SSME SEAL TEST PROGRAM: TEST RESULTS FOR HOLE-PATTERN DAMPER SEALS

INTERIM PROGRESS REPORT

NASA CONTRACT NAS8-33716

Prepared by

Dara W. Childs, Ph.D., P.E.

Professor of Mechanical Engineering

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TRC-Seal-4-85

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ABSTRACT

Test results consisting of direct and transverse force coefficients are presented for thirteen, hole-pattern, damper-seal configurations. The designation "damper" seal refers to a seal which uses a deliberately roughened stator and smooth rotor as suggested by von Pragenau [1] to increase the net damping force developed by a seal. The designation "hole-pattern" refers to a stator roughness pattern which is developed by a pattern of round holes which are milled into the stator. All seals tested use the same smooth rotor and have the same constant minimum clearance. The seal tests examined the following major design options:

(a) hole-area density, i.e., the proportion of stator surface area consumed by holes.

(b) hole depth, particularly the ratio of hole depth to minimum clearance.

In addition, limited data were taken to examine the influence of "in-line" versus "staggered" hole patterns and flat-bottomed versus spherical-bottomed holes.

A comparison of the results shows that, from a damping viewpoint, the optimum seal configuration used a hole-area density of approximately 34% and that the optimum hole depth is approximately three times the minimum clearance. As compared to a smooth seal, the optimum damper seal increases net damping by a factor of 1.38, reduces direct stiffness by a factor of 0.73, and reduces leakage by a factor of 0.53. A staggered pattern seems to be better than an in-line pattern, and flat-bottomed holes are much better than spherical-bottomed holes.

The theory of reference [2] does an adequate job of predicting the stiffness and damping coefficients of optimum and near-optimum configurations; however, it substantially underestimates the effective added-mass coefficients.

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NOMENCLATURE

c: Cross-coupled damping coefficient, introduced in Eq. (1), FT/L.

k: Cross-coupled stiffness coefficient, introduced in Eq. (1), F/L.

mr, nr: Empirical turbulence coefficients to define the seal-rotor friction factor.

ms, ns: Empirical turbulence coefficients to define the seal-stator friction factor.

A: Dynamic seal eccentricity, introduced in Eq. (2).

C: Direct damping coefficient, introduced in Eq. (1), FT/L.

C_{ef}: Net damping coefficient, introduced in Eq. (10), FT/L.

C_D: Discharge coefficient, introduced in Eq. (11).

C_L: Leakage coefficient, introduced in Eq. (12).

C_r: Minimum radial seal clearance, L.

F_X, F_Y: Cartesian components of the seal reaction force, introduced in Eq. (1), F.

F_r, F_θ: Radial and circumferential components of the seal reaction force, F.

K: Direct seal stiffness coefficient, introduced in Eq. (1), F/L.

M: Seal added mass coefficient, introduced in Eq. (1), M.

M_{ef}: Effective seal added-mass coefficient, introduced in Eq. (10), M.

ΔP: Seal pressure differential, F/L^2.

R: Seal radius, L.

$R_a = 2\rho V C_r/\mu$: Reynolds number.

V: Average axial fluid velocity in the seal L/T.

X, Y: Seal displacement components, introduced in Eq. (1), L.

λ_r: Seal rotor friction factor, defined in Eq. (5).

$\sigma = \lambda(L/C_r)$: Axial pressure-gradient coefficient.

ρ: Seal density, M/L^3.

ω: Seal rotational and precessional velocity, T^{-1}.

μ: Seal viscosity, FT/L^2.

INTRODUCTION

The test and analysis results which are reported here were obtained under NASA Contract NAS8-35824. The present work continues research activity which was begun in January of 1980 under NASA Contract NAS8-33716. Earlier contract reports [3-6] provide detailed information covering the following points:

(a) test-section and facility description,

(b) test-objectives and procedures, and

(c) data acquisition, analysis and procedures.

Most of this information is not repeated here, and interested readers are referred to earlier reports.

From a rotordynamics viewpoint, seal analysis has the objective of predicting the coefficients for the following motion/reaction-force model

$$-\begin{Bmatrix} F_X \\ F_Y \end{Bmatrix} = \begin{bmatrix} K & k \\ -k & K \end{bmatrix} \begin{Bmatrix} X \\ Y \end{Bmatrix} + \begin{bmatrix} C & c \\ -c & C \end{bmatrix} \begin{Bmatrix} \dot{X} \\ \dot{Y} \end{Bmatrix} + M \begin{Bmatrix} \ddot{X} \\ \ddot{Y} \end{Bmatrix} , \qquad (1)$$

where X, Y are components of the seal-rotor displacement relative to its stator and F_X, F_Y are components of the reaction force. The diagonal and off-diagonal stiffness and damping coefficients are referred to, respectively, as "direct" and "cross-coupled". The cross-coupled coefficients arise due to fluid rotation within the seal. The coefficient M accounts for the seal's added mass.

If a circular orbit of the form

$$X = A \cos\omega t, \qquad Y = A \sin\omega t \qquad (2)$$

is assumed, Eq. (1) yields the following definition of force coefficients which are, respectively, parallel and perpendicular to the rotating displacement vector

$$F_r/A = -K - c\omega + M\omega^2$$
$$F_\theta/A = k - C\omega \qquad (3)$$

Observe that the cross-coupled-stiffness coefficient k yields a "driving" tangential contribution in the direction of rotation, while the direct damping coefficient develops a drag force opposing the tangential velocity.

A prior investigation [6] examined five new "damper seal" configurations which were largely inspired by von Pragenau's work [1]. Von Pragenau's analysis predicts that a smooth-rotor/rough-stator combination will yield a reduced asymptotic fluid tangential velocity within the seal, which will, in turn, yield a reduction in the cross-coupled stiffness coefficient. A reduced cross-coupled stiffness coefficient reduces the destabilizing tangential driving force on the rotor, yields an increased net damping force, and generally enhances rotor stability and response. A subsequent and more comprehensive analysis by Childs and Kim [2], yields the same sort of encouraging predictions.

The results of [6] confirmed that damper seals could yield increased net damping coefficients and showed particularly encouraging results for the round-hole pattern configuration of figure 1. This report provides test data for twelve additional round-hole-pattern seal configurations.

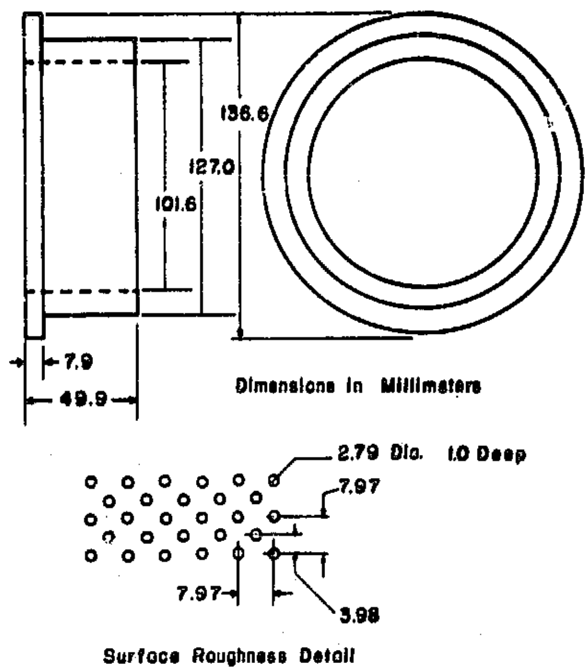


Figure 1. Round-hole pattern stator insert.

TEST CONFIGURATIONS, CAPABILITY, AND RESULTS

Test Configurations

The seal test section is illustrated in figure 2 and is designed to accept candidate seal inserts. All seals tested use a smooth rotor and have a constant minimum clearance, i.e., no taper. Tests were carried out to examine the influence of changes in the following parameters:

(a) Hole-area density. This parameter is defined by

$$\gamma = \frac{\text{hole area}}{\text{total area}} \quad . \tag{4}$$

(b) Hole depth to minimum-clearance ratio, h/C_r, as illustrated in figure 4.

Figure 3 illustrates the eight hole-patterns which were tested. Figures 4 and 5 illustrate, respectively, the two types of hole bottoms which were tested, viz., flat-bottomed and spherical-bottomed. Table 1 provides the detailed data for all thirteen hole-pattern seals.

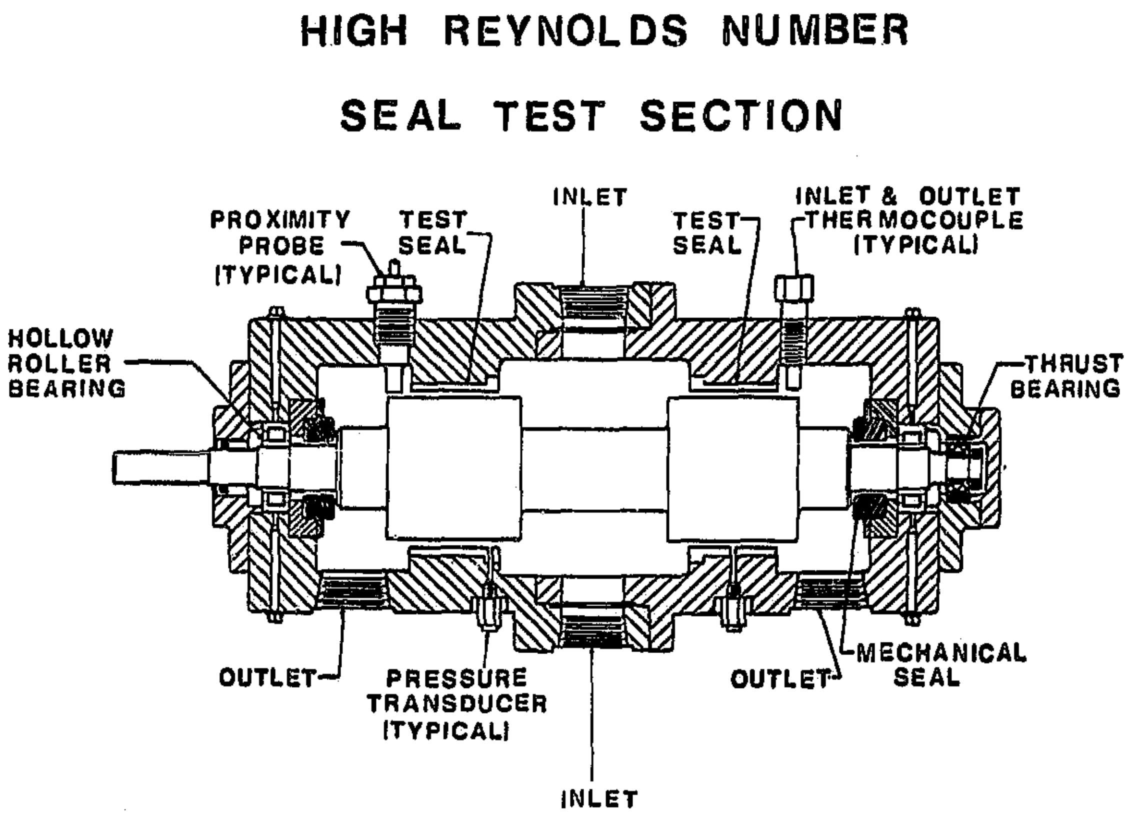


Figure 2. High-Reynolds-Number seal test section.

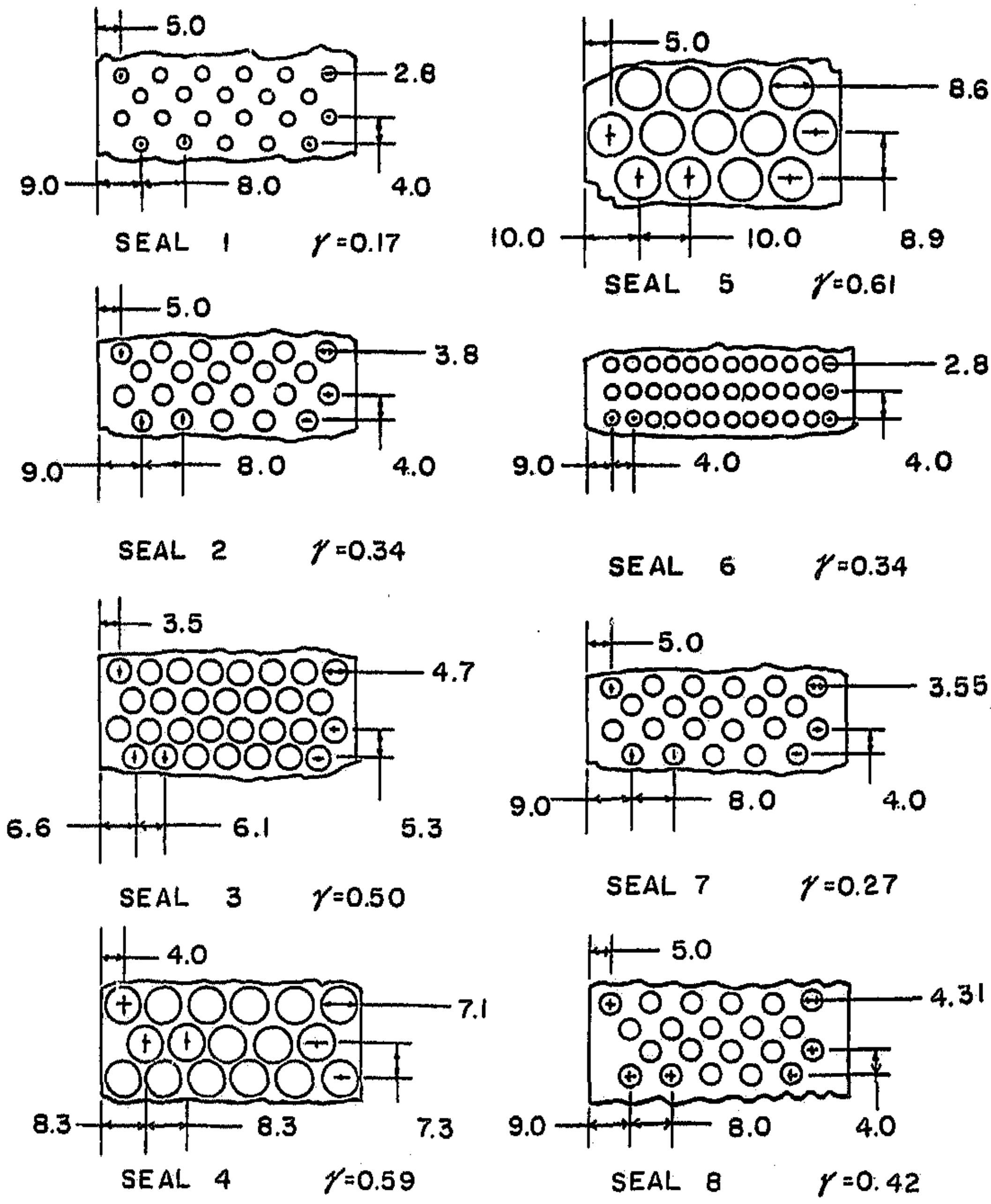


Figure 3. Hole-pattern configurations

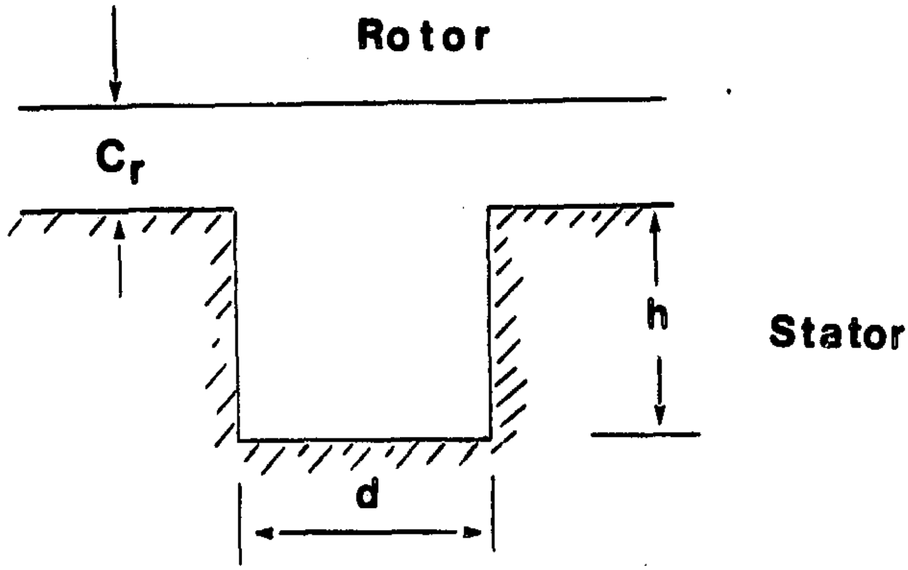


Figure 4. Flat-bottom hole detail.

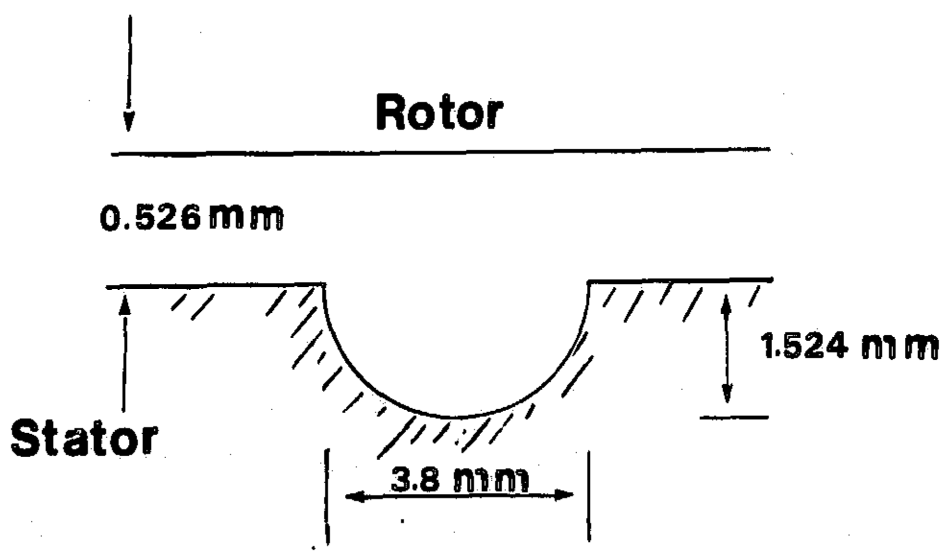


Figure 5. Spherical-bottom hole detail.

Stator	Hole Pattern	γ	h/C_r	Hole Bottom
1	1	.17	1.93	flat
2	2	.34	1.93	flat
3	3	.50	1.93	flat
4	4	.59	1.93	flat
5	5	.61	1.93	flat
6	6	.34	1.93	flat
7	2	.34	.96	flat
8	2	.34	2.89	flat
9	2	.34	3.37	flat
10	2	.34	3.86	flat
11	7	.27	2.89	flat
12	8	.42	2.89	flat
13	2	.34	2.89	spherical

Table 1. Hole-pattern-stator configurations, C_r (min) = 0.526 mm.

Test Capability

The rotor segments of the test seal are mounted eccentrically on the rotor of figure 2 with the eccentricity A. Hence rotor rotation generates a synchronously precessing pressure field. Axially spaced, strain-gauge, pressure transducers are provided to measure the transient pressure field, and the transient pressure measurements are recorded and integrated to define F_r/A, F_θ/A, and $|F|$. In any test, five to ten cycles of data, containing on the order of 2,000 data points, are analyzed. Each data point yields a calculated value for F_r/A, F_θ/A and $|F|$, and average and standard-deviation values are calculated for the test case. Observe from Eq. (3) that the test apparatus yields only the <u>net</u> radial and tangential force coefficients and can not be used to separately identify the seal coefficients.

The analysis of von Pragenau [1] and Childs and Kim [2] indicates that the seal rotor and stator roughness are important in defining the cross-coupled stiffness coefficient k and net-damping-force coefficient F_θ/A. Estimates for the relative roughness parameters can be obtained from measured results for the axial pressure gradient and leakage rate. The required data, consisting of the supply and discharge pressures and pressure measurements at axial locations throughout the seal, are sampled, averaged, and recorded immediately before transient data are recorded.

Test Results

For a given seal configuration, a test matrix is carried out with variations in the flowrate (axial Reynolds number) and shaft rotational speed. The flowrate is varied from a minimum value, which is sufficient to yield adequate signal-to-noise ratios of the transient pressure measurements,out to the maximum flow capability of the circuit. Shaft rotation speed is incremented from approximately 1,000 rpm to 7,200 rpm. In a given test series, the axial Reynolds number is held constant and the running speed incremented.

For a given test, the following two types of data are secured:

(a) steady-state "input" data consisting of the pressure differential average fluid densitv and viscosity mass leakage rate, and rotational speed, and

(b) "output" data consisting of F_r/A, F_θ/A, $|F|$ versus the axial Reynolds number and shaft running speed.

The tables of Appendices A and B provide this type of data for each test of each seal configuration.

DISCUSSION OF RESULTS: COMPARISON TO THEORY

Introduction

The theory of reference [2] should be adequate as a model for the hole-pattern damper seals tested in this study. The adequacy of the theory, as determined by comparison to applicable experimental results, is the subject of this section.

Empirical Turbulence Coefficients

The theory of [2] characterizes the roughness of the stator and rotor by the empirical turbulence coefficients mr, nr (rotor) and ms, ns (stator) in basically the same procedure used by Yamada [7] and Hirs [8]. The theory requires estimates for these parameters based on the axial pressure gradient and leakage/axial Reynolds number data. Identification of these data was accomplished as follows.

Of the two seal inserts illustrated in figure 2, the seal on the left-hand side used the smooth seal insert, while the remaining seal inserts were tested in the right-hand-side housing. To the extent possible, the same "very-smooth" finish was provided for both the smooth-seal insert and the rotor. The pressure gradient was measured for both the smooth and damper seals during all dynamic tests. The axial pressure gradient equation has the form

$$-\frac{\partial p}{\partial z} = \sigma \left(\frac{\rho V^2}{2}\right)$$

Hence, with a measured pressure gradient, and a known density ρ and axial velocity V, one can calculate the parameter σ, which is related to the friction-factor coefficient by

$$\sigma = \lambda \left(\frac{L}{C_r}\right)$$

The smooth-rotor/smooth-stator data were used to calculate values σ_r and λ_r which were assumed to apply for both the rotor and the smooth stator. From the λ_r versus running-speed, ω, and axial Reynolds, R_a, data, the empirical coefficients, mr, nr of the following friction-factor formula are calculated

$$\lambda_r = nr\ R_a^{mr}\ [1 + (R\omega/V)^2]^{\frac{mr+1}{2}} \qquad (5)$$

These coefficients are calculated on a least-square-error basis, and determined as follows

$$nr = 0.06736, \qquad mr = -0.21663 \qquad (6)$$

These values can be compared to

$$no = -\ 0.079, \qquad mo = -0.25$$

from Yamada's data for "smooth" annulli.

