CR-170891

TECHNICAL NOTE

Lockheed
Missiles & Space Company, Inc.
Huntsville Research & Engineering Center

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Title RESULTS OF TESTS OF MTA-2 TPS ON THE SRB HOLD-DOWN BOLT BLAST CONTAINER

BACKGROUND

The SRB sits on the MLP before launch on four hold-down posts. These four hold-down posts are fastened to the MLP with four large nuts. At liftoff these nuts are split with explosive charges to release the SRB/Shuttle. A "blast container" is placed over these nuts to protect the vehicle from flying debris. This blast container is a reusable part and has to be protected from aerodynamic heating during flight. Presently, the TPS used to protect these blast containers is cork. Fitting the flat cork sheet to this hemispherical shaped blast container is both time consuming and expensive. Another problem is removing the charred cork and epoxy glue from the blast containers. It is therefore desirable to replace this cork with another TPS material such as MTA-2.

OBJECTIVE

The purpose of the tests presented herein is to demonstrate the feasibility of using 1/2 in. MTA-2 on the SRB blast containers for protection from ascent, plume impingement and reentry heating.

TEST DESCRIPTION

Calibration Runs: A calibration model was fabricated and run in position 1 of the NASA-MSFC Hot Gas Facility (HGF).

The purpose of this model/test was to determine the heating rates along the centerline of the forward facing area of the blast container. The model was fabricated using an existing, "spare" blast container obtained from NASA.

(NASA-CR-170891) RESULTS OF TESTS OF MTA-2 TPS ON THE SRB HOLD-DOWN BOLT BLAST CONTAINER (Lockheed Missiles and Space Co.) 13 p HC A02/MF A01 CSCL 21H
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The model is roughly a hemisphere with about 10 in. diameter and approximately 7 in. high. A "thin skin" strip of 304 stainless steel was instrumented with 10 thermocouples and fastened to the outside surface of the model. Two 1/8 in thick, 3/4-in. wide, cork strips were placed under this stainless steel strip with about a 1/2-in. gap between them to form an air cavity behind the thermocouples. Figure 1 is a photo of this completed model. Sketch 1 shows the approximate locations of these thermocouple locations. The hemisphere model was recessed into the HGF "floor" by about 3/4 in. to help prevent chocking of the flow.

This model was run for two 5 sec runs in position 1 of the HGF. Results in the form of heating rates at each TC location are shown in Table 1. The maximum heating rate of approximately 80 Btu/ft^2-sec occurred at location 2. Table 1 also presents the run conditions and thin skin material properties used to reduce the data. The data were reduced using the standard thin skin, temperature-time slope method.

Data from the second run were not used because the cork strips charred and allowed flow under the thin skin stainless steel strip.

<u>TPS Test</u>: After these cal tests, the model was refurbished and covered with a nominal 1/2-in. thickness of MTA-2. The basic hemisphere was first sandblasted and then primed and painted before trowelling the MTA-2 in place. The MTA-2 was then cured overnight in an oven. (This TPS was applied in-house at the MSFC Materials Lab.) A photo of this finished model is shown in Fig. 2. Five thermocouples were used to monitor the inside surface temperature of the blast container during the test, the locations of which are shown in sketch 2. A maximum allowble temperature of 400 F on any TC was selected for cutoff purposes.

The run time for this TPS model was selected as follows. The plume impingement heat load of 278 Btu/ft^2 was obtained from Northrop document No. M-9230-76-60 from W. Youngblood to D. Seymour, for an X location of 1870 in., and a θ = 30 deg. The combined ascent and reentry heat load of 512 Btu/ft^2 was obtained from the October 1980, Design Environment for Body Point 2186 for ascent and 7037 for reentry. This gave a total heat load of 790 Btu/ft^2. An over-test factor of 40% was used to give a total heat load required of 1106 Btu/ft^2. With a peak heating rate of 79.6 Btu/ft^{2}sec the required test time would be 13.9 sec.

