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TECHNICAL NOTE

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Title SRB TPS CLOSEOUT MATERIALS CHARACTERIZATION

FOREWORD

This report documents the recession characteristics of the materials used to closeout the Thermal Protection System (TPS) on the Space Shuttle Solid Rocket Booster (SRB). The work was performed under Contract NAS8-32982, "Solid Rocket Booster Thermal Protection System Material Development." The NASA-MSFC Contracting Officer's Representative for this work is Mr. Bill Baker, EP44.

INTRODUCTION

An approach similar to the one used to characterize the main TPS on the SRB was taken to evaluate the recession rate characteristic for two candidate closeout materials namely, K5NA and MTA2. K5NA is moldable, trowelable cork particles filled with epoxy and MTA2 is the Marshall Trowelable Ablator. Test panels of each of these two materials were subjected to aerodynamic heat and shear in the NASA Hot Gas Facility. Pretest and Post-test measurements were taken and the rate of recession ($\dot{R}$) thus determined was correlated with the heating rate. A least squares curve fit of the data, together with another least squares 95% confidence level fit, was performed. The characteristics of the two materials when compared showed that both materials performed equally well at the higher heating rates ($10 < \dot{q} < 30$ Btu/ft^2-sec) but MTA2 was slightly better, not receding as fast, at the lower $\dot{q}$ values. The comparison of the $\dot{R}$ versus $\dot{q}$ curves for K5NA and MTA2 with that of primary TPS P-50 cork on the SRB Aft Skirt was good.

TECHNICAL DISCUSSION

The performance of the K5NA and MTA2 closeout materials was evaluated at a wide range of heating rates (4.3 to 33.4 Btu/ft^2-sec) and aerodynamic shear (0.5 to 5.5 psf). The heating rate and shear conditions were obtained in the long test section of the NASA Hot Gas Facility (Ref. 1). Three panels were made up for each closeout material. The panels consisted of P-50 sheet cork on 1/8 in. thick Al 22 1/4 x 28 1/2 in. standard Hot Gas Facility (HGF) panel with three 2 in. wide grooves in the sheet cork running axially down the panel. The cork thicknesses on the set of three panels were 1/4, 3/8 and 1/2 in., respectively, and the closeout materials were troweled in the grooves flush with the top surface of the cork. A sketch showing the general layout of the test panel is shown in Fig. 1.

Pretest thickness measurement of the closeout materials was made at four locations in each groove as shown in Fig. 2. The three K5NA closeout panels were mounted in HGF panel mounting adapters and loaded inside the test section with 1/4, 3/8 and 1/2 in. panels in Position 1, 2 and 3, respectively. The test duration was 60 sec. The test was repeated for the three MTA2 panels.

Post-Test thickness measurements were made on the closeout materials with the char as is and then with the char scraped off to reveal the virgin material.

RESULTS

An average rate of recession was determined from the run time for the closeout materials at each of the measurement point locations and plotted against the respective heating rate. This is shown by the data points in Fig. 3 and 4 for the two materials. A linear, mean least squares fit of the data was then performed and is shown in the figures by a straight line through the field of data points. Another line, known as the "95% confidence level" line (See Ref. 2), to be used as a "design" curve in analytical models or for comparisons

with "design" curves of other materials, was also determined and is shown in Figs. 3 and 4.

CONCLUSIONS

Both the closeout materials performed very well. The K5NA unlike the MTA2 did not form a char layer that was separate or detached from the material. Both materials adhered very well to the aluminum substrate and the adjacent cork TPS. There was no sign of any debond. Also both protected the aluminum substrate from the heat as the thermocouples on the back of the panel under a strip of the closeout material did not register a temperature rise of more than 10 deg.

A comparison of the mean least squares fit curves for the two materials is shown in Fig. 5. Both materials compare favorably except the slope of the curve for MTA2 shows that it does not recede as fast as the K5NA at the lower heating rates. Also the difference in the performance, as far as recession rate is concerned, between the K5NA and MTA2 closeout materials and the main P-50 cork TPS is not appreciable as can be seen by comparing their curves in Fig. 6.