For the smooth-rotor/damper-stator combinations, a combined σ_c is measured, which is related to the corresponding rotor σ_r and (rough) stator σ_s by

$$\sigma_c = \frac{\sigma_r + \sigma_s}{2}$$

Hence

$$\sigma_s = 2\sigma_c - \sigma_r$$

This formula was used to calculate σ_s for the damper stators by using measured values for σ_c and calculating a value for σ_r from Eq. (5) with the parameters of Eq. (6). The resultant empirical coefficients for the damper-seal stators are given in table 2. The entrance-loss coefficients of the entrance-pressure-loss relationship

$$\Delta P_{inlet} = (1+\xi) \frac{\rho V^2}{2} \tag{7}$$

are also provided in table 2.

	m s	n s	$(1+\xi)_{av}$
1	0.011904	0.015027	1.2845
2	-0.03719	0.31633	1.3707
3	-0.29173	1.0277	1.2126
4	-0.42715	6.8275	1.3131
5	-0.24746	0.37522	1.295
6	-0.03329	0.045493	1.4795
7	-0.29623	0.90612	1.3023
8	-0.34246	1.9609	1.475
9	-0.39178	3.8690	1.2278
10	-0.13812	0.12587	1.593
11	-0.39178	3.9405	1.5446
12	-0.04649	0.046746	1.4142
13	-0.46849	10.981	1.656

Table 2. Empirical turbulence coefficients (ms,ns) and entrance-loss coefficients for the hole-pattern stator configurations of figure 3 and table 1.

Problems were encountered in calculating the ms, ns values of table 2 because of flow-meter difficulties. Specifically, the Fisher-Porter vortex flowmeters yielded unusable oscillatory output at higher Reynolds numbers. An accurate least-square calculation of ms, ns requires data over a fairly wide Reynolds-number range which, in many cases, was simply not available. The values for ms, ns provided in table 2 were the best which could be extracted from the available test data; however, they are not generally satisfactory. Note that new turbine flowmeters have been purchased and should be installed in July 1985.

The entrance-loss coefficients are high compared to earlier results for smooth seals. However, the damper seals operate at significantly lower Reynolds numbers than our earlier smooth seals; hence, some increase would be expected.

Dynamic Test Data

Figure 6 illustrates measured and theoretical results for F_r/A and F_θ/A versus R_a and ω for the hole-pattern stator. The measured results are taken from table B.1, while the theoretical results are calculated using the analysis of [2] with the empirical parameters of table 2. An inspection of these results demonstrates a "reasonable" agreement between theory and experiment with respect to the tangential force but much larger measured radial-force-coefficient magnitudes at low speeds than predicted. Further, the magnitude of F_r/A decreases more rapidly with increasing running speed than predicted. Figures 7 through 18 illustrate measured and theoretical predictions for the remaining seals which were tested.

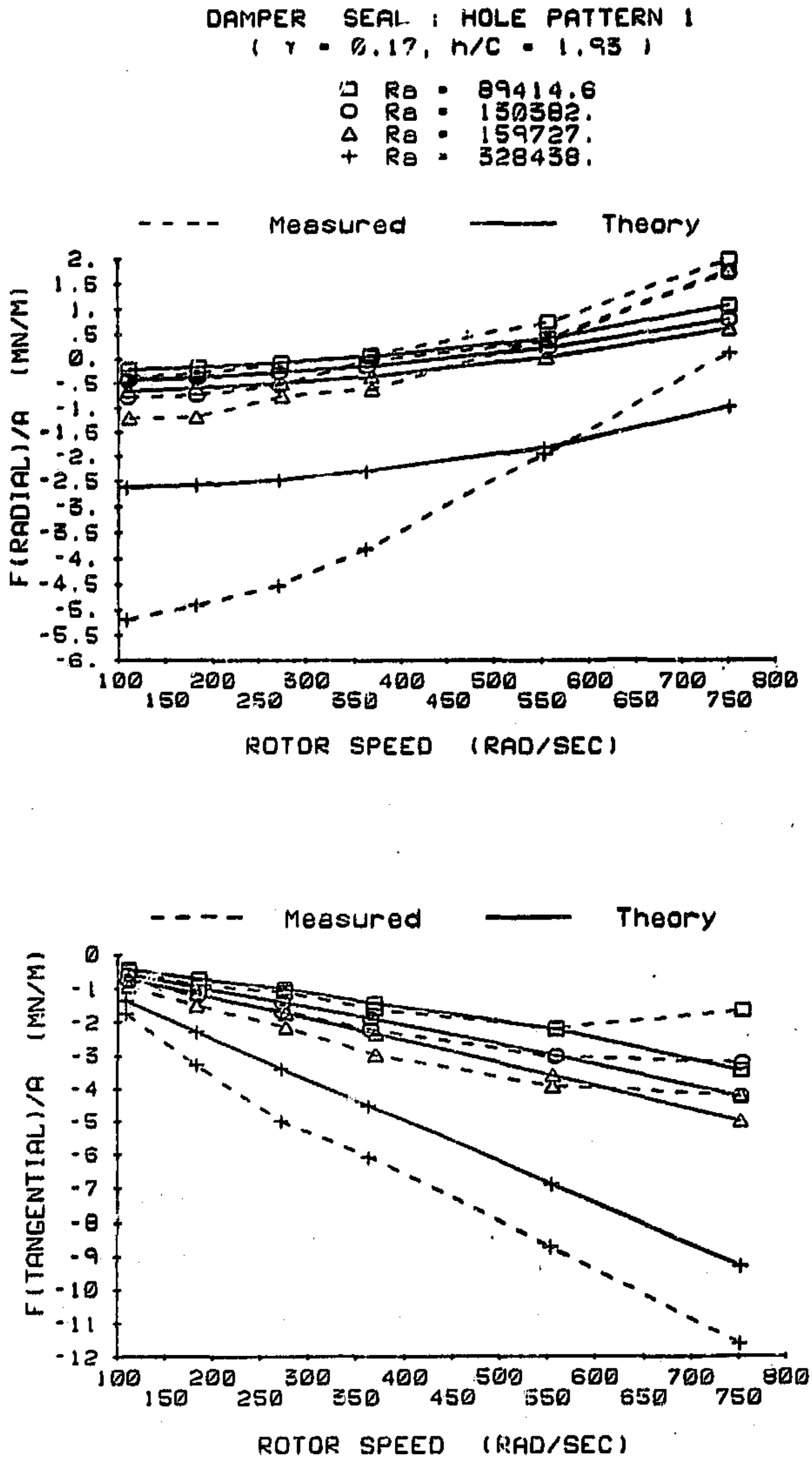


Figure 6. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 1.

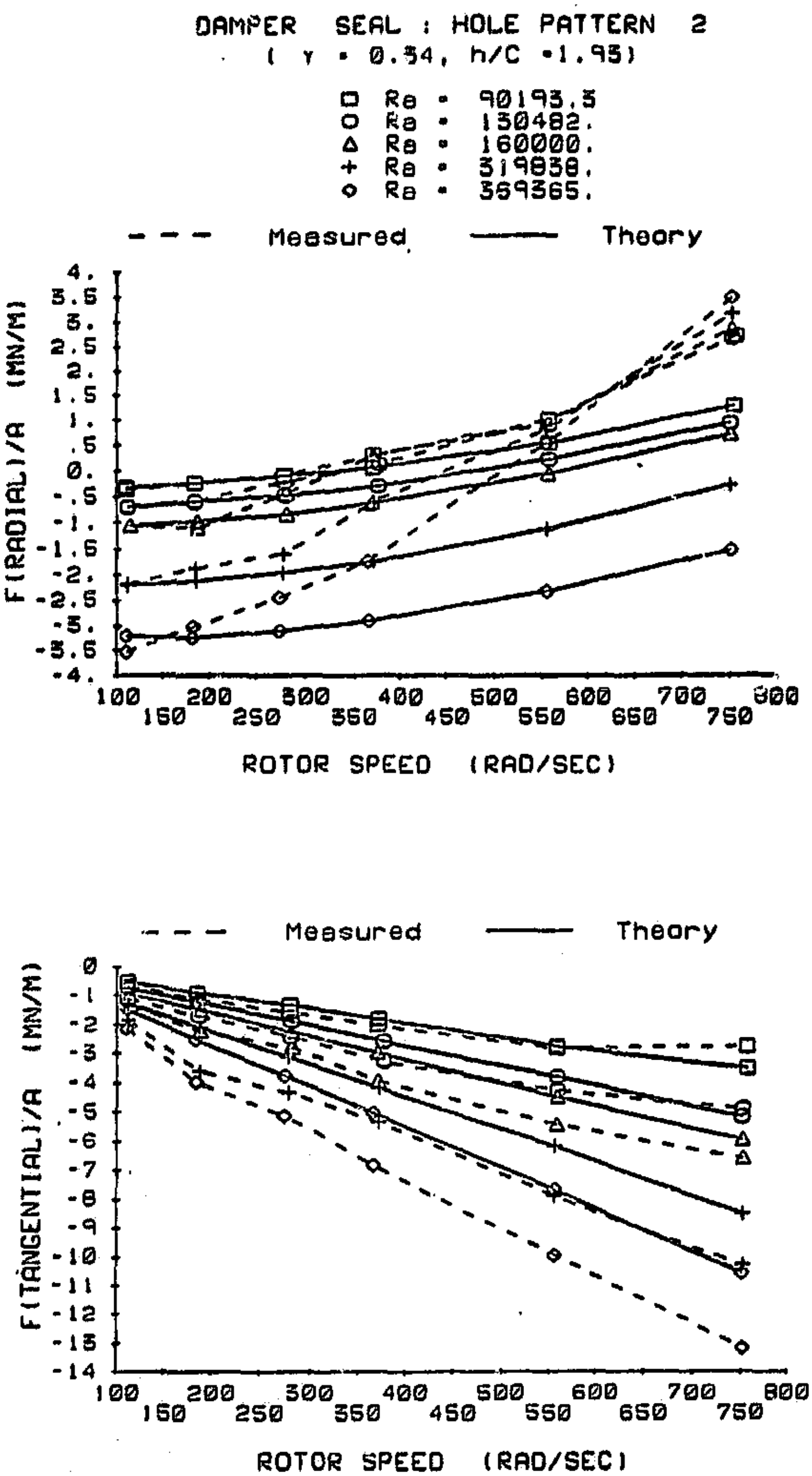


Figure 7. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 2

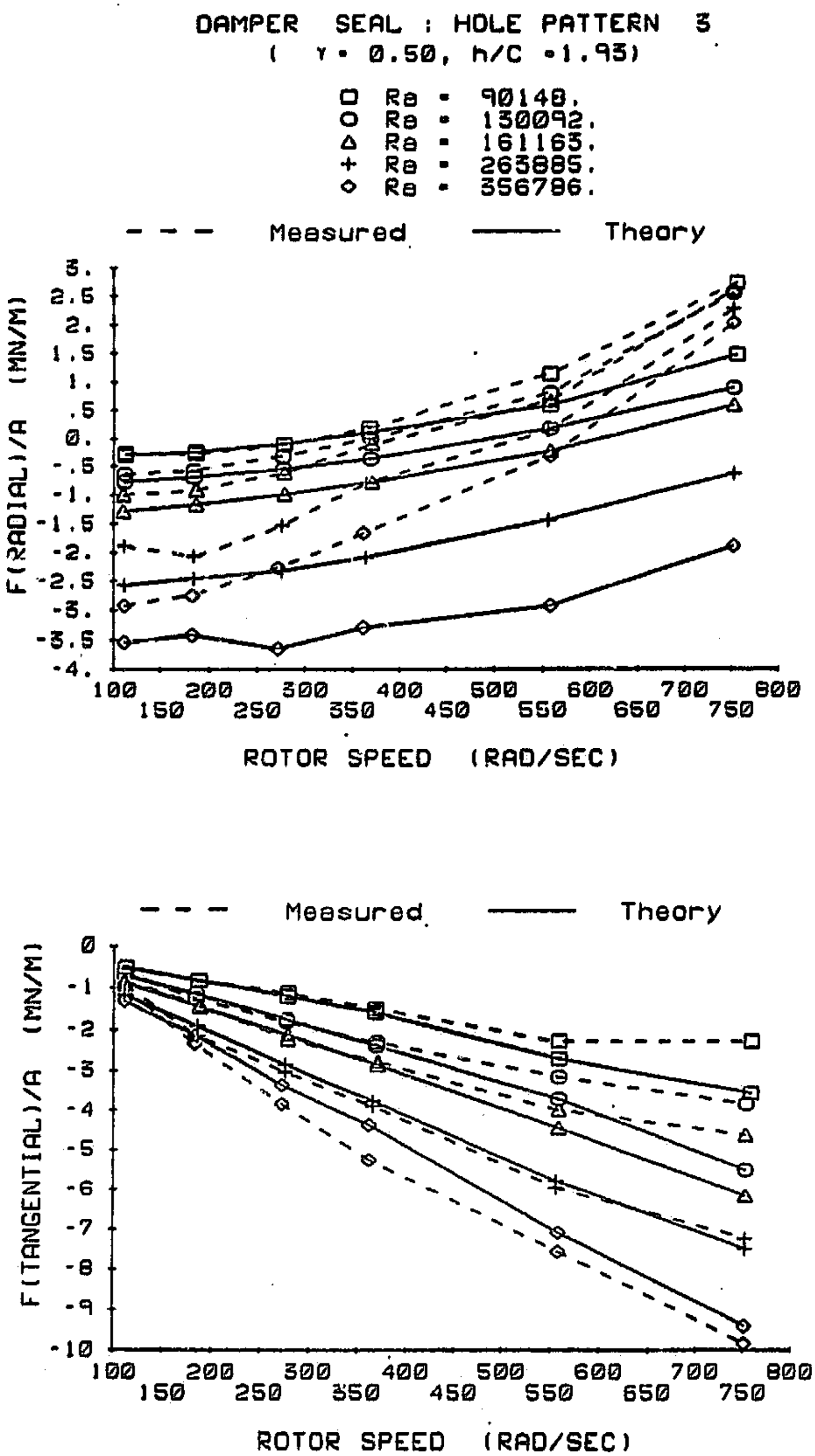
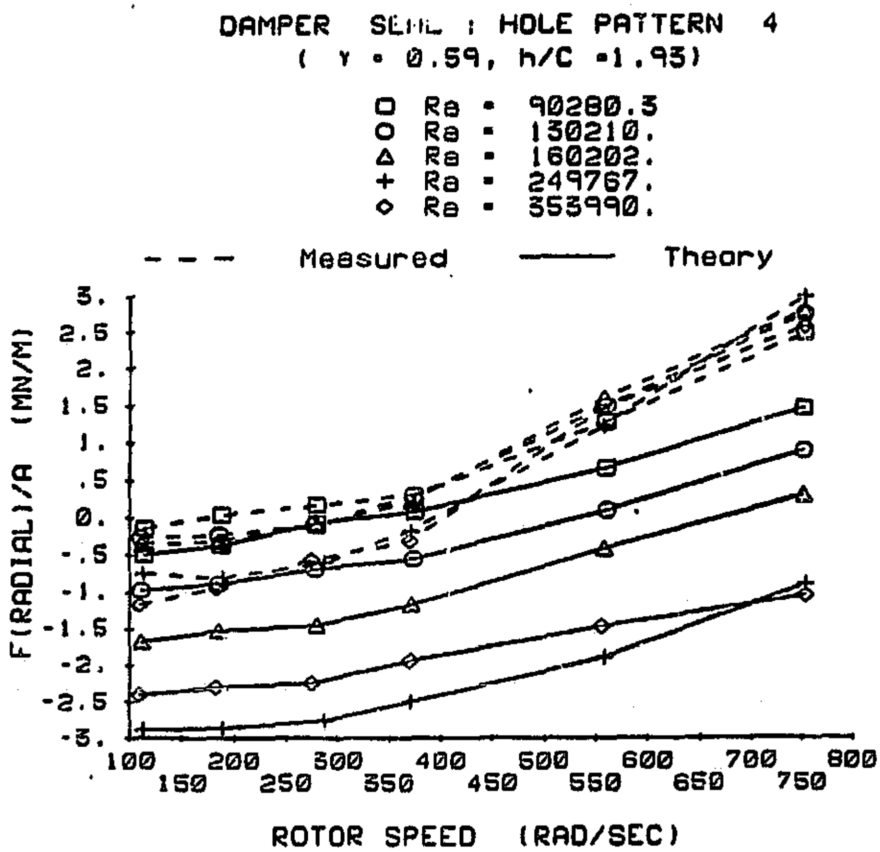


Figure 8. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 3.



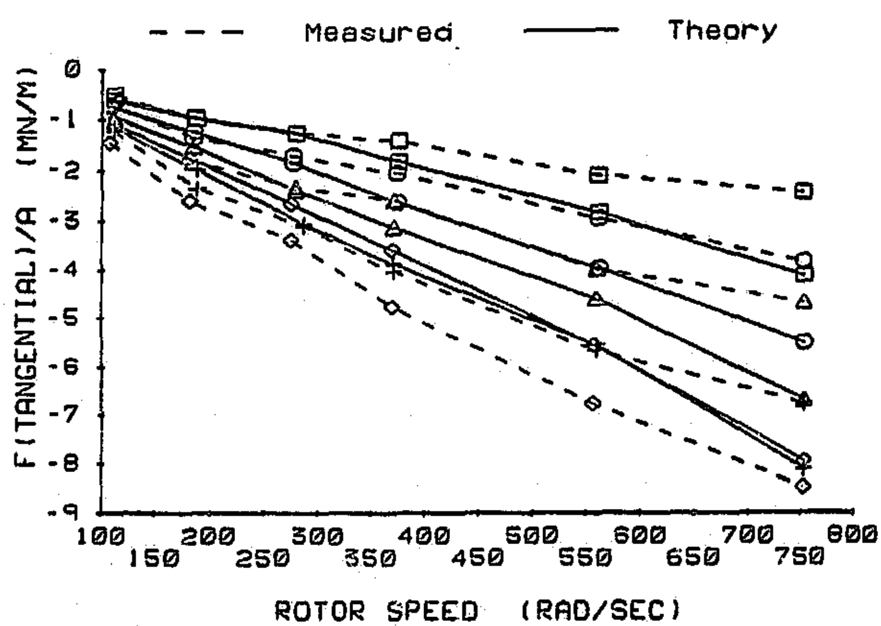


Figure 9. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 4.

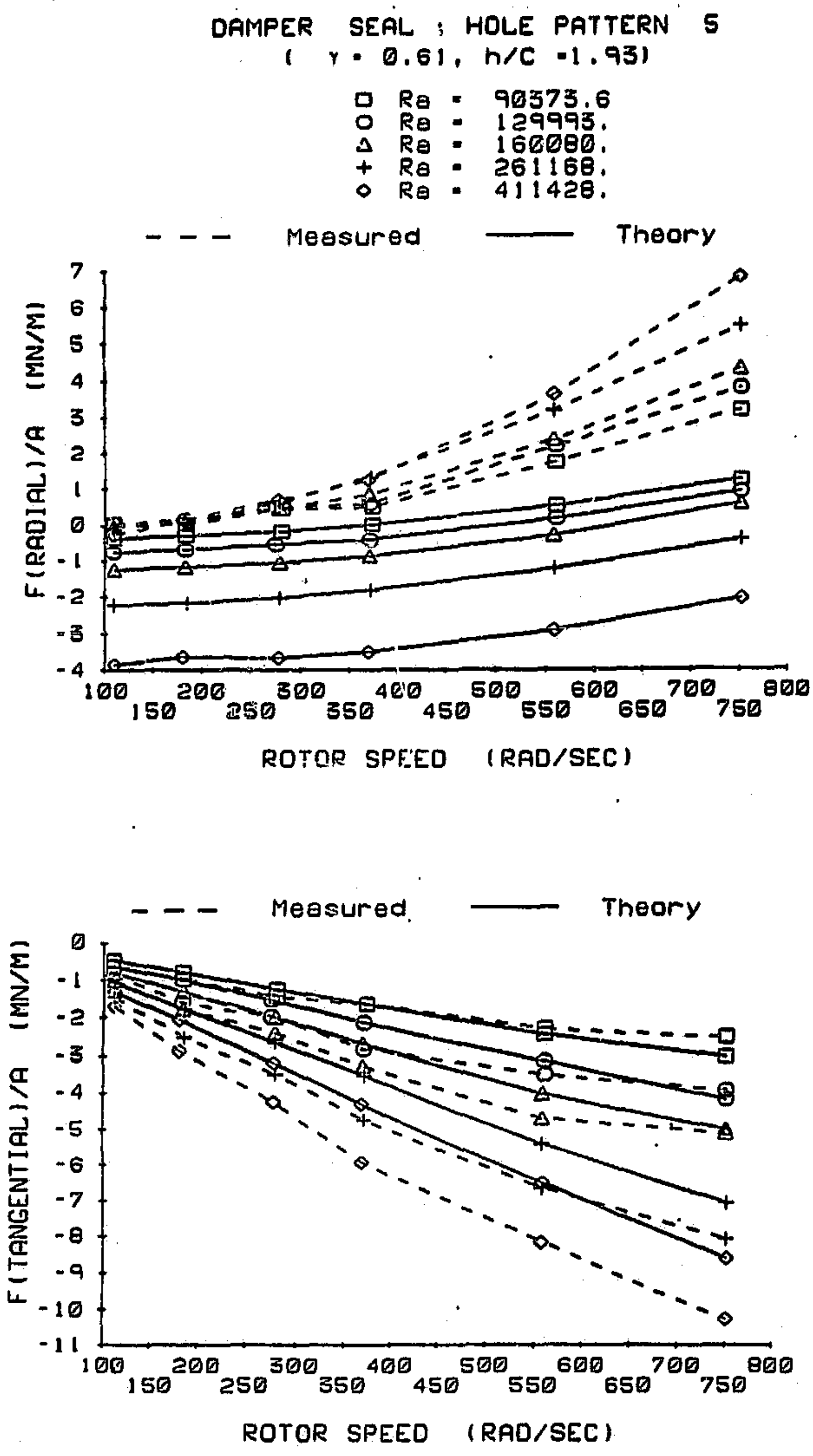


Figure 10. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 5.

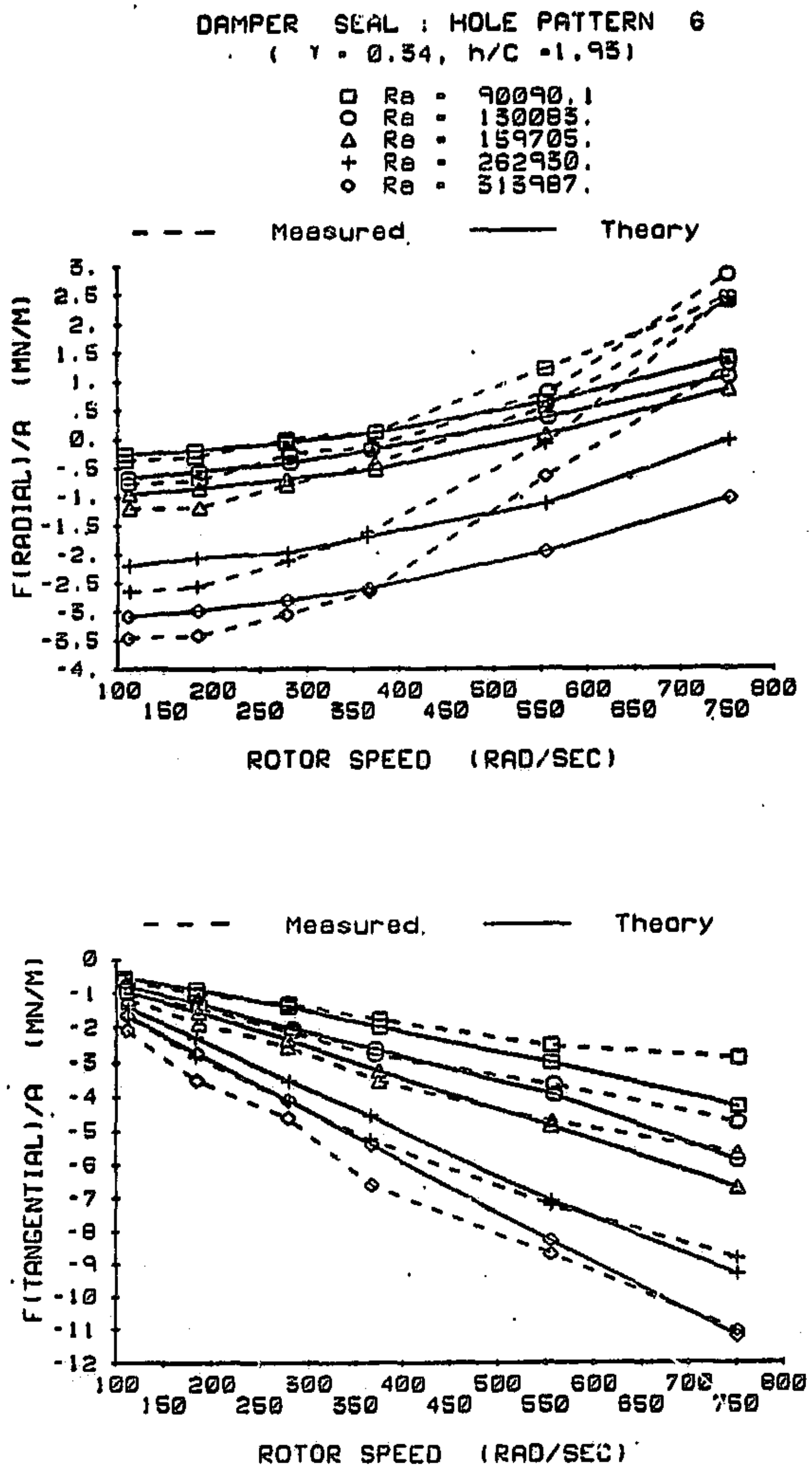


Figure 11. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 6.

