Report of

CANTILEVER DIAPHRAGM TESTS FOR StarTherm/StarWall PANELS

by

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INTRODUCTION

A series of cantilever diaphragm tests were conducted at the Fears Structural Engineering Laboratory under the sponsorship of Star Manufacturing Company, Oklahoma City, Oklahoma. Profiles for the test panels are found in Appendix A. The panel is designed for use as a structural wall panel.

The tests were conducted in accordance with Notes on Steel Diaphragms by James M. Fisher dated April 23, 1982. (This document reportedly forms the draft of a forthcoming American Iron and Steel Institute standard for steel diaphragm evaluation). Several exceptions to the recommended procedure were made as noted in the following. The purpose of the tests was to determine the strength and stiffness of the diaphragm shear panel as opposed to a test of the complete system.

TEST DETAILS

Test Setup. The test setup is shown in Figure 1. The setup consists of an exterior reaction frame constructed of built-up H-shaped sections and an interior panel support frame constructed of cold-formed C-sections. All connections in the exterior frame are moment resistant and all connections in the interior frame are pinned. Both frames lie in the same vertical plane and are supported by short sections of H-shaped sections which rest on the laboratory floor.

Loading and Measurement. Load was applied using a 35 kip capacity, dual action, hydraulic ram and electric pump. The load was monitored with a calibrated 10 kip capacity load cell and associated instrumentation. Accuracy of load measurements is estimated to be ±0.02 kips. Horizontal displacement of the load frame at the line of load application and of the upper right corner of the diaphragm (Figure 1) were measured using electronic displacement transducers with an accuracy of ±0.001 in. Two transducers were used at this location, one on each side of the diaphragm. The measured deflections were then averaged to eliminate torsional effects. Vertical displacements at support locations (Figure 1) were also measured with electronic displacement transducers.

Vertical displacement transducers were attached to the centerline of the bottom H member of the reaction frame for Tests ST/SW-1A through E, to the bottom channel near each support for Test ST/SW-2A, and to the lower corners of the panel for Tests ST/SW-2B and 3. The transducers were relocated to the panel corners because of excessive torsional deformation of the hinges at the corners of the interior panel support frame. Horizontal displacements at the pin support were measured by averaging the measurements of two .00375 in. accuracy extensometers. As previously, measurements were averaged to eliminate torsional effects. All readings were recorded and corrections were made to measured horizontal displacements using the procedure outlined in the referenced paper.

The loading procedure consisted of a preload and a final load applied in increments. A preload of approximately 10% of the estimated ultimate load was first applied to remove initial system movement. The diaphragm was then loaded in increments to yield between 10 and 15 data points. The diaphragm was loaded until failure was imminent, as determined from the plotted load deflection curve, whereupon the size of the increment was decreased. Displacement readings were recorded at all increments using a micro-computer based data acquisition system.

Assembly. All tests were conducted using six nominally 3 ft. wide panels. The panels were connected to angles previously bolted to the top and bottom horizontal channels using #12-14 by 1½ in. long self-drilling Teks fasteners with relief threads. Fastener spacing was nominally 12 in. on-center. Fastener installation was started from the male shaped side of the first panel. Sidelaps were fastened using the same fastener spaced nominally at 24 in. on-center. The panels were not attached to vertical side channels. Tests ST/SW-1A - D were conducted without sidelap fasteners.

