NASA CR-182233

ADIABATIC WANKEL TYPE ROTARY ENGINE

PHASE II FINAL REPORT

BY

R. KAMO, P. BADGLEY, AND D. DOUP

ADIABATICS, INC.
COLUMBUS, INDIANA

PREPARED FOR

NASA LEWIS RESEARCH CENTER

CONTRACT NAS3-24880

SEPTEMBER 1988

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No.

4. Title and Subtitle	5. Report Date
Adiabatic Wankel Type Rotary Engine	Sept. 1988
	6.
7. Author(s) R. Kamo, P. Badgley and D. Doup	8. Performing Organization Rept. No. AI-120
9. Performing Organization Name and Address Adiabatics, Inc. 630 South Mapleton Street Columbus, Indiana 47201	10. Project/Task/Work Unit No.
	11. Contract(C) or Grant(G) No. (C) NAS3-24880 (G)
12. Sponsoring Organization Name and Address National Aeronautics and Space Administration Lewis Research Center Attn: Mr. John McFadden, Mail Stop 77-6 Cleveland, Ohio 44135	13. Type of Report & Period Covered
	14.

15. Supplementary Notes

Project Manager, J. McFadden, NASA-Lewis Research Center, Cleveland, Ohio 44135

16. Abstract (Limit: 200 words)

This SBIR Phase program accomplished the objective of advancing the technology of the Wankel type rotary engine for aircraft applications through the use of adiabatic engine technology. Based upon the results of this program, technology is in place to provide a rotor and side and intermediate housings with thermal barrier coatings.

A detailed cycle analysis of the NASA 1007R Direct Injection Stratified Charge (DISC) rotary engine was performed which concluded that applying thermal barrier coatings to the rotor should be successful and that it was unlikely that the rotor housing could be successfully run with thermal barrier coatings as the thermal stresses were excessive.

17. Document Analysis a. Descriptors

Wankel rotary engine, Adiabatic engine, Wankel Simulation Model, Aircraft engines, Turbocharging, Turbocompound.

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unclassified	Unclassified	215
	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

ADIABATICS WANKEL TYPE ROTAY ENGINE
PHASE II

TABLE OF CONTENTS

ADIABATICS WANKEL TYPE ROTAY ENGINE

PHASE II

TABLE OF CONTENTS

ADIABATIC WANKEL TYPE ROTARY ENGINE
PHASE II

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont.)

ADIABATIC WANKEL TYPE ROTARY ENGINE
PHASE II

LIST OF TALBES

1.0 Introduction

This final report is prepared by Adiabatics, Inc. for the National Aeronautics and Space Administrations' Lewis Research Center (NASA LeRC) per an SBIR contract No. NAS3-24880 as amended in Modification No. 2. This report documents the two-year SBIR Phase II program, from July 10, 1986 to September 10, 1988, to develop and test a prototype low-heat-rejection rotary engine.

This SBIR Phase II program was a result of the studies performed in the Phase I contract entitled "Adiabatic Wankel-Type Rotary Engine" completed in 1985. Under Phase I, an analytical study, significant results in areas such as decreased fuel consumption and increased power output were cited when thermal-barrier (insulative) coatings were applied to internal components of the rotary engine, and with the subsequent removal of the cooling system.

The work in this Phase II program was the first step in applying the ideas and theory elaborated in Phase I to an actual engine. The objective of this Phase II project was to design, fabricate, procure, assemble, and test a prototype low-heat-rejection rotary engine to see if the results of Phase I are actual and that this type of engine can run dependably.

2.0 EXECUTIVE SUMMARY

This SBIR Phase II program accomplished the objective of advancing the technology of the Wankel type rotary engine for aircraft applications through the use of adiabatic engine technology. Curtiss-Wright and John Deere as part of their "Technology Enablement" program for aircraft rotary engines have identified a need for reduced heat rejection as a key technology for a highly advanced aircraft engine [1].

Based upon the results of this program technology is in place to provide a rotor (using either the available 17-4PH stainless steel rotor or preferably a titanium alloy rotor) and side and intermediate housings (of preferably titanium alloy) with proven thermal barrier coatings. These components by themselves make a large improvement in the engine package by substantially reducing the net heat transfer and thus reducing the size and weight of the cooling systems (lube and coolant) and will also improve the efficiency of the engine by improving the combustion through increased cycle temperatures. To achieve the best overall powerplant package a single high temperature fluid combining lubrication and rotor housing cooling should be incorporated. Incorporation of a compounding cycle such as turbo-compounding or a bottoming cycle will be even more attractive and show larger benefits as more heat is diverted from coolant to the exhaust.

A detailed cycle analysis of the NASA 1007R Direct Injection Stratified Charge (DISC) rotary engine was performed by ADAPCO, Inc. utilizing the DISC cycle simulator developed by MIT under a program sponsored by NASA. The analysis was calibrated by matching measured performance data supplied by John Deere. The analysis was then conducted for two cases consisting of both an uncooled engine with thermal barrier coatings on cast iron engine housings and an intermediate case with thermal barrier coatings on water cooled aluminum housings with thermal barrier coatings on the rotor in both cases. A finite element model for the 1007R rotor and rotor housing was developed for each of the three cases (standard water cooled, thermal barrier coatings with water cooling, and thermal barrier coating with no cooling). Detailed thermal and stress analyses were then performed for these three cases utilizing boundary conditions as defined by the respective cycle simulations. This study concluded that applying thermal barrier coatings to the rotor should be successful and that it was unlikely that the rotor housing could be successfully run with thermal barrier coatings as the thermal stresses were excessive.

Concurrently with the analytical study all of the major internal engine components including the rotors, rotor housings and side housings have been coated with thermal barrier coatings and the components durability tested in a racing Mazda engine for over 300 test hours. The Mazda engine was utilized for this design and durability screening effort rather than the 1007R engine for reasons of availability and cost effectiveness and because it runs hotter that the DISC engine which serves to accelerate the testing.

The results of the iterative design, fabrication and testing cycles are that successful designs for both the rotor and side housings with thermal barrier coatings are proven and that the use of thermal barrier coatings on the rotor housing appears to raise the inner surface temperature to the point where available liquid lubricants are inadequate to lubricate the apex seal interface.

Based upon the test results, components have been supplied to NASA for the NASA 1007R engine which have been modified with thermal barrier coatings. The plan is for NASA to have the components engine tested by John Deere's Rotary Engine Division to determine their performance in the DISC engine.

3.0 Background-Phase I

The SBIR phase I program was an analytical study of the potential benefits of the adiabatic Wankel-type engine and advanced heat engine concepts. Also, the design of adiabatic engine components, methods of applying ceramic (insulative) materials, and the technical feasibility of an adiabatic Wankel engine concepts were presented. The baseline engine selected for this study was the single rotor 1007R engine built by John Deere and owned by NASA. The 1007R is a highly advanced, stratified charge, 0.7 liter prototype engine.
The results of the Phase I study confirmed a significant improvement in the performance of the Wankel engine when modified to be adiabatic. Also, advanced concepts like turbocompounding, advanced turbocharging, high compression ratios, faster combustion, and reduced leakage showed significant improvements in engine performance. An overall improvement of 25.5% in ISFC and 34.5% in power output was predicted for the 1007R engine when 100% adiabatic and turbocharged. The potential application and performance benefits of the low-heat-rejection Wankel engine are extremely attractive for future advanced power plants for aircraft, automotive, and industrial engines. These discoveries and potential benefits are what prompted the funding of Phase II.

4.0 Technical Approach

To meet the objectives of this Phase II project a management plan was developed whereby Phase II was broken into two separate parts. The first part to be performed by Adiabatics Inc. consists of development of insulated components. A Management Plan submitted by Adiabatics Inc. at the beginning of the program is found in Appendix A. The second part consists of testing the fully insulated engine which will be performed by John Deere at a later date.

To meet the first contract objectives, a nine-task plan was developed is as follows:

Tasks

1. Engine Selection and Baseline Testing,
2. Thermal Analysis,
3. Adiabatic Component Design,
4. High Temperature Apex/Side Seal Tribology,
5. Prototype Engine-Procurement/Assembly-Mazda 13,B
6. Engine Testing,
7. Prototype Engine-Procurement/Assembly-NASA 1007R,
8. Exhaust Energy Utilization. and
9. Reporting.

5.0 Discussion

The following sections detail each of the tasks from start to finish.

5.1.0 Task 1 Engine Selection and Baseline Testing

An economic and feasibility study was to be made to select the best rotary engine available for modification to an adiabatic design. After selection of the engine, an engine test plan was to be conceived and baseline testing commenced. The candidate engine needed to be both easy and economical to modify while offering as much control of the hot combustion as possible and capable of producing enough power output to meet NASA's requirements for use in light aviation.

5.1.1 Engine selection

Engine selection was based on the following criteria:

- Ease of modification and compatibility with insulated coating,
- Lowest cost,
- Availability of spare parts,
- Fuel introduction (fuel injection into the combustion chamber being preferred), and
- Power output.

A survey of the available prototype and commercial Wankel rotary engines showed the following existing engines:

Engine	Comment
NASA 1007R Research Rig	• Only one available with John Deere • Expensive • Fuel injection system meets requirements

John Deere RC1-60 (Curtiss-Wright)	• Not Available
Wedtech 312 c.c.	• Small size • Not stratified-charge • Combustion chamber for natural gas fuel
OMC Rig Engine at NASA	• OMC not interested in supporting
Norton/Teledyne	• Not Stratified charge • Small size • Teledyne not interested
Mazda 13B (2 rotor)	• Low cost • Parts easily available • Not stratified charge
Mazda 13B (1 rotor) Research Rig	• Expensive to fabricate • NASA research rig given to NSRDC

Of the above engines, only the John Deere 1007R offered the desired power output and fuel introduction system. The other engines are either not available, too small, or not fuel injected. The problem with the 1007R is it is a prototype engine and only one existed which was being used by John Deere.

The other engine which held some promise, was the naturally aspirated two-rotor Mazda 13B. Though this engine is not fuel injected, parts are readily available at low cost. Also, the Mazda has a power range comparable to the 1007R meaning both engines meet the requirements set by NASA.

The conclusion of this survey was to use the two-rotor Mazda 13B engine for component screening (mechanical screening as opposed to performance development) because of its low cost, availability of parts, and the maturity of the engine. Once components were successfully tested for durability and integrity in the Mazda, the knowledge gained would be used to modify parts for a second engine - the NASA 1007R. Assembly and testing of the uncooled adiabatic NASA engine will be under a contract performed at John Deere (the 1007R will then be the advanced engine which strives for the goals outlined in this SBIR Phase I report).

This selected approach was reviewed with Mr. William Hady at NASA LeRC on November 12, 1986 which was followed by a Management Plan which detailed the program.

A two-rotor Mazda 13B engine was purchased from Racing Beat Inc. of Anaheim, California. The configuration of the engine is listed in the following table:

Table 1. Configuration of the Mazda 13B Engine

Model	Mazda 13B
Displacement	1.308L(80 Cu In)
Rated Power	132KW (177 Horsepower)
Intake Ports	6 Side Ports (2 Valved)
Exhaust Ports	2 Peripheral
Exhaust Manifold	Racing Type Header
Corporation	Dellorto 48 DHLA (Dual side draft)
Ignition	Mazda Breakerless distributor (Integral Electronics)
Ignition Coils	Mazda Transistor Ignition Type
Flywheel	Lightweight Steel Type

5.1.2 Engine Test Plan

With the test engine selected, the next step was to develop an engine test plan (Appendix B) consisting of the following:

- Descriptions of configurations being tested,
- Test conditions,
- Parameters to be measured,
- Instrumentations, and
- Detailed location of the thermocouples in the rotor housing and intermediate housing.

5.1.3 Baseline Testing

The first test was to baseline the engine and refine the test facility. The data gathered from the baseline test (Appendix C) were used for comparison purposes in later tests to help evaluate changes brought about by testing different insulated components. The baseline test ran approximately 23 hours.

The baseline test consisted of six (6) basic operations. The first three operations were disassembly, inspection, and reassembly. The Mazda engine was disassembled as specified in the 1987 Mazda shop manual. While disassembled, the components were inspected as specified in the Mazda shop manual.

Before reassembly, the standard rotor housings and intermediate housing were replaced with new housings which had been machined for thermocouple installation. These were the only internal components changed for instrumentation and should not effect engine performance. Engine assembly was done as specified in the Mazda shop manual.

The fourth step was to install the engine in test cell No. 2 and connect it to the Eaton eddy-current-type dynamometer. All instrumentation was installed in a standard manner and calibrated. Pictures of the Mazda engine mounted in the test cell can be seen in figure 5.1.3-1.

The fifth operation was the test itself. Engine testing started with a compression test. The compression tester takes six (6) measurements (one for each rotor face). Next, the engine was started and run through the break-in cycle which consisted of running at varying speeds with light to no-load. During this run all systems were checked to make sure they were functioning properly.