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Attach: (1) References
(2) Figs. 1 through 6

REFERENCES

1. Karu, Z.S., and W.G. Dean, "SRB Materials Test and Evaluation in NASA-MSFC Hot Gas Facility, NASA-Ames 3.5 Foot HWT and AEDC Tunnel C," LMSC-HREC TM D497497, Lockheed Missiles & Space Company, Huntsville, Ala., November 1977.

2. Karu, Z.S., "Space Shuttle SRB B-Stage Cork TPS Test and Evaluation in AEDC Tunnel C," LMSC-HREC TN D697584, Lockheed Missiles & Space Company, Huntsville, Ala., June 1979.

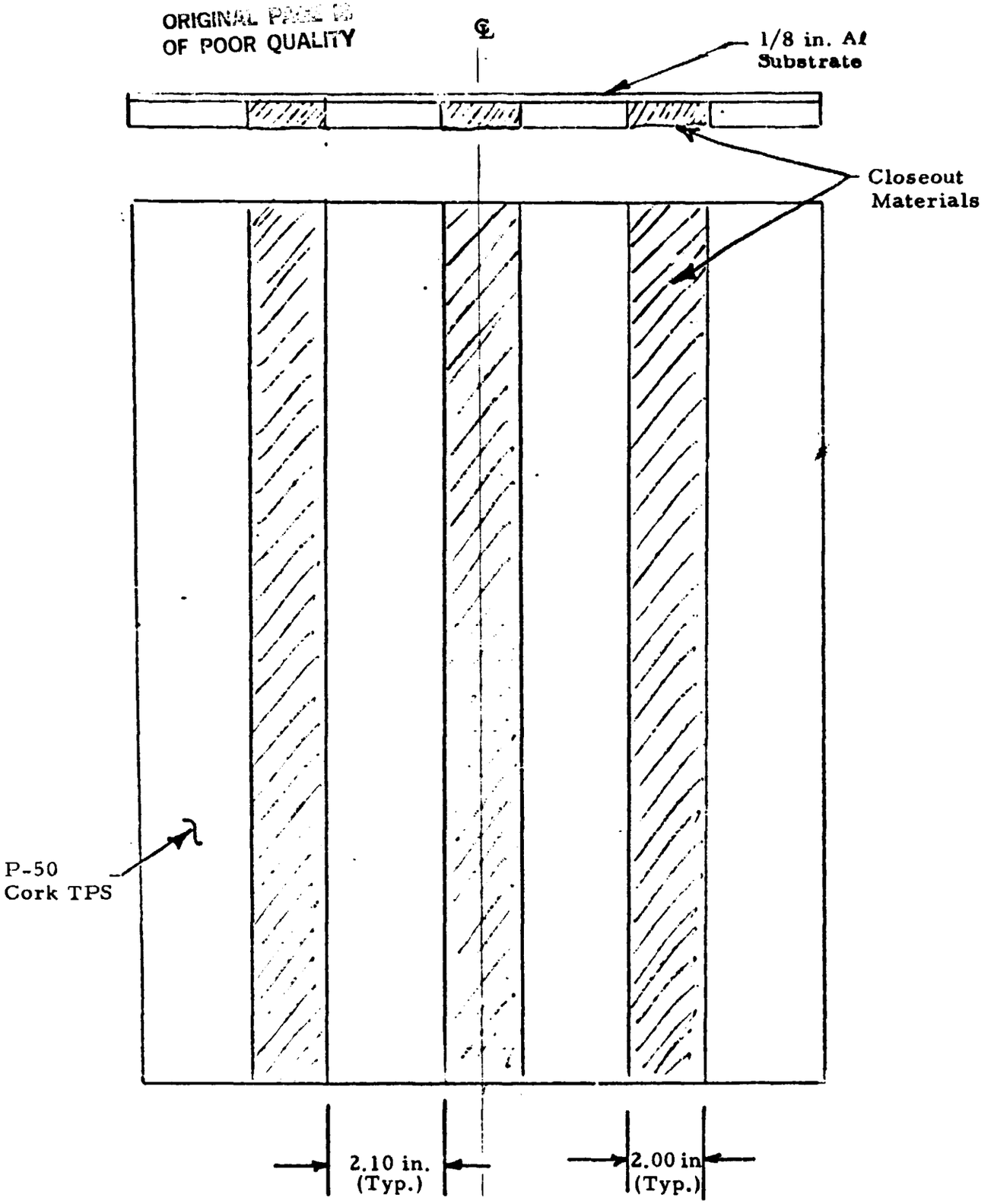

Fig. 1 - Sketch of the Test Panel Showing Position of the Three Strips of Closeout Material