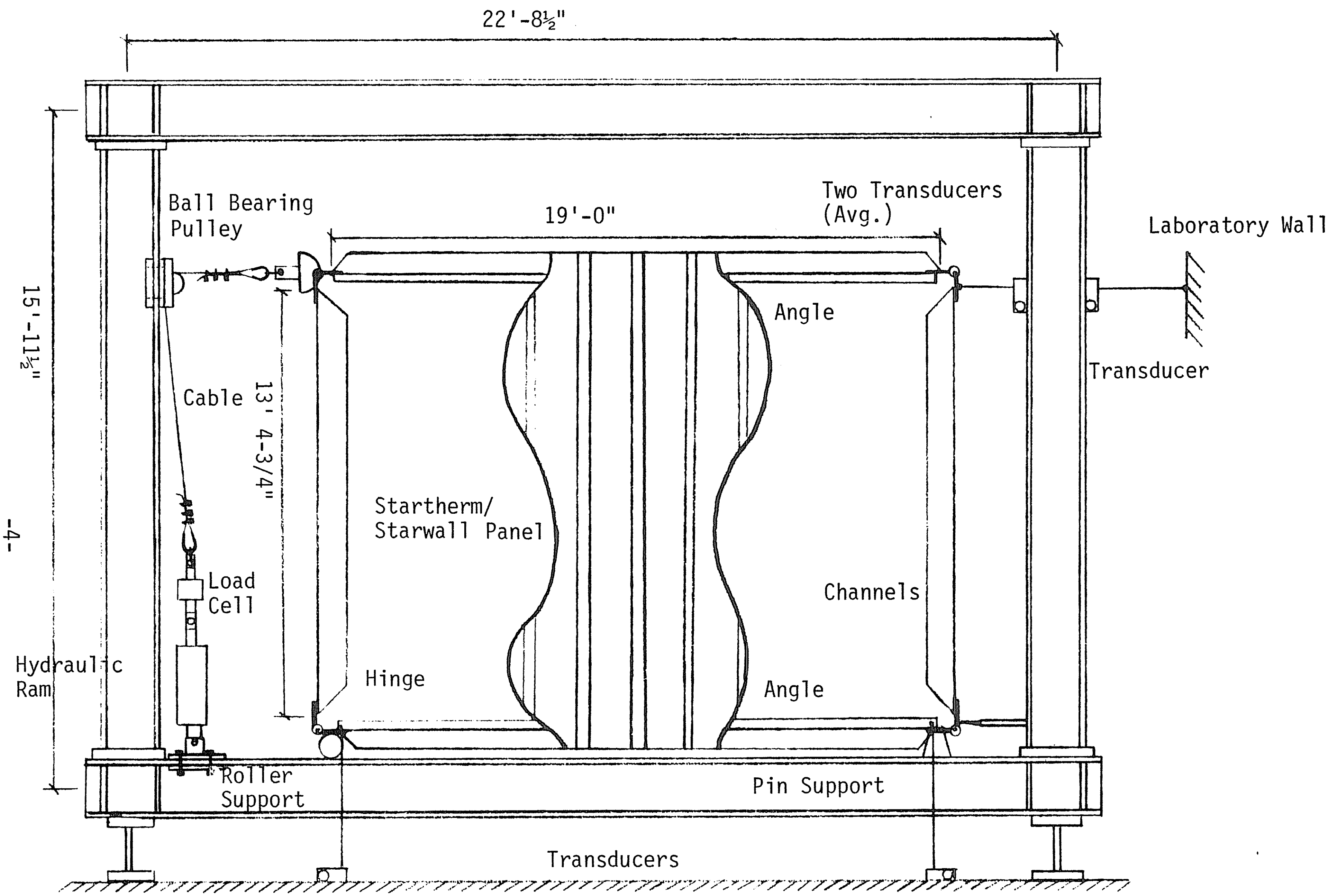

Figure 1. Diaphragm Test Set-up

TEST RESULTS

Results of three 13 ft. 4 3/4 in. high cantilever diaphragm tests are given in Table 1. The average shear strength is 294.4 lb/ft. The average shear stiffness is 1979 lb/in.

Load-deflection plots for all tests are found in Appendix B. The $0.4P_u$ load level is indicated for all tests that were conducted to failure. Tests ST/SW-1A, -1B, -1C, -1D and -2A were not conducted to failure for various reasons. These five tests were not considered in determining the average shear stiffness.

The maximum applied load in Test ST/SW-1E was 4900 lb., however, additional strength may have been realized because of extremely large deformations of the "base angle". Consequently, the maximum load for this test was taken as 4320 lb. (see Figure B.5). Test ST/SW-2B was stopped at 5300 lb. due to a base angle compression failure and a panel shear out at the bottom tension corner. Test ST/SW-3 failed at 5300 lb. due to a panel shear out at the bottom tension corner.

No evidence of panel sidelap slippage was found in any test.

Table 1
Cantilever Diaphragm Test Results

Test No.	Channel Spacing	P_u (lbs)	Δ_{max} (in.)	S_u (lb/ft)	$.4P_u$ (lbs)	D' (in.)	D'_b (in.)	G' (lb/in)
1E	13' 4-3/4"	4320	4.419	240.0	1728	1.588		
2B	13' 4-3/4"	5300	1.859	294.4	2120	0.268		
3	13' 4-3/4"	5300	3.017	294.4	2120	1.331		
Avg. 2B&3		5300		294.4	2120	0.800	.00259	1979

Notes: P_u = Maximum applied load
Δ_{max} = Maximum horizontal
S_u = Shear strength
D' = Deflection at $.4P_u$ (corrected)
D'_b = Bending deflection of cantilever beam
G' = Shear stiffness