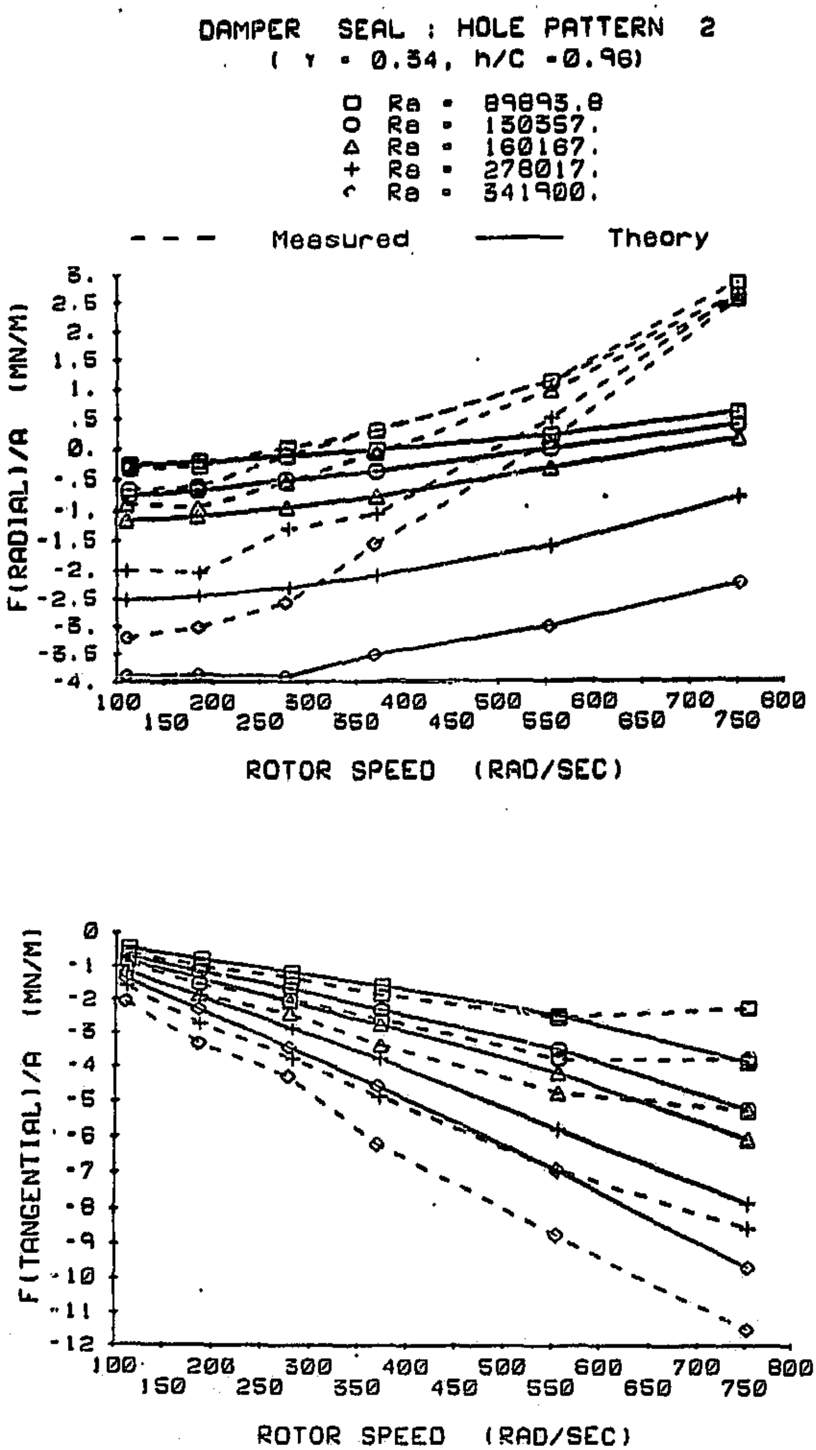


Figure 12. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 7.

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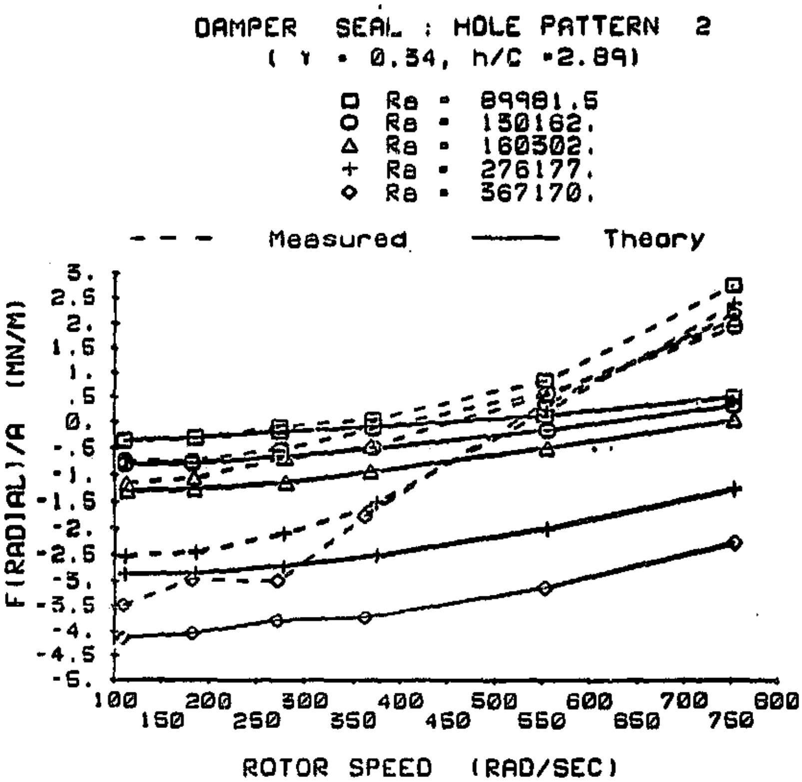

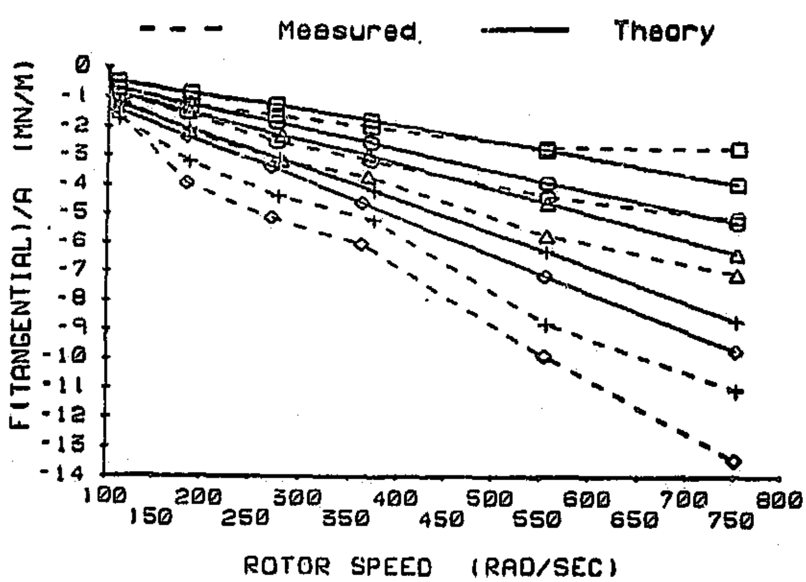

Figure 13. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 8.

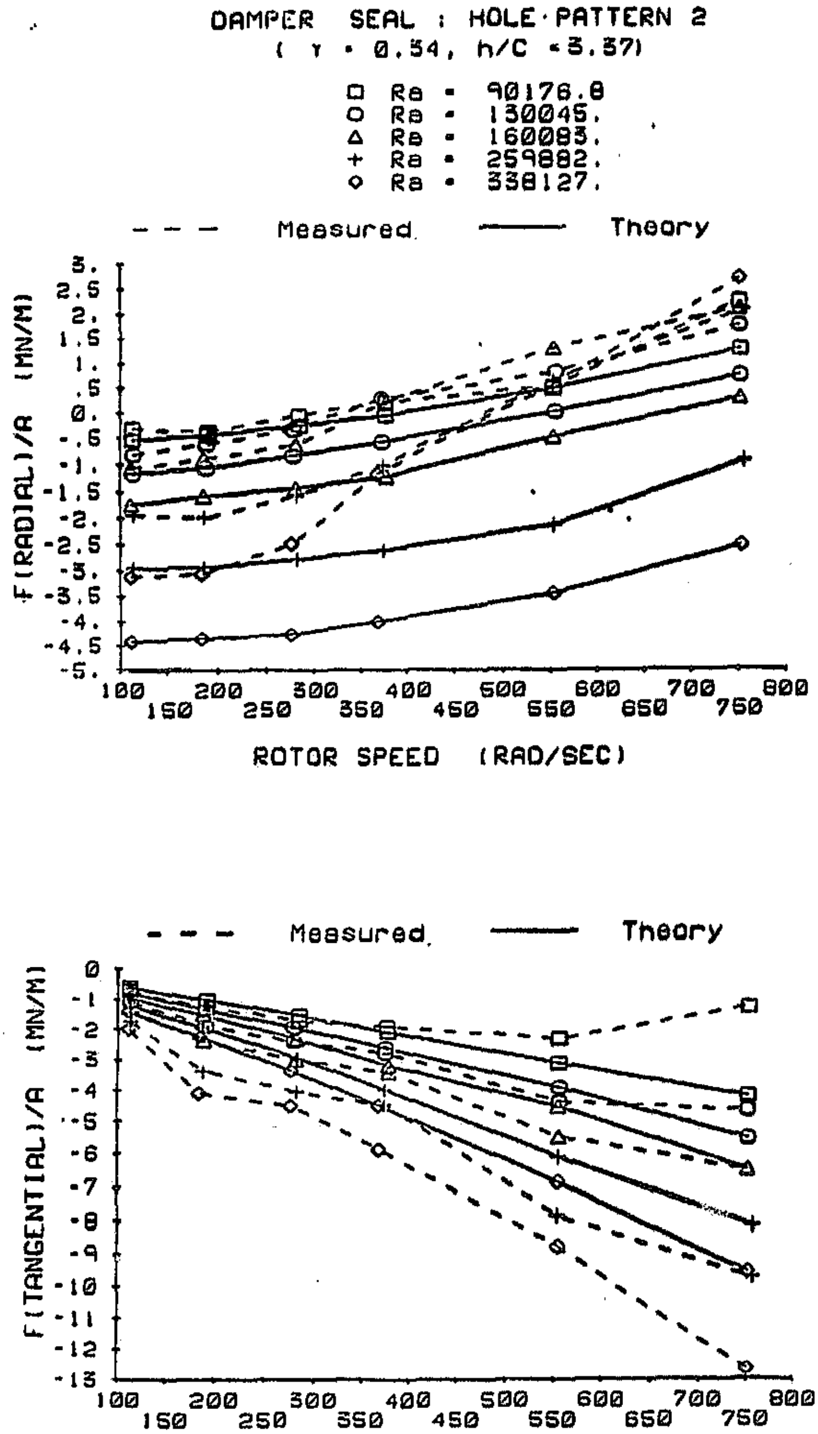

Figure 14. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 9.

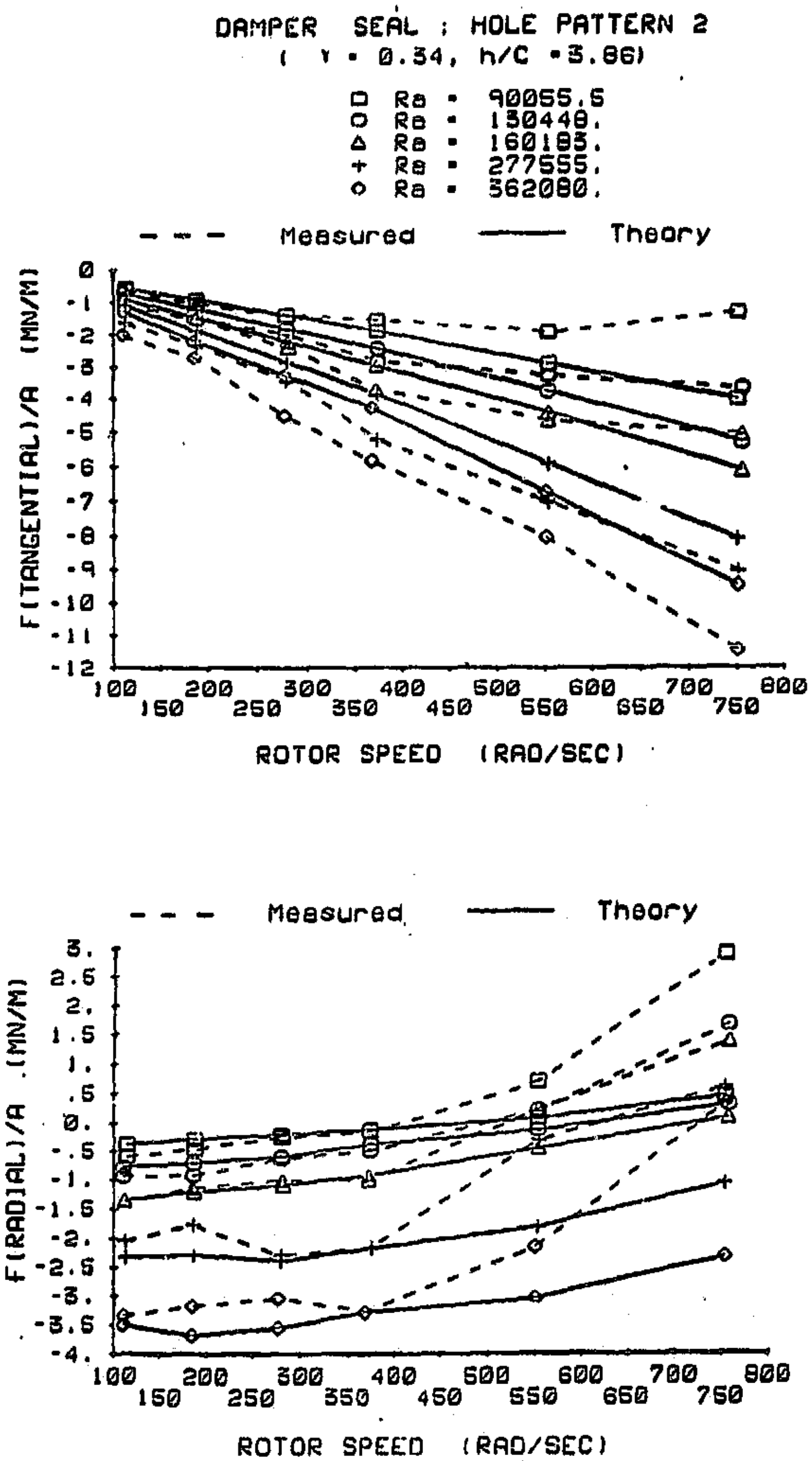

Figure 15. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 10.

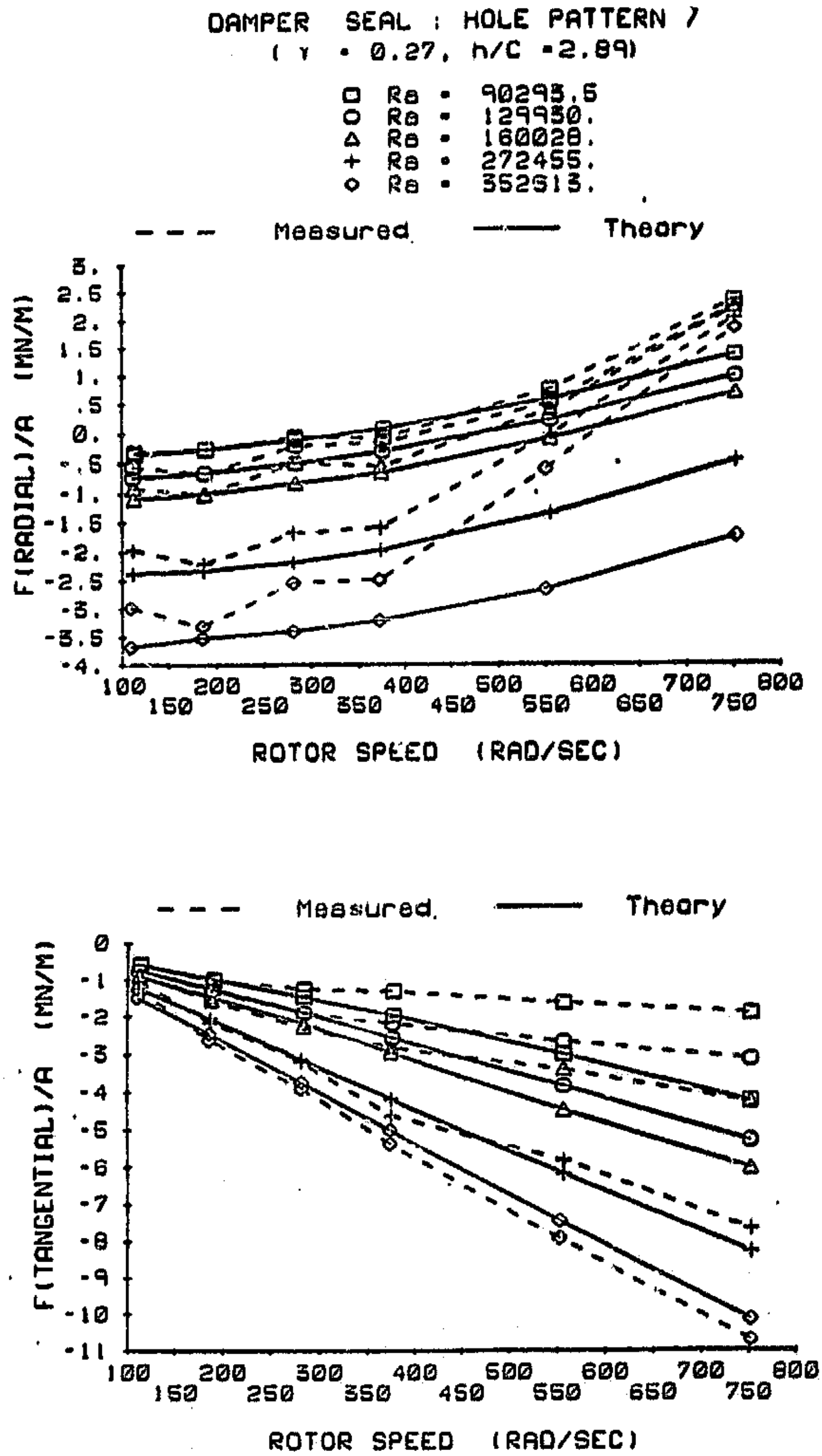

Figure 16. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 11.

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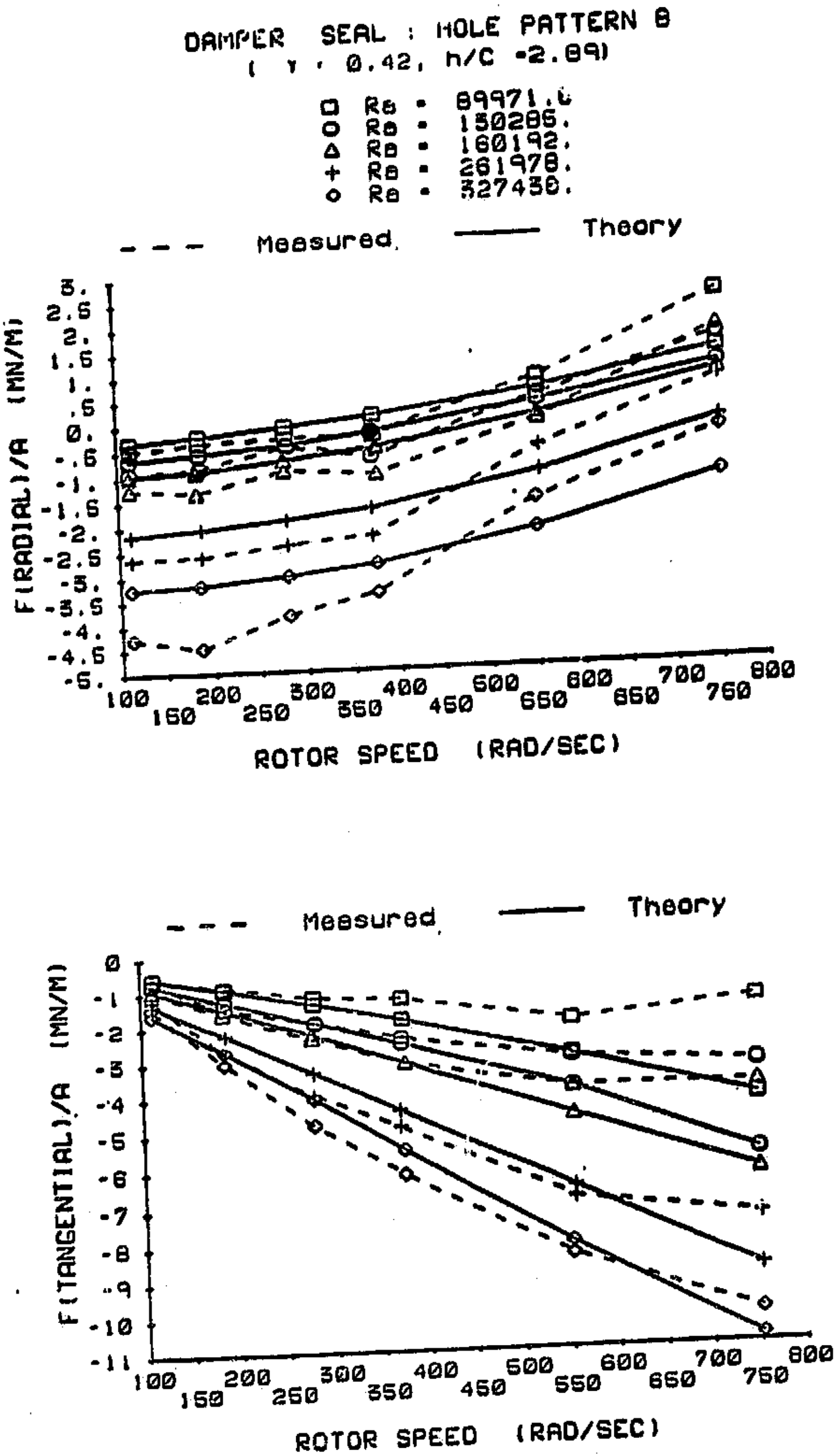

Figure 17. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 12.