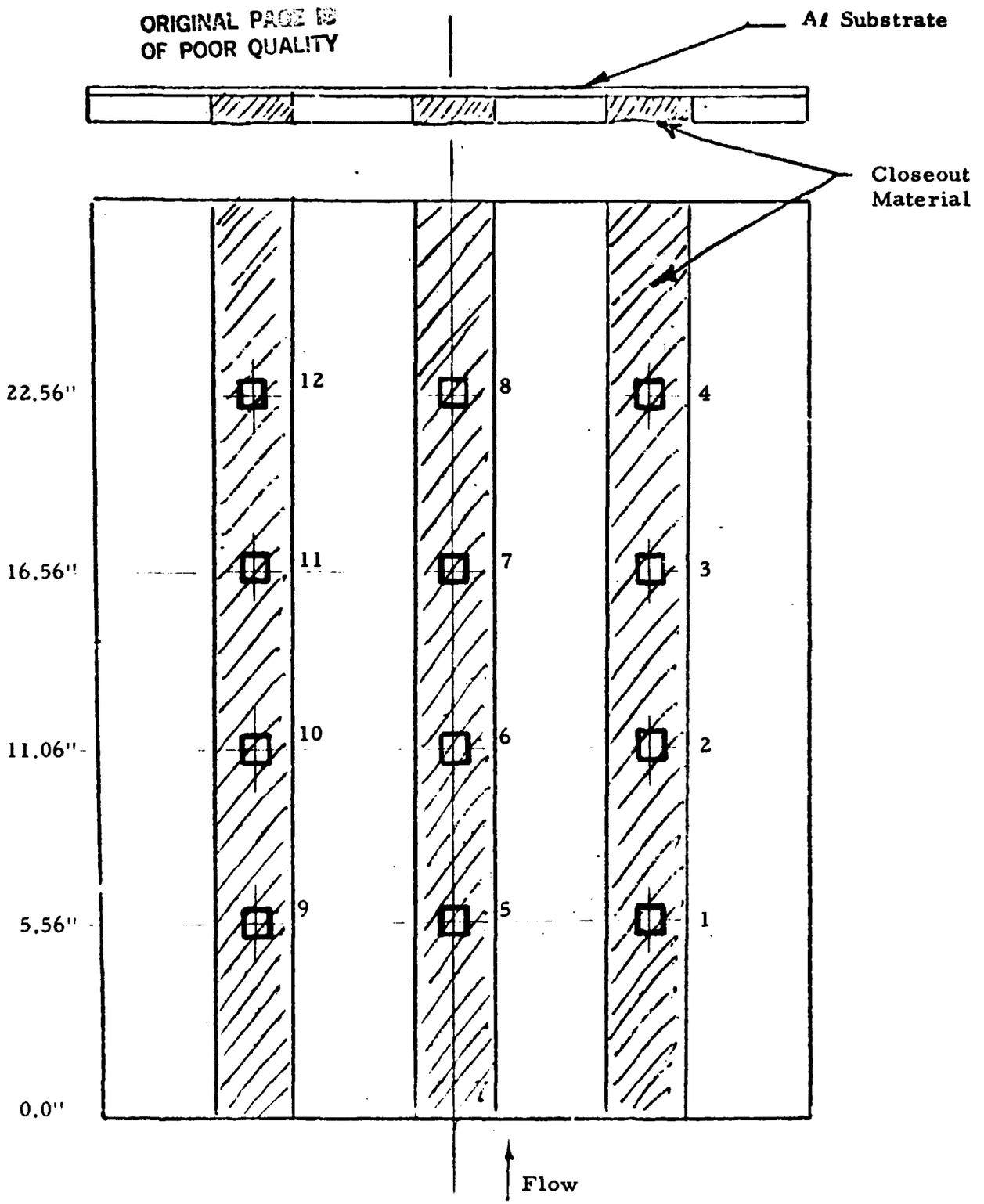

Fig. 2 - Sketch of the Test Panel Showing the Twelve Pretest and Post-Test Measurement Point Locations on the Closeout Material

