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CALIBRATION OF PRESSURE-MEASURING SYSTEMS OF MOVABLE-WALL COKE OVENS

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CALIBRATION OF PRESSURE-MEASURING SYSTEMS OF MOVABLE-WALL COKE OVENS

by

D.A. Reeve* and J.C. Botham**

SUMMARY

Whenever technical-scale movable-wall coke ovens are used to evaluate the relative coking propensities of metallurgical coals, carbonization pressures generated within the ovens must be recorded accurately. A Task Group of ASTM Committee D-5 on coal and coke requested the Mines Branch to design a system for the calibration of movable-wall coke ovens for pressure. In the method adopted, known internal pressures were applied to the hot oven walls with a rubber bag connected to a compressed air supply and protected by a ceramic form from the walls. A second method was also developed in which an hydraulic jack within the hot oven generated the required pressures. The first method was found to be unsatisfactory because of friction between the oven sole and the ceramic form and because of distortion of the rubber bag. The second method provided an acceptable correlation between internally-applied and externally-measured pressures when the oven was hot and has now been adopted for use in the Mines Branch movable-wall coke ovens.

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ETALONNAGE DES SYSTEMES DE MESURE DE PRESSION DANS LES FOURS A COKE A PAROI MOBILE

par

D.A. Reeve et J.C. Botham***

RESUME

Lorsqu'on utilise des fours à coke à paroi mobile pour évaluer les caractéristiques de cokéfaction des charbons métallurgiques, on doit pouvoir enregistrer avec précision les pressions de carbonisation produites à l'intérieur des fours. Un groupe de travail du comité D-5 du charbon et du coke (ASTM) a demandé à la Direction des mines de mettre au point un système d'étalonnage pour mesurer la pression dans les fours à coke à paroi mobile. Dans la méthode choisie, les pressions internes connues étaient appliquées aux parois chaudes du four à l'aide d'un sac de caoutchouc raccordé à une source d'air comprimé et protégé des parois par un moulage de céramique. Une deuxième méthode exigeait à l'intérieur du four chauffé la présence d'un cric hydraulique qui était appelé à fournir les pressions requises. La première méthode a été jugée non satisfaisante en raison d'abord de la friction entre la sole du four et le moulage en céramique et ensuite de la déformation du sac de caoutchouc. La deuxième méthode rendait possible une corrélation acceptable entre les pressions appliquées à l'intérieur et les pressions mesurées à l'extérieur pendant que le four était chaud et la Direction des mines l'a maintenant adoptée pour utilisation dans ses fours à coke à paroi mobile.

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INTRODUCTION

Whenever technical-scale movable-wall coke ovens are used to evaluate the relative propensities of metallurgical coals for cokemaking, it is important that pressures generated within the ovens during carbonization are recorded accurately. As a general rule, the pressure generated during carbonization of a metallurgical coal blend in an industrial slot-type oven should not exceed about 2 lb/in.^{2} to prevent damage to the oven walls.

This report describes two methods used to calibrate movable-wall coke ovens for pressure, and recommends one of them. The program originated from the results of a series of carbonization tests involving up to fifteen different ovens under the auspices of a Task Group (on the movable-wall oven test) of ASTM Committee D-5, Subcommittee XV (Plasticity and Swelling of Coal). The results obtained showed a wide variation in coke quality parameters and maximum wall pressures developed during the tests. Interpretation of results from the ovens of the various laboratories participating in the test series shed some light on the discrepancies obtained, but there were still differences in wall pressures which could not be explained. For example, identical ovens operated by different laboratories gave pressures between 1.5 and 6.0 lb/in.^{2}

Following this test series, the Task Group requested the Mines Branch to design a system for the calibration of movable-wall coke ovens for pressure. In 1968, a project was started in co-operation with the Technical Services Division of the Mines Branch to construct a pressure-bag system for calibration of test ovens at temperatures of normal operation. In 1971, another method, known as the hydraulic-cage method, was developed. In this report, the two methods are described and their relative performance evaluated.

For reasons of reproducibility, economy, and ease of operation, the hydraulic-cage method was ultimately selected over the pressure-bag method.

