0			
516			20.0			
517		↓	25.0			
518		CPR-488/SLA-561	25.0			
524	↓	CPR-488/SLA-561 MACHINED	25.0			
519	10 DEGREE STRINGERS	CPR-488	12.0			
521			20.0			
522			25.0			
520		↓	16.0			
523		CPR-488/SLA-561	25.0			
525	↓	CPR-488/SLA-561 MACHINED	25.0			
529	FLAT PANELS	PDL-4034	16.0			
526			12.0			
527			16.0			
528	↓	↓	20.0	↓	↓	↓

APPENDIX III

SAMPLE TABULATED DATA

180,140 - 8100 DIVISION
 A SUPPLEMENT INFORMATION COMPANY
 VON KARMAN GAS DYNAMICS FACILITY
 ARNOLD AIR FORCE STATION, TENN.

PROJECT NO V41A-48
 NASA/WM MATERIALS

DATE COMPUTED 17-OCT-79
 DATE RECORDED 17-OCT-79
 TIME RECORDED 9:41:47

RUN 1 MODEL CARLE TRAY BRACKET
 SAMPLE 1 MATERIAL CALIBR M PT TT ALPPB CR
 359.3 1.15 3.211 1858.4 0.268E-03 0.277E-06 0.180E+07 0.155E+03
 T P Q V RND MU RE ITT
 0.0 TAP 1 2 3 4 5 6 7 8
 0.0 PW 5.28 4.62 2.98 2.78 1.78
 0.0 DELP 4.28 3.62 1.98 1.78

WEDGE ATTITUDE AND PRESSURE DATA

WA TAP 1 2 3 4 5 6 7 8
 5.0 PW 5.61 4.92 3.35 3.19 2.35
 5.0 DELP 4.77 4.09 2.52 2.35

WA TAP 1 2 3 4 5 6 7 8
 9.9 PW 5.27 5.85 4.69 4.71 3.89
 9.9 DELP 4.45 5.02 3.86 3.89

WA TAP 1 2 3 4 5 6 7 8
 0.0 PW 5.36 4.67 3.01 2.79 1.79
 0.0 DELP 4.36 3.67 2.01 1.79

92

a. Calibration

SAMPLE 1. Entry 1 Data

AD-A093 310

ARNOLD ENGINEERING DEVELOPMENT CENTER ARNOLD AFS TN F/G 22/2
MATERIALS TESTS OF SPACE SHUTTLE ALTERNATE FOAMS AND PROTUBERAN--ETC(U)
JUN 80 G L DOMMERMAN
AEDC-TSR-80-V31

UNCLASSIFIED

NL

2 of 2
AD-A
10933



END
DATE FILMED
2-81
DTIC

800, INC - ABC DIVISION
A SVERDRUP CORPORATION COMPANY
VON PARAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TFWN

DATE COMPUTED 17-OCT-79
DATE RECORDED 17-OCT-78
TIME RECORDED 12:28:45

PROJECT NO V418-A8
NASA/MN MATERIALS

RUN 8 CABLE TRAY BRACKET W/15 R
MODEL
338.7 P 1.94 5.435 1804.4 V
SAMPLE 1 MATERIAL PDL-4034 H 2.00 PT 15.19 TT 609.7 CR 9.85
RHO 0.481E-03 MU 0.243E-06 RE 0.329E+07 ITT 0.148E+03
TIMEINJ 15.24 TIMECL 12 27 9 303 TIMEEXPT 93.75

WEDGE ATTITUDE HISTORY

TIMEEXP	WA	TIMEEXP	WA
0.00	0.00	89.52	-0.02
3.76	-0.03	90.05	-0.02
5.70	-0.14		
7.71	0.05		
9.70	0.66		
11.70	1.86		
15.52	3.43		
17.52	4.31		
19.52	5.48		
21.52	6.32		
23.52	7.19		
25.52	8.31		
27.52	9.20		
29.52	10.03		
31.52	10.01		
33.52	10.04		
35.52	10.03		
37.52	10.02		
39.52	9.99		
41.52	8.96		
43.52	8.06		
45.52	6.92		
47.52	5.98		
49.52	5.11		
51.52	4.23		
53.52	3.01		
55.52	2.33		
57.52	1.45		
59.52	0.20		
61.52	-0.01		
63.52	-0.00		
65.52	0.00		
67.52	0.01		
69.52	0.01		
71.52	-0.00		
73.52	0.00		
75.52	0.01		
77.52	-0.02		
79.52	-0.02		
81.52	-0.01		
83.52	-0.02		
85.52	-0.02		
87.52	-0.02		

b. Materials

SAMPLE 1. concluded.