APPENDIX A

PROFILES FOR PANELS

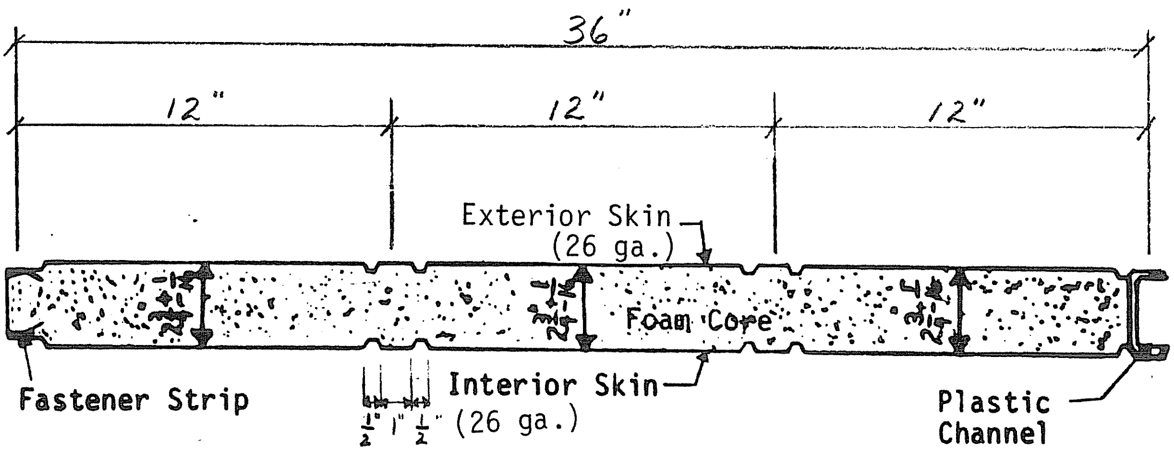

Figure A.1 StarTherm/StarWall Wall Panel, Cross-Sectional View