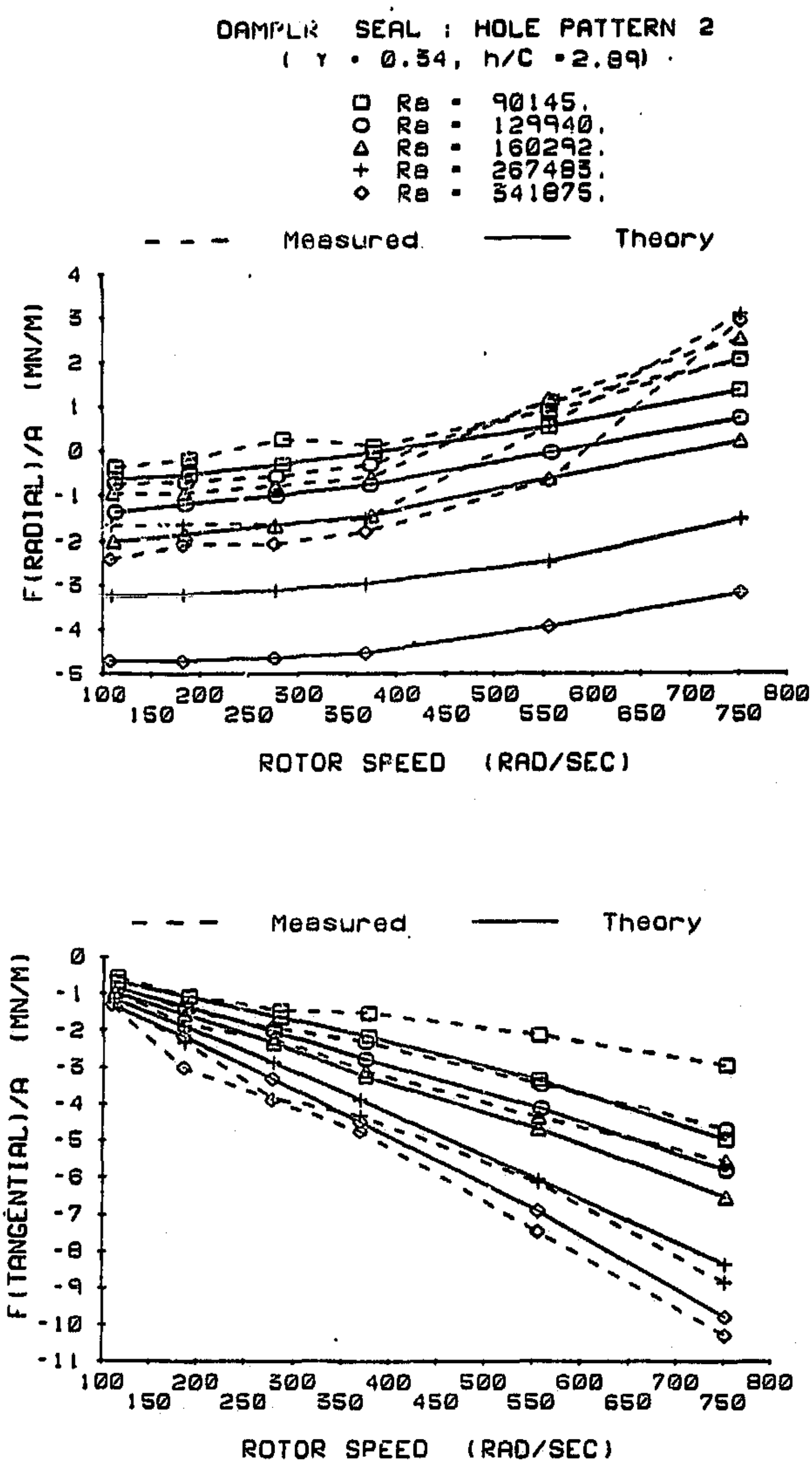

Figure 18. Measured and theoretical [2] results for F_r/A and F_θ/A; stator 13.

Eq. (3) provides the basis for a quantitative comparison of theory and experiment. At first glance these equations suggest that sufficient independent equations could be obtained to calculate all the rotordynamic coefficients by simply testing at three running speeds. However, the fact that the coefficients depend on ω precludes this approach. While K, C, and M are weak functions of ω through their dependence on σ, the "cross-coupled" coefficients k and c are linear functions of ω. In fact, if the fluid is prerotated prior to entering the seal such that the inlet tangential velocity is $U_{\theta o} = R\omega/2$, then theory predicts that $k = C\omega/2$, $c = M\omega$, and

$$F_r/A = -K, \; F_\theta/A = -C\omega/2 \tag{8}$$

The present test apparatus provides no intentional prerotation, and the expected result is of the form

$$\begin{aligned} k &= b_1 C\omega/2, \; b_1<1 \\ c &= b_2 M\omega, \; b_2<1 \end{aligned} \tag{9}$$

$$\begin{aligned} F_\theta/A &\cong -C_{ef}\,\omega = -C(1-b_1/2)\omega \\ F_r/A &\cong -K_{ef} + M_{ef}\,\omega^2 = -K + M(1-b_2)\omega^2 \end{aligned} \tag{10}$$

The term C_{ef} denotes the "net damping coefficient" resulting from the drag force $C\omega A$ and the forward whirl excitation force kA. A direct comparison between theory and experiment is obtained by curvefitting the theoretical and experimental results for the F_r/A and F_θ/A to obtain predictions for K_{ef}, C_{ef}, and M_{ef}. Note that the procedure of curvefitting the data with respect to ω eliminates the running-speed dependency. Further, K_{ef} is the zero-running speed intercept of the F_r/A versus ω curve, and C_{ef} is the slope of the F_θ/A versus ω curve.

Experimentally-determined values are presented in tables 3(a) through 3(c) for K_{ef}, C_{ef}, and M_{ef}. A comparison of theoretical and

S. I. Units	KEF(EXP)	CEF(EXP)	MEF(EXP)	KEF(EX/TH)	CEF(EX/TH)	MEF(EX/TH)
STATOR 1	DAMPER SEAL : HOLE PATTERN 1		C = 0.5271 mm			
	Hole Dia.=2.8mm, Hole Depth=1.016mm, Gamma=0.17, h/C =1.93					
RA= 0.8941E 05	0.2755E 06	2100.	5.200	1.573	0.4506	1.94
RA= 0.1304E 06	0.8111E 06	3974.	4.395	1.768	0.6997	2.25
RA= 0.1597E 06	0.1268E 07	5275.	5.292	1.876	0.7867	2.58
RA= 0.3284E 06	0.5616E 07	0.1486E 05	6.693	2.175	1.205	1.88
STATOR 2	DAMPER SEAL : HOLE PATTERN 2		C = 0.5271 mm			
	Hole Dia.=3.8mm, Hole Depth=1.016mm, Gamma=0.34, h/C =1.93					
RA= 0.9019E 05	0.2323E 06	3470.	6.85	0.6626	0.7308	2.59
RA= 0.1305E 06	0.7260E 06	0.6070E 04	6.09	0.9654	0.8728	2.32
RA= 0.1600E 06	0.1446E 07	0.8295E 04	4.505	1.297	1.049	1.54
RA= 0.3198E 06	0.2514E 07	0.1269E 05	7.44	1.106	1.129	2.34
RA= 0.3694E 06	0.3870E 07	0.1683E 05	9.65	1.198	1.192	2.64
STATOR 3	DAMPER SEAL : HOLE PATTERN 3		C = 0.5271 mm			
	Hole Dia.=4.7mm, Hole Depth=1.016mm, Gamma=0.50, h/C =1.93					
RA= 0.9015E 05	0.1735E 06	2961.	7.365	0.5407	0.6081	2.34
RA= 0.1301E 06	0.5442E 06	4882.	7.068	0.6470	0.6612	2.81
RA= 0.1612E 06	0.9886E 06	6001.	7.107	0.7214	0.7297	2.75
RA= 0.2639E 06	0.2133E 07	9715.	7.239	0.8040	0.9752	2.49
RA= 0.3568E 06	0.3093E 07	0.1354E 05	7.818	0.9420	1.060	1.43
STATOR 4	DAMPER SEAL : HOLE PATTERN 4		C = 0.5271 mm			
	Hole Dia.=7.1mm, Hole Depth=1.016mm, Gamma=0.59, h/C =1.93					
RA= 0.9028E 05	0.5960E 05	2927.	5.658	0.9543E-01	0.5336	2.69
RA= 0.1302E 06	0.3373E 06	4675.	6.258	0.3235	0.6287	2.12
RA= 0.1602E 06	0.5196E 06	5619.	5.723	0.2839	0.6348	2.21
RA= 0.2498E 06	0.7377E 06	8607.	8.996	0.2601	0.8120	1.95
RA= 0.3540E 06	0.1553E 07	0.1093E 05	4.046	0.5971	1.026	4.57
STATOR 5	DAMPER SEAL : HOLE PATTERN 5		C = 0.5271 mm			
	Hole Dia.=8.6mm, Hole Depth=1.016mm, Gamma=0.61, h/C =1.93					
RA= 0.9037E 05	-0.6725E 05	2970.	6.896	-0.1708	0.7276	2.40
RA= 0.1300E 06	-0.5320E 05	4810.	7.827	-0.6836E-01	0.8600	2.63
RA= 0.1601E 06	0.1038E 06	6649.	8.171	0.8459E-01	0.9858	2.20
RA= 0.2612E 06	0.4555E 06	0.1043E 05	8.012	0.2023	1.099	2.36
RA= 0.4114E 06	0.3527E 06	0.1344E 05	12.62	0.9456E-01	1.165	3.21
STATOR 6	DAMPER SEAL : HOLE PATTERN 6		C = 0.5271 mm			
	Hole Dia.=2.8mm, Hole Depth=1.016mm, Gamma=0.34, h/C =1.93					
RA= 0.9009E 05	0.4284E 06	3598.	5.250	1.447	0.6171	1.78
RA= 0.1301E 06	0.6089E 06	5824.	8.315	0.7796	0.7524	3.77
RA= 0.1597E 06	0.1224E 07	7076.	7.183	1.215	0.7904	2.49
RA= 0.2629E 06	0.2676E 07	0.1104E 05	10.24	1.222	0.8890	2.48
RA= 0.3140E 06	0.3676E 07	0.1389E 05	8.774	1.171	0.9297	2.6[illegible]

Table 3(a). Measured values for K_{ef}, C_{ef}, and M_{ef}; comparison of theory and experiment for stators 1 through 6, $h/C_r = 1.93$.

		KEF(EXP)	CEF(EXP)	MEF(EXP)	KEF(EX/TH)	CEF(EX/TH)	MEF(EX/TH)
STATOR 7	DAMPER SEAL : HOLE PATTERN 2 C = 0.5271 mm						
	Hole Dia.=3.8mm, Hole Depth=0.508mm, Gamma=0.34, h/C =0.96						
	RA= 0.8989E 05	0.2190E 06	2852.	7.199	0.7205	0.5360	6.45
	RA= 0.1304E 06	0.9267E 06	4814.	4.113	1.011	0.6806	7.10
	RA= 0.1602E 06	0.1084E 07	6706.	5.895	0.8380	0.8223	4.53
	RA= 0.2780E 06	0.2193E 07	0.1085E 05	8.106	0.8598	1.029	2.71
	RA= 0.3419E 06	0.3649E 07	0.1479E 05	7.776	0.9279	1.147	2.27
STATOR 8	DAMPER SEAL : HOLE PATTERN 2 C = 0.5271 mm						
	Hole Dia.=3.8mm, Hole Depth=1.524mm, Gamma=0.34, h/C =2.89						
	RA= 0.8998E 05	0.1059E 05	3232.	9.027	0.2898E-01	0.5923	9.16
	RA= 0.1302E 06	0.7763E 06	6708.	5.218	0.8833	0.9288	3.56
	RA= 0.1603E 06	0.1205E 07	9307.	5.745	0.8512	1.078	3.68
	RA= 0.2762E 06	0.2662E 07	0.1470E 05	9.426	0.9087	1.256	3.36
	RA= 0.3672E 06	0.4133E 07	0.1774E 05	5.277	0.9893	1.358	1.95
STATOR 9	DAMPER SEAL : HOLE PATTERN 2 C = 0.5271 mm						
	Hole Dia.=3.8mm, Hole Depth=1.778mm, Gamma=0.34, h/C =3.37						
	RA= 0.9018E 05	0.1058E 06	1068.	6.873	0.1710	0.1850	2.69
	RA= 0.1300E 06	0.1231E 07	5880.	0.6532	0.9044	0.7903	0.369
	RA= 0.1601E 06	0.1772E 07	8169.	0.3152	0.9510	0.9378	0.120
	RA= 0.2599E 06	0.2408E 07	0.1231E 05	5.383	0.8491	1.122	1.06
	RA= 0.3381E 06	0.4001E 07	0.1578E 05	4.858	0.9045	1.234	1.29
STATOR 10	DAMPER SEAL : HOLE PATTERN 2 C = 0.5271mm						
	Hole Dia.=3.8mm, Hole Depth=2.032mm, Gamma=0.34, h/C =3.86						
	RA= 0.9006E 05	0.1485E 06	1194.	10.43	0.3773	0.2184	10.9
	RA= 0.1304E 06	0.8381E 06	4379.	6.007	0.9473	0.6132	7.36
	RA= 0.1602E 06	0.1315E 07	6653.	5.605	0.9046	0.8159	3.97
	RA= 0.2776E 06	0.1763E 07	0.1193E 05	8.983	0.8134	1.086	2.13
	RA= 0.3621E 06	0.2605E 07	0.1467E 05	13.33	0.7410	1.150	4.22

Table 3(b). Measured values for K_{ef}, C_{ef}, and M_{ef}; comparison of theory and experiment for stators 7 through 10, $\gamma = 0.34$.

S. I. Units

	KEF(EXP)	CEF(EXP)	MEF(EXP)	KEF(EX/TH)	CEF(EX/TH)	MEF(EX/TH)
STATOR 11 DAMPER SEAL : HOLE PATTERN 7 C = 0.5271 mm						
Hole Dia.=3.55mm, Hole Depth=1.524mm, Gamma=0.27, h/C =2.89						
RA= 0.9029E 05	-1279.	1936.	8.094	-0.3138E-02	0.3363	2.93
RA= 0.1299E 06	0.3823E 06	3599.	7.500	0.4760	0.5045	2.80
RA= 0.1600E 06	0.7315E 06	5111.	8.319	0.6294	0.6279	2.98
RA= 0.2725E 06	0.1883E 07	0.1015E 05	10.66	0.7844	0.9169	2.85
RA= 0.3526E 06	0.2945E 07	0.1464E 05	12.19	0.7987	1.079	3.74
STATOR 12 DAMPER SEAL : HOLE PATTERN 8 C = 0.5271 mm						
Hole dia.=4.31mm, Hole depth=1.524mm, Gamma=0.42, h/C =2.89						
RA= 0.8997E 05	0.1325E 06	1725.	8.789	0.3671	0.2979	3.64
RA= 0.1303E 06	0.8475E 06	3914.	5.403	1.129	0.5068	2.47
RA= 0.1602E 06	0.9309E 06	4753.	9.074	0.8972	0.5668	3.27
RA= 0.2620E 06	0.2712E 07	9689.	7.283	1.238	0.8247	2.00
RA= 0.3274E 06	0.4861E 07	0.1337E 05	4.877	1.499	0.9274	1.18
STATOR 13 DAMPER SEAL : HOLE PATTERN 2 C = 0.5271 mm						
Hole Dia.=3.8mm, Hole Depth=1.524mm, Gamma=0.34(Round Bottom), h/C =2.89						
RA= 0.9015E 05	0.3207E 06	3526.	4.106	0.4033	0.5264	1.85
RA= 0.1299E 06	0.8894E 06	5905.	5.172	0.5731	0.7602	2.71
RA= 0.1603E 06	0.9691E 06	7124.	8.108	0.4500	0.8184	2.83
RA= 0.2675E 06	0.1149E 07	0.1130E 05	15.55	0.3703	0.9998	3.38
RA= 0.3419E 06	0.1541E 07	0.1340E 05	17.35	0.3332	1.019	4.35

Table 3(c). Measured values for K_{ef}, C_{ef}, and M_{ef}; comparison of theory and experiment for stators 11 through 13.

experimental results is also presented in these tables. The results of table 3(a) generally reflect the changes in hole patterns 1 through 6 with a constant h/C_r ratio. The results of table 3(a) support the following general conclusions:

(a) Measured direct stiffness values are larger than predicted for γ = 0.17, 0.34.

(b) Measured direct stiffness values are smaller than predicted for γ = 0.50, 0.59, 0.61.

(c) Measured effective damping coefficients are reasonably well predicted by theory, and the prediction improves with increasing values of R_a.

(d) Measured M_{ef} values are much larger than theory, generally by a factor of 2 to 2.5.

The test results of table 3(b) were taken to examine the influence of changing the h/C_r ratio of a hole-pattern-two stator. The results support the following general conclusions:

(a) Measured direct stiffness values are slightly smaller than predicted (generally by about 10%)

(b) Measured damping values are slightly larger than predicted.

(c) Measured added mass values are much larger than predicted.

As will be discussed in more detail in the following section, test results from tables 3(a) and 3(b) showed that the optimum seal, from a damping viewpoint, used hole pattern 2 (γ = 0.34) with h/C_r = 2.89. The results of table 3(c) were taken to further refine the optimum choice by maintaining the h/C_r ratio and (a) varying γ, and (b) holding γ and h/C_r constant and testing the influence of a spherical bottom.

The results for stators 11 and 12 are similar to earlier results with respect to K_{ef}, C_{ef}, and M_{ef}; however, the spherical-bottomed hole of stator 13 shows the measured stiffness values to be much lower than predicted.

DISCUSSION OF RESULTS: COMPARISON OF STATOR CONFIGURATIONS

The relative merit of the stator configurations which were tested with respect to stiffness, net damping, and leakage characteristics is the subject of this section. The K_{ef} and C_{ef} parameters of the preceeding sections are used as a measure of the direct stiffness and net damping. The leakage coefficient C_L is defined using the conventional discharge coefficient definition

$$\Delta P = C_d \frac{\rho V^2}{2} \tag{11}$$

which yields

$$\dot{Q} = 2\pi R C_r V = \left(\frac{C_r}{R}\right) C_d^{-1/2} \cdot 2\pi R^2 \sqrt{\frac{2\Delta P}{\rho}} = C_L \cdot 2\pi R^2 \sqrt{\frac{2\Delta P}{\rho}}$$

Hence,

$$C_L = \left(\frac{C_r}{R}\right) C_d^{-1/2} = \dot{Q} / \left(2\pi R^2 \sqrt{\frac{2\Delta P}{\rho}}\right) \tag{12}$$

The coefficient C_L is a nondimensional relative measure of the leakage to be expected through seals housing the same radius.

The tests which were carried out had the objective of experimentally determining the round-hole-pattern-stator configuration which would yield a maximum net damping coefficient, C_{ef}. The test program proceeded by first testing hole patterns 1 through 6 with a constant hole depth such that $h/C_r = 1.93$. The results of this test series is presented in figures 19 through 21 and supports the following general conclusions:

(a) Hole pattern 2 with $\gamma = 0.34$ yields the maximum damping value.

(b) Direct stiffness generally falls with increasing γ.

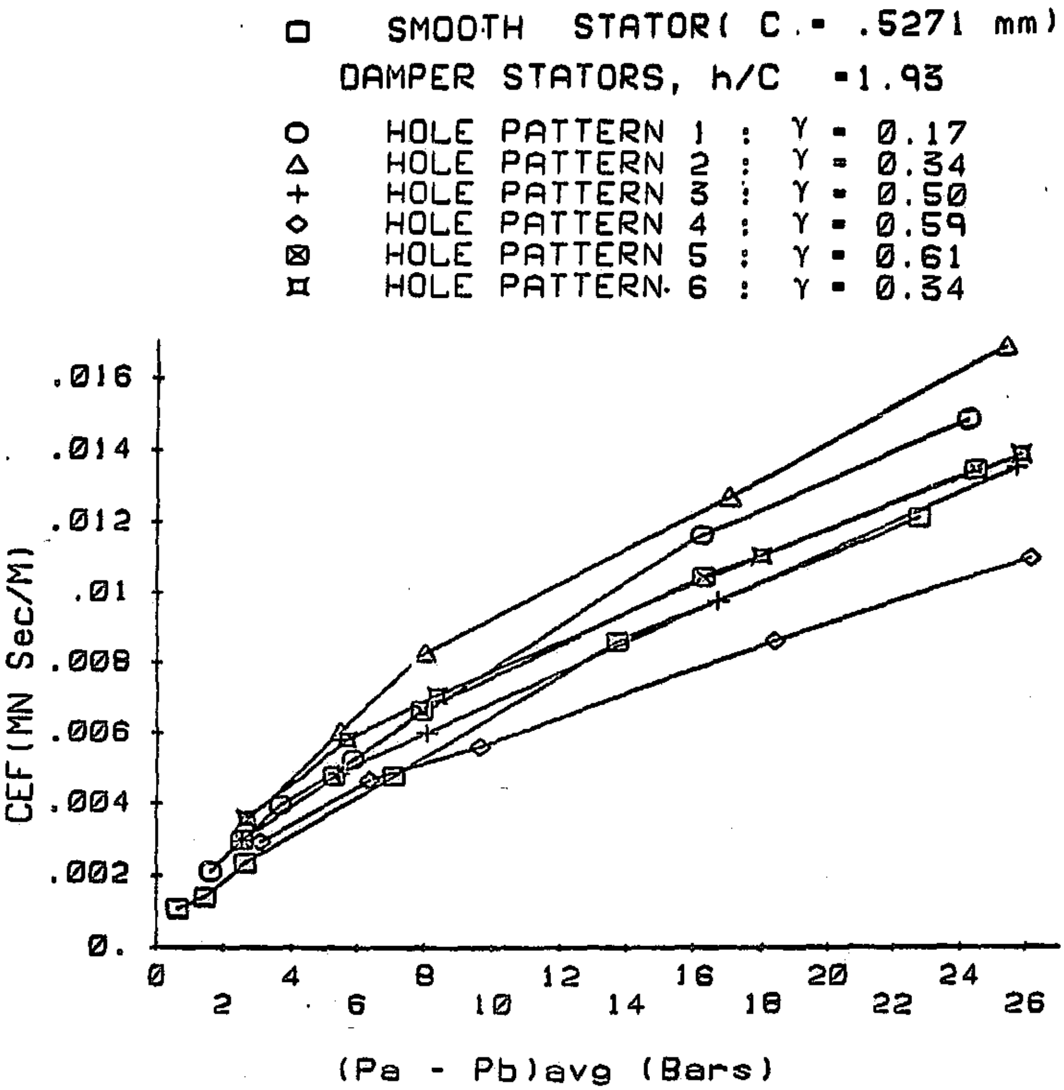

Figure 19. C_{ef} versus ΔP for a smooth stator and six different hole pattern with h/C_r = 1.93.