ARGONIC - AGENC DIVISION
A STEWARDSON CORPORATION COMPANY
VON PARAN GAS DYNAMICS FACILITY
ARNDOLD AIR FORCE STATION, TENN

PROJECT NO VAIC-AS
WASA/HN MATERIALS

DATE COMPUTED 19-NOV-79
DATE RECORDED 19-OCT-79
TIME RECORDED 11: 9:18

RUN	MODEL	SAMPLE	MATERIAL	M	PT	TT	ALPPB	CR
1	PAPRY MOUNT	1	CALIB	10.05	596.64	1896.7	12.00	16.00

T	P	Q	V	RHO	MU	RE	ITT
93.8	0.0130	0.920	4772.8	0.1182-04	0.7552-07	0.7352+06	0.4772+03

WEDGE ATTITUDE AND PRESSURE DATA

WA	-0.0	TIME	11	9	18								
GAGE	1	2	3	4	5	6	7	8	95	96	97	98	99
ODUT	1.06	3.47	32.74	3.29	1.04	1.97	2.01	1.68	0.28	0.29	0.16	0.04	0.11
TH	540.1	577.5	843.1	574.2	839.2	944.6	954.6	944.7	931.8	931.3	929.7	928.6	929.6
HTT	0.0008	0.0026	0.0310	0.0025	0.0008	0.0015	0.0015	0.0012	0.0002	0.0002	0.0001	0.0000	0.0001
ODUT-Q	1.12	3.78	44.62	3.38	1.10	2.09	2.15	1.78	0.30	0.30	0.16	0.04	0.11

WA	-0.0	TIME	11	9	22								
GAGE	1	2	3	4	5	6	7	8	95	96	97	98	99
ODUT	1.03	3.31	30.57	3.08	1.01	1.97	1.87	1.58	0.26	0.29	0.12	0.03	0.11
TH	543.2	596.1	887.1	592.3	842.7	950.7	957.3	950.8	932.3	931.8	929.5	928.5	929.8
HTT	0.0008	0.0025	0.0303	0.0024	0.0007	0.0015	0.0014	0.0012	0.0002	0.0002	0.0001	0.0000	0.0001
ODUT-Q	1.09	3.66	43.50	3.38	1.08	2.10	2.02	1.69	0.27	0.30	0.12	0.03	0.11

WA	TAP	1	2	3	4	5	6	7	TIME
-0.0	PM	0.10	0.07	0.28	0.06	0.09	0.03	0.03	11 9 54
	DELP	0.07	0.03	0.25	0.03	0.06			

a. Calibration

SAMPLE 2. Entry 2 Data

BOB, INC 'COC DIVISION
A SYSTEM CORPORATION COMPANY
700 WABASH GAS DYNAMICS FACILITY
ARMOED AIR FORCE STATION, TENN

PROJECT NO VASC-AB
WANA/NN MATERIALS

DATE COMPUTED NOV-79
DATE RECORDED OCT-79
TIME RECORDED 17:20:59

RUN	MODEL	SAMPLE	MATERIAL	N	PT	TT	ALPD	CR
22	CABLE TRAY BRACKET W/ 15' DAMP	1	PGL-4034	10.02	300.98	1896.7	12.00	16.00
94.3	P 0.0066 0.465 4769.6	RNO 0.589E-08	MU 0.759E-07	RE 0.370E+06	ITT 0.477E+03	TINEINJ 2.59	TINECL 17 21 14 911	TINEEPT 19.40