APPENDIX B

LOAD VS. DEFLECTION PLOTS FOR CANTILEVER DIAPHRAGM TESTS

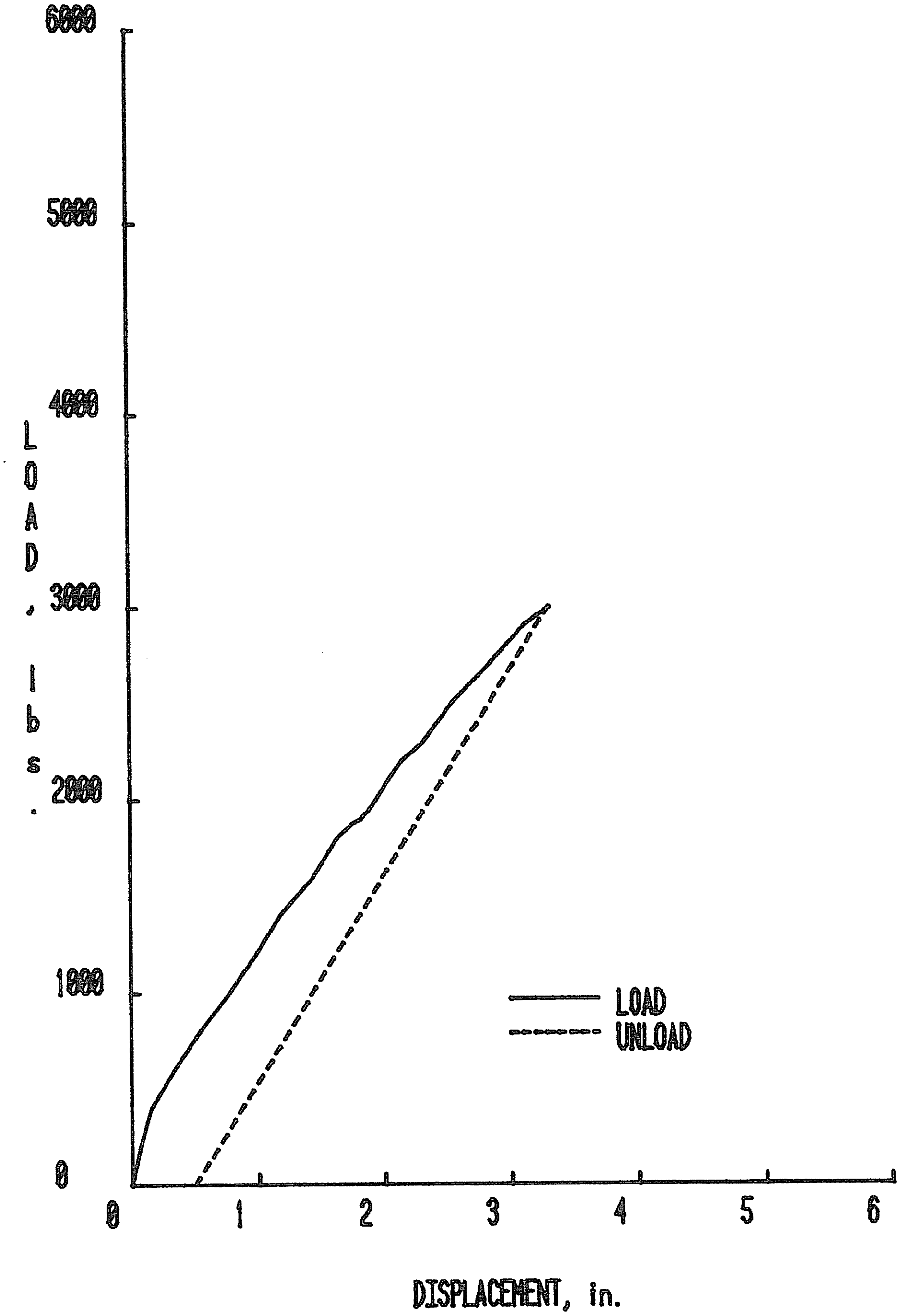

Figure B.1 Star Diaphragm Test ST/SW-1A