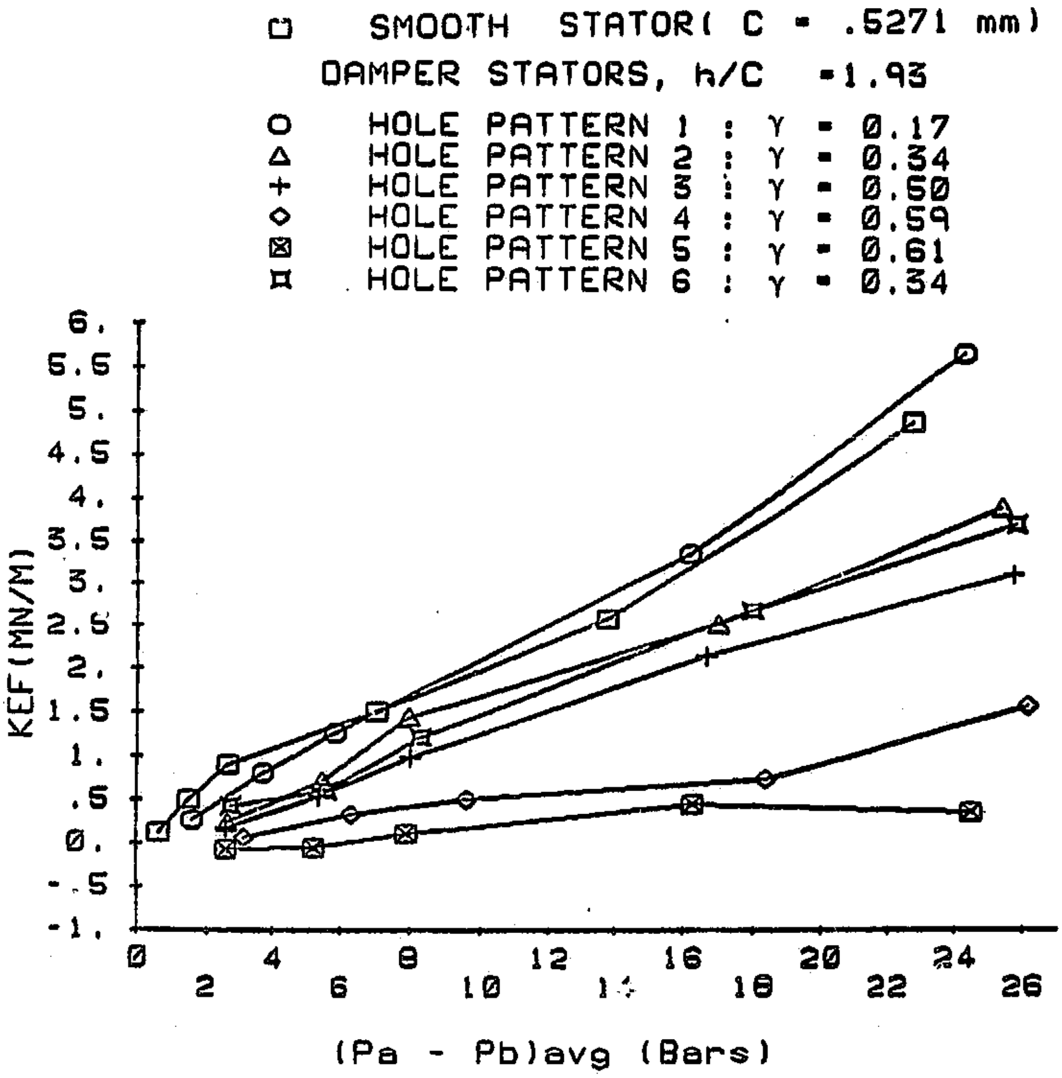

Figure 20. K_{ef} versus ΔP for a smooth stator and six different hole pattern with h/C_r = 1.93.

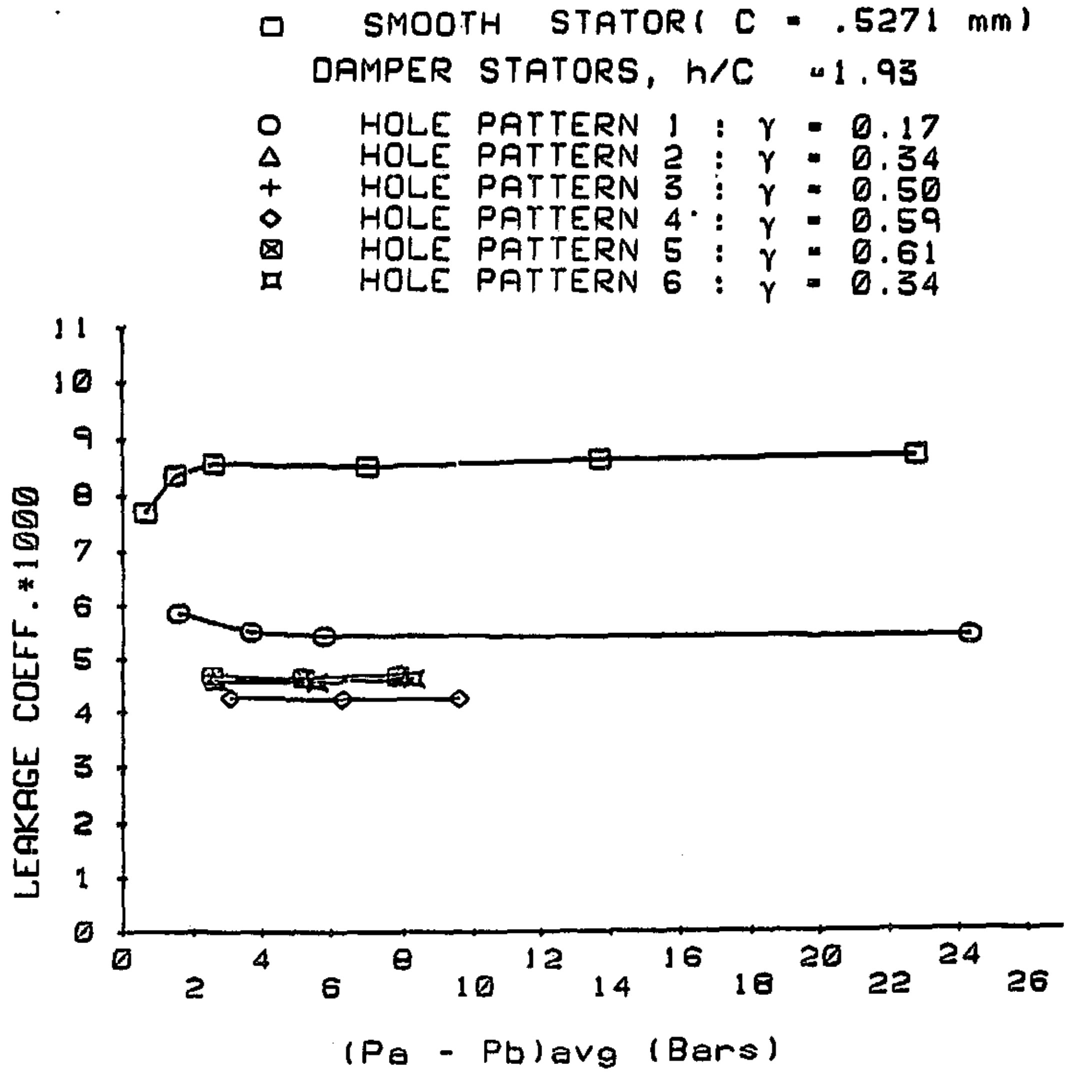

Figure 21. C_L versus ΔP for a smooth stator and six different hole pattern with h/C_r = 1.93.

(c) Leakage drops with increasing γ but rapidly reaches an asymptote.

(d) The in-line pattern of stator 6 has the same γ as hole pattern 2, but substantially less damping.

As a consequence of the results illustrated in figure 19, additional tests were carried out for hole pattern 2 ($\gamma = 0.34$), with different hole depths. Figures 22 through 24 illustrate C_{ef}, K_{ef}, and C_L versus ΔP for a smooth stator and stators using hole pattern 2 with five different h/C_r ratios. The results presented support the following general conclusions:

(a) Starting with a smooth rotor, C_{ef} increases with hole depth out to $h/C_r = 2.89$, but fall off for larger values of h/C_r.

(b) K_{ef} is about the same for all hole-pattern stators except for $h/Cr = 3.86$. All of the hole-pattern stators yield smaller K_{ef} values than does the smooth stator.

(c) C_L is relatively constant for all hole-pattern stators, and is approximately one half of the corresponding value for a smooth stator.

Combining the results of the first two test series suggests that the optimum seal configuration would use hole-pattern 2 with $\gamma = 0.34$ and $h/C_r = 2.89$. To verify this optimum two additional stators were tested which used hole-patterns 7 ($\gamma = 0.27$) and hole-pattern 8 ($\gamma = 0.42$) with $h/C_r = 2.89$. The results of these tests are shown in figures 25 through 27 and are seen to yield smaller C_{ef} values than hole pattern 2 with $h/C_r = 2.89$. Finally, a stator was manufactured which coincided with the maximum-damping configuration except in the

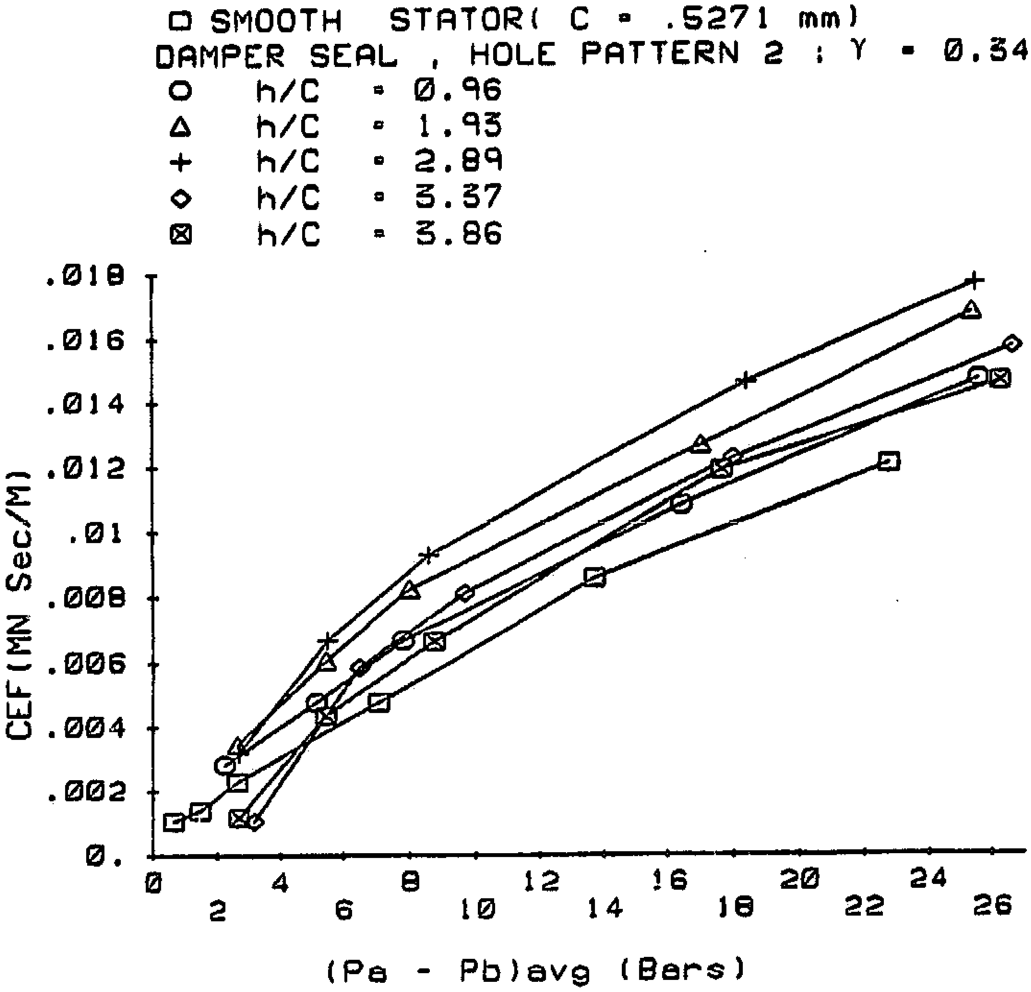

Figure 22. C_{ef} versus ΔP for a smooth stator and stators using hole-pattern 2 with five values of h/C_r.

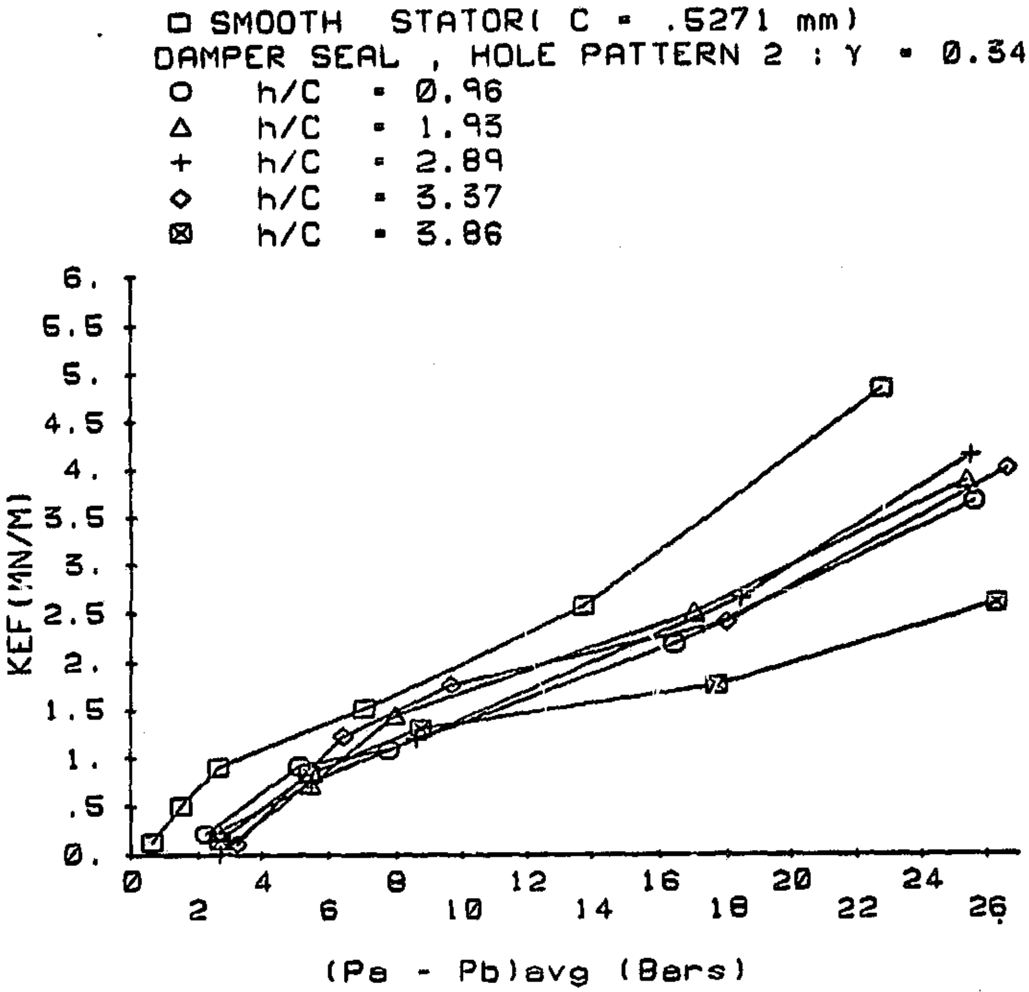

Figure 23. K_{ef} versus ΔP for a smooth stator and stators using hole-pattern 2 with five values of h/C_r.

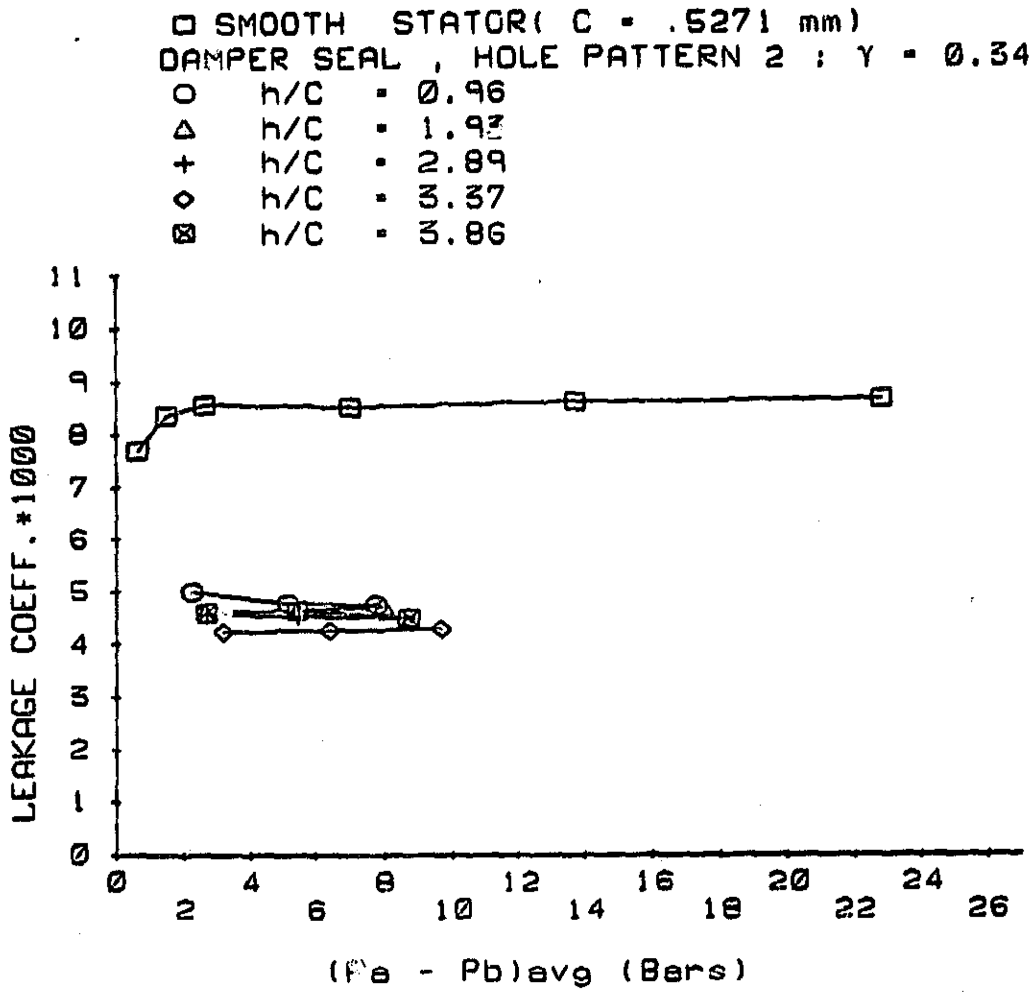

Figure 24. C_L versus ΔP for a smooth stator and stators using hole-pattern 2 with five values of h/C_r.

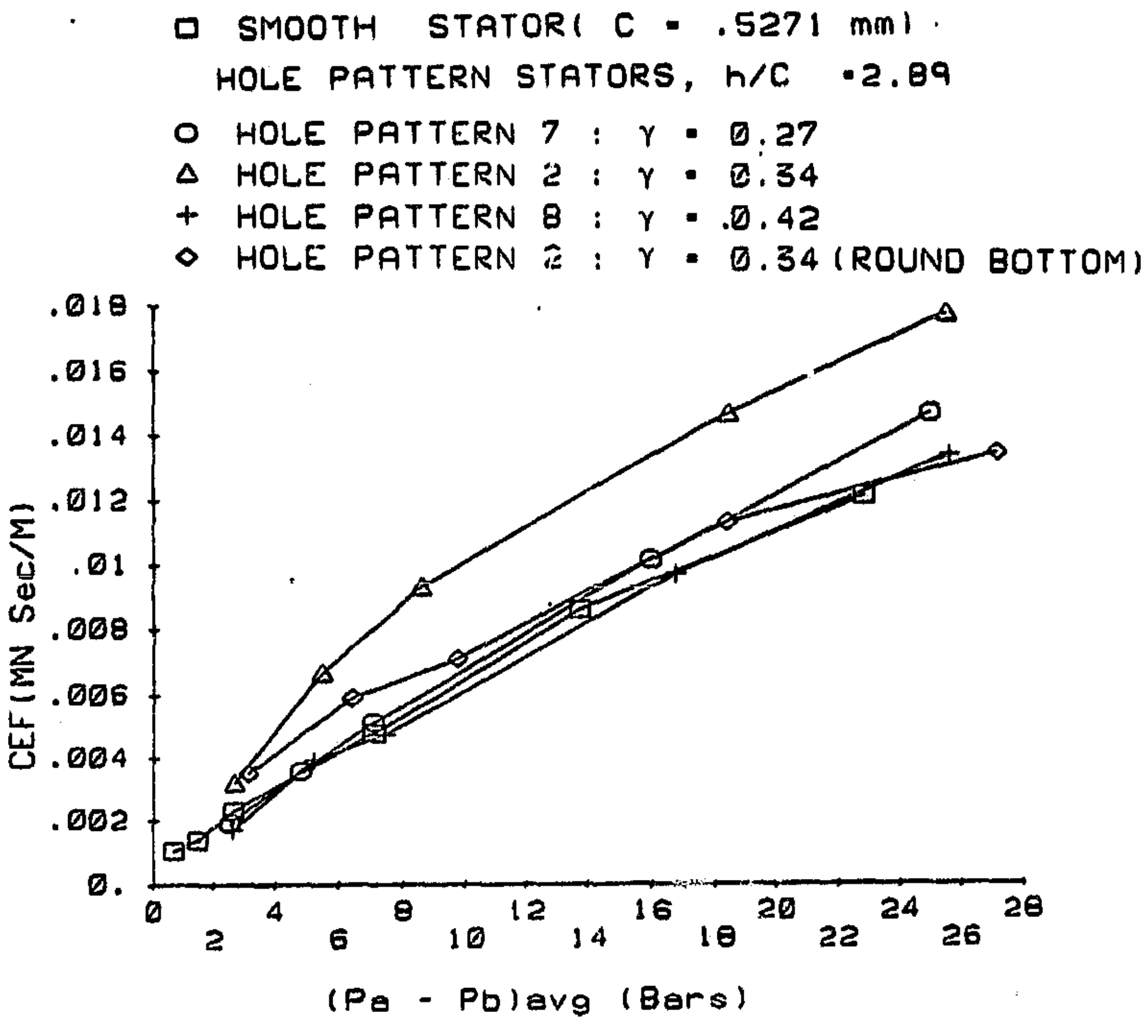

Figure 25. C_{ef} versus ΔP for a smooth stator and four hole-pattern stators with h/C_r = 2.89.