WEDGE ATTITUDE HISTORY

TIMEEXP	WA
0.00	0.00
1.00	7.55
16.50	7.57

b. Materials
SAMPLE 2. concluded

ALC DIVISION
A. EVERETT CORPORATION COMPANY
VON KARM. GAS DYNAMICS FACILITY
ANNHOLD AIR FORCE STATION, TEXAS

PROJECT NO V41A-40
NASA/WM MATERIALS

DATE COMPUTED JAN-80
DATE RECORDED JAN-80
TIME RECORDED 9:59:41

RUN	MODEL	ST/SRR	CABLE	TRAY	RAMP	SAMPLE	MATERIAL	N	PT	TT	ALPPB	CR
301	1.7782	4.970	1807.4	0.439E-03	0.264E-06	0.300E+07	0.147E+03	13.51	8 59 3 162	85.62		

WEDGE ATTITUDE HISTORY

TIMEEXP	WA
0.00	0.00
3.70	0.01
5.70	-0.04
7.70	-0.08
9.70	-0.01
11.90	-0.01
13.90	-0.01
15.90	0.43
17.90	1.57
19.90	2.41
21.90	3.29
23.90	4.19
25.90	5.79
27.90	6.20
29.90	7.12
31.90	8.14
33.90	9.08
35.90	10.04
37.90	10.00
39.90	9.99
41.90	9.99
43.90	9.99
45.90	9.99
47.90	9.10
49.90	8.22
51.90	7.04
53.90	6.19
55.90	5.29
57.90	4.40
59.90	3.22
61.90	2.55
63.90	1.35
65.90	0.70
67.90	-0.01
69.90	0.01
71.90	0.01
73.90	0.01
75.90	0.01
77.90	0.00
79.90	-0.00
81.92	0.03

SAMPLE 3. Entry 3 Data

ARG, INC. - JC DIVISION
A SVERDRUP CORPORATION COMPANY
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/HRA SPACE SHUTTLE NATL. TEST

DATE COMPUTED 9-APR-88
TIME COMPUTED 21:42:00
DATE RECORDED 9-APR-88
TIME RECORDED 21:40: 9
PROJECT NUMBER V41C-AB

50 INCH HYPERSONIC TUNNEL C

RUN	SAMPLE	MATERIAL	M	PT	TT	ALPPB	ALPI	CR	WA	PAGE 1
401	CTC13-1	ACFI-25-13	10.10	1747.0	1900.7	18.65	8.60	10.00	10.05	
T	P	O	V	RHO	MU	RE	ITT	SIMINJ	TIMECL	TIMEEXPT
93.6	0.038	2.697	4788.9	1.090E-03	7.533E-08	2.153E+06	4.784E+02	3.358	21 40 27 577	62.83

WEDGE ATTITUDE AND TEMPERATURE HISTORY

TIMEEXP	WA	TS 1	TS 2	TS 3
-1.6	0.00	80.0	79.0	81.0
1.0	10.05	82.0	80.0	82.0
		GRID LINE PICTURE TAKEN AT 2.1 SECONDS.		
3.0	9.98	81.0	79.0	82.0
		SHADOWGRAPH TAKEN AT 3.0 SECONDS.		
3.8	9.98	81.0	79.0	82.0
		GRID LINE PICTURE TAKEN AT 5.7 SECONDS.		
5.0	9.98	81.0	79.0	82.0
7.0	9.98	81.0	79.0	82.0
		GRID LINE PICTURE TAKEN AT 9.4 SECONDS.		
9.8	9.98	81.0	80.0	82.0
11.8	9.98	81.0	80.0	83.0
		GRID LINE PICTURE TAKEN AT 13.0 SECONDS.		
13.4	9.98	81.0	80.0	83.0
		SHADOWGRAPH TAKEN AT 13.4 SECONDS.		
13.8	9.98	81.0	80.0	83.0
15.8	9.98	81.0	80.0	83.0
		GRID LINE PICTURE TAKEN AT 16.7 SECONDS.		
17.8	9.98	81.0	80.0	83.0
19.8	9.97	81.0	80.0	84.0
		GRID LINE PICTURE TAKEN AT 20.4 SECONDS.		
21.8	9.97	81.0	80.0	84.0
		GRID LINE PICTURE TAKEN AT 23.6 SECONDS.		
		SHADOWGRAPH TAKEN AT 23.7 SECONDS.		
23.8	9.97	82.0	80.0	84.0
25.8	9.97	82.0	80.0	84.0
		GRID LINE PICTURE TAKEN AT 27.3 SECONDS.		
27.8	9.97	82.0	80.0	85.0
29.8	9.97	82.0	80.0	85.0
		GRID LINE PICTURE TAKEN AT 31.0 SECONDS.		
31.8	9.97	82.0	80.0	85.0
33.8	9.97	82.0	80.0	85.0
		GRID LINE PICTURE TAKEN AT 33.9 SECONDS.		
		SHADOWGRAPH TAKEN AT 33.9 SECONDS.		
36.0	9.97	82.0	80.0	85.0
38.8	9.97	82.0	80.0	86.0
		GRID LINE PICTURE TAKEN AT 37.6 SECONDS.		
37.8	9.97	83.0	80.0	86.0