This TPS model was run on 4 June 1982 (Run 1166) in position 1 of the HGF. The test ran for 13.4 sec at which time it was terminated when TC 1 exceeded 400 F. Figure 3 shows the post-test photo of this model. Results of this test are shown in terms of pretest and post-test thicknesses, recession and recession rates at each location in Table 2. Since the model surface is curved, two measurements were made at each location - one perpendicular to the centerline and one parallel to the centerline. The TPS burned through at two locations (3 and 4). These were in the area where the flow probably re-attached to the model and were therefore not typical of the flight environments on the blast container. The first two points (1 and 2) were probably in a separated flow region - again probably not typical of the flight environments. It was therefore decided to exclude these four points from the analysis.

Figure 4 shows a plot of recession rate versus heating rate from this test. A straight line was put through these data by "eyeball" - not by the least squares method. The equation of this line was found to be $R = 0.33\ q^{1.154}$. This equation was input to the Lockheed ablation program using standard MTA-2 thermal properties from previous analyses. An analysis was performed for a point on the vehicle near the "hottest" thrust post/blast container location. The October 1980 Design Environments were applied for ascent body point 679, and reentry body point 7412. (The equivalent body point for reentry is 7105). These points are at 30 deg from the +Z toward the +Y axis on the left hand SRB, as seen on Fig. 5. Plume heating was applied from a point at X = 1870 in. 0 = 30 deg from Northrop document No. M-9230-76-60 from W. Youngblood to D. Seymour. The total heat loads from these points added up to 804 Btu/ft^2 as compared to the 790 Btu/ft^2 originally planned for the HGF test model.

The computer program calculated temperature and recession for these conditions, using a 1/2 in. thickness of MTA-2. At the end of the trajectory (410 sec), the MTA-2 had receded 0.28 in. and the maximum temperature on the blast container was 157 F. Therefore this 1/2 in. thickness gives a 1.78 overdesign margin.

CONCLUSIONS

As a result of these tests and analyses it is concluded that the 0.5 in. MTA-2 is adequate for the blast container on the SRB flight vehicle.

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Contract NAS8-32982

Approved:

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Attach: (1) Tables 1 and 2
(2) Figs. 1 through 5

Table 1
CALIBRATION TEST RESULTS
(Run #1160)

TC	S, Approx. Dist. Along Surface from Base of Model (In.)	Cold Wall Heating Rate (Btu/ft^2-sec)
1	1.0	78.2
2	2.0	79.6
3	3.0	61.4
4	4.0	38.7
5	5.0	37.7
6	6.0	24.0
7	7.0	Bad
8	8.0	11.6
9	9.0	21.9
10	10.0	Bad

Notes:

1. Thin-skin wall thickness = .0295 in.
2. Thin-skin wall material = 304 stainless steel
3. Thin-skin wall properties $[\rho\, C_p\, t] = .126$
4. Run conditions: $P_c = 138$ psia, $T_c = 1600$ F,
   $P_{air} = 1350$ psig, $P_{GH_z} = 900$ psig

Table 2

RECESSION RESULTS FROM MTA-2 ON BLAST CONTAINER (Run #1166)

S, Distance Along Surface from Base (in.)	Pretest Thick.		Post-Test Thick.		Recession		Ave Rec. (in.)	Ave Recess Rate (mil/sec)	Cold Wall Heating Rate (Btu/ft^2-sec)
	Note 1 (in.)	Note 2 (in.)	Note 1 (in.)	Note 2 (in.)	Note 1 (in.)	Note 2 (in.)			
1	.545	.545	.210	.212	.335	.333	.334	24.9	78.25
2	.575	.545	.124	.120	.451	.425	.438	32.7	79.58
3	.410	.420	0	0	.410	.420	.415	*	61.40
4	.412	.412	0	0	.412	.412	.412	*	38.60
5	.412	.420	.041	.050	.370	.370	.371	27.7	37.70
6	.490	.495	.318	.312	.172	.183	.177	13.2	24.00
7	.594	.589	.520	.522	.074	.069	.072	5.4	Bad
8	.612	.610	.534	.536	.078	.074	.076	5.7	11.60
9	.555	.525	.448	.445	.107	.118	.113	8.4	21.86
10	.510	.525	.395	.389	.115	.136	.125	9.4	Bad

Notes:

1. Measurement made with probe along centerline.
2. Measurement made with probe perpendicular to centerline.

* TPS burned at these locations.