PRESSURE-BAG METHOD

In this method, an internal pressure within the test oven was produced with a rubber bag connected to a compressed air system. The rubber bag was protected from the hot oven environment by an interlocking ceramic form (Figure 1) which transmitted pressure from the bag to the oven wall. The known pressure within the oven was then compared with that from the calibrated gauge attached to the outside of the movable-wall.

The ceramic form (3' x 3' x 12"; internal dimensions of the Mines Branch 12-inch movable-wall oven) was manufactured from "Duolite 24" castable refractory cement and the rubber bag (14" x 14" x 4") within the ceramic form was attached to a compressed air supply. The ceramic form was designed to distribute pressure from the bag over the whole of the area of the fixed and movable walls and to allow several measurements to be made before the rubber bag was damaged by heat transfer through the form.

HYDRAULIC-CAGE METHOD

The cage was divided into two vertical 3' x 3' sections incorporating an hydraulic jack (Figure 2). The two sections were forced apart by the hydraulic jack, the pressure applied to the insides of the oven walls being calculated from a calibrated hydraulic gauge (0-4000 lb). The two parts of the cage were fabricated from mild steel channel section (2" x 1" x 1/8") and lengths of angle iron provided a housing for the jack. Compressible-block insulation

(two-inch) allowed the applied force to be distributed evenly over the oven walls (three foot square). The cage was suspended in the oven with a bar through the levelling doors. The jack and connecting hose to the pump were thermally insulated with "Kaowool" blanket, allowing approximately 15 minutes operating time when the oven was at 1200^{o}F.

RESULTS AND DISCUSSION

Comparison tests of the two methods were done within the empty Mines Branch 12-inch movable-wall coke oven 12-61 (Figure 3). At the start of the tests, the movable-wall was allowed to hang freely to permit zeroing of the external pressure-measuring gauge. As pressure was applied by either method to the inner surfaces of the oven walls, external wall pressures were recorded.

Pressure calibration results using the pressure-bag method with the oven cold are given in Figure 4. The correlation between applied and measured pressures was not linear or reproducible. Two factors may contribute to this lack of reproducibility:

(i) Static friction was considerable between the ceramic form (protecting the rubber bag) and the oven sole, as well as between the interlocking surfaces of the form.

(ii) Expansion of the rubber bag caused distortion at its corners; the effective area over which the pressure was being applied was thus not known accurately.

The lack of reproducibility between applied and measured pressures for the pressure-bag method with the oven cold made measurements superfluous in the hot oven.

Pressure calibration results using the hydraulic-cage method with the oven at 1200°F are given in Figure 5 and compared with the theoretical correlation for applied and measured pressures. An oven wall pressure of 2 lb/in.^{2} lies at approximately 2600 lb on the abscissa.

The difference between the actual and theoretical measured pressure was about 150 lb (approximately 0.1 lb/in.^{2}) attributable to the static friction of the movable-wall roller suspension system.

Use of the pressure-bag method, which is expensive because of the short life of the ceramic form and the bag, has been discontinued at the Mines Branch in favour of the hydraulic-cage method. The new 12-inch oven (12-71), the 18-inch (18-70), and the gas-fired Koppers oven at the Western Regional Laboratory, Edmonton, Alberta, have all been calibrated using the latter method.

ACKNOWLEDGEMENT

Mr. E.W. Montgomery of MREC and Mr. D.M. Norman (Mechanical Engineer) of the Technical Services Division of the Mines Branch designed the pressure-bag system. Results from the pressure-bag system given in this report were obtained by Mr. D.D. Cameron, Senior Pilot Plant Technologist, MREC. The hydraulic-cage method was designed and built by Mr. P.C. Lorince (Mechanical Engineer) previously with MREC, with assistance from Mr. D.D. Cameron.

The writers are grateful to Dr. B.J.P. Whalley of MREC for critically reading the manuscript.