SAMPLE 4. Entry 4 Data

APG, INC. - AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
NASA/AMA SPACE SHUTTLE NATL. TEST

DATE COMPUTED 9-APR-80
TIME COMPUTED 21:42:00
DATE RECORDED 9-APR-80
TIME RECORDED 21:40: 9
PROJECT NUMBER V41C-AA

50 INCH HYPERSONIC TUNNEL C

RUN	SAMPLE	MATERIAL	M	PT	IT	ALPBB	ALPI	CR	WA	PAGE 2
401	CTC13-1	NCV1-25-13	10.10	1747.8	1900.7	14.65	8.60	10.00	10.05	
T	P	O	V	RHO	MU	RE	ITT	TIMEINJ	TIMEECL	TIMEEPT
93.6	0.038	2.697	4788.9	1.090E-03	7.533E-08	2.153E+06	4.784E+02	3.358	31 40 27 577	62.03

WEDGE ATTITUDE AND TEMPERATURE HISTORY

TIMEEPT	WA	TS 1	TS 2	TS 3
39.8	9.97	83.0	80.0	86.0
		GRID LINE PICTURE TAKEN AT 41.3 SECONDS.		
41.8	9.97	83.0	80.0	87.0
43.8	9.97	83.0	80.0	87.0
44.2	9.97	84.0	80.0	87.0
		SHADOWGRAPH TAKEN AT 44.3 SECONDS.		
45.8	9.97	84.0	80.0	87.0
47.8	9.97	84.0	81.0	88.0
		GRID LINE PICTURE TAKEN AT 48.2 SECONDS.		
49.8	9.97	84.0	81.0	88.0
51.8	9.97	84.0	81.0	88.0
		GRID LINE PICTURE TAKEN AT 51.8 SECONDS.		
53.8	9.97	85.0	81.0	89.0
54.5	9.97	85.0	81.0	89.0
		SHADOWGRAPH TAKEN AT 54.5 SECONDS.		
55.8	9.97	85.0	81.0	89.0
57.8	9.97	86.0	81.0	90.0
		GRID LINE PICTURE TAKEN AT 59.2 SECONDS.		
59.8	10.10	86.0	81.0	90.0

SAMPLE 4. concluded.