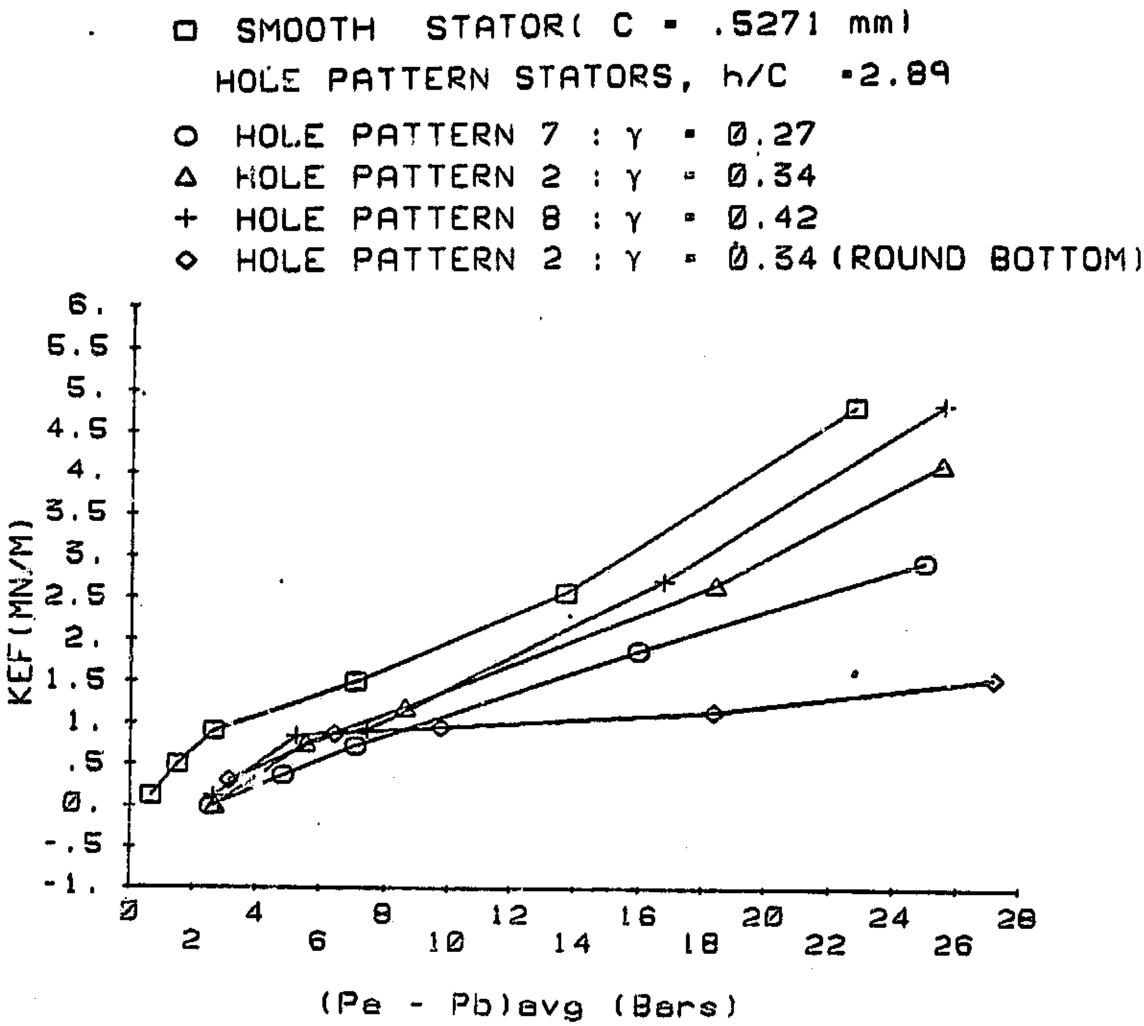

Figure 26. K_{ef} versus ΔP for a smooth stator and four hole-pattern stators with $h/C_r = 2.89$.

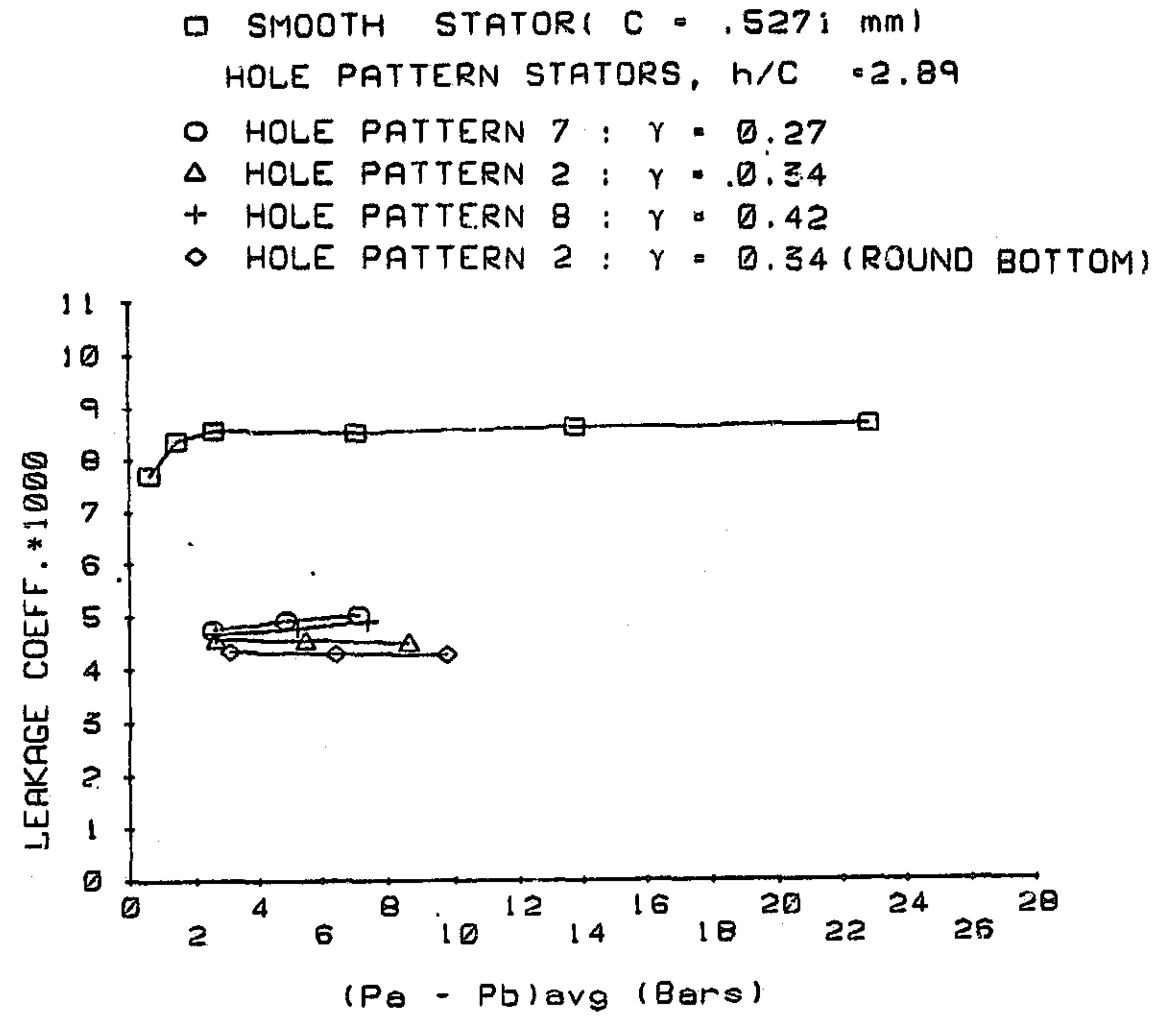

Figure 27. C_L versus ΔP for a smooth stator and four hole-pattern stators with $h/C_r = 2.89$.

introduction of a spherical bottom to the hole instead of a flat bottom. Figure 5 illustrates the spherical-bottom-hole cross section. The results of this stator test are also shown in figures 25 through 27 and show a reduction in C_{ef} as compared to the maximum-damping configuration. The spherical-bottom configuration shows a very sharp drop in K_{ef}.

CONCLUSIONS:

The combined experimental-analytical results of this study support the following conclusions:

<u>Optimum-Damping Configuration</u>

(a) A damper stator which uses hole-pattern 2. ($\gamma = 0.34$), h/C_r = 2.89, and flat-bottomed holes will yield an increase in net damping of 38% as compared to a smooth stator. The optimum damping configuration yields 73% of the stiffness of a smooth seal and reduces leakage by 53%.

(b) Flat-bottomed holes are significantly better than round-bottomed holes.

<u>Experiment Versus Theory</u>

(a) The stiffness of the optimum-damping configuration is slightly underpredicted by theory (approximately 10%).

(b) The net damping of the optimum configuration is slightly over predicted by theory (approximately 20 to 30%).

(c) Measured added-mass terms are consistently higher than predicted.

(d) Theoretical predictions are poor for larger values of γ, specifically, $\gamma = 0.50, 0.59, 0.61$.

The suggestion has been made that the ratio of r/d where d is the hole diameter of figure 4 might be more meaningful than the ratio h/C_r used in this study as an independent parameter. However, no correlation could be established between h/d and the test results.

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APPENDIX A. Static Test Results for Hole-Pattern Stators.

A.1 Test data: Operating conditions and parameters for stator 1.

ROUGH STATOR : HOLE PATTERN 2 (C=.508mm)
HOLE DIA.=2.8mm, HOLE DEPTH=1.016mm, GAMMA=.17
DR. D. CHILDS TEXAS A&M DEC. 83

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU (N sec/M^2)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	1.239	1552.474	0.146E-03	2.079	1060.
2.	1.394	1558.114	0.147E-03	2.102	1765.
3.	1.408	1551.696	0.146E-03	2.074	2626.
4.	1.579	1554.577	0.147E-03	2.083	3519.
5.	1.644	1549.698	0.145E-03	2.065	5333.
6.	2.399	1545.424	0.144E-03	2.035	7186.
7.	3.451	1554.154	0.146E-03	2.994	1049.
8.	3.410	1548.627	0.145E-03	2.982	1754.
9.	3.390	1546.151	0.144E-03	2.971	2603.
10.	3.477	1546.851	0.144E-03	2.959	3478.
11.	3.769	1544.624	0.144E-03	2.980	5333.
12.	4.727	1551.683	0.145E-03	3.006	7186.
13.	5.471	1551.120	0.145E-03	3.696	1060.
14.	5.492	1552.587	0.146E-03	3.678	1744.
15.	5.476	1552.371	0.146E-03	3.673	2632.
16.	5.730	1555.686	0.146E-03	3.709	3529.
17.	6.268	1568.950	0.150E-03	3.797	5310.
18.	6.672	1552.338	0.146E-03	3.740	7186.
19.	24.235	1550.553	0.145E-03	7.659	1034.
20.	24.129	1549.943	0.144E-03	7.629	1744.
21.	24.128	1548.763	0.144E-03	7.664	2597.

22.	24.135	1546.753	0.144E-03	7.551	3468.
23.	24.416	1553.221	0.145E-03	7.584	5286.
24.	24.773	1552.569	0.145E-03	7.057	7186.

A.2 Test data: Operating conditions and parameters for stator 2.

ROUGH STATOR : HOLE PATTERN 2 (C=.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.016mm, GAMMA=.345
DR. D. CHILDS TEXAS A&M AUG. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N\ sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.344	1562.244	0.148E-03	2.126	1056.
2.	2.339	1557.355	0.147E-03	2.142	1770.
3.	2.399	1561.705	0.148E-03	2.134	2667.
4.	2.566	1558.059	0.147E-03	2.116	3540.
5.	2.881	1552.637	0.146E-03	2.067	5333.
6.	3.269	1550.125	0.145E-03	2.054	7229.
7.	5.180	1564.334	0.149E-03	3.087	1064.
8.	5.036	1562.503	0.148E-03	3.082	1775.
9.	5.200	1568.167	0.150E-03	3.114	2685.
10.	5.420	1573.362	0.151E-03	3.098	3604.
11.	5.724	1563.704	0.149E-03	3.065	5333.
12.	6.228	1551.347	0.146E-03	3.023	7186.
13.	7.831	1571.519	0.152E-03	3.838	1091.
14.	7.784	1568.312	0.151E-03	3.828	1796.
15.	7.899	1570.882	0.151E-03	3.858	2691.
16.	7.818	1563.781	0.149E-03	3.763	3540.
17.	8.127	1564.784	0.150E-03	3.792	5333.
18.	8.606	1557.519	0.148E-03	3.754	7186.
19.	17.148	1559.147	0.147E-03	6.707	1060.
20.	17.106	1563.453	0.149E-03	7.280	1786.
21.	17.054	1558.613	0.147E-03	6.686	2655.

22.	17.032	1560.589	0.148E-03	7.760	3550.
23.	16.998	1562.405	0.148E-03	6.585	5310.
24.	16.937	1556.292	0.147E-03	6.380	7186.
25.	24.907	1544.234	0.143E-03	9.245	1049.
26.	25.307	1552.118	0.145E-03	8.151	1749.
27.	25.265	1553.704	0.145E-03	8.776	2620.
28.	25.390	1556.351	0.146E-03	8.241	3499.
29.	25.601	1556.929	0.146E-03	8.425	5310.
30.	26.137	1557.142	0.146E-03	7.835	7186.

A.3 Test data: Operating conditions and parameters for stator 3.

DAMPER SEAL : HOLE PATTERN 3 (C=0.5271mm)
HOLE DIA.=4.7mm, HOLE DEPTH=1.016mm, GAMMA=0.50
DR. D. CHILDS TEXAS A&M SEP. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.219	1560.732	0.148E-03	2.127	1071.
2.	2.294	1565.128	0.149E-03	2.139	1780.
3.	2.358	1560.529	0.148E-03	2.108	2655.
4.	2.430	1557.534	0.147E-03	2.091	3519.
5.	2.984	1557.337	0.147E-03	2.094	5333.
6.	3.175	1557.666	0.147E-03	2.112	7229.
7.	4.952	1553.460	0.146E-03	3.015	1060.
8.	4.924	1554.655	0.147E-03	3.000	1754.
9.	5.007	1555.716	0.147E-03	3.041	2643.
10.	5.212	1556.289	0.147E-03	3.062	3529.
11.	5.681	1558.640	0.148E-03	3.062	5333.
12.	6.477	1546.833	0.144E-03	3.009	7186.
13.	7.890	1561.920	0.149E-03	3.749	1056.
14.	7.761	1564.798	0.150E-03	3.780	1786.
15.	7.731	1562.192	0.149E-03	3.779	2661.
16.	7.809	1559.801	0.148E-03	3.779	3540.
17.	8.303	1564.298	0.149E-03	3.794	5333.
18.	8.740	1565.755	0.150E-03	3.805	7186.
19.	16.849	1559.766	0.148E-03	7.007	1068.
20.	16.726	1556.073	0.147E-03	6.247	1760.
21.	16.611	1551.626	0.145E-03	6.478	2632.

22.	16.691	1550.118	0.145E-03	5.907	3488.
23.	16.648	1546.461	0.144E-03	5.610	5310.
24.	16.615	1451.913	0.119E-03	5.283	7186.
25.	25.840	1546.480	0.144E-03	7.509	1060.
26.	25.600	1548.217	0.144E-03	7.872	1739.
27.	25.567	1548.100	0.144E-03	6.965	2597.
28.	25.484	1546.250	0.143E-03	9.457	3458.
29.	25.750	1552.362	0.145E-03	7.097	5333.
30.	26.193	1555.773	0.146E-03	8.158	7186.

A.4 Test data: Operating conditions and parameters for stator 4.

DAMPER SEAL : HOLE PATTERN 4 (C=0.5271mm)
HOLE DIA.=7.1mm, HOLE DEPTH=1.016mm, GAMMA=0.59
DR. D. CHILDS TEXAS A&M SEP. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU (N sec/M^2)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	3.086	1564.061	0.149E-03	2.141	1083.
2.	3.026	1566.115	0.150E-03	2.163	1791.
3.	2.709	1560.285	0.148E-03	2.132	2673.
4.	2.909	1566.656	0.150E-03	2.143	3582.
5.	3.209	1557.314	0.148E-03	2.114	5357.
6.	3.739	1551.408	0.145E-03	2.109	7186.
7.	6.166	1553.218	0.146E-03	2.993	1049.
8.	6.076	1554.900	0.146E-03	3.019	1765.
9.	5.943	1555.315	0.147E-03	3.016	2643.
10.	6.356	1565.625	0.149E-03	3.089	3571.
11.	6.336	1560.210	0.148E-03	3.053	5357.
12.	7.197	1557.726	0.147E-03	3.061	7186.
13.	9.697	1558.624	0.147E-03	3.735	1068.
14.	9.388	1557.975	0.147E-03	3.723	1770.
15.	9.609	1565.278	0.149E-03	3.781	2673.
16.	9.475	1559.228	0.147E-03	3.743	3540.
17.	9.226	1556.091	0.147E-03	3.714	5333.
18.	10.304	1561.440	0.148E-03	3.751	7186.
19.	18.322	1567.516	0.150E-03	5.292	1075.
20.	18.295	1574.043	0.151E-03	5.495	1802.
21.	18.407	1583.479	0.154E-03	6.113	2740.

22.	18.400	1562.516	0.148E-03	5.591	3540.
23.	18.332	1462.124	0.122E-03	5.368	5333.
24.	18.439	1561.377	0.148E-03	5.374	7186.
25.	26.176	1546.343	0.144E-03	8.245	1038.
26.	26.214	1551.659	0.145E-03	7.973	1749.
27.	26.088	1552.112	0.145E-03	8.387	2620.
28.	26.198	1562.686	0.148E-03	8.658	3529.
29.	26.214	1562.517	0.148E-03	7.412	5310.
30.	26.187	1550.515	0.145E-03	7.632	7186.

A.5 Test data: Operating conditions and parameters for stator 5.

DAMPER SEAL : HOLE PATTERN 5 (C=0.5271mm)
HOLE DIA.=8.6mm, HOLE DEPTH=1.016mm, GAMMA=0.61
DR. D. CHILDS TEXAS A&M SEP. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU (N sec/M^2)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.373	1557.158	0.147E-03	2.112	1056.
2.	2.313	1559.796	0.148E-03	2.124	1770.
3.	2.492	1568.729	0.150E-03	2.129	2685.
4.	2.535	1568.717	0.150E-03	2.153	3571.
5.	2.566	1559.746	0.148E-03	2.102	5357.
6.	3.184	1562.153	0.148E-03	2.147	7186.
7.	5.289	1560.371	0.148E-03	3.058	1049.
8.	5.068	1554.541	0.146E-03	3.004	1754.
9.	5.147	1553.143	0.146E-03	3.026	2637.
10.	5.294	1561.406	0.148E-03	3.043	3550.
11.	5.139	1551.513	0.146E-03	3.016	5357.
12.	5.644	1557.536	0.147E-03	3.012	7186.
13.	7.899	1555.098	0.146E-03	3.704	1060.
14.	7.892	1555.286	0.146E-03	3.728	1760.
15.	7.888	1561.310	0.148E-03	3.742	2667.
16.	7.884	1562.151	0.148E-03	3.745	3540.
17.	7.823	1553.518	0.146E-03	3.725	5333.
18.	8.147	1553.348	0.146E-03	3.751	7186.
19.	16.336	1560.269	0.148E-03	5.529	1056.
20.	16.366	1565.115	0.149E-03	6.128	1780.
21.	16.339	1563.758	0.149E-03	5.508	2673.

22.	16.174	1562.112	0.148E-03	6.177	3550.
23.	16.238	1559.309	0.147E-03	5.798	5333.
24.	16.321	1561.520	0.148E-03	6.229	7186.
25.	24.656	1554.147	0.146E-03	9.213	1064.
26.	23.828	1546.323	0.143E-03	8.962	1734.
27.	24.505	1561.454	0.147E-03	9.458	2655.
28.	24.524	1560.413	0.147E-03	9.365	3529.
29.	24.699	1565.103	0.148E-03	9.396	5333.
30.	24.887	1553.694	0.145E-03	9.015	7186.

A.6 Test data: Operating conditions and parameters for stator 6.

DAMPER SEAL : HOLE PATTERN 6 (C=0.5271mm)
HOLE DIA.=2.8mm, HOLE DEPTH=1.016mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M OCT. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N\ sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.145	1546.240	0.144E-03	2.073	1042.
2.	2.212	1553.100	0.146E-03	2.109	1749.
3.	2.429	1561.155	0.148E-03	2.104	2661.
4.	2.765	1567.508	0.150E-03	2.155	3582.
5.	2.979	1560.684	0.148E-03	2.154	5310.
6.	3.788	1555.101	0.146E-03	2.094	7186.
7.	5.305	1568.062	0.150E-03	3.133	1068.
8.	5.059	1561.301	0.148E-03	3.076	1780.
9.	5.253	1572.420	0.151E-03	3.102	2691.
10.	5.331	1555.903	0.147E-03	3.051	3540.
11.	5.835	1557.075	0.147E-03	3.019	5333.
12.	7.055	1550.410	0.145E-03	2.987	7186.
13.	7.863	1562.180	0.149E-03	3.795	1075.
14.	7.852	1564.140	0.149E-03	3.796	1780.
15.	7.729	1559.632	0.148E-03	3.776	2661.
16.	8.122	1567.640	0.150E-03	3.806	3582.
17.	8.627	1568.561	0.150E-03	3.845	5310.
18.	9.815	1544.370	0.144E-03	3.642	7186.
19.	18.080	1559.775	0.148E-03	6.222	1075.
20.	17.958	1552.155	0.146E-03	6.366	1754.
21.	18.037	1564.194	0.149E-03	6.333	2673.

22.	17.926	1548.551	0.145E-03	5.622	3499.
23.	18.035	1558.744	0.147E-03	6.896	5310.
24.	17.894	1563.378	0.149E-03	6.086	7186.
25.	25.833	1559.305	0.147E-03	6.753	1060.
26.	25.716	1561.562	0.147E-03	7.456	1770.
27.	25.826	1564.420	0.148E-03	7.007	2655.
28.	25.642	1557.276	0.146E-03	6.784	3509.
29.	25.832	1561.941	0.148E-03	6.861	5310.
30.	26.349	1544.891	0.143E-03	8.222	7186.

A.7 Test data: Operating conditions and parameters for stator 7.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=0.508mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M NOV. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N\ sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	1.898	1561.952	0.148E-03	2.102	1083.
2.	1.960	1567.672	0.150E-03	2.124	1791.
3.	2.007	1564.306	0.149E-03	2.133	2673.
4.	2.068	1563.861	0.149E-03	2.109	3561.
5.	2.356	1554.877	0.147E-03	2.084	5310.
6.	3.271	1549.367	0.145E-03	2.090	7186.
7.	5.064	1580.052	0.153E-03	3.173	1075.
8.	4.845	1563.644	0.149E-03	3.085	1770.
9.	4.749	1560.574	0.148E-03	3.051	2655.
10.	4.856	1566.200	0.149E-03	3.066	3561.
11.	5.125	1563.008	0.149E-03	3.072	5310.
12.	6.355	1554.171	0.146E-03	3.017	7186.
13.	7.512	1566.394	0.149E-03	3.781	1053.
14.	7.533	1563.938	0.149E-03	3.743	1770.
15.	7.547	1565.661	0.149E-03	3.789	2661.
16.	7.607	1564.519	0.149E-03	3.791	3550.
17.	7.752	1564.910	0.149E-03	3.761	5310.
18.	8.849	1553.305	0.146E-03	3.715	7186.
19.	16.477	1561.418	0.148E-03	6.671	1056.
20.	16.449	1562.724	0.148E-03	6.619	1780.
21.	16.436	1571.264	0.151E-03	6.499	2685.

22.	16.456	1563.162	0.149E-03	6.555	3550.
23.	16.479	1563.726	0.149E-03	6.412	5310.
24.	16.468	1559.383	0.148E-03	6.248	7186.
25.	25.494	1559.293	0.147E-03	8.609	1053.
26.	25.573	1564.045	0.148E-03	8.556	1770.
27.	25.372	1560.025	0.147E-03	9.069	2643.
28.	25.613	1562.216	0.148E-03	8.493	3529.
29.	25.677	1558.703	0.147E-03	8.419	5286.
30.	26.043	1557.183	0.146E-03	8.204	7186.