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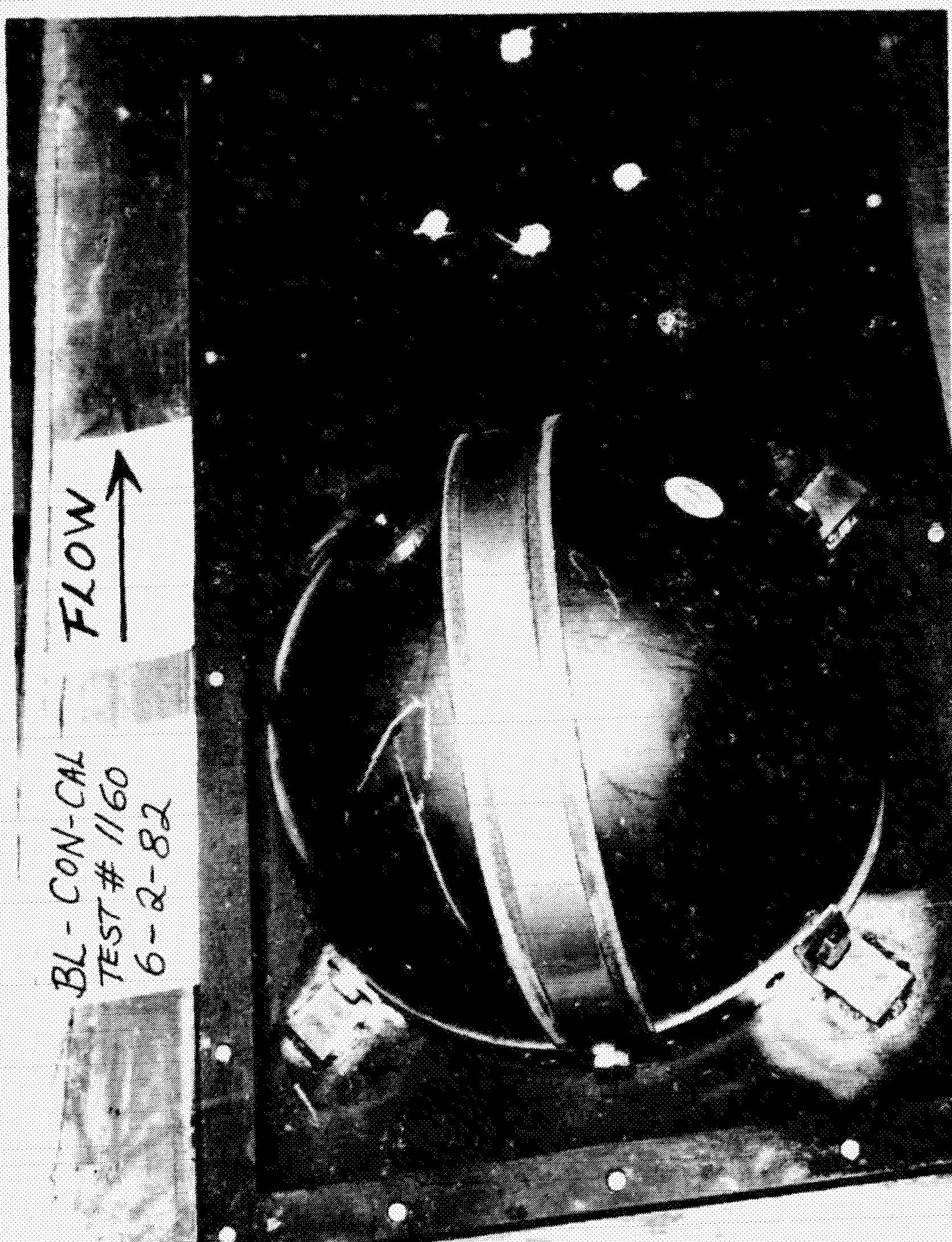