ARD, INC. - AERC DIVISION
A SVERDRUP CORPORATION COMPANY
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE

DATE COMPUTED 20-MAY-60
TIME COMPUTED 20:49:51
DATE RECORDED 16-MAY-60
TIME RECORDED 09: 7:02
PROJECT NUMBER V41C-A0

RUN	CONFIG	M	PT (PSIA)	TT (DEG R)	ALPI (DEG)	MA (DEG)	PHII (DEG)	TIMECL (HOUR MIN SEC MSEC)
501	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987
T (DEGR)	P (PSIA)	Q (PSIA)	V (FT-SEC)	W (LBM/FT ³)	NU (LB-SFC/FT ²)	RE (FT-1)	ITT (BTU/LBM)	CR (IN)
93.65	0.06	2.711	4790.	1.093E-03	7.536E-08	2.163E+06	478.7	21.000
TC	ROW	COLUMN	TM (DEGR)	DTM/DT (DEG/SEC)	ODUT (BTU/FT ² -SEC)	M(TT)	ODOT-0 (BTU/FT ² -SEC)	
1	1	2	539.3	11.844	2.751	1.653E-03	2.3030	
2	1	3	535.1	7.758	1.471	1.076E-03	1.5520	
3	1	4	529.6	4.697	0.887	6.468E-04	0.9327	
4	1	5	528.0	1.206	0.228	1.657E-04	0.2390	
5	1	6	535.6	3.399	0.445	4.720E-04	0.6806	
6	1	1	536.4	6.726	1.276	9.348E-04	1.3479	
7	2	2	534.7	8.765	1.661	1.715E-03	1.7525	
8	2	3	532.3	6.642	1.757	9.180E-04	1.3238	
9	2	4	528.2	4.483	0.846	6.162E-04	0.8886	
10	2	5	525.8	1.092	0.266	1.496E-04	0.2157	
11	2	6	540.4	9.266	1.743	1.295E-03	1.6671	
12	2	1	534.4	6.956	1.318	9.642E-04	1.3904	
13	3	2	536.9	7.232	1.373	1.006E-03	1.4506	
14	3	3	534.7	6.901	1.308	9.570E-04	1.3800	
15	3	4	529.8	3.716	0.702	5.119E-04	0.3381	
16	3	5	530.1	2.144	0.405	2.954E-04	0.4260	
17	3	6	543.2	6.787	1.293	9.519E-04	1.3726	
18	3	1	535.6	5.814	1.103	8.072E-04	1.1640	
19	4	2	536.4	6.535	1.240	9.082E-04	1.3097	
20	4	3	535.0	6.383	1.210	8.854E-04	1.2768	
21	4	4	531.1	3.099	0.586	4.276E-04	0.6166	
22	4	5	533.7	3.538	0.670	4.900E-04	0.7066	
23	4	6	542.4	6.176	1.167	8.583E-04	1.2376	
24	4	1	536.5	5.310	1.008	7.381E-04	1.0644	
25	5	2	540.4	6.471	1.231	9.042E-04	1.3038	
26	5	3	538.3	5.739	1.050	7.996E-04	1.1530	
27	5	4	535.0	3.586	0.680	4.975E-04	0.7175	
28	5	5	536.9	3.516	0.667	4.890E-04	0.7051	
29	5	6	547.4	9.831	1.878	1.386E-03	1.9993	
30	5	1	537.6	4.923	0.935	6.853E-04	0.9882	

a. Calibration
SAMPLE 5. Entry 5 Data

ARD, INC. - AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
VON KARMAN GAS DYNAMICS FACILITY
ARMOLD AIR FORCE STATION, TENNESSEE

DATE COMPUTED 20-MAY-80
TIME COMPUTED 20150108
DATE RECORDED 16-MAY-80
TIME RECORDED 01 342
PROJECT NUMBER V41C-A8

TC	RDW	CONFIG	M	PT (PSIA)	TT (DEG R)	ALPI (DEG)	WA (DEG)	PHII (DEG)	TIMECL (HOUR MIN SEC MSEC)	TIMEINJ (SEC)	CR (IN)
31	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
32	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
33	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
34	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
35	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
36	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
37	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
38	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
39	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
40	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
41	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
42	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
43	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
44	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
45	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
46	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
47	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
48	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
49	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
50	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
51	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
52	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
53	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
54	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
55	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
56	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
57	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
58	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
59	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000
60	6	1	10.10	1756.55	1901.67	1.95	10.05	0.00	0 0 1 987	2.98	21.000

a. Calibration concluded
SAMPLE 5. continued

ARO, INC. - AEDC DIVISION
A SVERDRUP CORPORATION COMPANY
VON KARMAN GAS DYNAMICS FACILITY
ARMOLO AIR FORCE STATION, TENNESSEE
NASA/AMA SPACE SHUTTLE MATL. TEST

DATE COMPUTED 16-MAY-80
TIME COMPUTED 04:30:56
DATE RECORDED 16-MAY-80
TIME RECORDED 4:30:40
PROJECT NUMBER V41C-AB
PAGE 1