A.8 Test data: Operating conditions and parameters for stator 8.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.524mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M NOV. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N\ sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.262	1552.077	0.146E-03	2.086	1049.
2.	2.355	1565.678	0.150E-03	2.134	1786.
3.	2.257	1551.055	0.146E-03	2.067	2626.
4.	2.509	1556.376	0.147E-03	2.098	3540.
5.	2.973	1555.157	0.147E-03	2.104	5286.
6.	3.748	1553.791	0.146E-03	2.076	7186.
7.	5.060	1552.654	0.146E-03	2.998	1060.
8.	5.212	1550.588	0.146E-03	3.013	1754.
9.	5.161	1555.151	0.147E-03	3.023	2637.
10.	5.347	1557.895	0.147E-03	3.052	3540.
11.	5.760	1554.625	0.147E-03	3.004	5310.
12.	6.573	1551.213	0.146E-03	3.008	7186.
13.	8.310	1558.385	0.148E-03	3.730	1071.
14.	8.439	1559.908	0.148E-03	3.758	1775.
15.	8.459	1565.629	0.149E-03	3.798	2679.
16.	8.406	1552.242	0.146E-03	3.716	3519.
17.	8.599	1555.446	0.147E-03	3.723	5310.
18.	9.468	1557.753	0.147E-03	3.746	7186.
19.	18.358	1557.865	0.147E-03	6.671	1060.
20.	18.399	1567.988	0.150E-03	6.593	1780.
21.	18.426	1565.774	0.149E-03	6.586	2661.

22.	18.429	1572.089	0.151E-03	6.540	3582.
23.	18.467	1559.279	0.148E-03	6.460	5310.
24.	18.417	1538.978	0.142E-03	6.181	7186.
25.	25.733	1553.041	0.145E-03	7.839	1042.
26.	25.716	1554.792	0.146E-03	7.857	1749.
27.	24.934	1546.309	0.143E-03	7.919	2592.
28.	25.566	1544.415	0.143E-03	7.752	3458.
29.	25.674	1545.609	0.143E-03	7.699	5286.
30.	25.629	1542.700	0.143E-03	7.679	7186.

A.9 Test data: Operating conditions and parameters for stator 9.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.778mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M APR 85

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU (N sec/M^2)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	3.005	1571.021	0.151E-03	2.147	1079.
2.	3.021	1583.207	0.154E-03	2.197	1824.
3.	2.796	1575.208	0.152E-03	2.170	2715.
4.	3.048	1571.587	0.151E-03	2.168	3604.
5.	3.497	1577.340	0.153E-03	2.176	5286.
6.	3.877	1551.941	0.146E-03	2.094	7186.
7.	6.665	1570.988	0.151E-03	3.120	1083.
8.	6.719	1577.068	0.152E-03	3.128	1807.
9.	6.149	1563.239	0.149E-03	3.073	2661.
10.	5.996	1566.624	0.150E-03	3.085	3571.
11.	6.212	1565.250	0.149E-03	3.068	5310.
12.	7.064	1552.381	0.146E-03	2.997	7186.
13.	10.156	1573.635	0.151E-03	3.840	1068.
14.	9.806	1566.137	0.150E-03	3.796	1786.
15.	9.713	1567.515	0.150E-03	3.809	2685.
16.	9.798	1575.960	0.152E-03	3.859	3614.
17.	8.770	1560.335	0.148E-03	3.745	5286.
18.	9.792	1557.725	0.147E-03	3.721	7186.
19.	18.154	1566.873	0.150E-03	6.324	1087.
20.	18.214	1567.766	0.150E-03	6.302	1786.
21.	18.213	1572.360	0.151E-03	6.259	2691.

22.	18.222	1571.510	0.151E-03	6.215	3582.
23.	18.238	1569.328	0.150E-03	6.046	5286.
24.	17.007	1552.019	0.145E-03	5.754	7229.
25.	26.945	1568.202	0.149E-03	8.023	1068.
26.	26.685	1560.464	0.147E-03	7.966	1754.
27.	26.679	1555.286	0.146E-03	7.918	2637.
28.	26.785	1561.128	0.147E-03	7.964	3519.
29.	26.798	1563.844	0.148E-03	7.861	5286.
30.	26.243	1560.130	0.147E-03	7.645	7186.

A.10 Test data: Operating conditions and parameters for stator 10.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=2.032mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M DEC. '84

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N\ sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.686	1570.427	0.151E-03	2.168	1083.
2.	2.326	1565.030	0.150E-03	2.120	1791.
3.	2.315	1565.672	0.150E-03	2.137	2673.
4.	2.431	1568.260	0.150E-03	2.142	3571.
5.	2.986	1566.458	0.150E-03	2.131	5286.
6.	3.388	1558.000	0.148E-03	2.113	7186.
7.	5.910	1558.027	0.148E-03	3.049	1056.
8.	5.343	1560.787	0.148E-03	3.058	1780.
9.	5.140	1562.102	0.149E-03	3.077	2673.
10.	4.606	1563.383	0.149E-03	3.069	3571.
11.	5.402	1567.150	0.150E-03	3.100	5286.
12.	6.328	1567.136	0.150E-03	3.102	7229.
13.	9.425	1567.068	0.150E-03	3.802	1068.
14.	9.170	1566.685	0.150E-03	3.807	1786.
15.	8.867	1565.742	0.150E-03	3.796	2679.
16.	8.742	1562.775	0.149E-03	3.777	3561.
17.	7.935	1561.726	0.149E-03	3.753	5286.
18.	8.317	1556.303	0.147E-03	3.732	7229.
19.	17.749	1563.983	0.149E-03	6.636	1071.
20.	17.649	1568.069	0.150E-03	6.753	1786.
21.	17.667	1559.697	0.148E-03	6.576	2667.

22.	17.752	1569.665	0.150E-03	6.501	3582.
23.	17.652	1559.752	0.148E-03	6.371	5286.
24.	17.685	1553.162	0.146E-03	6.359	7186.
25.	26.540	1553.521	0.145E-03	8.469	1049.
26.	26.446	1559.480	0.147E-03	8.582	1765.
27.	26.419	1563.840	0.148E-03	8.502	2649.
28.	26.385	1557.150	0.146E-03	8.497	3519.
29.	26.170	1552.464	0.145E-03	8.248	5263.
30.	25.938	1550.184	0.145E-03	7.986	7186.

A.11 Test data: Operating conditions and parameters for stator 11.

DAMPER SEAL : HOLE PATTERN 7 (C=0.5271mm)
HOLE DIA.=3.55mm, HOLE DEPTH=1.524mm, GAMMA=0.27
DR. D. CHILDS TEXAS A&M MAY 85

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N\ sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.290	1575.920	0.152E-03	2.182	1091.
2.	2.322	1576.961	0.153E-03	2.188	1807.
3.	2.396	1576.666	0.153E-03	2.181	2703.
4.	2.492	1573.271	0.152E-03	2.167	3604.
5.	2.759	1569.607	0.151E-03	2.150	5310.
6.	3.120	1555.113	0.147E-03	2.092	7186.
7.	4.542	1571.111	0.151E-03	3.106	1068.
8.	4.546	1569.387	0.151E-03	3.099	1796.
9.	4.583	1572.943	0.151E-03	3.109	2703.
10.	4.838	1572.190	0.151E-03	3.108	3593.
11.	5.162	1572.082	0.151E-03	3.107	5310.
12.	5.479	1555.987	0.147E-03	3.035	7186.
13.	7.011	1576.404	0.152E-03	3.862	1075.
14.	6.845	1572.054	0.151E-03	3.848	1791.
15.	6.731	1571.719	0.151E-03	3.826	2703.
16.	7.030	1571.493	0.151E-03	3.844	3582.
17.	7.270	1572.563	0.151E-03	3.825	5310.
18.	7.702	1557.776	0.147E-03	3.726	7186.
19.	15.975	1574.128	0.151E-03	6.467	1068.
20.	15.931	1570.455	0.150E-03	6.469	1780.
21.	15.979	1570.293	0.150E-03	6.514	2679.

22.	15.975	1570.171	0.150E-03	6.501	3571.
23.	15.980	1571.177	0.151E-03	6.414	5310.
24.	15.986	1547.313	0.144E-03	6.343	7186.
25.	25.106	1565.448	0.148E-03	8.253	1045.
26.	24.837	1568.194	0.149E-03	8.308	1770.
27.	24.912	1573.044	0.150E-03	8.361	2679.
28.	24.950	1570.903	0.150E-03	8.401	3561.
29.	24.967	1576.031	0.151E-03	8.372	5263.
30.	25.167	1553.828	0.145E-03	8.250	7186.

A.12 Test data: Operating conditions and parameters for stator 12.

DAMPER SEAL : HOLE PATTERN B (C=0.5271mm)
HOLE DIA.=4.31mm, HOLE DEPTH=1.524mm, GAMMA=0.42
DR. D. CHILDS TEXAS A&M MAY 85

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	2.285	1567.477	0.150E-03	2.144	1087.
2.	2.200	1569.904	0.151E-03	2.144	1802.
3.	2.249	1567.785	0.150E-03	2.128	2691.
4.	2.445	1570.382	0.151E-03	2.144	3593.
5.	3.099	1575.767	0.152E-03	2.173	5310.
6.	3.702	1567.889	0.150E-03	2.150	7186.
7.	4.737	1564.205	0.149E-03	3.087	1071.
8.	4.842	1576.266	0.152E-03	3.150	1802.
9.	4.914	1576.231	0.152E-03	3.124	2703.
10.	4.971	1569.562	0.151E-03	3.110	3571.
11.	5.357	1569.173	0.150E-03	3.100	5310.
12.	6.658	1562.869	0.149E-03	3.071	7186.
13.	7.209	1566.459	0.150E-03	3.798	1075.
14.	7.263	1566.817	0.150E-03	3.783	1775.
15.	7.076	1564.179	0.149E-03	3.788	2667.
16.	7.444	1573.861	0.152E-03	3.857	3614.
17.	7.527	1568.427	0.150E-03	3.802	5310.
18.	8.106	1554.660	0.146E-03	3.726	7186.
19.	16.762	1572.885	0.151E-03	6.268	1079.
20.	16.786	1579.124	0.153E-03	6.279	1802.
21.	16.779	1571.677	0.151E-03	6.229	2685.

22.	16.774	1562.630	0.148E-03	6.196	3550.
23.	16.780	1557.929	0.147E-03	6.119	5310.
24.	16.756	1554.239	0.146E-03	6.081	7186.
25.	25.537	1564.319	0.148E-03	7.788	1068.
26.	25.546	1569.067	0.149E-03	7.787	1786.
27.	25.637	1573.256	0.151E-03	7.794	2685.
28.	25.688	1576.923	0.151E-03	7.740	3593.
29.	25.707	1577.407	0.152E-03	7.703	5263.
30.	25.453	1544.816	0.143E-03	7.547	7186.

A.13 Test data: Operating conditions and parameters for stator 13.

DAMPER SEAL : HOLE PATTERN 9 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.524, GAMMA=0.34(SPHERE BOTTOM)
DR. D. CHILDS TEXAS A&M MAY 85

Case	Pa-Pb (Bars)	RHO (Kg/M^3)	MU ($N sec/M^2$)	MDOT (Kg/sec)	CPM (Cyc/min)
1.	3.199	1580.824	0.1[illegible]4E-03	2.187	1095.
2.	2.988	1583.856	0.154E-03	2.202	1824.
3.	2.797	1579.632	0.153E-03	2.197	2727.
4.	2.765	1576.617	0.152E-03	2.168	3614.
5.	3.117	1573.474	0.152E-03	2.180	5310.
6.	4.002	1574.785	0.152E-03	2.167	7186.
7.	7.269	1578.158	0.153E-03	3.135	1095.
8.	6.490	1566.626	0.150E-03	3.070	1791.
9.	6.088	1564.792	0.149E-03	3.072	2667.
10.	6.026	1567.886	0.150E-03	3.103	3571.
11.	5.886	1563.355	0.149E-03	3.080	5333.
12.	6.813	1561.669	0.149E-03	3.05[illegible]	7186.
13.	11.043	1570.003	0.151E-03	3.815	1075.
14.	10.435	1565.961	0.150E-03	3.791	1780.
15.	9.773	1564.262	0.149E-03	3.791	2661.
16.	9.654	1568.121	0.150E-03	3.822	3582.
17.	8.650	1562.615	0.149E-03	3.767	5310.
18.	9.057	1553.772	0.146E-03	3.724	7186.
19.	18.400	1559.983	0.148E-03	6.427	1064.
20.	18.347	1563.773	0.149E-03	6.366	1779.
21.	18.427	1556.719	0.147E-03	6.336	265[illegible].

22.	18.363	1556.170	0.147E-03	6.230	3529.
23.	18.374	1554.245	0.146E-03	6.064	5310.
24.	18.397	1559.210	0.147E-03	6.002	7186.
25.	27.283	1558.154	0.147E-03	8.228	1042.
26.	27.293	1562.056	0.148E-03	8.197	1760.
27.	27.239	1561.605	0.148E-03	8.095	2649.
28.	27.279	1562.955	0.148E-03	8.015	3529.
29.	27.186	1564.218	0.148E-03	7.858	5310.
30.	26.810	1567.221	0.149E-03	7.612	7186.

APPENDIX B. Dynamic Test Data for Hole-Pattern Seals

B.1 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 1.

ROUGH STATOR : HOLE PATTERN 1 (C=.508mm)
HOLE DIA.=2.8mm, HOLE DEPTH=1.016mm, GAMMA=.17
DR. D. CHILDS TEXAS A&M DEC. 83

Case	Ra	RPM	R_T/A (MN/M)	dev. (MN/M)	R_0/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90081.	1060.	-0.3425	0.1142	0.4400	0.1030	0.0726
2.	87269.	1765.	-0.2850	0.0537	0.8891	0.0704	0.1168
3.	90287.	2626.	-0.0707	0.0532	1.0708	0.0566	0.1347
4.	90691.	3519.	0.1101	0.0627	1.5963	0.0406	0.1998
5.	89609.	5333.	0.7439	0.1432	2.1693	0.1051	0.2931
6.	88551.	7186.	1.9980	0.4122	1.6380	0.3673	0.3429
7.	129806.	1049.	-0.7626	0.1720	0.7203	0.1723	0.1336
8.	130709.	1754.	-0.7114	0.1065	1.1838	0.0763	0.1733
9.	130627.	2603.	-0.5059	0.0794	1.6455	0.1267	0.2157
10.	130816.	3478.	-0.0197	0.0717	2.2152	0.1191	0.2765
11.	129497.	5333.	0.3767	0.1869	3.0220	0.1295	0.3900
12.	130819.	7186.	1.7450	0.2691	3.1921	0.3392	0.4750
13.	160279.	1060.	-1.1806	0.1962	0.9126	0.2619	0.1890
14.	160689.	1744.	-1.1526	0.1690	1.4742	0.1378	0.2328
15.	159279.	2632.	-0.7366	0.0969	2.1330	0.0932	0.2829
16.	159801.	3529.	-0.5844	0.1530	2.9671	0.1600	0.3872
17.	159903.	5310.	0.4026	0.1665	3.9076	0.1545	0.4960
18.	158409.	7186.	1.7762	0.2725	4.1801	0.3156	0.5877
19.	335238.	1034.	-5.1836	0.4935	1.7302	1.0361	0.6649
20.	334707.	1744.	-4.8976	0.3017	3.2653	0.1996	0.7002
21.	336938.	2597.	-4.5033	0.3621	4.9820	0.2974	0.8027

22.	331562.	3468.	-3.8063	0.2146	6.0478	0.1967	0.8557
23.	325604.	5286.	-1.9258	0.3734	8.7138	0.3726	1.0697
24.	306583.	7186.	0.1359	0.3688	11.5721	0.4461	1.3705

B.2 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 2.

ROUGH STATOR : HOLE PATTERN 2 (C=.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.016mm, GAMMA=.345
DR. D. CHILDS TEXAS A&M AUG. '84

Rase	Ca	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90579.	1056.	-0.3452	0.1530	0.6353	0.1024	0.0941
2.	90394.	1770.	-0.2189	0.0841	1.0857	0.1178	0.1411
3.	89924.	2667.	-0.0682	0.0445	1.5531	0.0413	0.1975
4.	90526.	3540.	0.3170	0.1072	2.0223	0.1493	0.2603
5.	89574.	5333.	1.0191	0.1635	2.8129	0.1330	0.3807
6.	90163.	7229.	2.7257	0.1112	2.7701	0.1259	0.4937
7.	130662.	1064.	-0.6627	0.2729	1.0827	0.1878	0.1660
8.	130001.	1775.	-0.5883	0.0843	1.6776	0.0984	0.2261
9.	129537.	2685.	-0.1916	0.0556	2.3826	0.0999	0.3036
10.	130960.	3604.	0.1436	0.1973	3.2434	0.1350	0.4130
11.	130780.	5333.	1.0377	0.1930	4.2605	0.3511	0.5573
12.	1309[illegible]7.	7186.	2.6854	0.2674	4.8932	0.1697	0.7095
13.	159765.	1091.	-1.0517	0.2473	1.3089	0.2066	0.2169
14.	160474.	1796.	-1.0895	0.0738	2.2171	0.0966	0.3139
15.	159766.	2691.	-0.4226	0.0986	2.7845	0.1414	0.3579
16.	161027.	3540.	0.3108	0.1899	3.9034	0.1741	0.4979
17.	159095.	5333.	0.9603	0.2442	5.4176	0.4008	0.6996
18.	159860.	7186.	2.8812	0.2762	6.5780	0.2230	0.9130
19.	292273.	1060.	-2.175[illegible]	0.4514	1.[illegible]341	0.3094	0.3670
20.	289253.	1786.	-1.8727	0.1498	3.5745	0.1831	0.5129
21.	289883.	2655.	-1.5826	0.1591	4.3058	0.1951	0.5831

22.	286825.	3550.	-0. 5800	0. 2171	5. 2940	0. 3215	0. 6769
23.	284690.	5310.	0. 8262	0. 4733	7. 8585	0. 4394	1. 0056
24.	279428.	7186.	3. 1686	0. 4001	10. 2805	0. 3761	1. 3670
25.	376602.	1049.	-3. 5097	0. 4607	2. 1075	0. 8009	0. 5325
26.	371952.	1749.	-3. 0216	0. 2013	3. 9417	0. 4068	0. 6321
27.	369170.	2620.	-2. 4308	0. 2683	5. 0833	0. 2596	0. 7164
28.	369743.	3499.	-1. 7204	0. 4650	6. 8012	0. 3996	0. 8930
29.	366083.	5310.	0. 5597	0. 6023	9. 9049	0. 4047	1. 2627
30.	364450.	7186.	3. 4904	0. 4899	13. 1465	0. 4135	1. 7285

B.3 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 3.

DAMPER SEAL : HOLE PATTERN 3 (C=0. 5271mm)
HOLE DIA. =4. 7mm, HOLE DEPTH=1. 016mm, GAMMA=0. 50
DR. D. CHILDS TEXAS A&M SEP. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90317.	1071.	-0. 2622	0. 1104	0. 5028	0. 0810	0. 0731
2.	89826.	1780.	-0. 2526	0. 0925	0. 8024	0. 1087	0. 1073
3.	90780.	2655.	-0. 0973	0. 0551	1. 1159	0. 0986	0. 1424
4.	89743.	3519.	0. 2096	0. 0733	1. 4724	0. 0890	0. 1891
5.	90476.	5333.	1. 1600	0. 1284	2. 2723	0. 1100	0. 3246
6.	89746.	7229.	2. 7412	0. 2016	2. 2737	0. 2039	0. 4522
7.	129752.	1060.	-0. 6310	0. 1305	0. 6105	0. 1776	0. 1142
8.	130282.	1754.	-0. 5525	0. 1231	1. 2413	0. 0774	0. 1733
9.	130141.	2643.	-0. 2977	0. 1129	1. 7892	0. 1181	0. 2307
10.	130913.	3529.	0. 0307	0. 0884	2. 2867	0. 1179	0. 2907
11.	128424.	5333.	0. 8252	0. 1676	3. 1287	0. 1220	0. 4117
12.	131046.	7186.	2. 5542	0. 2007	3. 8230	0. 1811	0. 5840
13.	160729.	1056.	-0. 9896	0. 1451	0. 8117	0. 1617	0. 1644
14.	160310.	1786.	-0. 9062	0. 2050	1. 3917	0. 1841	0. 2122
15.	160676.	2661.	-0. 6022	0. 1487	2. 2077	0. 1287	0. 2914
16.	160377.	3540.	-0. 0855	0. 1495	2. 7686	0. 1300	0. 3523
17.	159814.	5333.	0. 6828	0. 1672	3. 9739	0. 1454	0. 5126
18.	165073.	7186.	2. 6083	0. 2697	4. 6011	0. 2011	0. 6732
19.	257423.	1068.	-1. 8765	0. 2688	0. 9149	0. 3460	0. 2699
20.	258623.	1760.	-2. 0543	0. 1429	2. 1367	0 2097	0. 3767
21.	257119.	2632.	-1. 5264	0. 1502	3. 0161	0. 1481	0. 4297

22.	258017.	3488.	-0.7766	0.1506	3.8745	0.1172	0.5021
23.	255468.	5310.	0.1609	0.2126	5.9297	0.2002	0.7538
24.	296615.	7186.	2.2701	0.3619	7.2079	0.3610	0.9603
25.	367572.	1060.	-2.9019	0.3027	1.0088	0.7086	0.4016
26.	364432.	1739.	-2.7262	0.1592	2.3239	0.2409	0.4555
27.	354647.	2597.	-2.2546	0.1541	3.8283	0.1347	0.5645
28.	357668.	3458.	-1.6450	0.2693	5.2200	0.6788	0.6979
29.	345832.	5333.	-0.2866	0.2737	7.5479	0.2925	0.9598
30.	348599.	7186.	2.0289	0.4512	9.8321	0.4709	1.2762

B.4 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 4.

DAMPER SEAL : HOLE PATTERN 4 (C=0.5271mm)
HOLE DIA.=7.1mm, HOLE DEPTH=1.016mm, GAMMA=0.59
DR. D. CHILDS TEXAS A&M SEP. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90587.	1083.	-0.1285	0.1204	0.4947	0.0836	0.0668
2.	89710.	1791.	0.0489	0.0762	0.9570	0.0855	0.1221
3.	89926.	2673.	0.1748	0.1403	1.2523	0.0894	0.1617
4.	90507.	3582.	0.3090	0.1387	1.3969	0.1378	0.1825
5.	90536.	5357.	1.2877	0.1012	2.0841	0.0695	0.3114
6.	90416.	7186.	2.4807	0.3513	2.4260	0.3093	0.4417
7.	130450.	1049.	-0.2566	0.1825	0.6747	0.0861	0.0947
8.	130941.	1765.	-0.2288	0.1034	1.3260	0.1084	0.1716
9.	130104.	2643.	-0.0952	0.0928	1.6962	0.1114	0.2161
10.	130516.	3571.	0.2976	0.0799	2.0463	0.0614	0.2628
11.	128862.	5357.	1.4864	0.1551	2.9367	0.1286	0.4186
12.	130390.	7186.	2.7590	0.3491	3.8220	0.2547	0.6006
13.	160888.	1068.	-0.3408	0.1584	0.9931	0.1690	0.1354
14.	160344.	1770.	-0.3120	0.1012	1.8030	0.0999	0.2328
15.	160003.	2673.	-0.0839	0.0988	2.3136	0.1559	0.2941
16.	160044.	3540.	0.2284	0.1422	2.5731	0.1330	0.3285
17.	160536.	5333.	1.5974	0.1947	3.9760	0.1561	0.5449
18.	159402.	7186.	2.8013	0.2823	4.6643	0.3058	0.6910
19.	247837.	1075.	-0.7330	0.2890	1.2003	0.2662	0.1843
20.	241502.	1802.	-0.7984	0.1734	2.3293	0.1423	0.3136
21.	235556.	2740.	-0.5911	0.1668	3.0957	0.1256	0.4009

22.	244140.	3540.	-0.1605	0.3133	4.0238	0.2044	0.5129
23.	295368.	5333.	1.2344	0.2309	5.6575	0.2057	0.7362
24.	234224.	7186.	2.9954	0.2746	6.7580	0.3548	0.9397
25.	364083.	1038.	-1.1592	0.3877	1.4246	0.3922	0.2426
26.	360624.	1749.	-0.9295	0.2121	2.5885	0.2055	0.3500
27.	357179.	2620.	-0.5597	0.2199	3.3668	0.1285	0.4345
28.	351082.	3529.	-0.3015	0.1965	4.7465	0.1875	0.6046
29.	346620.	5310.	1.4464	0.3001	6.7691	0.2917	0.8799
30.	344377.	7186.	2.5832	0.3145	8.4555	0.3228	1.1236

B.5 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 5.