Fig. 1 - Pretest Photo of Blast Container Cal Model

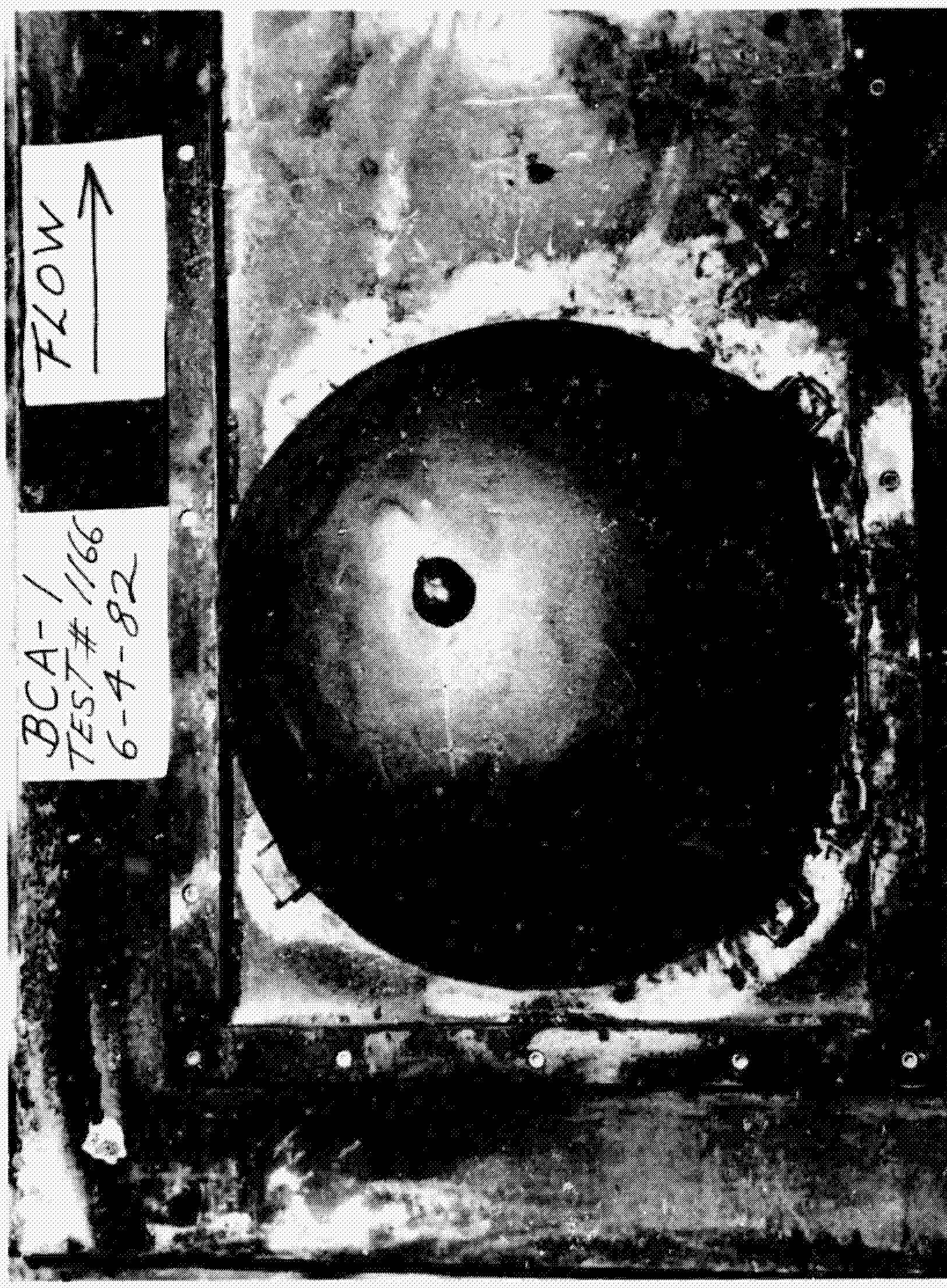


Fig. 2 - Pretest