A test was to be run to develop the torque curve. From the torque curve 5 test speeds were to be selected. Each of the five speeds were then to be run at 25%, 50%, 65%, 75%, and 100% of full load. All the parameters listed in the engine test plan (found Appendix B) were to then be recorded at the various speeds and loads.

The last operation was to be disassembly and re-inspection once the engine completed testing.
Although test conditions were ideal problems were encountered. The engine developed excessive vibration at high speeds and problems were encountered controlling the dynamometer. This reduced testing speeds and loads. Upon post-disassembly a source of this problem was found. A needle type thrust bearing on the crankshaft had become pinched which inhibited its "free" rotation. Another source of the problem was found part way through the second test (the coated intermediate housing test). A factory mislabeled distributor caused the leading and trailing spark plugs to be fired in a backwards order. In other words, the trailing spark plugs fired first. These problems were corrected but their effect on the data remains unknown. Therefore, all comparisons of data are made under like conditions. For example, the data gathered from testing the engine with insulated rotors is compared with data gathered from testing with the insulated intermediate housing (with correct ignition in both cases). The baseline test is compared with the insulated intermediate housing test when both had incorrect ignition.

5.2 Task II Thermal Analysis

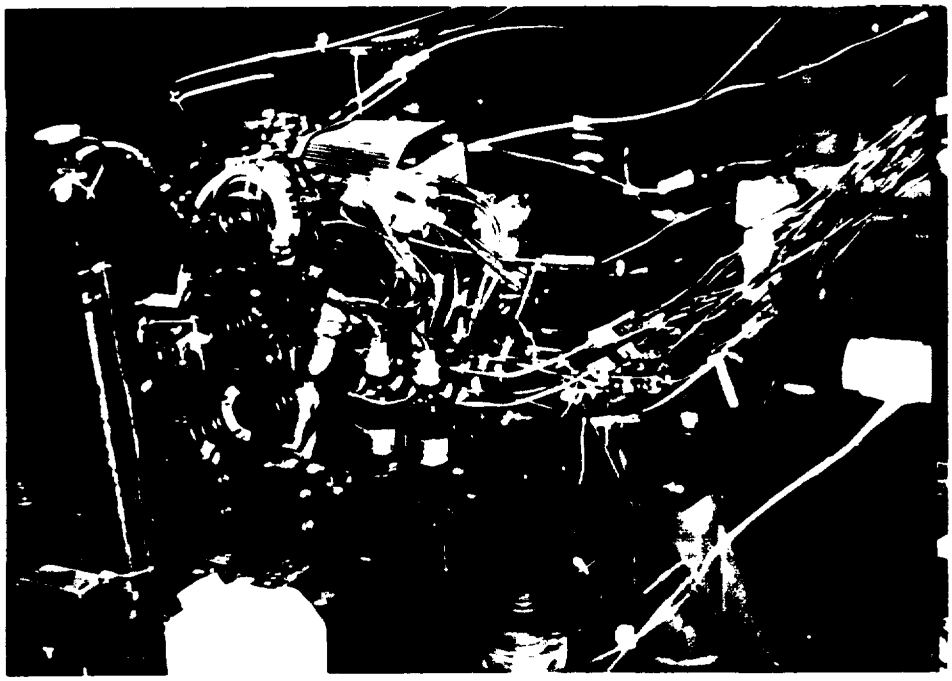
On April 1, 1987 a subcontract was let to (Appendix D) ADAPCO, Inc. for the thermal analysis on the 1007R engine. The purpose of this analytical effort was to determine the structural implications of an "adiabatic" direct-injection stratified charge (DISC) rotary engine. The analysis was to predict a thermal history to provide the basis for calculating the distortion, allowable clearances, and thermal stresses. These calculated stresses were then to be combined with rotating stresses and pressure loading stresses to provide input for component design.

The method for conducting this analysis was to be as follows:

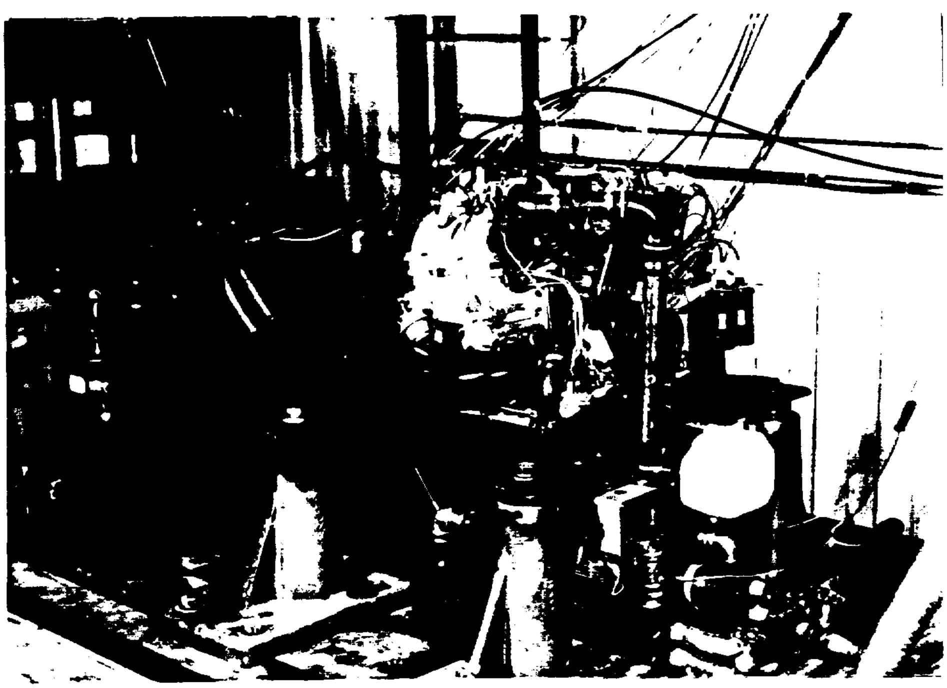
A NASA to furnish 1007R drawings and test data to ADAPCO,

B NASA to furnish MIT stratified charge combustion model (DISC),

C ADAPCO to incorporate 1007R geometry and run the MIT Model to generate boundary conditions,



AI-C/111-2A



AI-C/111-6A

Figure 5.1.3-1. Mazda Engine Ready for Baseline Testing.

D ADAPCO to use John Deere data to verify model,

E ADAPCO to generate FE model of 1007R rotor and rotor housing,

F ADAPCO to use boundary conditions from C and run FE model, and

G ADAPCO to prepare report.

A copy of ADAPCO's final report number 44-01-001 dated March 4, 1988 entitled "Heat Transfer and Structural Analysis of a Thermal Barrier Coated Direct Injection Stratified Charge Rotary Engine" is hereby submitted to NASA as appendix to this report.

The conclusion of ADAPCO's report was that the insulated rotor was the most likely component to survive in the adiabatic engine (though it showed high levels of stress in the coating around the "lip" of the combustion bowl). The stock aluminum 1007R rotor housing (coated with a combination of insulation and wear surface coating) when run with coolant was predicted as having a likely chance of failure. Due to the difficulty of applying thermal barrier coatings on aluminum, a coated cast iron rotor housing was modeled as an alternative to aluminum. The simulation predicted that the only outcome of using a coated cast iron rotor housing in a uncooled engine was coating failure. This failure was chiefly predicted because of the thermal expansion mismatches between the insulative coating on the trochoid contour and the cast iron.

5.3 <u>Task III Adiabatic Component Design</u>

Adiabatic component design was included in the subcontract with ADAPCO. Once ADAPCO had completed a computer simulation run of the baseline 1007R engine, ADAPCO was to proceed and modify the models for combustion and the FE models for the rotor and rotor housing to include selected low-heat-rejection conditions. These results were then used in an interactive manner to design insulated 1007R components. These preliminary designs were then coupled with the knowledge gained from screening tests in the Mazda engine.

Drawings, completed by Adiabatics, of the final modifications to the 1007R parts are included (Section 5.7 Prototype Engine - Procurement/Assembly - NASA 1007R).

5.4 <u>Task IV High Temperature Apex/Side Seal Tribology</u>

This Task is to evaluate and procure candidate apex seals, side seals, and high-temperature lubricants to be tested in the Mazda engine for later inclusion in the 1007R engine. The procurement of the apex and side seals is summarized in Table 2. The initial work performed in this task was to find material combinations which would be most likely to survive the harsh conditions encountered in a high-temperature engine.

Based on past experience with high temperature reciprocating piston engines, chrome-oxide or chrome-carbide coated piston rings rubbing against zirconia thermal-barrier coated liners densified with chrome oxide are the prime candidate materials.

Efforts were then spent trying to procure side seals and apex seals micropocketed and coated with thin [(0.051 mm (0.002 inch) to 0.127 mm (0.005 inch)] layers of chrome oxide and or chrome carbide. Unfortunately, vendors could not be located to supply these components.

TABLE 2. PROTOTYPE PROCUREMENT - MAZDA 13B

	COMPONENT	QUANTITY	MATERIAL	TYPE OF COATING APPLIED	VENDOR	CONDITION AFTER COATING
1)	SIDE SEALS	3	STOCK CAST IRON	0.051mm (0.002 INCH) THICK PROPRIETARY SLURRY COATING -SLURRY THEN DENSIFIED	ADIABATICS ADIABATICS	EXCELLENT EXCELLENT
2)	SIDE SEALS	6	STOCK CAST IRON	0.051mm (0.002 INCH) THICK CHEMICALLY DEPOSITED LAYER OF NICKEL, CHROME, AND BORON	CHEMKOTE	EXCELLENT
3)	APEX SEALS	12	M2 TOOL STEEL	NONE	BOYER MACHINE	EXCELLENT
4)	ROTORS	4	STOCK CAST IRON	0.762mm (0.030 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN DENSIFIED	APS MATERIALS KAMAN SCIENCES	EXCELLENT SCRAP
5)	ROTORS	2	STOCK CAST IRON	0.762mm (0.030 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA	APS MATERIALS	EXCELLENT
6)	ROTOR	1	STOCK CAST IRON	0.762mm (0.030 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN DENSIFIED	APS MATERIALS ADIABATICS	EXCELLENT EXCELLENT
7)	INTERMEDIATE HOUSING	1	STOCK CAST IRON	0.762mm (0.030 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN DENSIFIED	APS MATERIALS KAMAN SCIENCES	EXCELLENT EXCELLENT
8)	ROTOR HOUSING	2	STOCK ALUMINUM	0.508mm (0.020 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN COVERED WITH TRIBALOY 800	APS MATERIALS STELLITE	EXCELLENT 1 SCRAP
9)	CAST ROTOR HOUSINGS	2	CAST DUCTILE IRON	0.762mm (0.030 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN DENSIFIED	APS MATERIALS ADIABATICS	EXCELLENT EXCELLENT

At this point two new approaches were utilized; the first, was an electro chemical coating process, and secondly, a slurry sprayed coating process applied at room temperature and low pressure.

The electro chemically deposited coating chosen for the side seal application was supplied by Cemkote, Inc. of Indianapolis, Indiana. The coating is called "Chem 2" and consists of nickel, chrome, and boron. Since this coating is chemically deposited, its application is very uniform across the entire surface. Before the side seals were coated, the Chem 2 coating was applied to specimens which Adiabatics tested in a wear test rig.

The wear and friction test rig was designed and built as a relatively quick and inexpensive way of screening materials under controlled test conditions. It employs the principle of a roller rotated against an oscillating bar specimen as shown in figure 5.4-1. The flat bar specimen is clamped to a steel bar which is supported by linear/rotary bearings and arranged for linear oscillation of $\pm$ 6.3 mm by a motor-driven cam at a fixed 4 rpm. The loading of the test specimen on the roller is provided by applying dead weights on the pivoting support structure. The roller is driven by a constant speed electric motor and any desired roller speed can be set by adjusting the variable diameter pulleys.

Test environment control is provided by encasing the roller and test specimen in an insulated enclosure. Electrical heaters built into the walls of the enclosure are thermostatically controlled and the heating of the enclosed air provides a means for test temperature variation of the roller and specimen, up to 538 C. In figure 5.4-1 the enclosure is shown operating open-ended with connections to a coal burner and a suction fan. This arrangement is used to test materials in the environment of coal combustion products. The test temperature is regulated by the use of the in-line damper to control the flow rate of the combustion air and the heating coils.

The coal burner can also be replaced by a gas burner or a feeder of other environment contaminants, like coal powder without combustion.
The torque required to drive the roller is measured by an in-line torque meter and is continuously recorded on a chart recorder. The temperatures of the roller and the test specimen are monitored by thermocouples installed as shown in figure 5.4-2, and also recorded on the chart recorder. A drawing of the assembly of the major components of the friction and wear test rig is shown in figure 5.4-3.