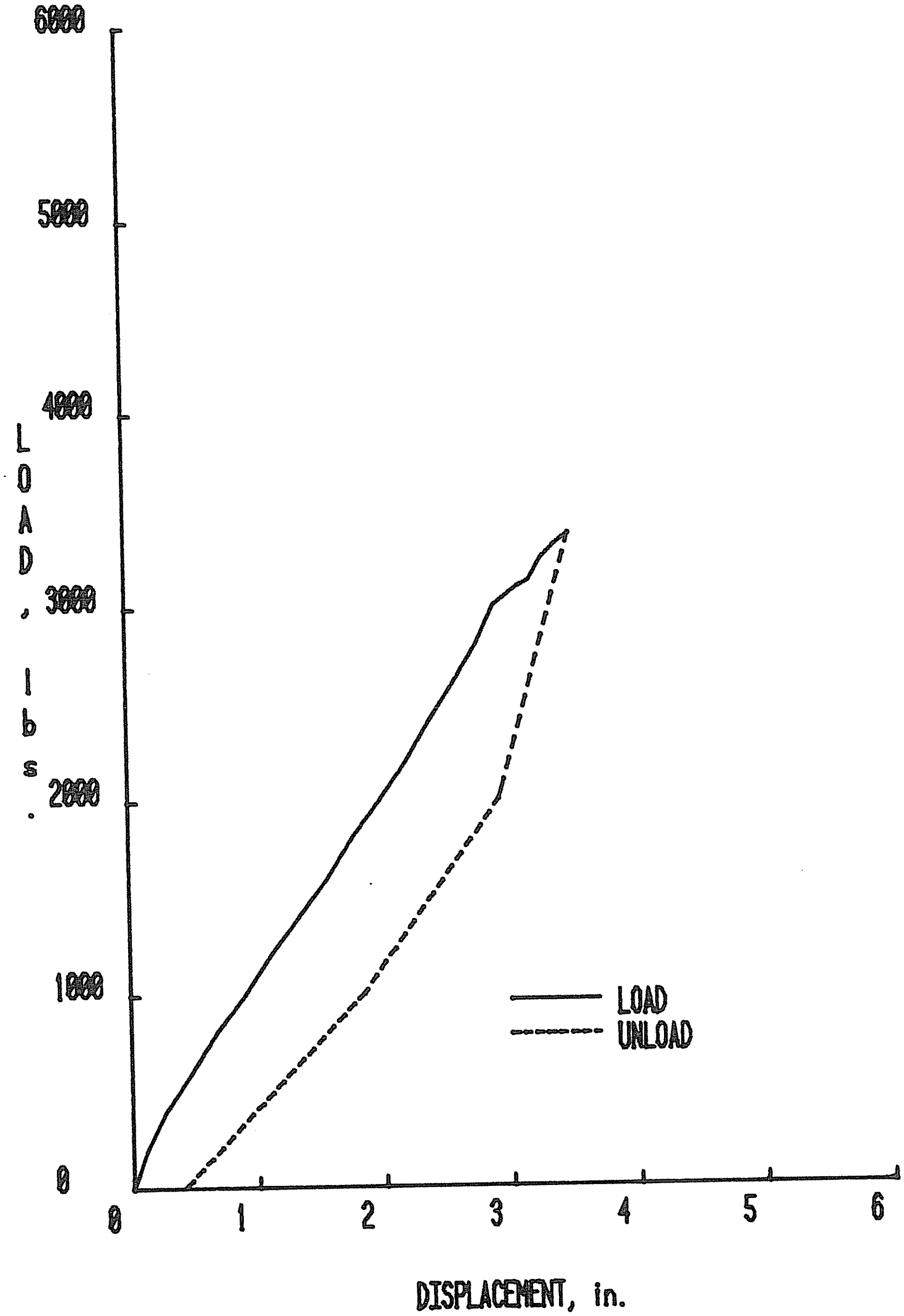

Figure B.2 Star Diaphragm Test ST/SW-1B

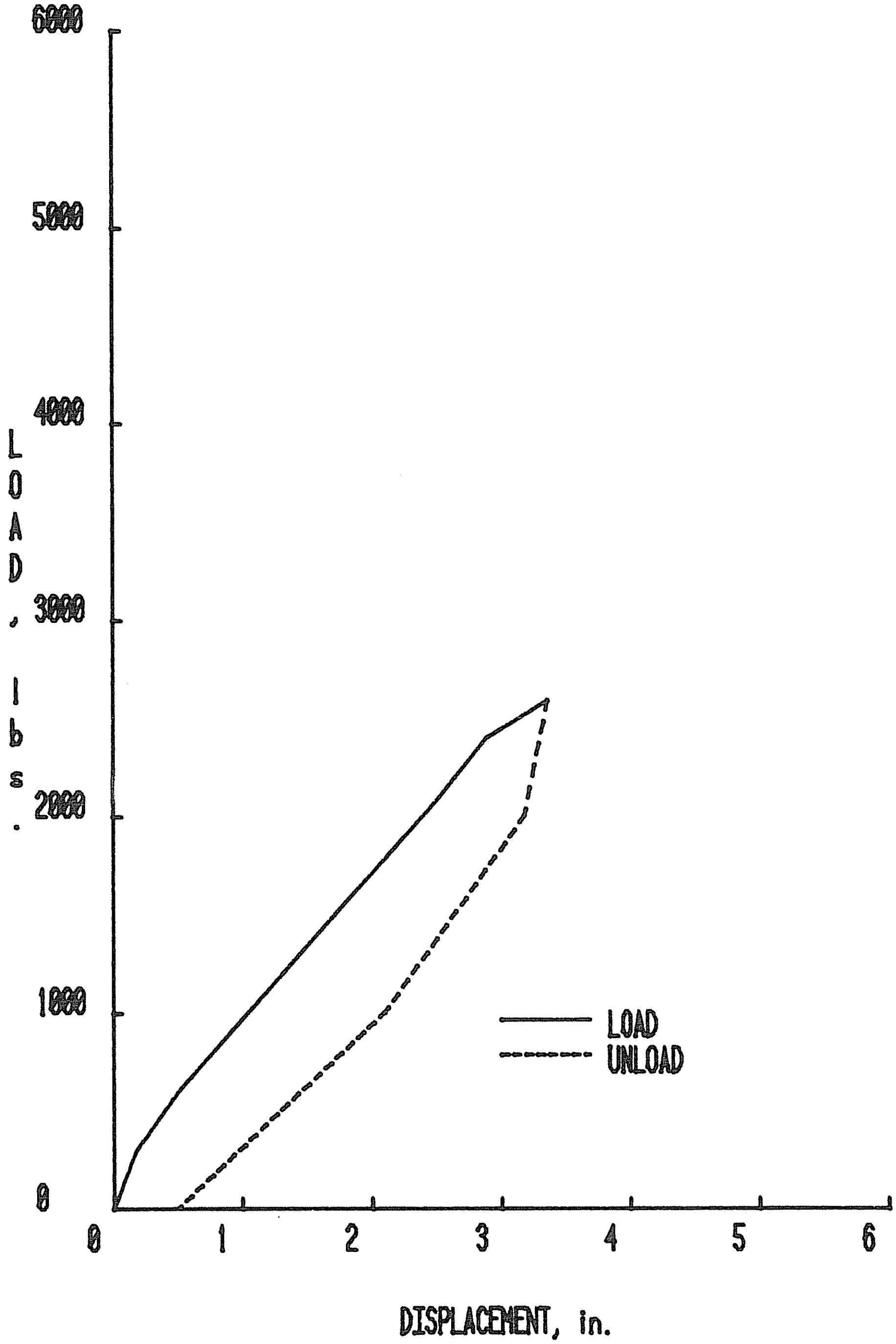