Photo of Blast Container TPS Model With 1/2 in. MTA-2

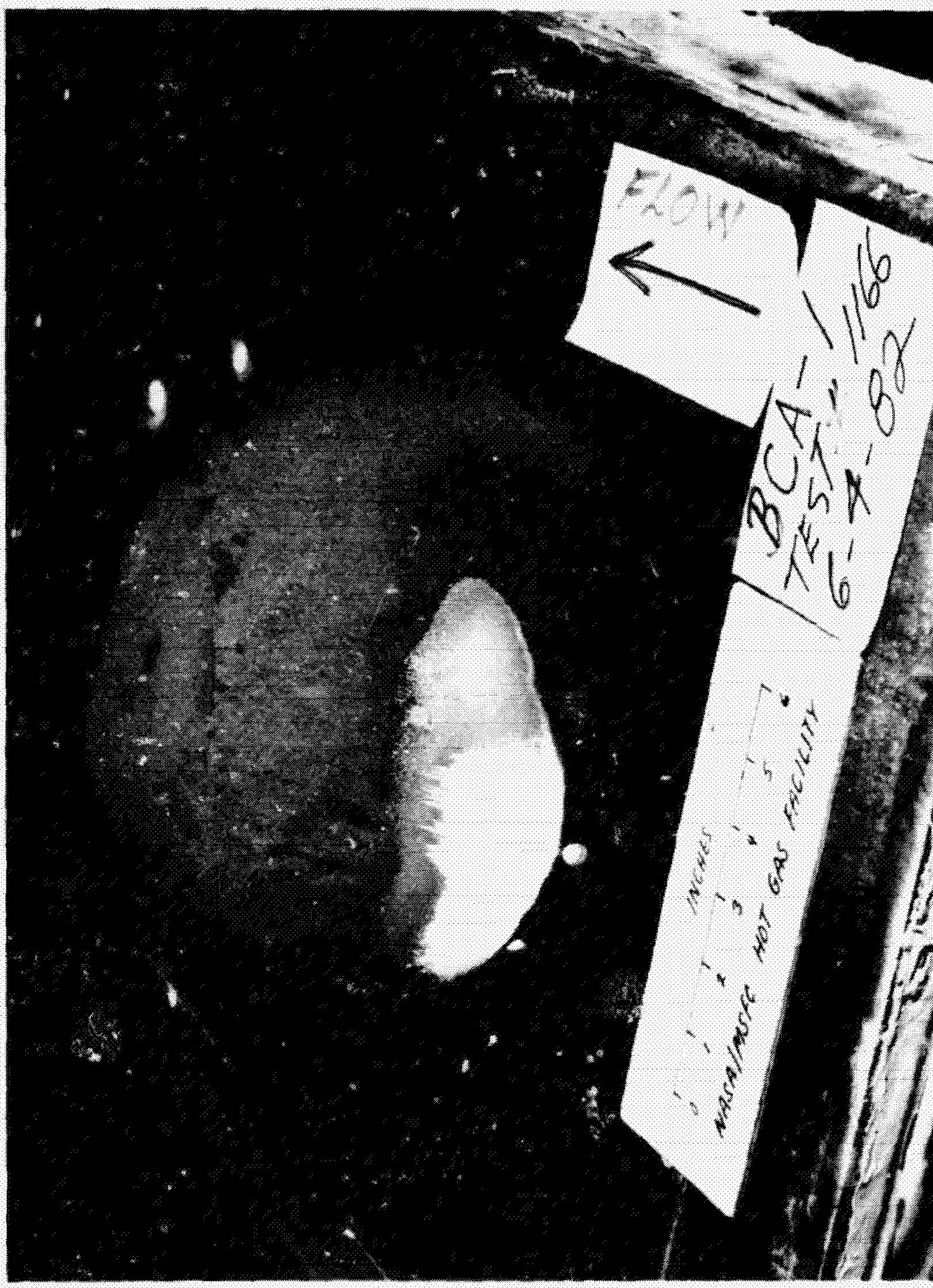


Fig. 3 - Post-Test