The duration of a test or any event during the test is determined from the chart paper speed, selected as needed. From this recording and the load applied by weights, the force between the roller and the specimen is evaluated, the coefficient of friction can be calculated at any time during the test.

Wear values are obtained by measuring the weight loss during the test. This is done by weighing test parts before and after a test. A balance of 0.0001 gram resolution is used to weigh the specimens. The accuracy of the wear measurement is dependent on the amount of weight loss produced and the resolution of the scale. Hence, to ensure acceptable accuracy, the duration of tests was varied depending on the wear rate of the materials tested. Most of these tests were run for 18 hours while a few were as short as 15 minutes [2].

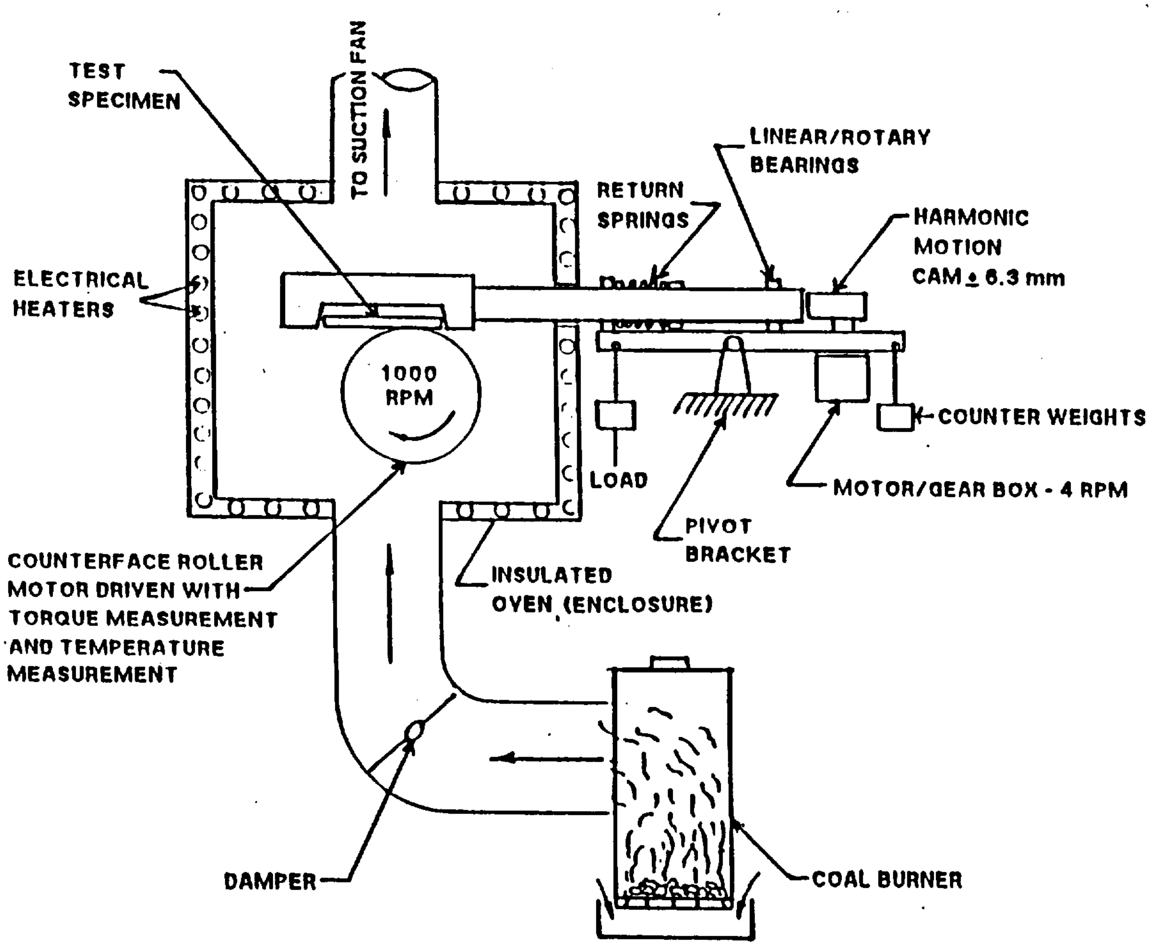


Figure 5.4-1. Schematic Drawing of Friction and Wear Test Rig.

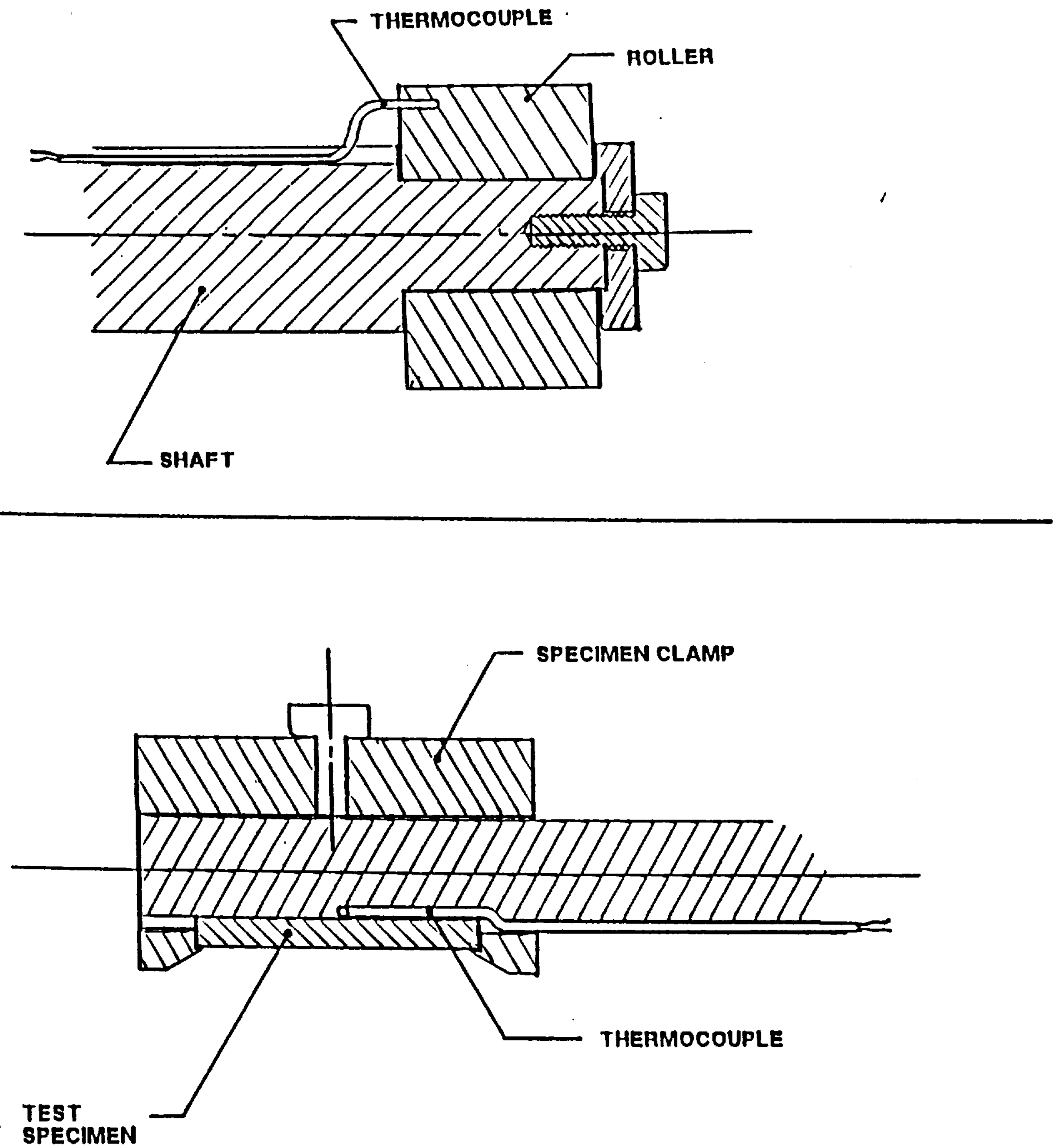


Figure 5.4-2. Thermocouple Installation for Roller and Specimen Temperature Measurement.

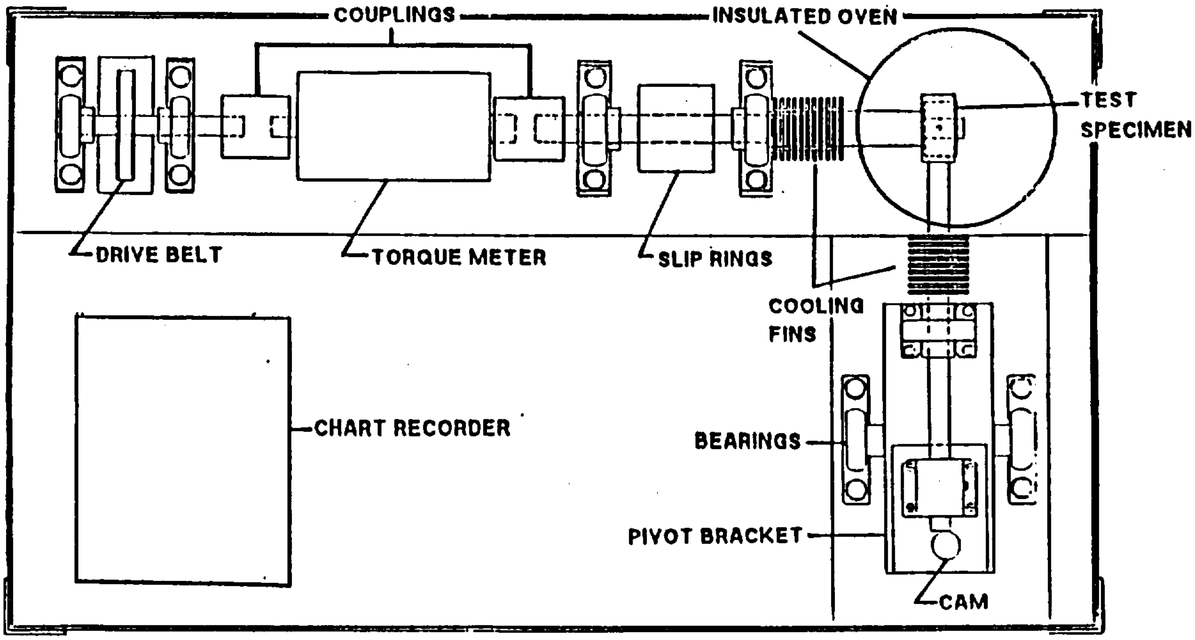


Figure 5.4-3. Drawing of Friction and Wear Test Rig Assembly.

The test results revealed that the Chem 2 is not very wear resistant but offered a very low friction coefficient.

A second set of rotor side seals was coated with a slurry coating developed by Adiabatics, Inc. The chrome molly chemical slurry type coating was sprayed at low velocity and room temperature to approximately a 0.051 mm (.002 inch) thickness. This coating is proprietary; therefore, its constituents are not listed. The results of the wear test showed this coating to be very resistive to wear.

For apex seals M2 tool steel was selected based on many tests of material specimens on Adiabatics' wear test rig, M2 was selected based on its resistance to wear and its high temperature capability. Two sets of apex seals were made from M2 tool steel by Boyer Machining, Inc. of Columbus, Indiana.

The last area of Task IV was selecting and procuring candidate high-temperature lubricants. A major portion of the Mazda testing was performed using a synthetic lubricant called SDL-1 which is sold through Bonneville Lubricants of Idaho Falls, Iowa.

This oil was chosen based on experience with reciprocating piston engine testing at Adiabatics.

Throughout all the coated component screening tests, oil temperatures varied between 93.33 C (200 F) and 126.67 C (260 F). No evidence of oil break down was noticed.