DAMPER SEAL : HOLE PATTERN 5 (C=0.5271mm)
HOLE DIA.=8.6mm, HOLE DEPTH=1.016mm, GAMMA=0.61
DR. D. CHILDS TEXAS A&M SEP. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90493.	1056.	0.0722	0.1237	0.6163	0.1044	0.0802
2.	90365.	1770.	0.0599	0.0529	0.9462	0.0669	0.1206
3.	90120.	2685.	0.4672	0.0778	1.4188	0.0609	0.1898
4.	90494.	3571.	0.5252	0.0424	1.5922	0.0516	0.2130
5.	90368.	5357.	1.7820	0.0886	2.2717	0.0773	0.3670
6.	90402.	7186.	3.2224	0.1219	2.5000	0.1286	0.5184
7.	130480.	1049.	0.0680	0.2041	0.7980	0.1606	0.1050
8.	130144.	1754.	0.1662	0.0549	1.5510	0.0840	0.1982
9.	129806.	2637.	0.5209	0.0615	1.9320	0.1056	0.2542
10.	130416.	3550.	0.6038	0.1357	2.7918	0.0832	0.3632
11.	129188.	5357.	2.2267	0.1664	3.4808	0.1138	0.5254
12.	129921.	7186.	3.8131	0.1482	3.9362	0.0997	0.6962
13.	160060.	1060.	-0.0001	0.1693	0.9701	0.1079	0.1250
14.	159976.	1760.	0.1158	0.0854	1.7502	0.0916	0.2231
15.	159413.	2667.	0.4813	0.1284	2.3731	0.1224	0.3077
16.	160374.	3540.	0.8792	0.1065	3.2545	0.0848	0.4283
17.	160670.	5333.	2.4007	0.1928	4.6761	0.1253	0.6681
18.	159993.	7186.	4.3383	0.2727	5.1110	0.1758	0.8520
19.	267882.	1056.	-0.0495	0.2591	1.4131	0.0833	0.1825
20.	262804.	1780.	0.0914	0.0925	2.4833	0.1224	0.3158
21.	261592.	2673.	0.6567	0.1626	3.4726	0.1241	0.4494

22.	257535.	3550.	1.3746	0.1539	4.7276	0.1180	0.6256
23.	255723.	5333.	3.2213	0.2771	6.6321	0.2151	0.9373
24.	261492.	7186.	5.4965	0.3022	8.0671	0.2161	1.2402
25.	418660.	1064.	-0.2622	0.3130	1.6583	0.1822	0.2168
26.	417050.	1734.	0.1611	0.2259	2.8446	0.1140	0.3630
27.	409732.	2655.	0.7278	0.1139	4.2364	0.1301	0.5464
28.	407523.	3529.	1.2729	0.1725	5.9111	0.1191	0.7683
29.	403651.	5333.	3.6427	0.2787	8.1418	0.2671	1.1334
30.	411964.	7186.	6.8460	0.3262	10.2663	0.2451	1.5678

C-2

B.6 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 6.

DAMPER SEAL : HOLE PATTERN 6 (C=0.5271mm)
HOLE DIA.=2.8mm, HOLE DEPTH=1.016mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M OCT. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90286.	1042.	−0.3611	0.1599	0.5960	0.1030	0.0915
2.	89889.	1749.	−0.2836	0.0864	0.9903	0.0625	0.1312
3.	90462.	2661.	0.0081	0.0756	1.3013	0.1370	0.1655
4.	89344.	3582.	0.1482	0.0899	1.7627	0.0686	0.2249
5.	90430.	5310.	1.2429	0.1350	2.5076	0.1002	0.3559
6.	90130.	7186.	2.4421	0.2124	2.8556	0.1424	0.4781
7.	130471.	1068.	−0.7655	0.1318	0.9847	0.1723	0.1604
8.	129893.	1780.	−0.6895	0.0823	1.4123	0.1086	0.2000
9.	130075.	2691.	−0.2349	0.0784	2.1107	0.1293	0.2698
10.	129881.	3540.	−0.1196	0.1135	2.7563	0.0894	0.3507
11.	130062.	5333.	0.8319	0.1383	3.6301	0.0878	0.4733
12.	130116.	7186.	2.8454	0.2893	4.7299	0.2241	0.7024
13.	160067.	1075.	−1.1900	0.1859	1.1503	0.2517	0.2136
14.	159741.	1780.	−1.1651	0.0583	1.8551	0.0685	0.2784
15.	160043.	2661.	−0.7815	0.0757	2.5277	0.0929	0.3361
16.	159351.	3582.	−0.3959	0.1261	3.5149	0.1455	0.4496
17.	160070.	5310.	0.5682	0.1628	4.6926	0.1261	0.6007
18.	158956.	7186.	2.3963	0.3018	5.6329	0.2192	0.7784
19.	264884.	1075.	−2.6355	0.3283	1.6810	0.5844	0.4056
20.	268211.	1754.	−2.5414	0.1818	2.8026	0.1880	0.4807
21.	260596.	2673.	−2.1370	0.1678	4.1195	0.1894	0.5882

22.	268168.	3499.	-1.6022	0.1408	5.2239	0.2234	0.6942
23.	259031.	5310.	-0.0577	0.2324	7.1822	0.2753	0.9127
24.	256710.	7186.	2.4456	0.4529	8.7947	0.3156	1.1612
25.	315649.	1060.	-3.4471	0.4077	2.0473	0.7117	0.5192
26.	313599.	1770.	-3.4047	0.2570	3.4969	0.2327	0.6204
27.	312789.	2655.	-3.0241	0.1182	4.5919	0.1477	0.6985
28.	313490.	3509.	-2.6344	0.2309	6.5809	0.2194	0.9009
29.	309368.	5310.	-0.6245	0.3531	8.6814	0.3519	1.1062
30.	319066.	7186.	1.2698	0.5174	11.0263	0.3619	1.4114

B.7 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 7.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=0.508mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M NOV. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	89471.	1083.	-0.2988	0.1179	0.5736	0.0996	0.0840
2.	89499.	1791.	-0.2655	0.0618	0.9813	0.0697	0.1294
3.	90313.	2673.	0.0286	0.0971	1.3056	0.0721	0.1663
4.	89410.	3561.	0.3007	0.0811	1.8332	0.0505	0.2361
5.	89799.	5310.	1.1425	0.1270	2.5186	0.0841	0.3515
6.	90871.	7186.	2.8424	0.5108	2.2416	0.4570	0.4640
7.	130825.	1075.	-0.6572	0.1517	0.8765	0.1695	0.1417
8.	130911.	1770.	-0.6063	0.0826	1.4993	0.0773	0.2057
9.	130183.	2655.	-0.1206	0.0838	1.9808	0.1752	0.2519
10.	129549.	3561.	0.3281	0.1214	2.5818	0.1462	0.3308
11.	130496.	5310.	1.1292	0.1803	3.7830	0.1130	0.5020
12.	130166.	7186.	2.6210	0.3927	3.8107	0.3566	0.5905
13.	160012.	1053.	-0.8794	0.2035	1.1054	0.1938	0.1825
14.	159075.	1770.	-0.9353	0.1219	1.8396	0.1106	0.2627
15.	160557.	2661.	-0.5412	0.1200	2.4249	0.1764	0.3155
16.	160969.	3550.	-0.0623	0.1068	3.3645	0.1116	0.4276
17.	159556.	5310.	0.9738	0.1692	4.7491	0.1171	0.6161
18.	160815.	7186.	2.5368	0.4106	5.2702	0.4012	0.7451
19.	286324.	1056.	-1.9889	0.2860	1.5517	0.3611	0.3251
20.	277971.	1780.	-2.0240	0.1266	2.7097	0.1783	0.4298
21.	278744.	2685.	-1.2953	0.1181	3.7594	0.1951	0.5052

22.	273769.	3550.	-1.0391	0.1501	4.8550	0.1512	0.6308
23.	276488.	5310.	0.5135	0.2728	6.9235	0.2406	0.8824
24.	274838.	7186.	2.6266	0.4563	8.5215	0.4355	1.1343
25.	341011.	1053.	-3.1935	0.4368	2.0067	0.5849	0.4873
26.	340526.	1770.	-2.9940	0.2301	3.3096	0.2049	0.5674
27.	348504.	2643.	-2.5825	0.2293	4.2757	0.1890	0.6354
28.	342201.	3529.	-1.5621	0.2834	6.1833	0.3005	0.8106
29.	339147.	5286.	0.1067	0.3980	8.7277	0.2671	1.1101
30.	340039.	7186.	2.5281	0.3004	11.4756	0.3911	1.4928

B.8 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 8.

DAMPER SEAL : HOLE PATTERN 2 (C = 0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.524mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M NOV. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90188.	1049.	-0.3349	0.1579	0.6646	0.0788	0.0970
2.	90079.	1786.	-0.2646	0.0809	1.2894	0.0942	0.1675
3.	89557.	2626.	-0.0821	0.0466	1.5924	0.0430	0.2026
4.	90083.	3540.	0.0682	0.0618	1.9880	0.0748	0.2528
5.	90461.	5286.	0.8406	0.1099	2.7089	0.1000	0.3606
6.	89521.	7186.	2.7572	0.2249	2.7487	0.1880	0.4951
7.	129598.	1060.	-0.7247	0.2313	0.9422	0.1836	0.1552
8.	130690.	1754.	-0.7138	0.0774	1.5157	0.0991	0.2131
9.	130120.	2637.	-0.4902	0.0824	2.5033	0.0819	0.3242
10.	130750.	3540.	-0.1095	0.0791	3.1280	0.0691	0.3977
11.	129440.	5310.	0.5952	0.1611	4.3953	0.1485	0.5637
12.	130365.	7186.	1.9310	0.1917	5.1881	0.1384	0.7036
13.	159641.	1071.	-1.1381	0.2553	1.0912	0.2593	0.2052
14.	160384.	1775.	-1.0338	0.1138	2.1352	0.1486	0.3018
15.	160486.	2679.	-0.6677	0.0836	3.1357	0.0901	0.4073
16.	160700.	3519.	-0.4459	0.1570	3.6978	0.1201	0.4734
17.	160123.	5310.	0.5532	0.1836	5.7284	0.1744	0.7313
18.	160483.	7186.	2.0735	0.1987	7.1138	0.1953	0.9414
19.	284517.	1060.	-2.5054	0.5206	1.6821	0.6324	0.3959
20.	281597.	1780.	-2.4220	0.3061	3.1751	0.2344	0.5089
21.	272480.	2661.	-2.0946	0.1625	4.3516	0.1622	0.6134

22.	278613.	3582.	-1.5113	0.1957	5.2250	0.1395	0.6912
23.	272537.	5310.	0.2396	0.3622	8.8020	0.3608	1.1192
24.	267343.	7186.	2.3857	0.3284	11.0811	0.2932	1.4404
25.	369902.	1042.	-3.4540	0.4321	1.5101	0.6381	0.4877
26.	364593.	1749.	-2.9511	0.2011	3.9082	0.1870	0.6223
27.	389222.	2592.	-2.9953	0.4181	5.1524	0.2882	0.7595
28.	363146.	3458.	-1.7432	0.3521	6.0467	0.2833	0.8002
29.	362145.	5286.	0.3735	0.3665	9.9312	0.3627	1.2631
30.	354033.	7186.	2.1899	0.4030	13.4101	0.3310	1.7265

B.9 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 9.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.778mm, GAMMA=0.34
DR. D. CHILDS TEXAS A&M APR 85

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	89768.	1079.	-0.2952	0.1168	0.6957	0.1023	0.0975
2.	89992.	1824.	-0.3531	0.0662	1.2786	0.0526	0.1686
3.	90086.	2715.	-0.0341	0.0945	1.6955	0.0937	0.2156
4.	90552.	3604.	0.2439	0.0704	1.9187	0.0848	0.2458
5.	90001.	5286.	0.5380	0.7612	2.3250	0.4648	0.3208
6.	90662.	7186.	2.2639	0.3832	1.2965	0.5346	0.3386
7.	130573.	1083.	-0.7941	0.1691	1.0439	0.1371	0.1683
8.	129576.	1807.	-0.5937	0.0840	1.8462	0.0849	0.2465
9.	130472.	2661.	-0.3088	0.0892	2.3985	0.0684	0.3074
10.	130189.	3571.	0.2997	0.1261	2.7695	0.1406	0.3541
11.	129783.	5310.	0.8283	0.1721	4.4126	0.1513	0.5707
12.	129682.	7186.	1.7522	0.9139	4.7177	0.7577	0.6529
13.	160105.	1068.	-1.0473	0.2428	1.2506	0.1999	0.2104
14.	160325.	1786.	-0.8806	0.1398	2.3667	0.1213	0.3211
15.	160528.	2685.	-0.6176	0.1360	3.0032	0.1984	0.3901
16.	160189.	3614.	0.2525	0.1412	3.4446	0.1502	0.4390
17.	159798.	5286.	1.3186	0.3057	5.5107	0.1466	0.7210
18.	159540.	7186.	2.1056	0.3374	6.5280	0.2542	0.8724
19.	267052.	1087.	-1.9235	0.4460	1.6996	0.3500	0.3321
20.	265871.	1786.	-1.9731	0.2321	3.3570	0.2229	0.4955
21.	261914.	2691.	-1.5443	0.1779	4.0541	0.1633	0.5516

22.	260450.	3582.	-1.0091	0.1727	4.4906	0.1829	0.5850
23.	254271.	5286.	0.6657	0.3510	7.8771	0.3117	1.0051
24.	249743.	7229.	2.0893	0.4061	9.7154	0.3442	1.2631
25.	339361.	1068.	-3.1015	0.6045	1.9725	0.7928	0.4822
26.	341694.	1754.	-3.0814	0.2917	4.0833	0.3708	0.6484
27.	342873.	2637.	-2.4732	0.1962	4.5055	0.4063	0.6536
28.	341272.	3519.	-1.1658	0.2573	5.8703	0.3745	0.7608
29.	335283.	5286.	0.5843	0.5029	8.7744	0.3388	1.1190
30.	328291.	7186.	2.6900	0.4625	12.6393	0.4367	1.6421

B.10 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 10.

DAMPER SEAL : HOLE PATTERN 2 (C=0.5271mm)
HOLE DIA.=3.8 mm, HOLE DEPTH=2.032mm, GAMMA= 0.34
DR. D. CHILDS TEXAS A&M DEC. '84

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90672.	1083.	-0.5821	0.1181	0.5694	0.0997	0.1050
2.	89509.	1791.	-0.4459	0.0575	1.0014	0.0580	0.1394
3.	90108.	2673.	-0.2485	0.0521	1.3665	0.0871	0.1765
4.	89948.	3571.	-0.1549	0.0682	1.4945	0.0894	0.1910
5.	89768.	5286.	0.7144	0.1414	1.8823	0.1361	0.2566
6.	90328.	7186.	2.8992	0.2583	1.2936	0.2891	0.4056
7.	130519.	1056.	-0.9232	0.1021	0.8083	0.1831	0.1575
8.	130170.	1780.	-0.9104	0.0360	1.4449	0.0723	0.2171
9.	130618.	2673.	-0.6154	0.0632	1.9463	0.1426	0.2592
10.	130229.	3571.	-0.4905	0.0672	2.7704	0.0878	0.3574
11.	130463.	5286.	0.2279	0.1928	3.2581	0.1541	0.4157
12.	130685.	7229.	1.6588	0.2585	3.6618	0.2124	0.5120
13.	160156.	1068.	-1.3523	0.2212	1.0586	0.3220	0.2226
14.	160499.	1786.	-1.1234	0.1033	1.4565	0.1315	0.2339
15.	160295.	2679.	-1.0051	0.1599	2.3542	0.1498	0.3259
16.	160278.	3561.	-0.9929	0.1297	3.6634	0.1599	0.4823
17.	159560.	5286.	0.2413	0.1678	4.6383	0.1649	0.5903
18.	160296.	7229.	1.3920	0.2759	5.0562	0.1832	0.6674
19.	281288.	1071.	-2.0322	0.3900	1.5736	0.4496	0.3342
20.	283452.	1786.	-1.7536	0.1677	2.2556	0.1484	0.3631
21.	280920.	2667.	-2.2904	0.1439	3.3996	0.1477	0.5209

22.	272841.	3582.	-2.1589	0.3180	5.1814	0.1723	0.7140
23.	272031.	5286.	-0.3040	0.4010	6.9722	0.2205	0.8879
24.	274810.	7186.	0.6162	0.4936	8.9997	0.3118	1.1475
25.	367614.	1049.	-3.3361	0.4029	1.9720	0.6482	0.5007
26.	368521.	1765.	-3.1501	0.1921	2.6492	0.1477	0.5231
27.	362380.	2649.	-3.0220	0.2327	4.4992	0.5371	0.6886
28.	366370.	3519.	-3.2586	0.2249	5.7931	0.1804	0.8445
29.	358774.	5263.	-2.1499	0.4103	7.9783	0.3448	1.0508
30.	348834.	7186.	0.3195	0.6680	11.4223	0.4598	1.4544

B.11 Test Data: Force coefficients (average and standard deviations) and average force magnitudes for stator 11.

DAMPER SEAL : HOLE PATTERN 7 (C=0.5271mm)
HOLE DIA.=3.55mm, HOLE DEPTH=1.524mm, GAMMA=0.27
DR. D. CHILDS TEXAS A&M MAY 85

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	90484.	1091.	-0.3031	0.1008	0.5339	0.1016	0.0796
2.	90556.	1807.	-0.2584	0.1203	1.0102	0.0678	0.1333
3.	90351.	2703.	-0.0399	0.0844	1.2438	0.0783	0.1584
4.	90241.	3604.	-0.0603	0.0866	1.3081	0.1186	0.1667
5.	90102.	5310.	0.7717	0.1253	1.6202	0.0830	0.2285
6.	90027.	7186.	2.3576	0.1692	1.9269	0.1834	0.3879
7.	129947.	1068.	-0.5589	0.1206	0.7126	0.0924	0.1164
8.	130000.	1796.	-0.6513	0.0863	1.2823	0.0909	0.1828
9.	129592.	2703.	-0.1986	0.1488	1.8965	0.0598	0.2429
10.	129720.	3593.	-0.1306	0.0857	2.1870	0.0980	0.2784
11.	129773.	5310.	0.5181	0.1246	2.6743	0.1209	0.3464
12.	130547.	7186.	2.2494	0.2259	3.1415	0.1768	0.4918
13.	160018.	1075.	-0.9083	0.1357	0.8172	0.0987	0.1564
14.	160630.	1791.	-1.0113	0.0964	1.5584	0.0663	0.2362
15.	159752.	2703.	-0.4680	0.1077	2.2785	0.1268	0.2957
16.	160582.	3582.	-0.5350	0.0784	2.8273	0.0831	0.3656
17.	159532.	5310.	0.4105	0.1704	3.4107	0.1209	0.4369
18.	159664.	7186.	2.2255	0.2041	4.2681	0.1791	0.6116
19.	269841.	1068.	-1.9641	0.2040	1.0227	0.3714	0.2857
20.	271653.	1780.	-2.2029	0.1242	2.1422	0.2103	0.3908
21.	273572.	2679.	-1.6653	0.1194	3.1799	0.1535	0.4562

22.	263851.	3550.	-2.2381	0.2502	4.8371	0.1544	0.6776
23.	262643.	5310.	-0.5495	0.2814	6.8553	0.2448	0.8743
24.	262724.	7186.	0.7347	0.2929	7.4248	0.2668	0.9484
25.	331941.	1068.	-4.2594	0.5327	1.4106	0.9520	0.5855
26.	329191.	1786.	-4.4640	0.4007	3.0002	0.2893	0.6838
27.	326932.	2685.	-3.8042	0.2932	4.7658	0.2964	0.7747
28.	322691.	3593.	-3.3849	0.3955	6.1338	0.3414	0.8916
29.	320883.	5263.	-1.5869	0.5001	8.3613	0.3998	1.0827
30.	333001.	7186.	-0.3019	0.3632	10.0505	0.4119	1.2780

B.13 Test Data: Force coefficientr (average and standard deviations) and average force magnitudes for stator 13.

DAMPER SEAL : HOLE PATTERN 9 (C=0.5271mm)
HOLE DIA.=3.8mm, HOLE DEPTH=1.524mm, GAMMA=0.34(SPHERE BOTTOM)
DR. D. CHILDS TEXAS A&M MAY 85

Case	Ra	CPM	Fr/A (MN/M)	dev. (MN/M)	Fo/A (MN/M)	dev. (MN/M)	|F| (KN)
1.	89857.	1095.	-0.3463	0.1673	0.5341	0.2095	0.0862
2.	90028.	1824.	-0.1624	0.0826	1.0520	0.0892	0.1356
3.	90510.	2727.	0.2950	0.0665	1.4352	0.1321	0.1864
4.	89798.	3614.	0.1406	0.1008	1.5076	0.1009	0.1927
5.	90710.	5310.	0.8950	0.1304	2.1266	0.0942	0.2934
6.	89967.	7186.	2.0844	0.3400	2.9670	0.2696	0.4629
7.	129464.	1095.	-0.7064	0.2163	0.7993	0.1607	0.1383
8.	129373.	1791.	-0.6733	0.1332	1.4121	0.1896	0.1991
9.	129911.	2667.	-0.5406	0.1097	1.9368	0.0962	0.2559
10.	130525.	3571.	-0.2847	0.1328	2.2946	0.1714	0.2941
11.	130586.	5333.	1.1306	0.1984	3.4527	0.2847	0.4621
12.	129781.	7186.	2.0634	0.3747	4.6852	0.2669	0.6519
13.	159936.	1075.	-0.9184	0.2408	0.8975	0.2070	0.1666
14.	160066.	1780.	-0.9183	0.1111	1.8352	0.1934	0.2612
15.	160470.	2661.	-0.7624	0.1332	2.2233	0.1639	0.2993
16.	160706.	3582.	-0.5579	0.3851	3.0858	0.2840	0.4013
17.	159924.	5310.	1.1851	0.2392	4.3534	0.2342	0.5737
18.	160642.	7186.	2.5484	0.3617	5.5614	0.3364	0.7784
19.	274861.	1064.	-1.6369	0.3856	1.2140	0.4290	0.2672
20.	270433.	1775.	-1.6083	0.3091	2.2952	0.2141	0.3578
21.	272482.	2655.	-1.6121	0.1863	3.8298	0.2296	0.5287

22.	268182.	3529.	-1. 4701	0. 4240	4. 3013	0. 2645	0. 5799
23.	261884.	5310.	0. 5757	0. 5872	6. 1190	0. 4188	0. 7841
24.	257071.	7186.	3. 1016	0. 7080	8. 8276	0. 4394	1. 1909
25.	354260.	1042.	-2. 4074	0. 5355	1. 2772	0. 6953	0. 3608
26.	350603.	1760.	-2. 0711	0. 2721	2. 9958	0. 3977	0. 4632
27.	346542.	2649.	-2. 0475	0. 4835	3. 8668	0. 5905	0. 5576
28.	342331.	3529.	-1. 7764	0. 2836	4. 7306	0. 5875	0. 6438
29	334882.	5310.	-0. 6271	0. 8208	7. 4478	0. 5602	0. 9551
30.	322641.	7186.	2. 9407	0. 8986	10. 2557	0. 5918	1. 3604