Photo of Blast Container TPS Model

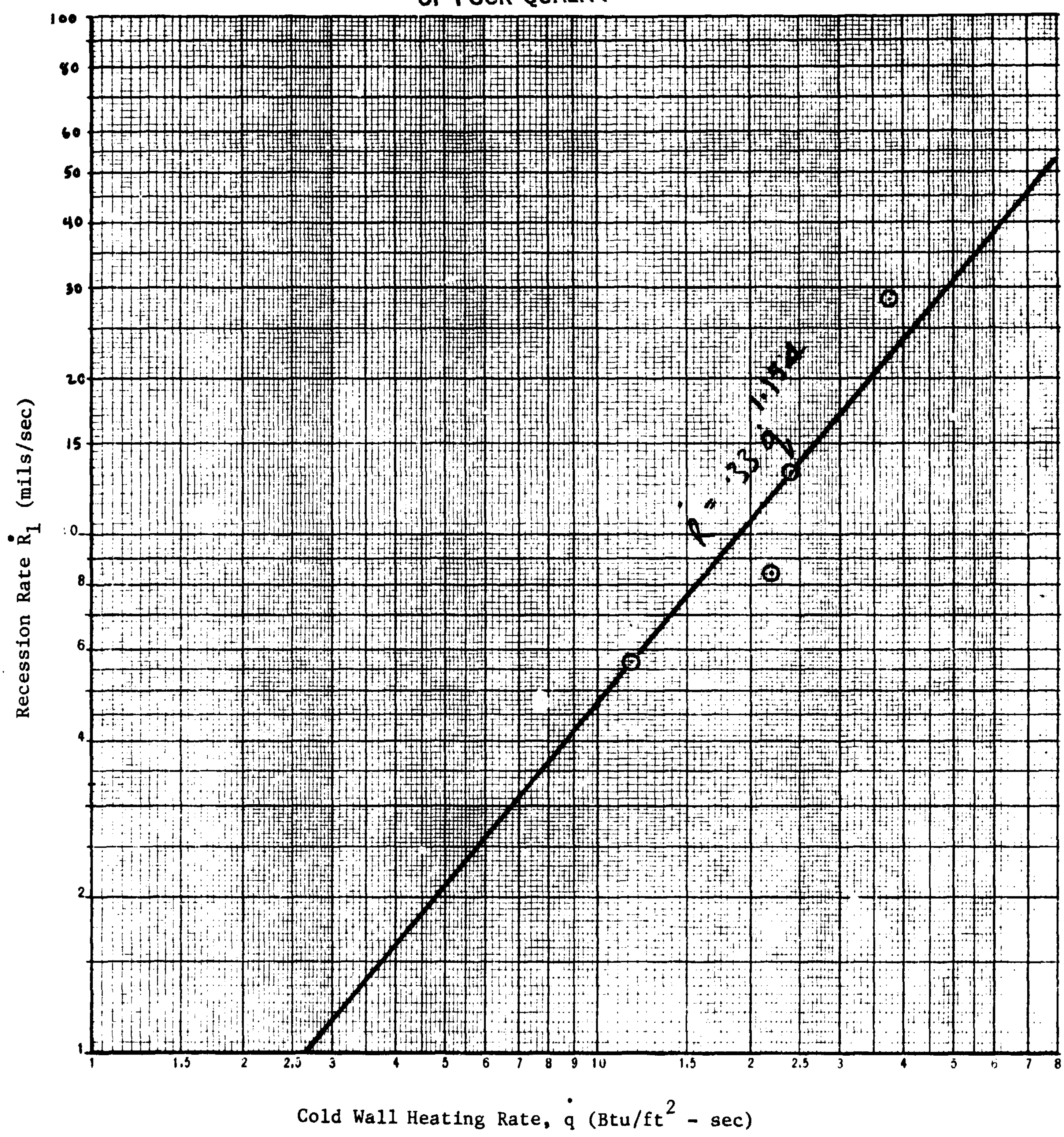


Fig. 4 - Recession Rate vs Heating Rate