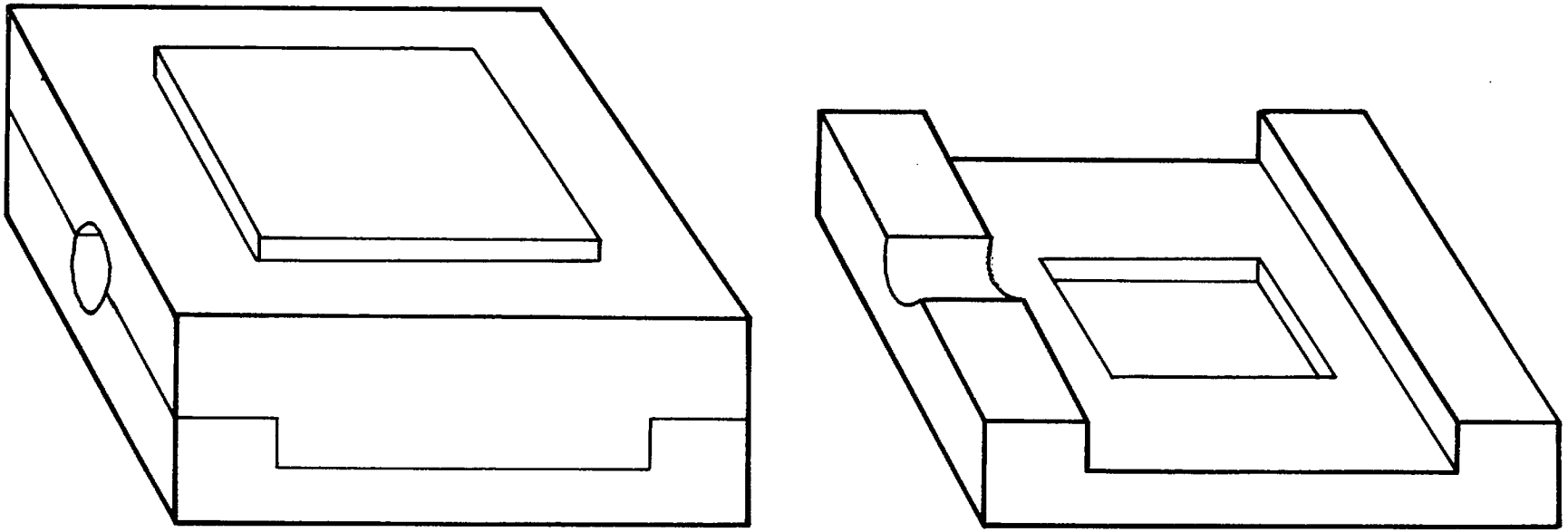

FIGURE 1 - Ceramic Forms for the Pressure-Bag Method

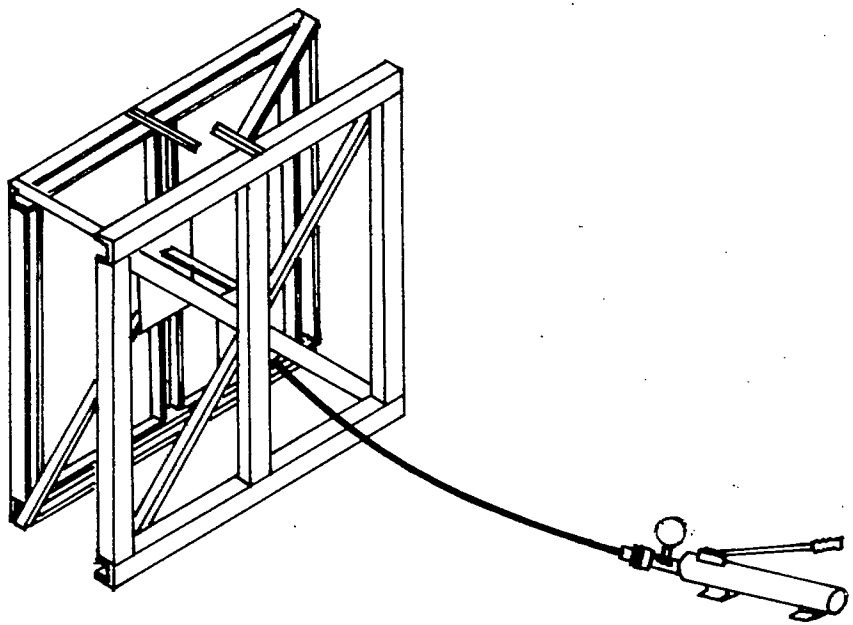

FIGURE 2 - Cage and Hydraulic Jack for Calibrating the Pressure-Measuring Systems of Movable-Wall Coke Ovens