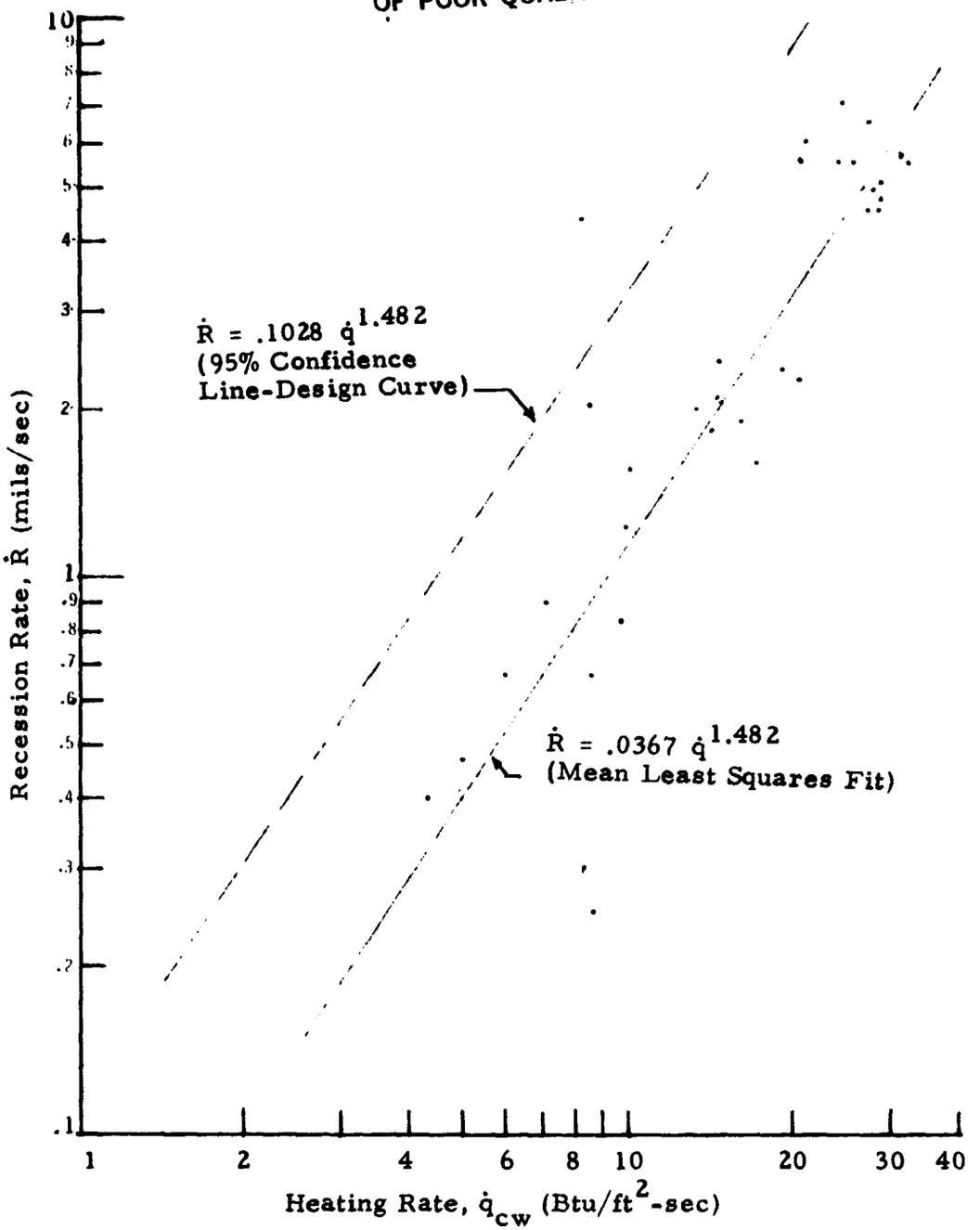

Fig. 3 - Recession Rate vs Heating Rate Data for K5NA Closeout Material with Least Squares Fit (Mean and 95% Confidence) of the Points