Figure B.3 Star Diaphragm Test ST/SW-1C

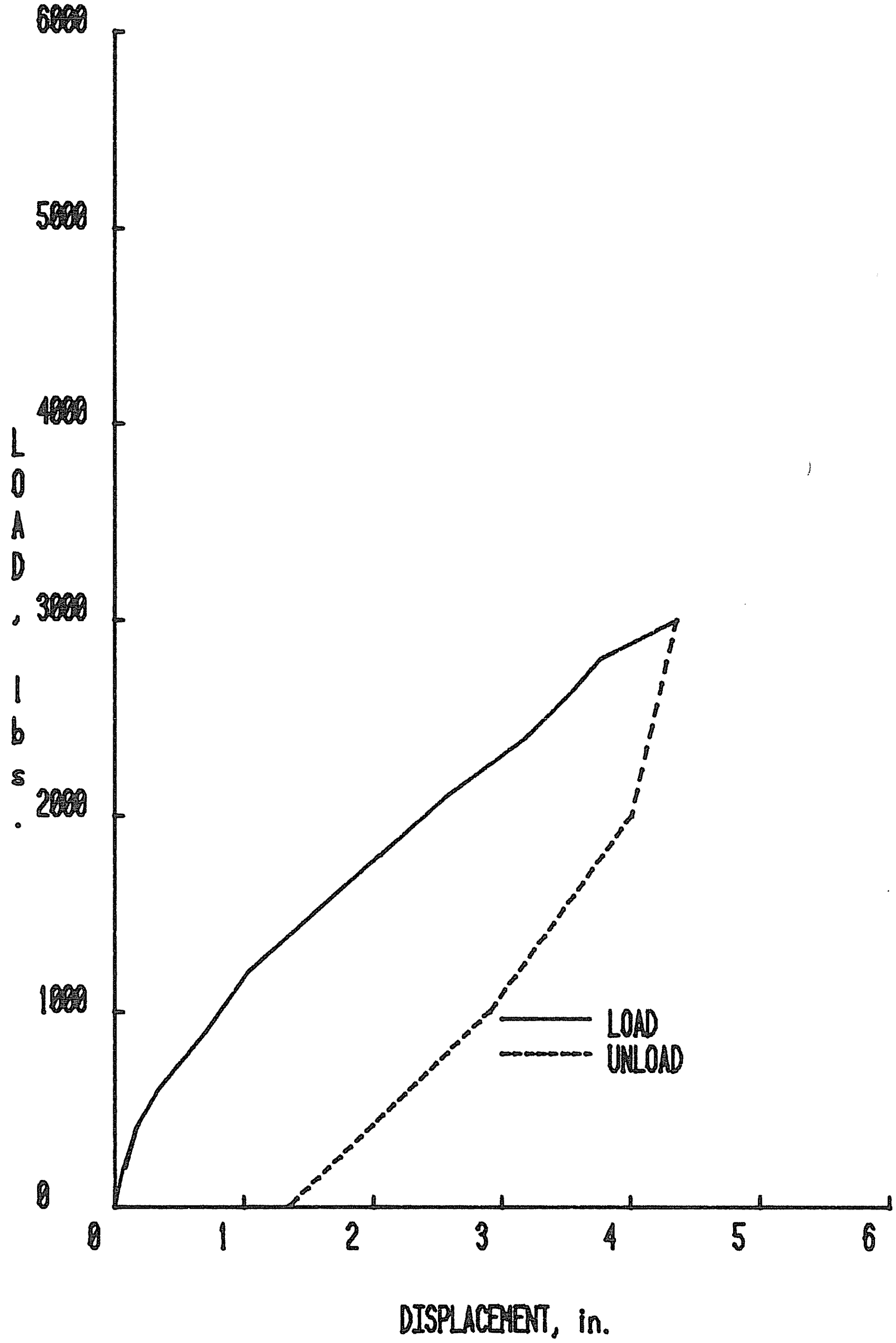

Figure B.4 Star Diaphragm Test ST/SW-1D

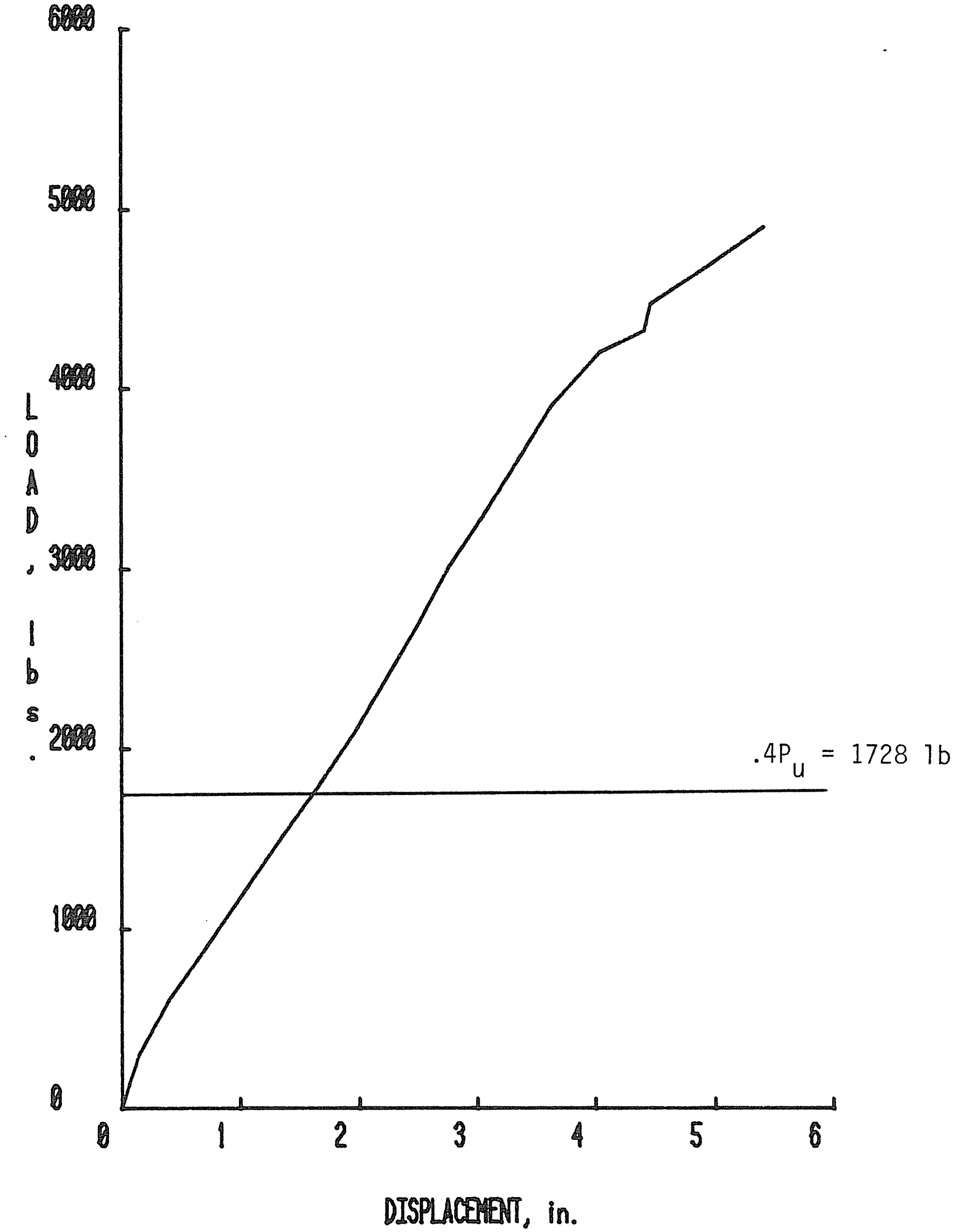