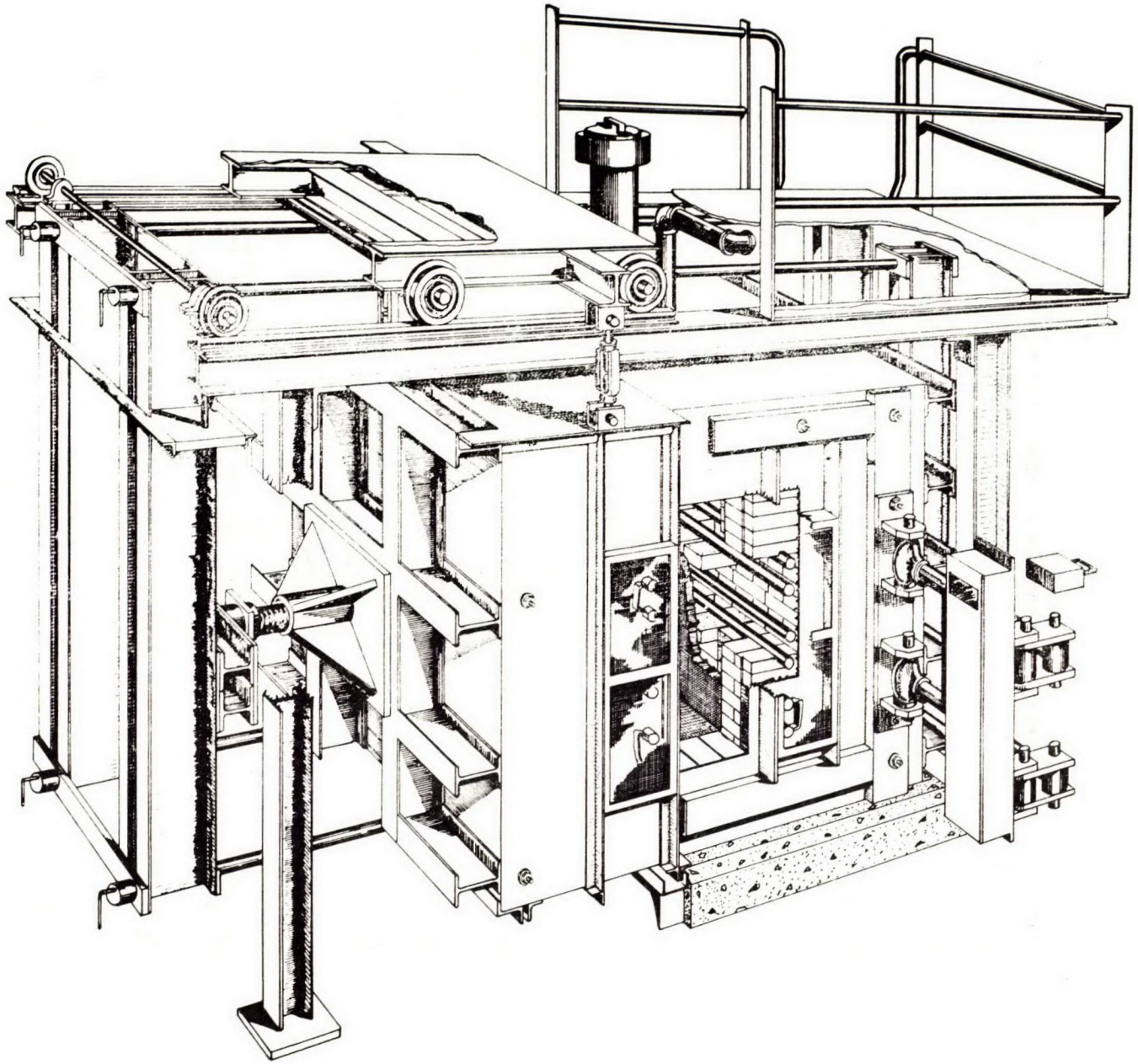

FIGURE 3 - Mines Branch Movable-Wall Coke Oven