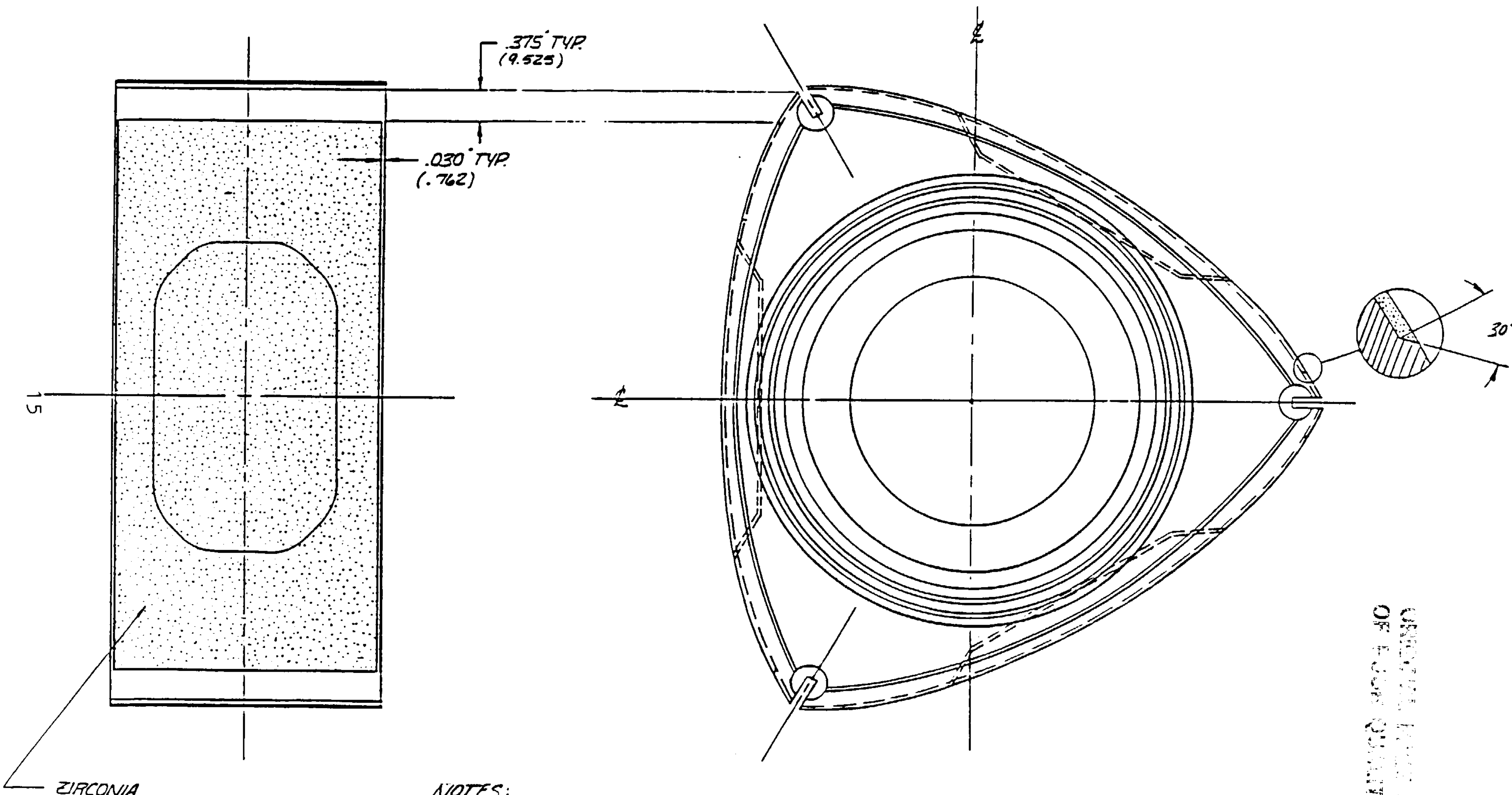
The stock John Deere 1007R apex seals and side seals will be suitable for running against the Tribaloy 800 coating on the aluminum side and rotor housing because Tribaloy 800 has excellent tribological characteristics and is compatible with the current John Deere seals. Therefore, no special side or apex seals were procured.

5.5 Task V Prototype Engine-Procurement/Assembly-Mazda 13B

The following is a listing of the low-heat-rejection components along with a description of how they were made.

5.5.0 Rotor

The rotor modification was application of thermal barrier coating to the combustion faces. The rotor combustion faces, with the exception of a 9.5 mm (0.375 inch) land at each apex (such that the apex seal was fully supported by the parent rotor material) and a 0.762 mm (0.030 inch) land along the side lands of the rotor, were machined to remove 0.762 mm (0.030 inch) of material. A 0.762 mm (0.030 inch) inlaid thermal barrier coating consisting of a 0.127 mm (0.005 inch) layer of plasma-sprayed NiCrAlY bond coat covered with a 0.635 mm (0.025 inch) layer of plasma-sprayed zirconia was then applied onto the machined inset on the faces of the rotor. With the coating applied, the high spots were removed and the coating then densified with the Kaman KaRamic Process. In doing this, an impenetrable barrier was formed which protects the bond coat. A drawing detailing this coating procedure is shown in figure 5.5.0-1.



NOTES:

1. MACHINE .030" (.762) OFF THE OUTSIDE OF ROTOR AND INSIDE POCKET AREA.
2. COATING - .005" (.127) BONDING THEN .025" (.635) ZIRCONIA

Figure 5.5.0-1. Details of Zirconia Coating Applied to Mazda 13B Rotors.

Two (2) rotors were processed as described above. During the densification process the coating on both rotors failed. Kaman Sciences Corp., who densified the pieces, claimed coating failure was caused by a problem with their oven. Densification is a process of filling the zirconia porosity near its outer boundaries with chrome oxide, thereby forming a barrier which protects the bond coating. To do this, a liquid chemical is applied to the zirconia and allowed to penetrate. Next, the whole part is heated to 537.8 C (1000 F) at which time the liquid chemical is converted into chrome oxide. Kaman said that oven temperatures reached 792.2 C (1458 F) which not only caused the coating to "pop off" but as discovered later, caused the rotor gear to lose its hardness. Since the gear is not replaceable these rotors could not be re-coated, and were therefore scrapped.

Two more rotors were machined and coated with plasma-sprayed zirconia. They were sent to Kaman Sciences for densification where, after one temperature cycle, the coating popped off (shown in figure 5.5.0-2) in the identical locations as before. Kaman claimed the problem this time was caused by "bad coating" and not their processing.

These last 2 rotors were recycled. The damaged coatings were sandblasted off and a thermal barrier coating was reapplied. These rotors were later tested in the engine without receiving densification.
Because zirconia is porous, the bond coat is susceptible to chemical attack in the engine which results in a shorter life. Therefore, one more attempt was made at densification. This time major changes were made in both the design of the rotor and the densification process itself. In every case the coatings failed in the same areas - along the lip of the combustion chamber (see figure 5.5.0-2). Therefore, a design change was made whereby a thin band of parent material was left untouched during machining around the lip of the combustion chamber (see figure 5.5.0-3). A new low-temperature process developed by Adiabatics which is not only better for the parts but it is non-toxic as well was applied. Through this combination of the lip design and the low temperature densification a first attempt provided one Mazda rotor successfully coated and densified. This rotor is shown in figure 5.5.0-4.

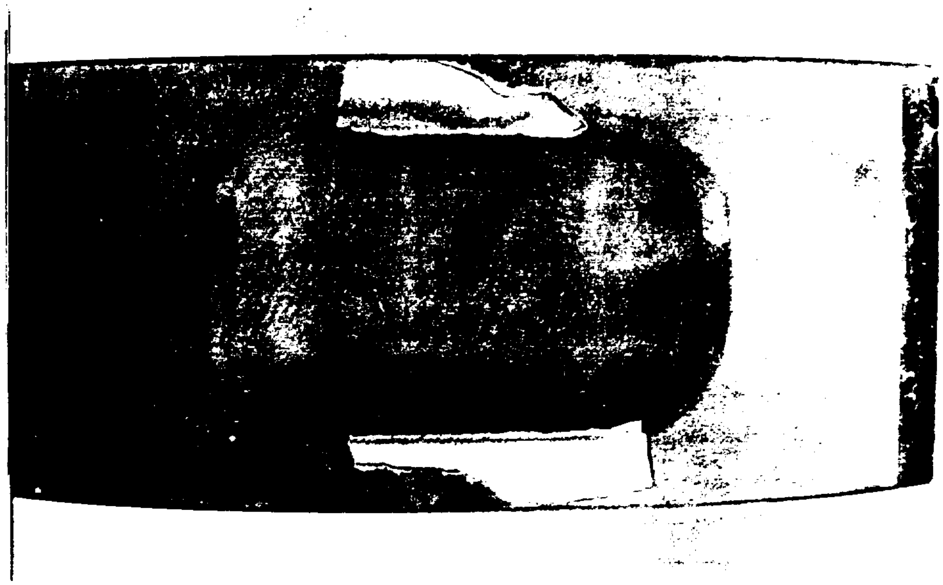
As a result, 2 different kinds of insulated rotors were successfully procured for testing in the 13B engine; firstly, 2 insulated rotors with undensified zirconia, and secondly, 1 insulated rotor densified by Adiabatics, Inc. incorporating a combustion chamber lip.

5.5.1 Side Housing

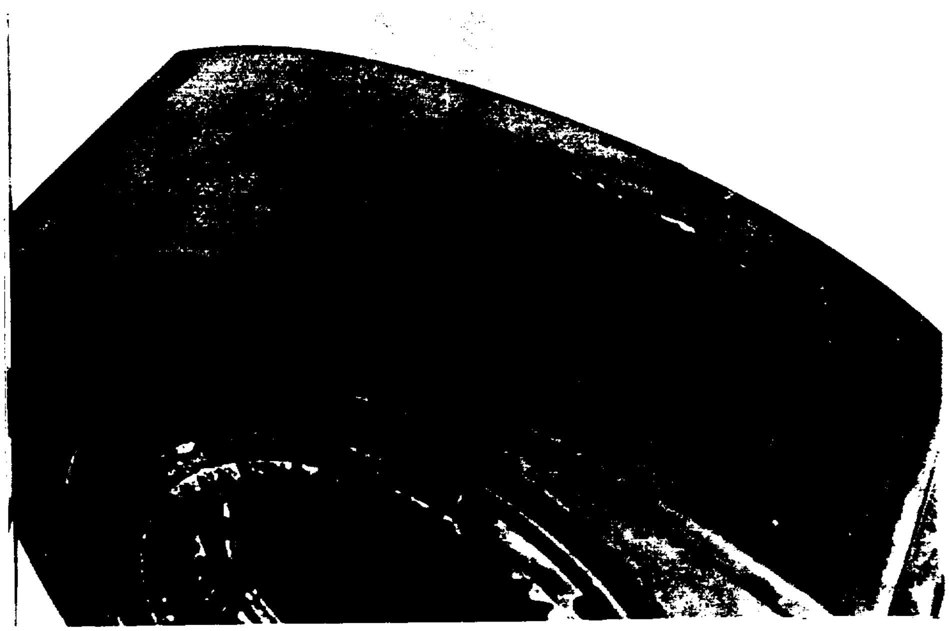
The initial approach to the side housing was to apply low-heat-rejection technology to only one side housing face in each combustion chamber by applying the insulation to both faces of the intermediate housing. To apply the thermal barrier coating, 0.762 mm thick (0.030 inch) of parent material was machined from both sides of the intermediate housing. A lip of parent material was left untouched during the machining operation around both the crankshaft hole and the intake port. This resulted in a coating which would be totally inlayed. Next, a 0.127 mm thick (0.005 inch) layer of NiCrAlY bond coat plus a 0.635 mm (0.025 inch) layer of plasma-sprayed zirconia was applied to the machined areas of the intermediate housing.

The coated housing was then machined back to maintain the original side housing thickness. The zirconia was then densified with chrome oxide by Kaman Sciences

ORIGINAL PAGE IS
OF POOR QUALITY



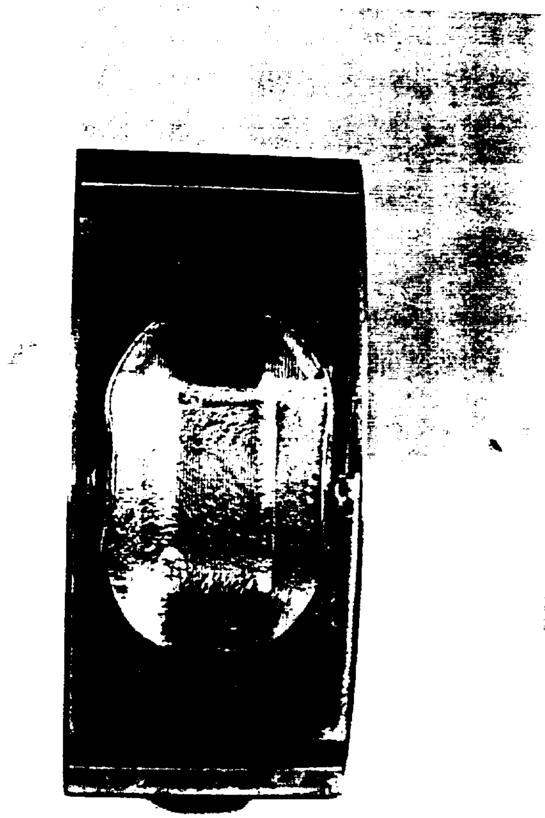
AI-C/114-12



AI-C/114-13

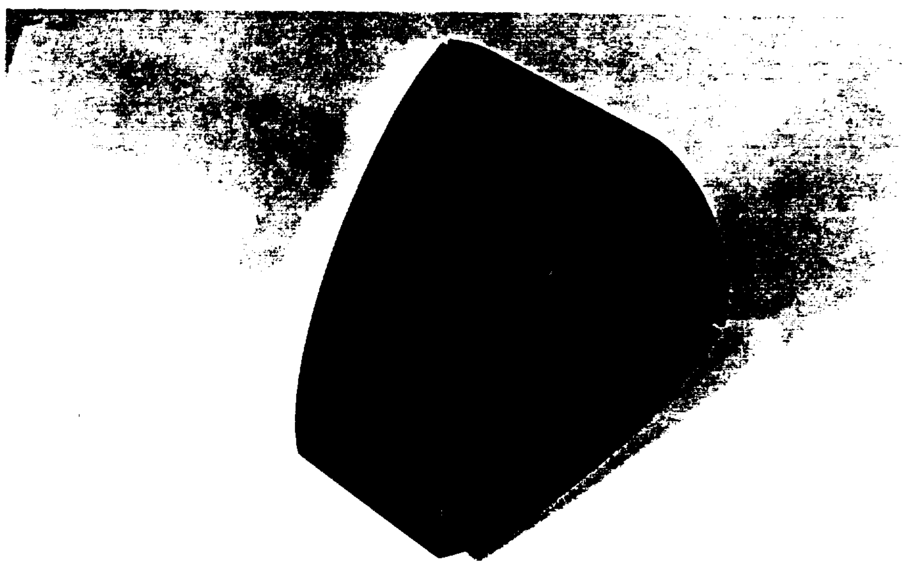
Figure 5.5.0-2. Zirconia Coated Rotor After One Densification Cycle.