Figure B.5 Star Diaphragm Test ST/SW-1E

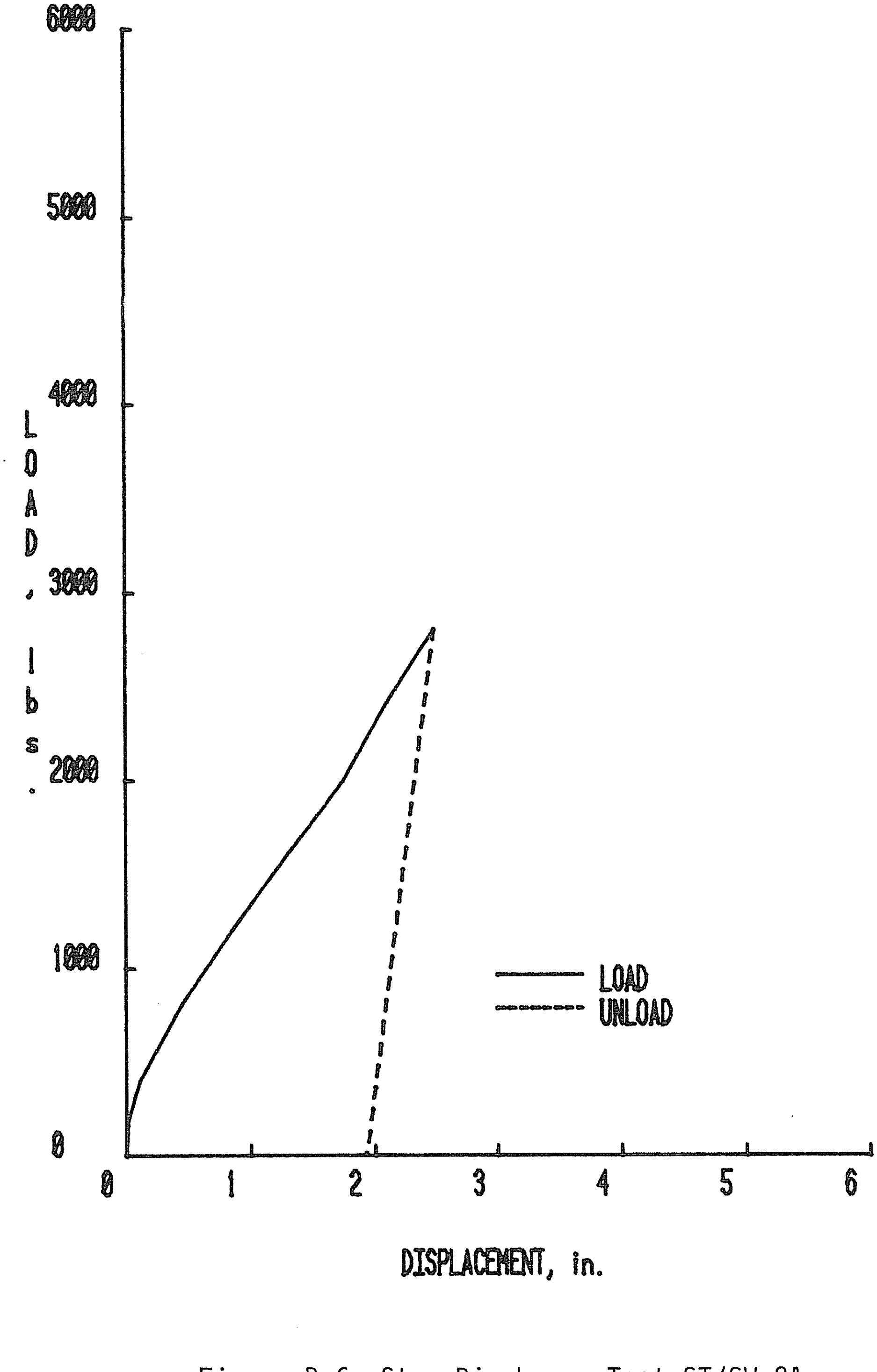

Figure B.6 Star Diaphragm Test ST/SW-2A