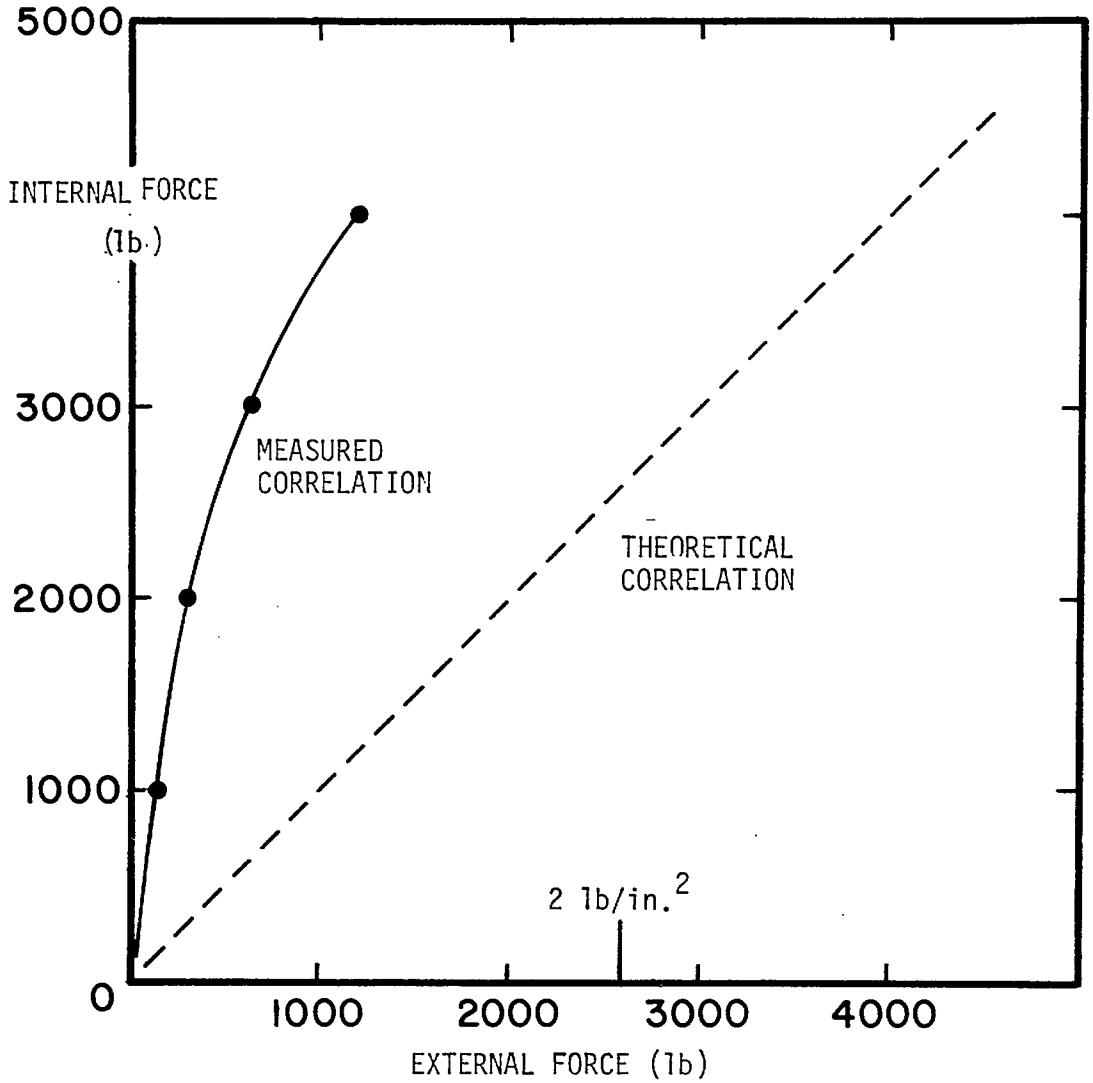

FIGURE 4 - Movable-Wall Oven Pressure Calibration Using the Pressure-Bag Method