ORIGINAL PAGE IS
OF POOR QUALITY



AI-C/128-8

Figure 5.5.0-3. Machined Mazda Rotor with Lip Design Around the Combustion Chamber.



MAZDA 13B ROTOR COATED 0.030 in. APS-PSZ
AND LOW CYCLE LOW TEMPERATURE MODIFIED NC PROCESSING

AI-C/128-8

Figure 5.5.0-4. Mazda Rotor After Adiabatics, Inc. Low Temperature Densification.

- successfully. In this case the densification served 2 purposes: 1) as in the rotor application, densification acts to protect the bond coat, and 2) the very hard chrome oxide densification provides an excellent wear surface which is needed since the rotor side seals rub against the thermal barrier. All experience with reciprocating piston engines reveals that this densification process provides the best wear characteristics when applied on cylinder liners. After densification the housing was lapped to a surface roughness of 20 micro-inches. Ideally a surface roughness of less than 10 micro-inches was desired but could no be obtained. As a result of the difficulty during the lapping, the finished coating thickness was 0.508 mm (0.020 inch) instead of 0.762 mm (0.030 inch). A drawing detailing the coating process is shown in figure 5.5.1-1.

5.5.2 Rotor Housings

This component presented the greatest challenge to effectively reduce its heat rejection. The rotor housing material for both the Mazda and the 1007R engine is aluminum (the Mazda side housings are cast iron) which means that the existing technology for cast iron reciprocating engine parts can not be used because the temperatures to which the material is subject during processing is in excess of 537.8 C (1000 F). Therefore, either a different process was required or else the rotor housing must be made of material other than aluminum. Both approaches were followed.

The stock aluminum rotor housing was coated as follows:

1. The housing was sent to Eonic, Inc. where 0.508 mm (0.020 inch) of parent material was removed from the steel trochoid contour.

2. The housing was sent to APS Materials, Inc. where a 0.127 mm (0.005 inch) layer of plasma-sprayed NiCrAlY bond coat plus a 0.381 mm (0.015 inch) layer of plasma-sprayed zirconia was applied to the machined trochoid contour.

3. The coated housing was sent back to Eonic, Inc. where the 0.254 mm (0.010 inch) of zirconia was ground off each side of the trochoid contour. This step was performed to ensure dimensional correctness and provide room for the wear coating.

4. The housing was sent to Stellite, Inc. where the ground zirconia was coated with more than a 0.254 mm (0.010 inch) layer of Tribaloy 800 which would act as a wear surface.

5. The housing was sent back to Eonic, Inc. for final grinding and lapping to the stock Mazda trochoid contour dimension.

This coating process was selected based on result of friction and wear testing with specimens (rollers) on Adiabatics' wear testing rig. The plasma-sprayed zirconia/Tribaloy 800 combination showed less wear with lower friction than combinations like plasma-sprayed zirconia/chrome oxide or zirconia/chrome carbide. Also, the zirconia/Tribaloy 800 specimen showed excellent adhesion characteristics. Its entire manufacturing process remains cool enough that aluminum is not damaged.

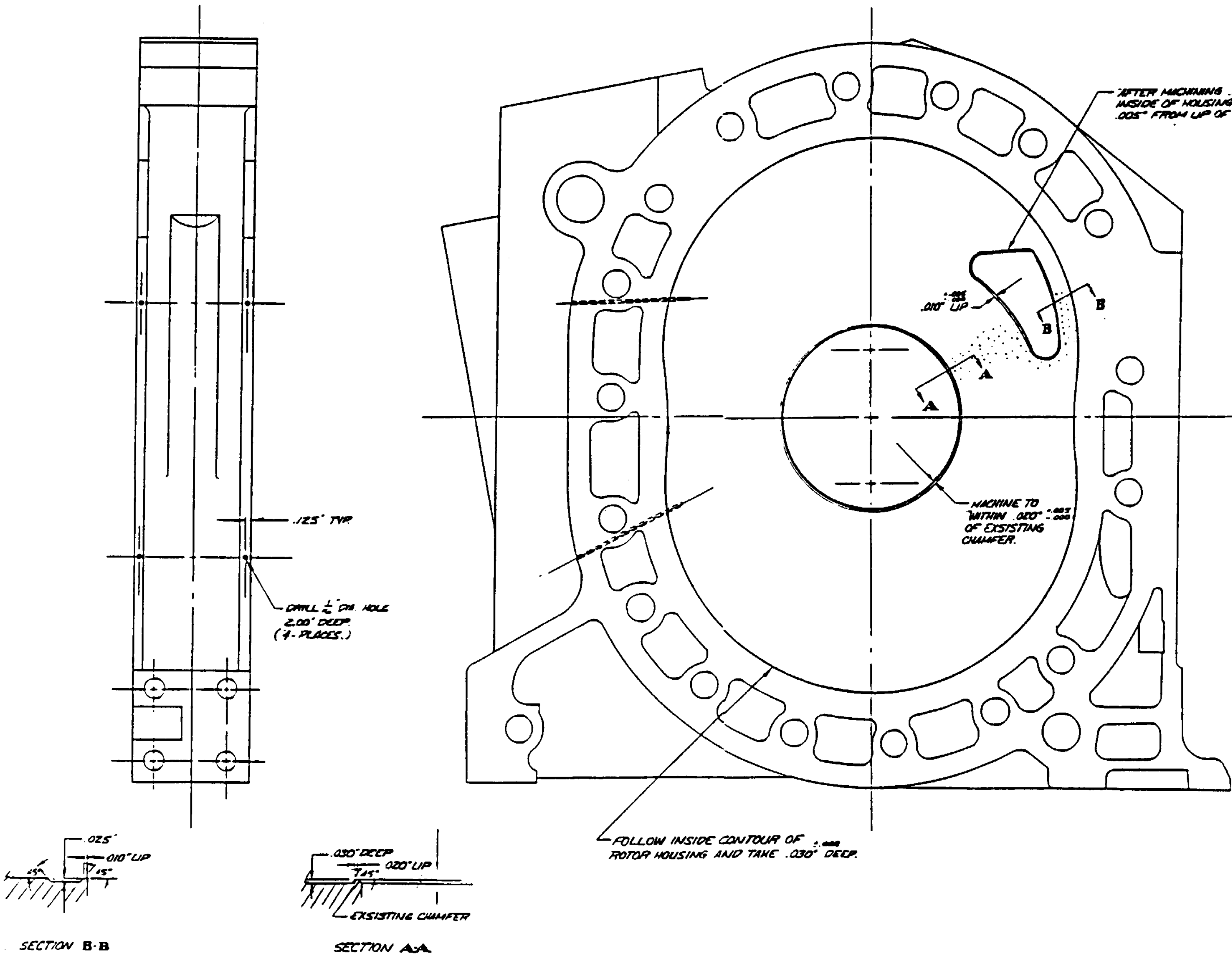


Figure 5.5.1-1, Details of Zirconia Coating on Mazda 13B Intermiediate Housing.

Photographs in figure 5.5.2-1 show the rotor housing after zirconia and Tribaloy 800 application. Two problems were encountered during the coating applications. During step 3 of the above process, areas of zirconia chipped when Eonic ground the zirconia to make room for the wear coating application. These chipped areas were repaired during step 4, application of the wear coating, by filling the damaged areas with Tribaloy 800.

Shown in figure 5.5.2-2, during step 5 Tribaloy 800 on one rotor housing tore during the grinding operation at Eonic. Therefore, only one of two rotor housings survived the coating operation.

As an alternative approach, Mazda rotor housings cast from ductile iron were made and coated with a thermal barrier coating. The advantage of the cast iron is its ability to withstand high temperatures which means the zirconia can be densified with chrome oxide at 537.8 C (1000 F).

Essex Casting Company of Columbus, Indiana cast the rotor housings after which they were sent to Eonic to be machined. Eonic machined the oil pan and manifold flats and bolt holes plus exhaust port, tension bolt holes, water seal grooves, and dowel holes. Also, they ground the trochoid contour 0.762 mm (0.030 inch) oversize to allow room for applying a thermal barrier coating. No cooling water passages were machined at this time.

Once the rotor housings were machined, they were sent to APS Materials, Inc. where a 0.127 mm (0.005 inch) layer of plasma-sprayed NiCrAlY bond coat plus a minimum of 0.635 mm (0.025 inch) plasma-sprayed zirconia was applied to the trochoid contour.

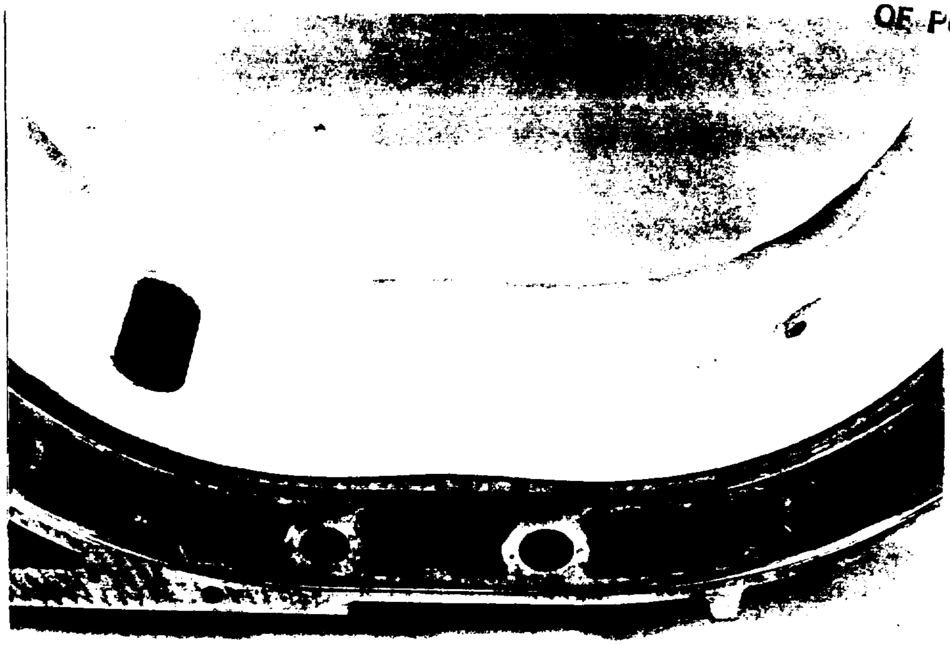
Then, the coated housings were sent back to Eonic where the coated trochoid contour was ground and lapped back to stock Mazda dimensions.

The coated and lapped rotor housings, were then densified the with 10 cycles of a high-temperature chrome-oxide treatment. Figure 5.5.2-3 shows pictures of a cast iron rotor housing in the different steps of the coating process.