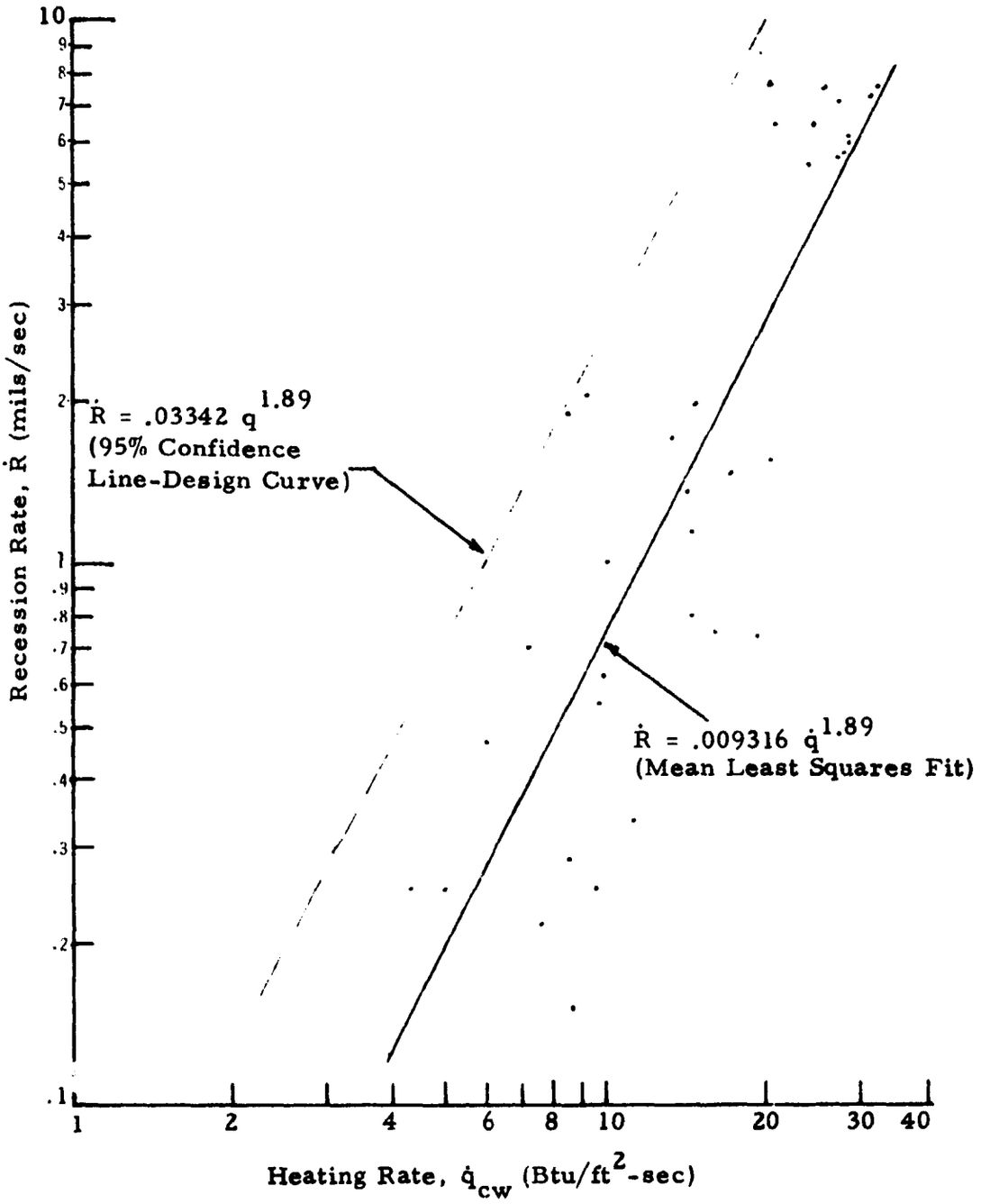

Fig. 4 - Recession Rate vs Heating Rate Data for MTA2 Closeout Material with Least Squares Fit (Mean and 95% Confidence) of the Points