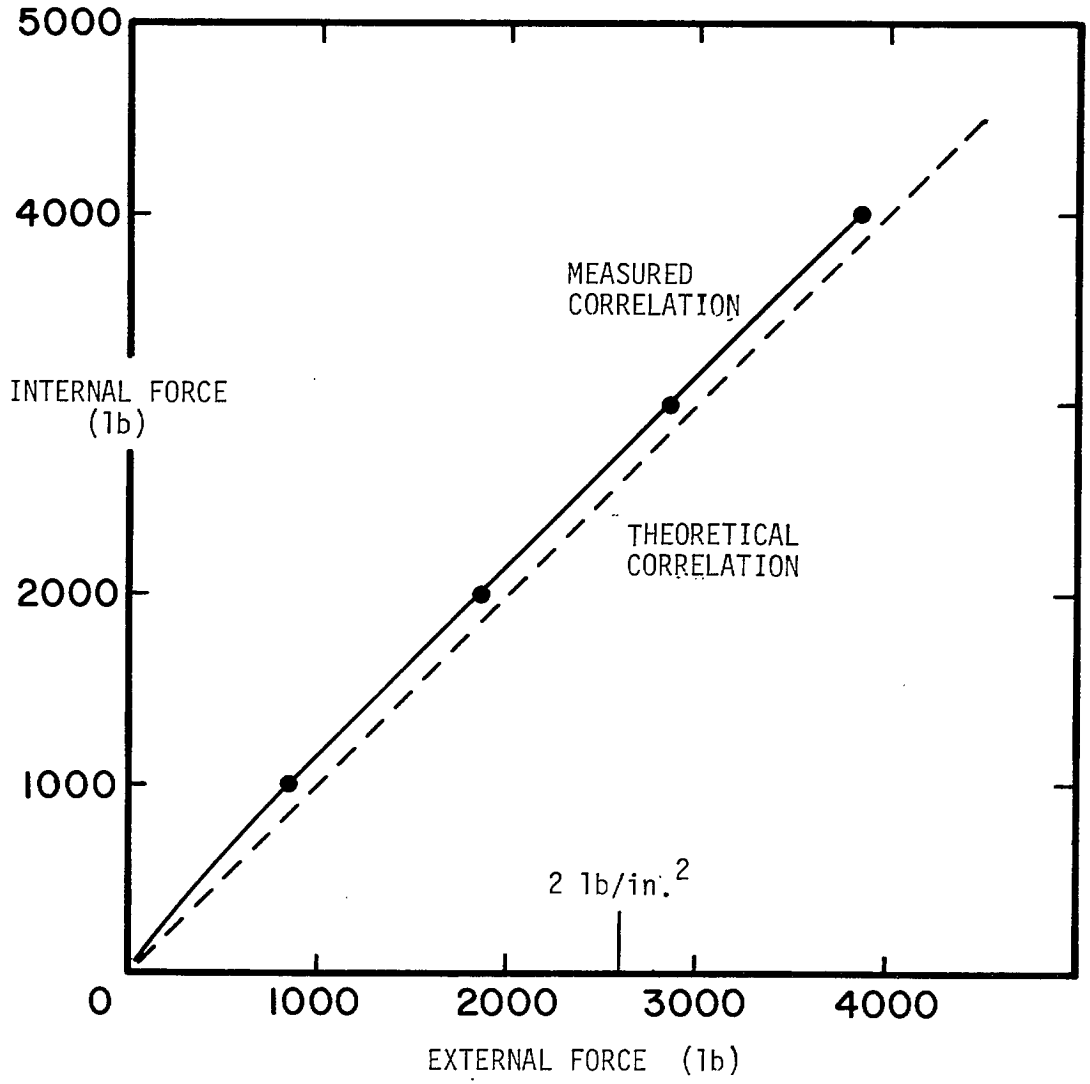

FIGURE 5 - Movable-Wall Pressure Calibration Using the Hydraulic-Cage Method