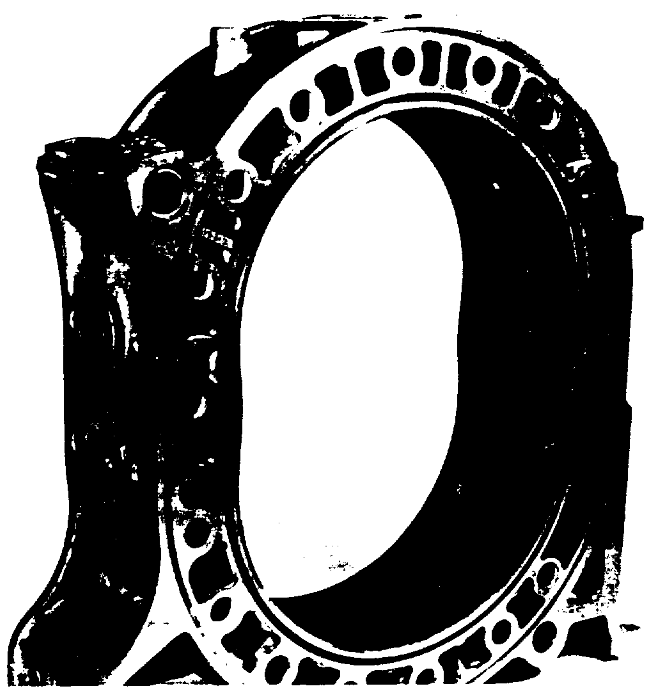
Once the rotor housings were successfully coated and densified 3 holes were drilled along the top and bottom of the housing which served the purpose of permitting cooling water flow to the standard side housings. These cooling passages (shown in figure 5.5.2-3) are 9.04 mm (0.356 inch) diameter and are smaller than the tension bolt holes. The outside diameter of the cooling passages are located 17.78 mm (0.7 inch) away from the trochoid contour and do very little to cool the rotor housings themselves.

There were 2 problems during the coating process. While Eonic was grinding and lapping the zirconia-coated trochoid contour, small areas of the coating chipped. Adiabatics, Inc. repaired the chipped areas by filling them with a proprietary slurry coating. The other problem with the coating was that cracking occurred throughout the surface area. This was especially apparent after densification. Figure 5.5.2-4 shows the extent of the cracking when checked with dye penetrant. Although it is not an ideal coating, this type of cracking has been seen before and does not mean the parts cannot be used.

A summary of all the components procured for the Mazda 13B engine are listed in Table 2.



AI-C/131-6A



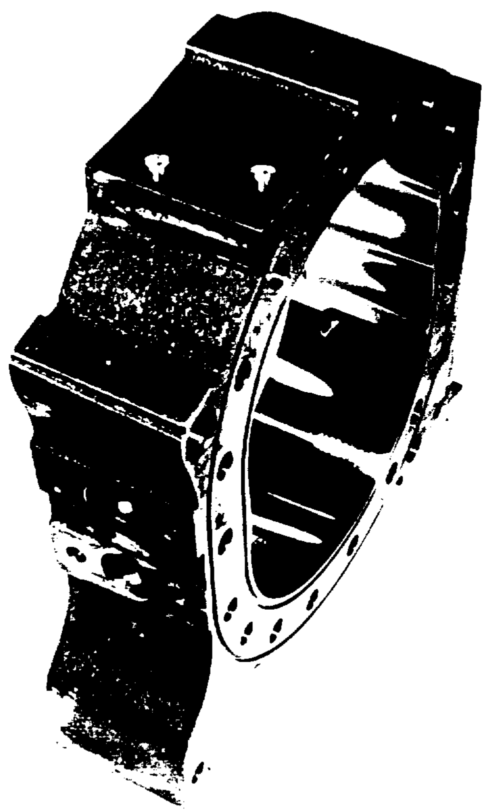
AI-C/142-23A

Figure 5.5.2-1. Stock Aluminum Mazda Rotor Housing After Zirconia (a) and Tribaloy 800 (b) Application.

ORIGINAL PAGE IS
OF POOR QUALITY

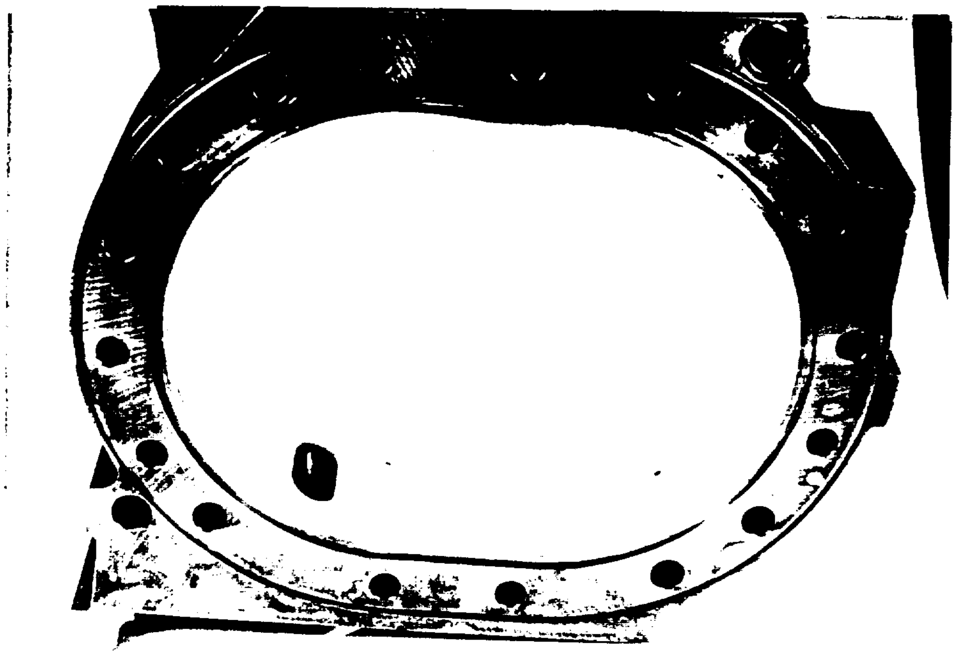
AI-C/155-15A

Figure 5.5.2-2. Failed Tribaloy 800 Coating on Mazda Stock Aluminum Rotor Housing.

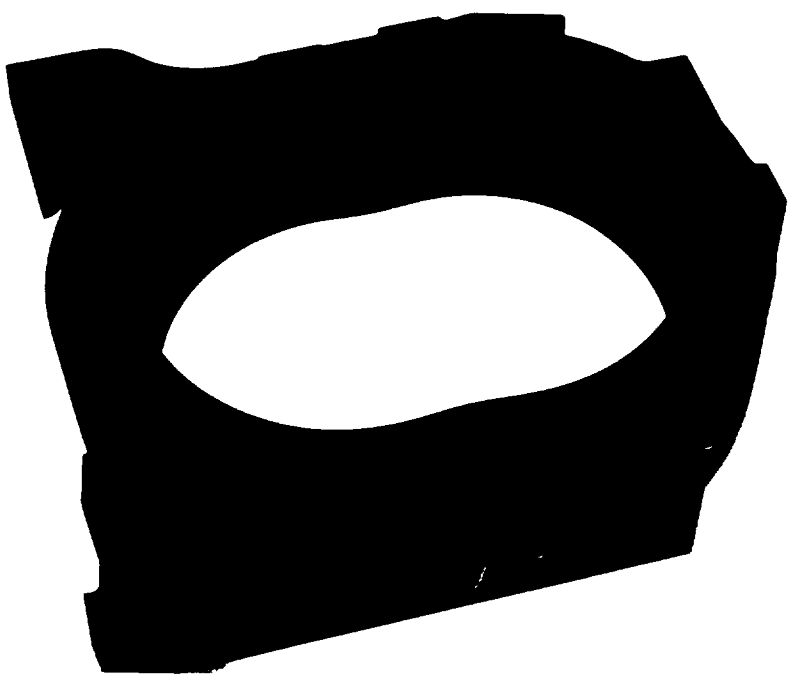


AI-C/131-15A

Figure 5.5.2-3 Cast Iron Rotor Housing After Initial Machining.

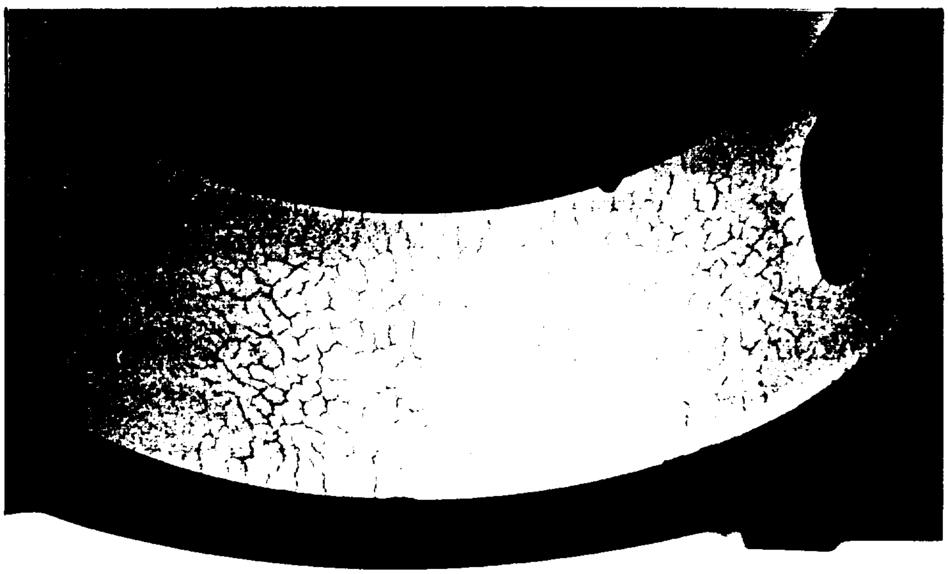


(a) AI-C/134-13



(b) AI-C/131-8A

Figure 5.5.2-3 Cont. Cast Iron Rotor Housing After Zirconia Application (a) and After Zirconia Densification.



AI-C/149-23

Figure 5.5.2-4. Coated Cast Iron Rotor Housing Showing "Mud" Cracks After Zirconia Densification.

5.6 Task VI Engine Testing

Engine testing was to consist of separate engine builds and tests for thermal-barrier-coated rotors, rotor housings, and side housings along with a final test of the combination of all low-heat-rejection components assembled together. A minimum of 4 separate engine builds and test cycles were required. The actual number of engine builds was 10 which encompassed 8 different engine configurations. The sections that follow details the events of all the configurations tested with the exception of the baseline test. These tests serve the purpose of testing the individual coated components for integrity and durability.

After the baseline test, the engine test plan described the first thermal barrier component screening as being a test with coated rotors. However, at this time in the program procurement of the thermal barrier coated rotors was meeting difficulties which were discussed in Task V. Therefore, the first thermal-barrier-coated component tested was an insulated intermediate housing.

5.6.0 Intermediate Housing

After the baseline test, the Mazda engine was disassembled as specified in the Mazda shop manual. While disassembled, all the components were inspected as specified in the Mazda shop manual. A list of the measurements taken can be seen in Appendix E. Before reassembly, the standard intermediate housing was replaced with the coated housing. New stock side seals and button seals were installed against the coated housing. The rest of the engine used the seals and housings which were run during the baseline test. The engine was then reassembled as specified in the Mazda shop manual. The same engine parameters were measured as outlined for the baseline test plus the engine was run for endurance.

The assembled engine was mounted into test cell No. 2 and connected to an Eaton dynamometer via a driveshaft with a one degree offset. Once the engine was mounted the Digalog dynamometer controller was calibrated as specified in the Digalog manual. All other instruments were checked and calibrated to ensure correct readouts.

The engine was then filled with standard coolant and SDL-1 synthetic lubricant. The engine was tested for compression (results shown in Appendix E). After compression testing the engine was started and run through the break-in cycle. Engine break-in consisted of running the engine at varying speeds with light to no-loads. During this run all systems were checked for proper functioning and the timing set.

The different test loads and speeds are detailed in the data found in Appendix F. These speed and loads were the same points used during the baseline test. The only noteworthy difference between the baseline test and this insulated housing test was that oil temperatures were increased to 101.7 C (215 F) plus or minus a few degrees going into the engine.

Thirty hours into the endurance test a problem with the spark plug firing order was found. Due to a factory mislabeling of the distributor cap the leading and trailing spark plugs were firing in a backwards order. In other words the trailing plugs were firing first. This problem affected the performance of the engine and unfortunately had occurred throughout the baseline test as well. The wiring problem was corrected and 51 total hours of endurance testing was completed without further incident.

After completion of the 51 hour test the engine was disassembled and inspected. Wear was detected on the rotor side seals and rotor oil seals which were rubbing against the thermal barrier coating. Similarly, the zirconia-coated intermediate housing experienced minor wear where it was rubbed by the seals. The intermediate housing, seen in figure 5.6.0-1 was still reusable despite the wear, and the coating itself were in excellent condition. No damage to other parts were found during post inspection. One of the most likely reasons for the excessive seal wear was the rough surface of the coating after lapping. The seals appeared to have lapped the coating because after testing the coating was smoother (down to 2 micro-inches from 20 micro-inches of roughness in some areas). At the time the coated intermediate housing was tested no candidate side seals had been procured.