for MTA-2 on Blast Container

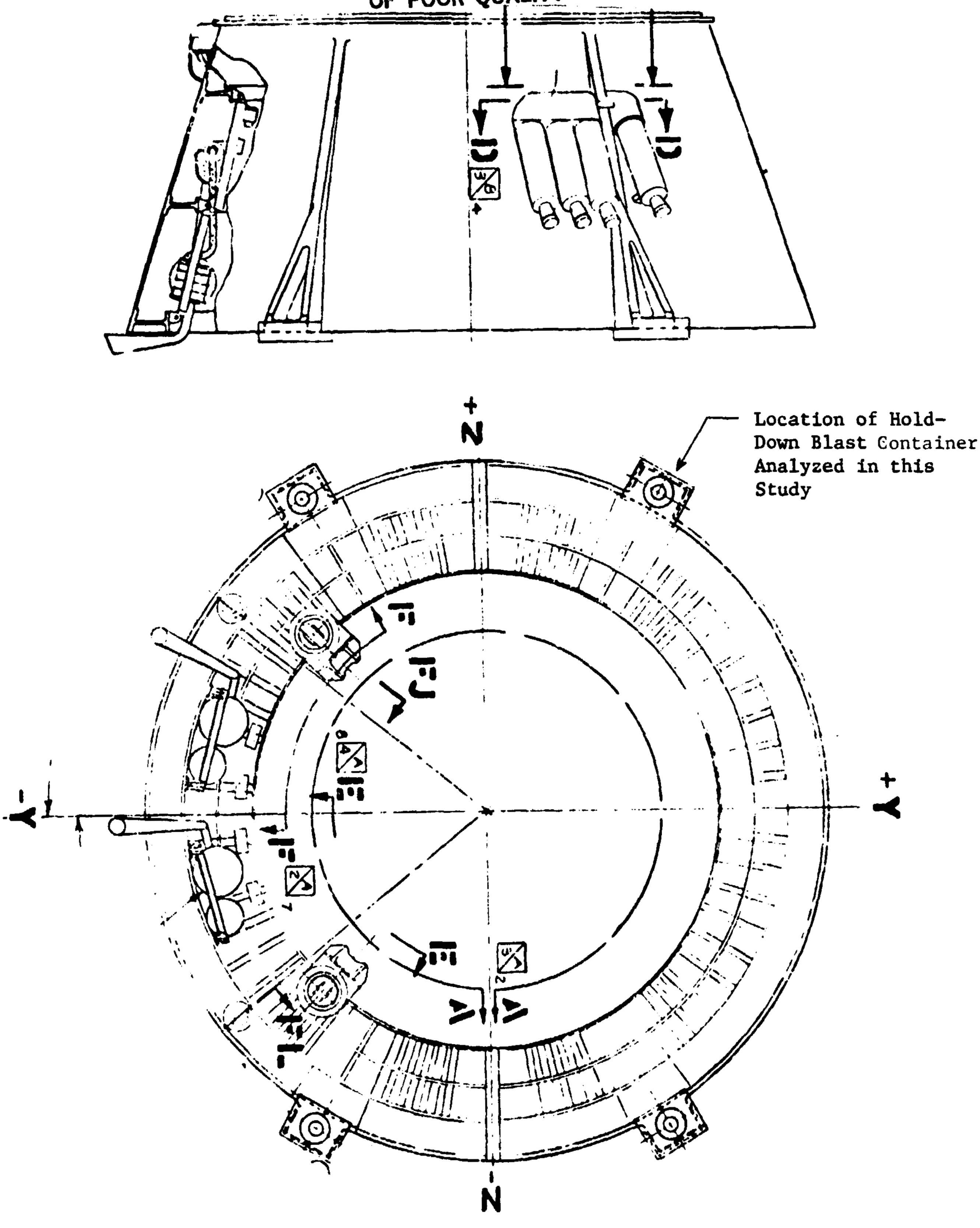
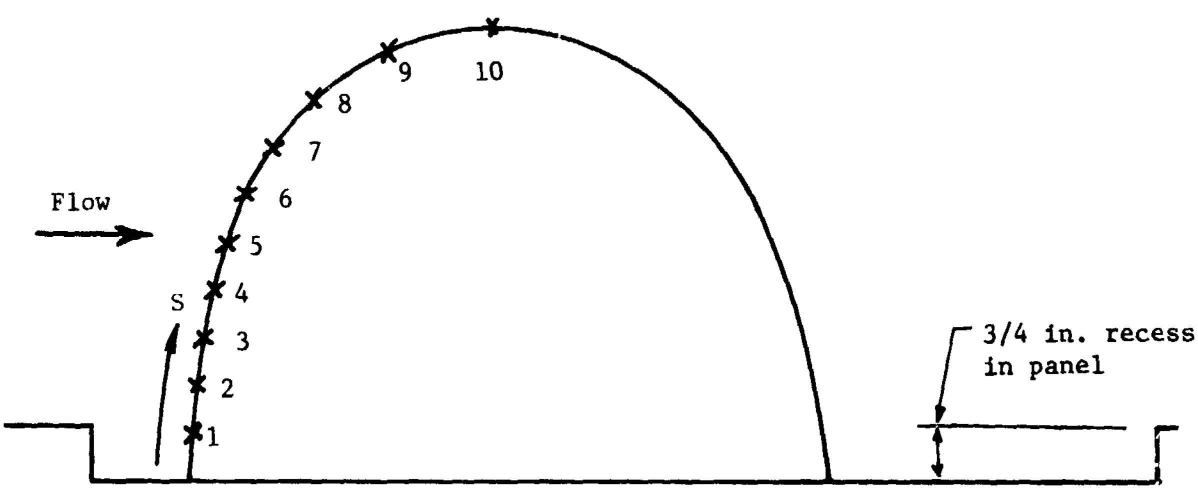