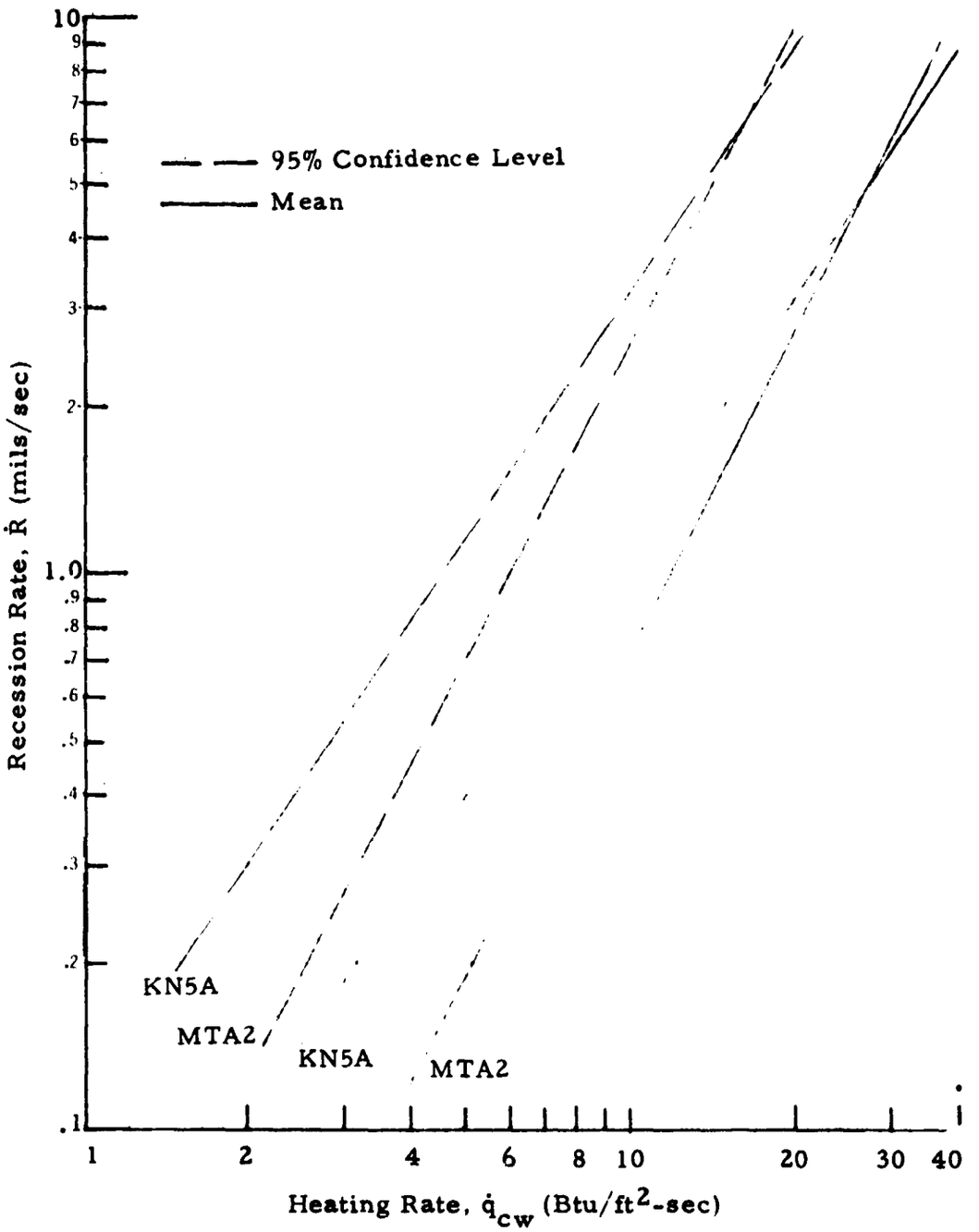

Fig. 5 - Comparison of the Least Squares Fit Curves of the Recession Rate vs Heating Rate Data for the K5NA and MTA2 Closeout Materials