As was already mentioned, an ignition problem was found part way through the coated intermediate housing test. In an effort to make fair comparisons to the baseline test all data comparisons are made under like-conditions. For example, the baseline test data are compared to only that first portion of the coated intermediate housing test data when the ignition was incorrect. The rest of the data taken during the test with the coated intermediate housing can only be compared with that data taken during the test with coated rotors and coated rotor housings (ignition correct in these cases).

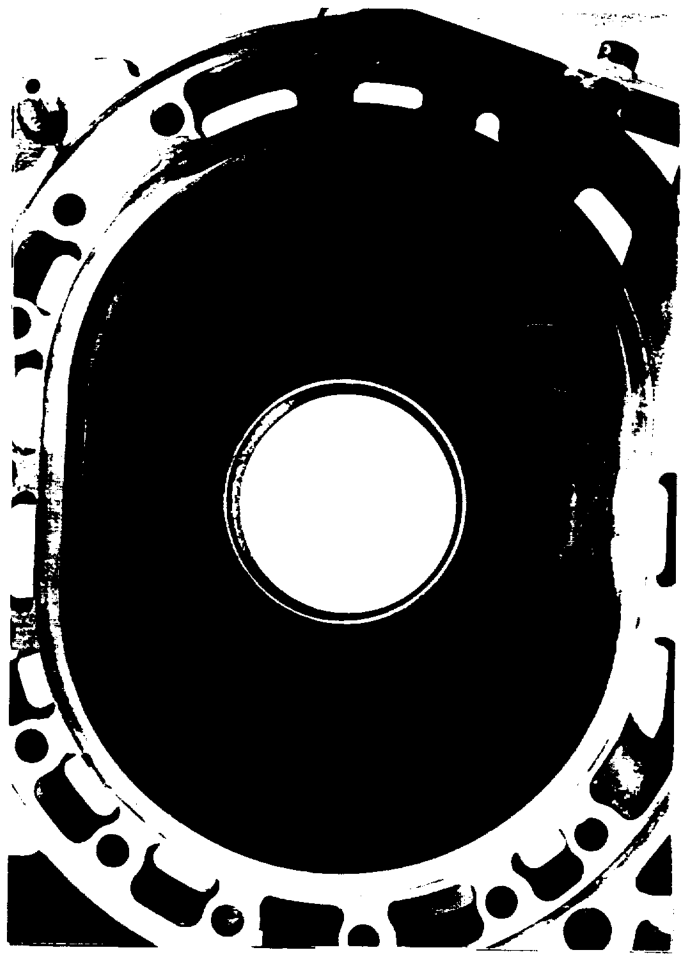
Figures 5.6.0-2 through 5.6.0-5 show the dramatic decrease in the amount of heat transferring into the oil system while testing the insulated intermediate housing as compared to the baseline test. These figures represent the oil temperature out of the engine subtracted by the oil temperature into the engine. Other areas such as power output and fuel consumption were basically unchanged by using the insulated housing.

5.6.1 Rotor

The second thermal-barrier-coated component screening test was with 2 undensified zirconia-coated rotors. The coated rotors were installed in the engine via the same disassembly, inspection, and reassembly procedures used in previous builds. The same testing parameters were measured as in previous tests. Likewise, the same speeds, loads, ignition timing, break-in cycle, oil type and temperature, and coolant were used.

During the first part of the test the engine ran quite well; but, as the test time was lengthened, carbon deposits built up on the rotors and rotor housings. These deposits were observed through exhaust port inspection (by removing the exhaust header and visually looking inside the engine through the exhaust ports). Thirty-one hours into the test a major problem developed. While running a point at 5000 rpm and 120 ft-lbs of torque the rear rotor housing began to experience scuffing. The extent of the scuffing is shown in figure 5.6.1-1. Although the front rotor housing did not have this problem, it probably would have given more time.

The scuffing appeared to be caused from overheating the rotor housing plus oil deposit build up on the rotor housing. Fortunately, the engine was shut down before major damage occurred. Upon post-inspection, the only parts found unusable were the apex seals which had uneven wear. The rotor housings were cleaned up and the engine reassembled with new apex seals. The engine then completed 100 hours of endurance tests successfully. A photograph of the coated rotors is seen after testing seen in figure 5.6.1-2. It should be noted that after scuffing had occurred the fifth and sixth auxiliary intake ports



AI-C/122-4

Figure 5.6.0-1. Zirconia Coated Intermediate Housing Densified by Kaman Science's Process After Completing 51 Hours of Testing.

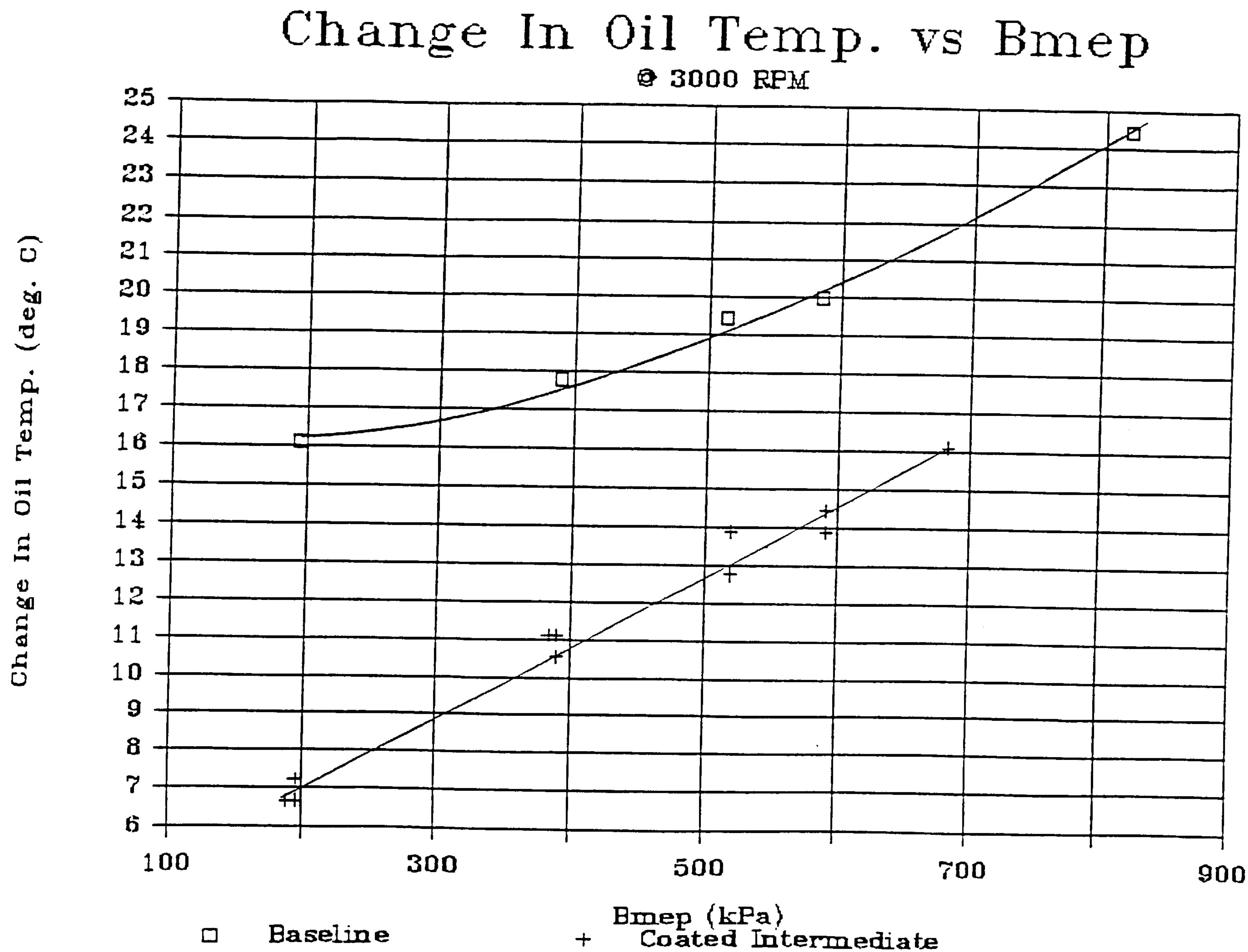


Figure 5.6.0-2. Change in Oil Temperature vs. Bmep Chart.

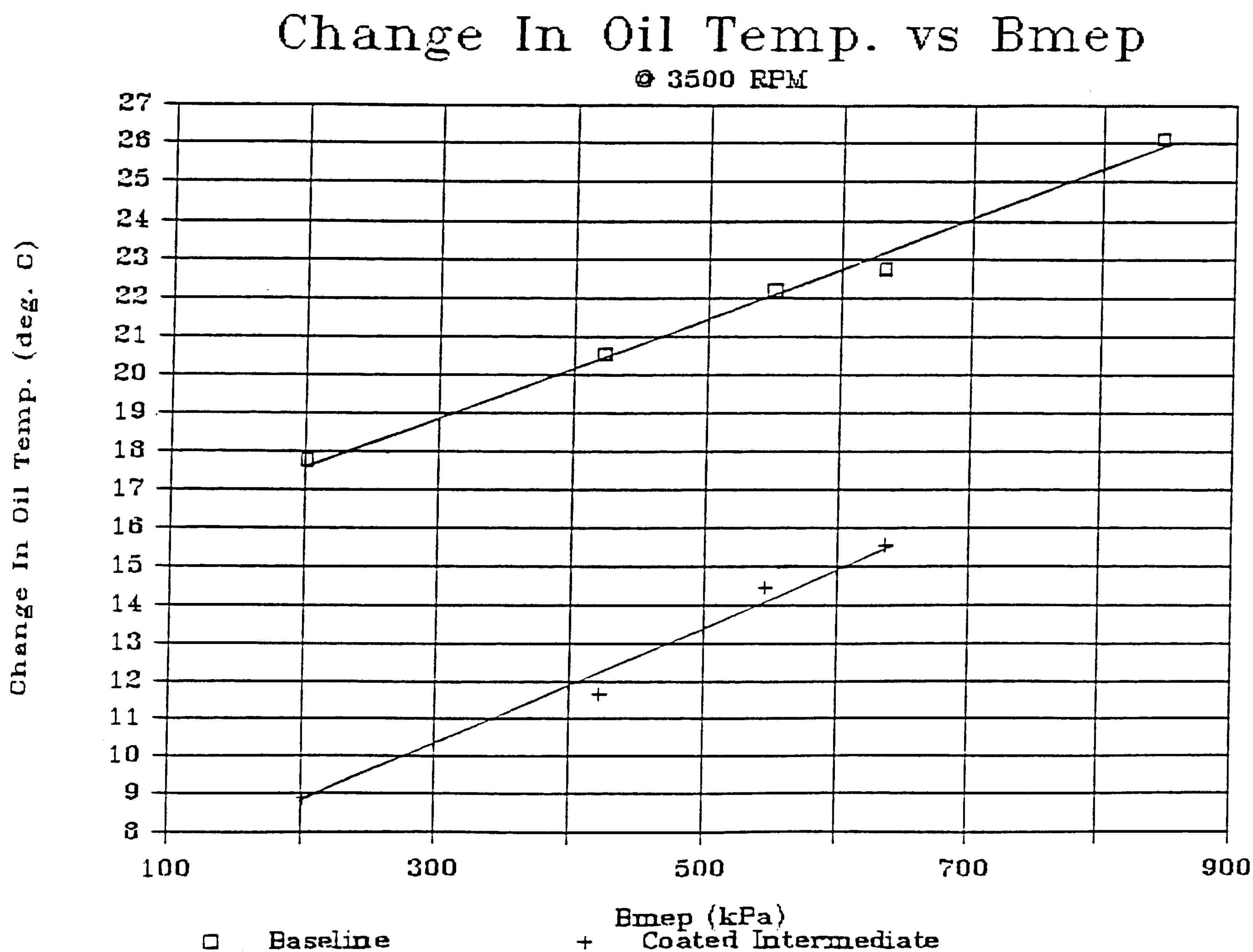


Figure 5.6.0-3. Change in Oil Temperature vs. Bmep Chart.