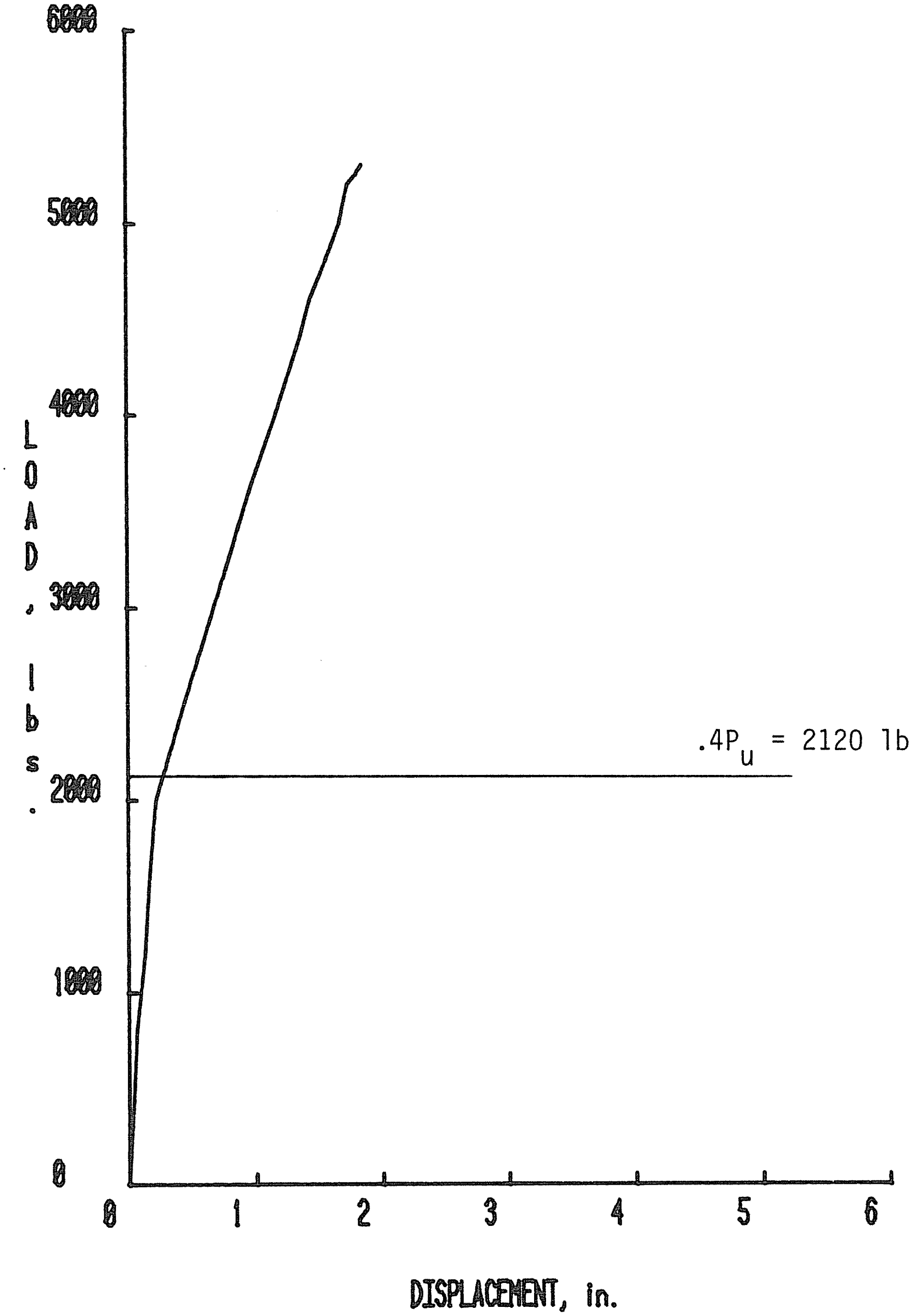

Figure B.7 Star Diaphragm Test ST/SW-2B

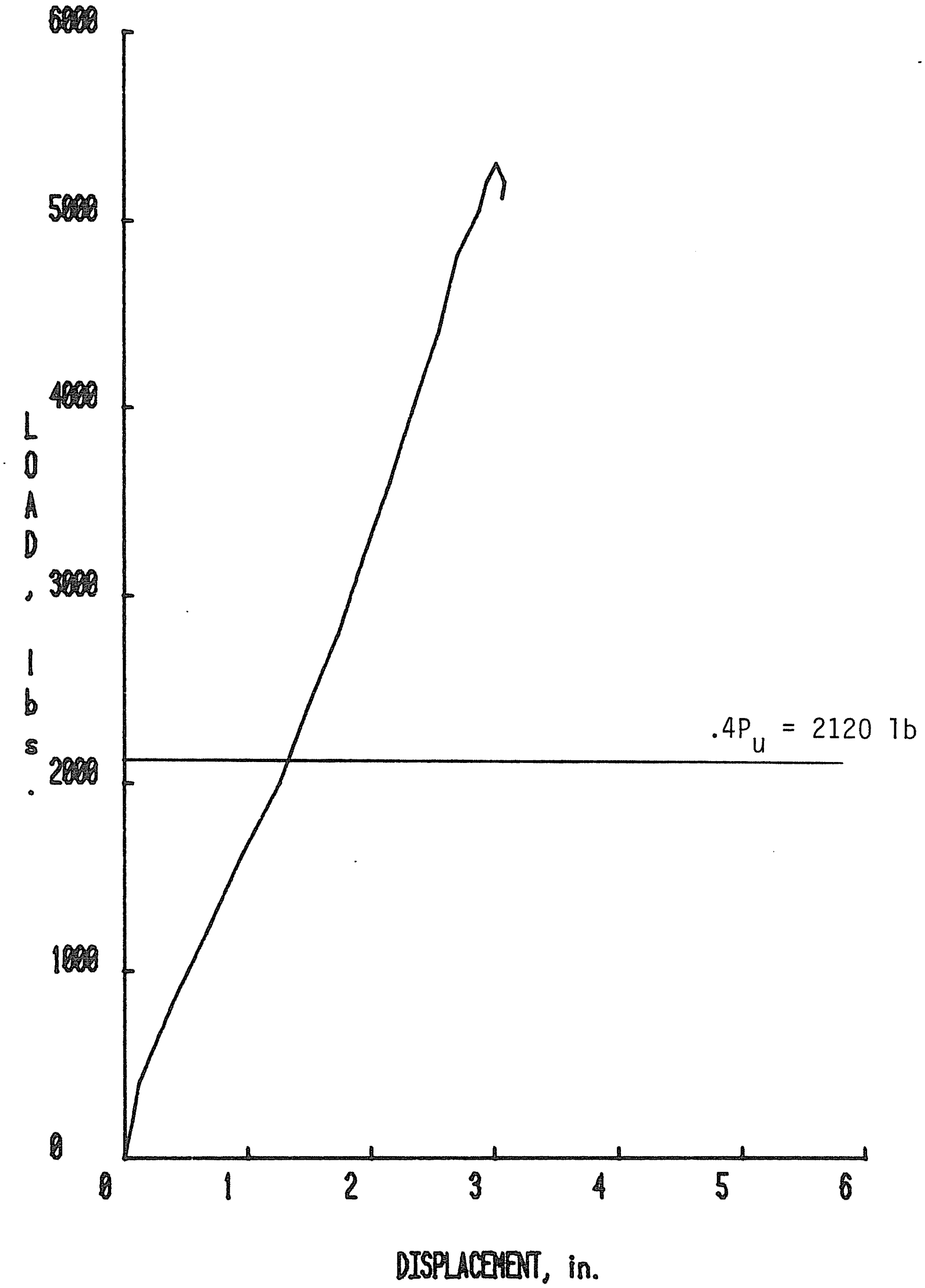

Figure B.8 Star Diaphragm Test ST/SW-3