50 INCH HYPERSONIC TUNNEL C

PUN	SAMPLE	CTC15- 2	T	P	Q	V	W	RHO	MU	RE	ITT	TIMEINJ	ALPPB	CR	WA	TIMEEXPT
515			93.5	0.038	2.703	4786.1	1.093E-03	7.524E-08	2.162E+06	4.779E+02	2.490	4	30	52	828	53.12

WEDGE ATTITUDE AND TEMPERATURE HISTORY

TIMEEXP	WA	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6
-0.7	0.00	87.0	80.0	80.0	86.0	80.0	80.0
1.8	16.07	87.0	80.0	80.0	86.0	80.0	80.0
		GRID LINE PICTURE TAKEN AT 3.3 SECONDS.					
3.4	16.00	87.0	81.0	81.0	86.0	80.0	80.0
4.0	16.00	87.0	81.0	81.0	86.0	81.0	80.0
		SHADOWGRAPH TAKEN AT 4.0 SECONDS.					
5.6	16.00	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 7.2 SECONDS.					
7.8	16.00	87.0	80.0	81.0	86.0	80.0	81.0
9.8	16.00	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 11.2 SECONDS.					
11.8	16.00	87.0	80.0	81.0	86.0	81.0	80.0
13.4	16.00	87.0	80.0	81.0	86.0	80.0	81.0
14.3	16.00	87.0	80.0	81.0	86.0	81.0	81.0
		SHADOWGRAPH TAKEN AT 14.4 SECONDS.					
15.8	16.00	87.0	80.0	81.0	86.0	81.0	81.0
17.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 15.2 SECONDS.					
19.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
21.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 19.2 SECONDS.					
23.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
24.6	15.99	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 23.2 SECONDS.					
25.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
		SHADOWGRAPH TAKEN AT 24.7 SECONDS.					
27.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
28.8	15.99	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 27.2 SECONDS.					
31.8	16.00	87.0	80.0	81.0	86.0	81.0	81.0
33.8	16.00	87.0	80.0	81.0	86.0	81.0	81.0
34.9	16.00	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 31.2 SECONDS.					
35.0	16.00	87.0	80.0	81.0	86.0	81.0	81.0
		SHADOWGRAPH TAKEN AT 35.0 SECONDS.					
35.8	16.00	87.0	80.0	81.0	86.0	81.0	81.0
37.8	16.00	87.0	80.0	81.0	86.0	81.0	81.0
		GRID LINE PICTURE TAKEN AT 35.1 SECONDS.					

b. Materials
Sample 5. Continued

AMU, INC. - AEDC DIVISION
 A SVERDRUP CORPORATION COMPANY
 VOR KAMMAR GAS DYNAMICS FACILITY
 ARNOLD AIR FORCE STATION, TENNESSEE
 NASA/AMA SPACE SHUTTLE MATL. TEST

DATE COMPUTED 16-MAY-80
 TIME COMPUTED 04:30:55
 DATE RECORDED 16-MAY-80
 TIME RECORDED 4:30:40
 PROJECT NUMBER V41C-A8
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50 INCH HYPERSONIC TUNNEL C

MIN	SAMPLE	TIMEEXP	WA	CR	ALPI	ALPPB	TT	PT	M	RE	ITT	TIMEINJ	TIMECL	TIMEEXPT
515	CTC15- 2				-4.07	12.00	1098.7	1750.5	10.10	2.162E+06	4.779E+02	2.490	4 30 52 428	51.12
93.5	P 0.038	2.703	4786.1											

WEDGE ATTITUDE AND TEMPERATURE HISTORY

TIMEEXP	WA	GRID LINE PICTURE	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6
39.8	16.00	87.0	80.0	82.0	86.0	81.0	81.0	81.0
41.8	16.00	87.0	80.0	82.0	86.0	81.0	81.0	81.0
43.8	16.00	87.0	81.0	82.0	87.0	82.0	82.0	82.0
45.2	16.00	87.0	81.0	82.0	87.0	82.0	82.0	82.0
45.8	16.00	87.0	81.0	82.0	87.0	82.0	82.0	82.0
47.8	16.00	88.0	81.0	82.0	87.0	82.0	82.0	82.0
49.8	16.11	88.0	81.0	82.0	87.0	82.0	82.0	82.0

b. Materials concluded
 Sample 5. Concluded