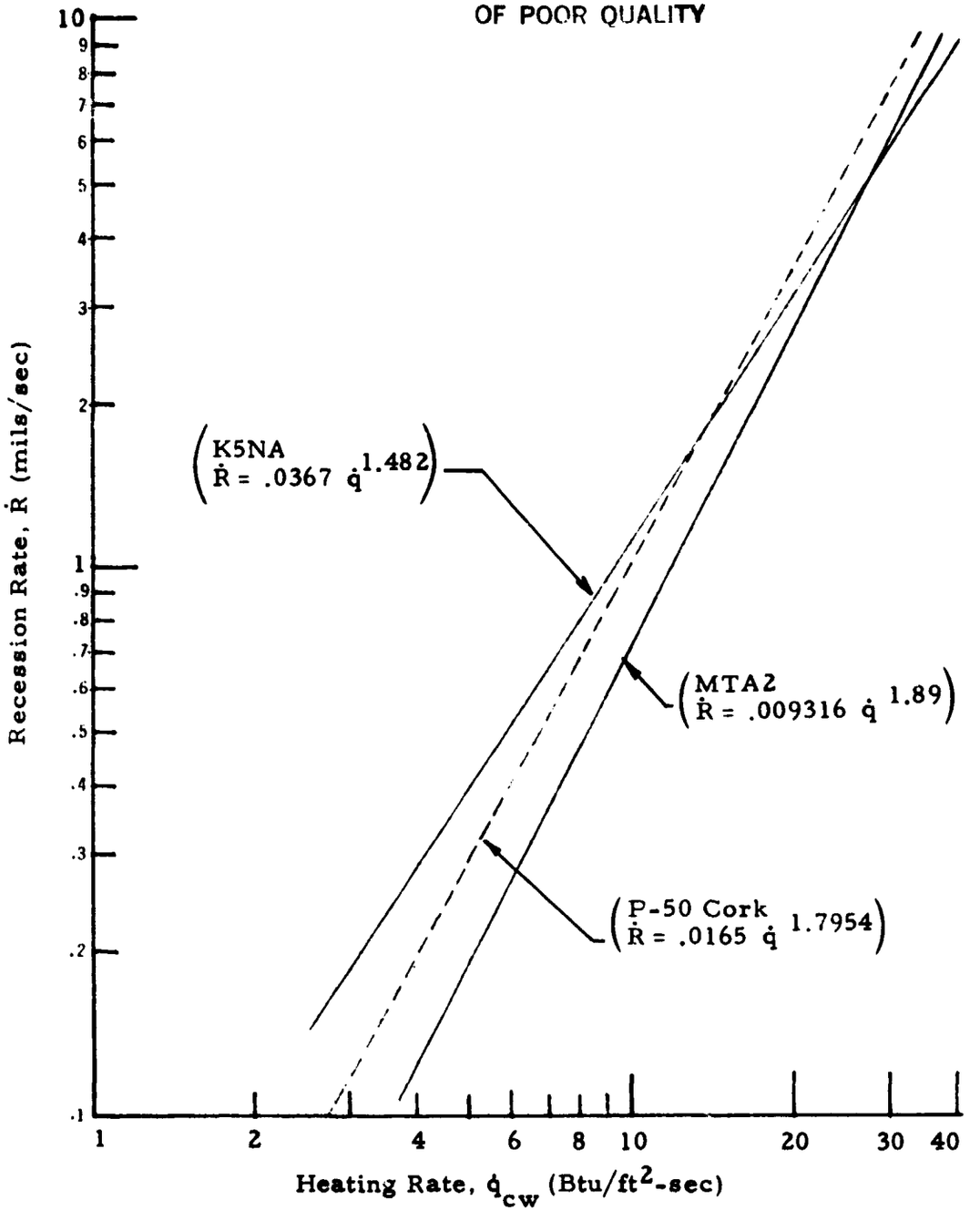

Fig. 6 - Comparison of the Mean Least Squares Fit Curves of $\dot{R}$ Versus $\dot{q}$ Data for K5NA and MTA2 with that for Baselined P-50 Cork TPS on Aft Skirt