Fig. 5 - Left-Hand SRB Aft Skirt

(Not to scale)

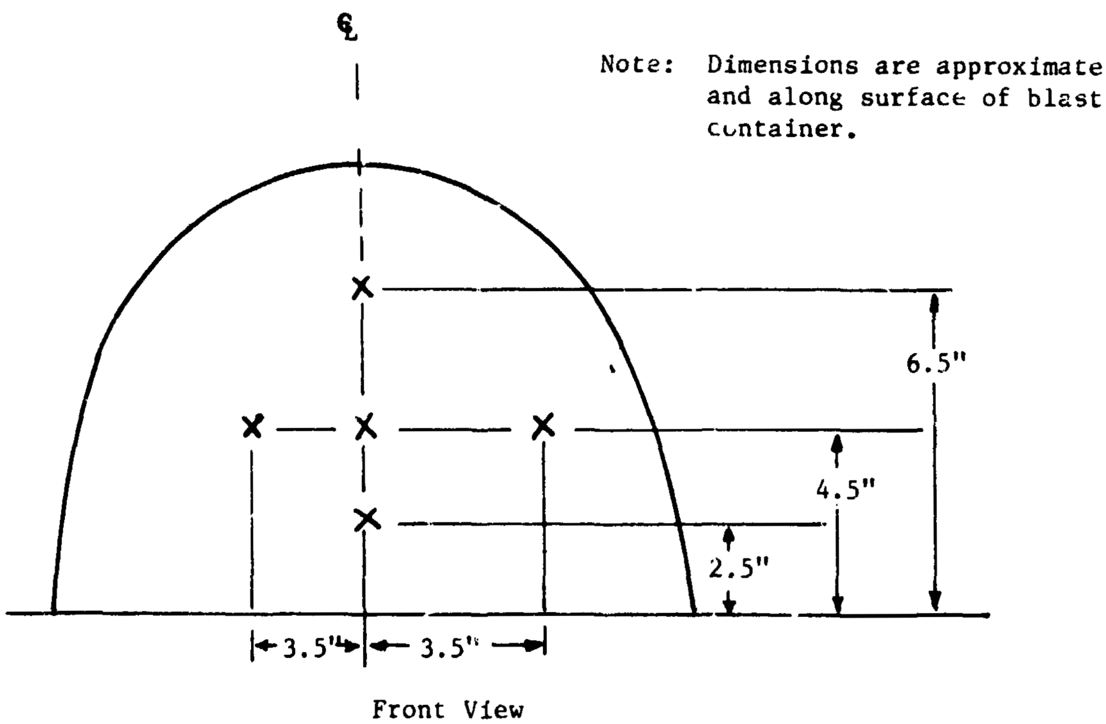


Side View

TC Number and Measurement No.	S, Approx. Distance Along Surface (in.)
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10

Sketch 1 - Approximate Thermocouple Location and Thickness Measurement Locations on Calibration Model BL-CONT-CAL, Run No. 1160

(Not to Scale)



Sketch 2 - Thermocouple Locations on TPS Model – BCA-1