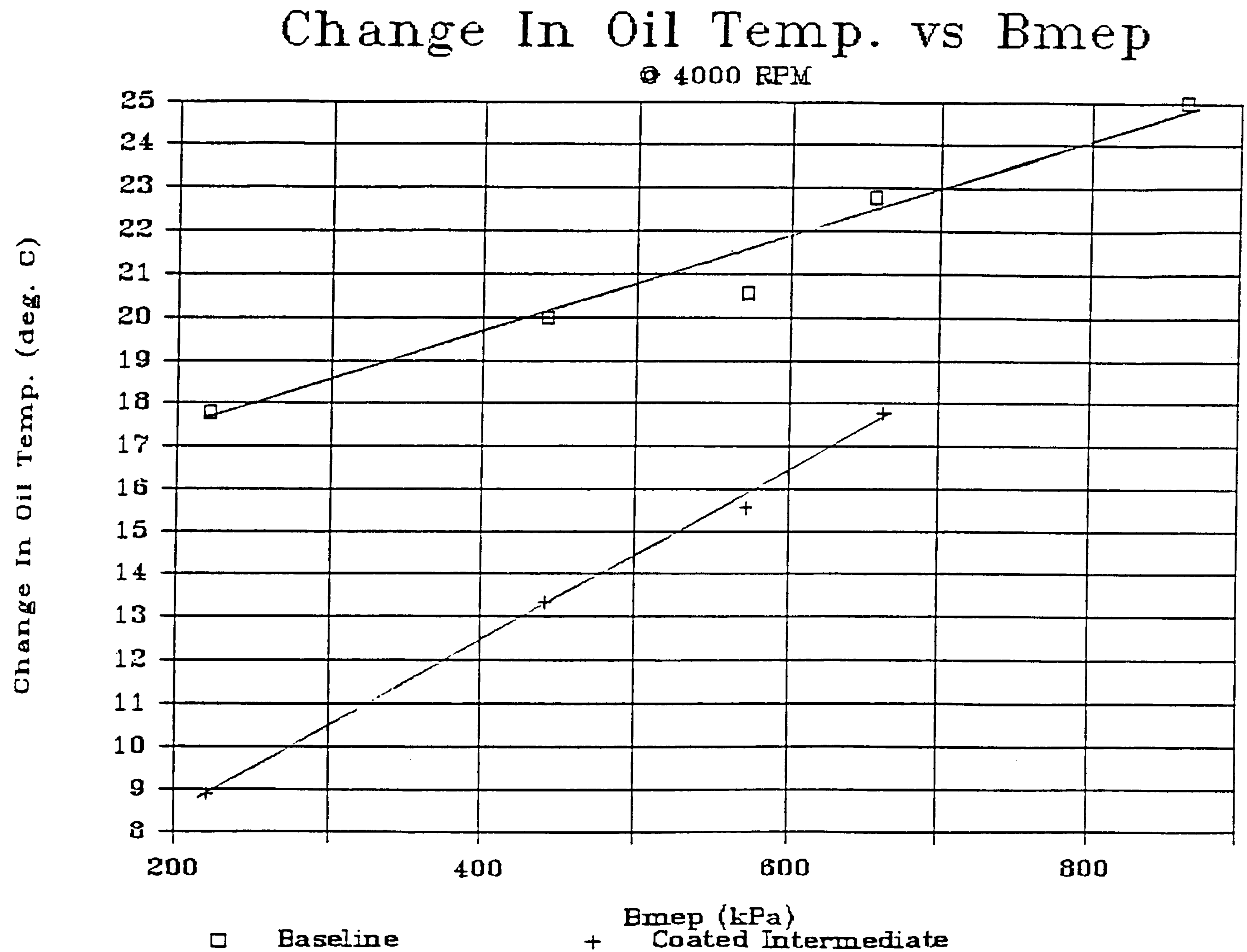


Figure 5.6.0-4. Change in Oil Temperature vs. Bmep Chart.

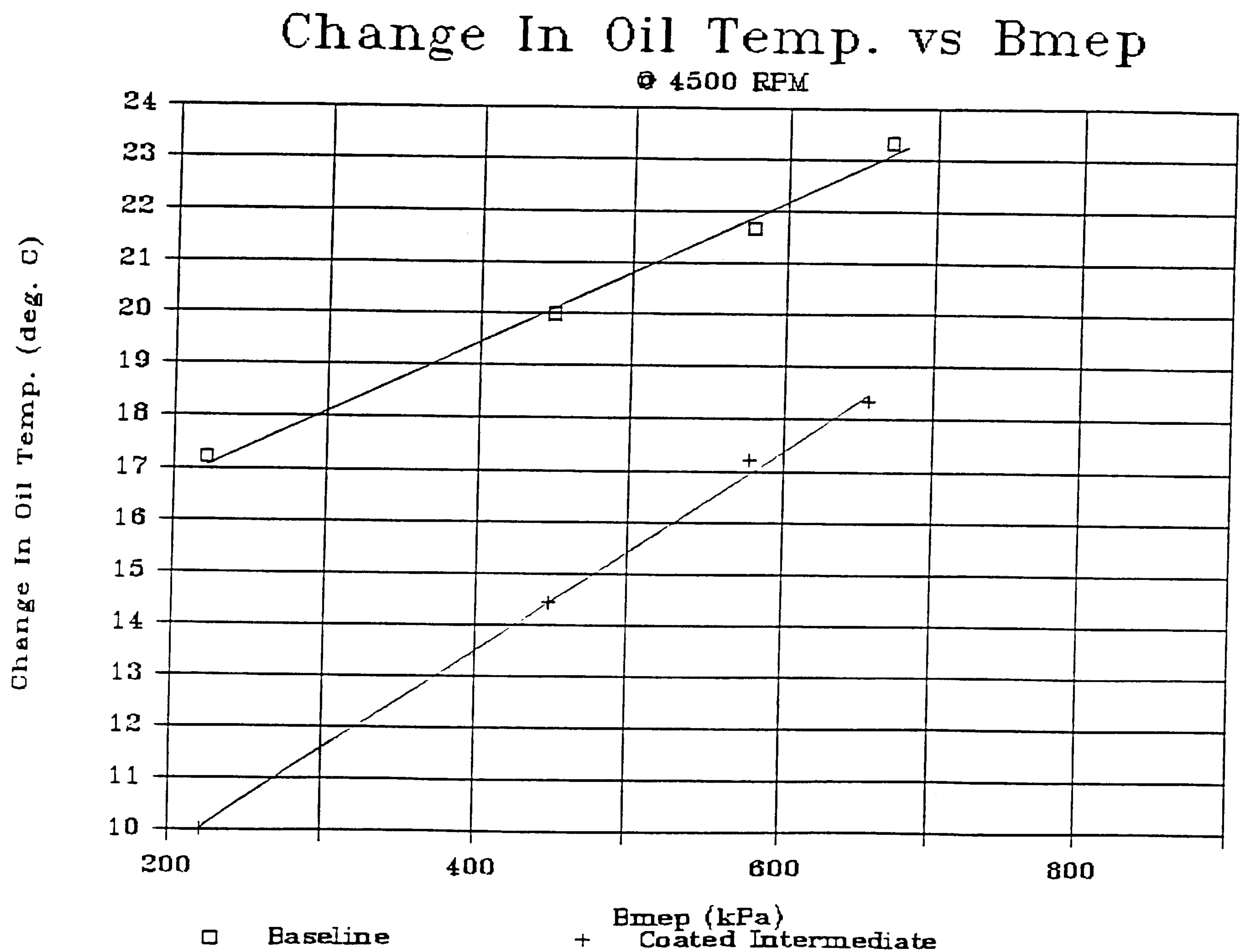
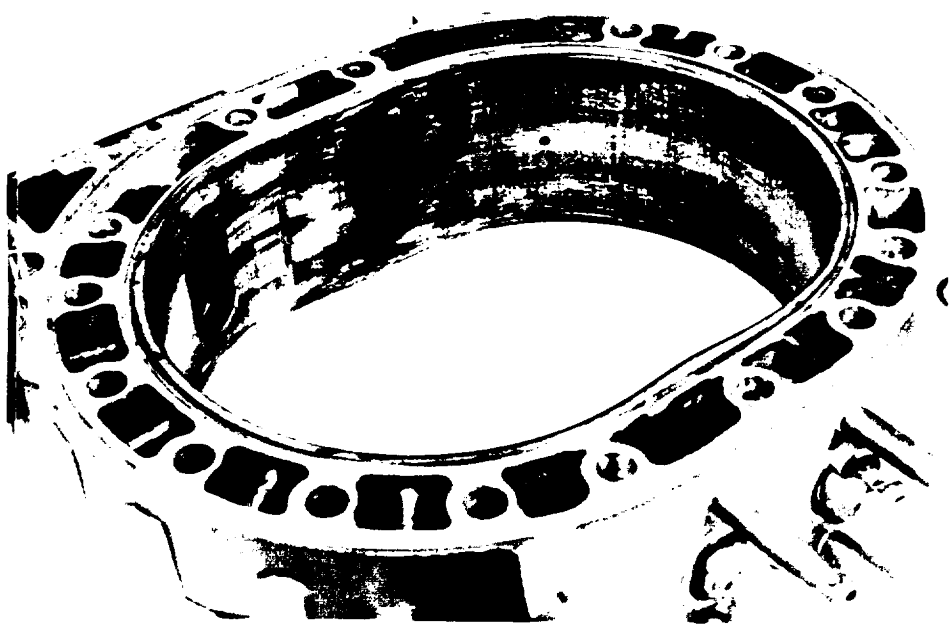


Figure 5.6.0-5. Change in Oil Temperature vs. Bmep Chart.

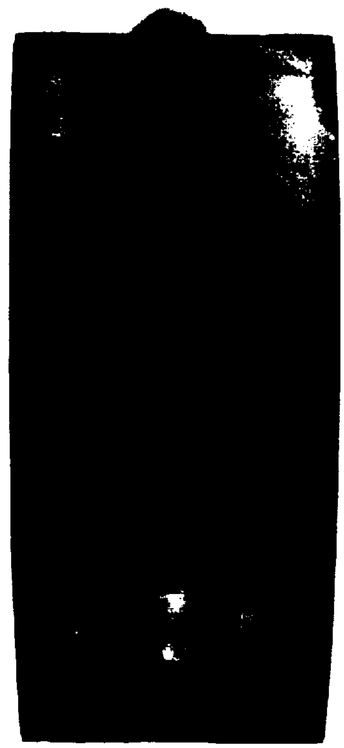
AI-C/126-4A



AI-C/126-3A

Figure 5.6.1-1. Rear Rotor Housing After 31 Hours of Testing Time with Thermal-Barrier-Coated Rotor.

ORIGINAL PAGE IS
OF POOR QUALITY



AI-C/130-1

Figure 5.6.1-2. Undensified Zirconia Coated Mazda Rotor After 100 Hours of Testing.

were manually opened in an effort to introduce a cool combustion charge later in the combustion cycle. These ports were left open for the remainder of the testing. By opening these 2 ports, both the fuel consumption and the power output did increase by a small amount. Data gathered from testing these undensified rotors is found in Appendix G-I.

There was a dramatic decrease in the amount of heat transferring into the oil system. Figures 5.6.1-3 through 5.6.1-7 show the data comparisons between the coated intermediate housing and the undensified coated rotors. Here, ignition timing was correct in both cases and though the 2 data plots are similar for every speed and load, both cases are much lower than that of the baseline test. The 2 coated rotors (combined in one assembly) are capable of reducing heat transfer into the oil system more than when using the one coated intermediate housing.

A second change in the data between the coated intermediate housing and the coated rotors was a dramatic increase in exhaust temperatures in the case of the coated rotors. Figures 5.6.1-8 through 5.6.1-12 show the comparison between the coated intermediate housing and the undensified coated rotors. Again, only data taken with correct ignition are compared.

One more candidate thermal-barrier-coated rotor was tested after completing the 100 hours of testing with the undensified zirconia-coated rotor. This test was with 1 zirconia-coated rotor densified by Adiabatics. This coated rotor was run in the engine along with 1 stock rotor. All conditions of the test were identical to the previous test including the open fifth and sixth intake ports. This test used stock seals and housings. This endurance test ran 100 hours without incident. A photograph in figure 5.6.1-13 show the rotor after testing. Everything passed inspection at the end of the test. It was noticed, however, more carbon deposits had developed in the rotor housing run with the stock rotor than in the rotor housing run with the coated rotor (seen in figure 5.6.1-14). The data gathered from the densified rotor test is found in Appendix G-II.

In both densified and undensified coated rotor durability tests the coating was in excellent condition after testing.

5.6.2 Rotor Housing

With the screening test successfully completed for thermal-barrier coated rotors and intermediate housing, testing proceeded to the rotor housings. The first rotor housing tested was the thermal-barrier coated stock aluminum rotor housing. As described in Task V, only 1 of 2 rotor housings survived the coating process. Therefore, this test consisted of only 1 coated rotor housing located in the front of the engine. High temperature apex seals made from M2 tool steel were used in the rotor placed in the coated rotor housing. The rest of the engine was built using stock components. The engine was built and tested in the same manner as in the previous tests including using the same high-temperature lubricant SDL-1.

During the break-in cycle the engine ran well. Visual inspection through the exhaust ports showed that the coating was holding up. As more testing time elapsed it was noticed that blow-by was creeping up to 12.7 mm (one half inch) of water whenever loads and or speeds were being changed. As the engine remained at a new load and or speed, blow-by would slowly go back to zero. Several low speed and low torque data points were run, but after 14.7 hours of

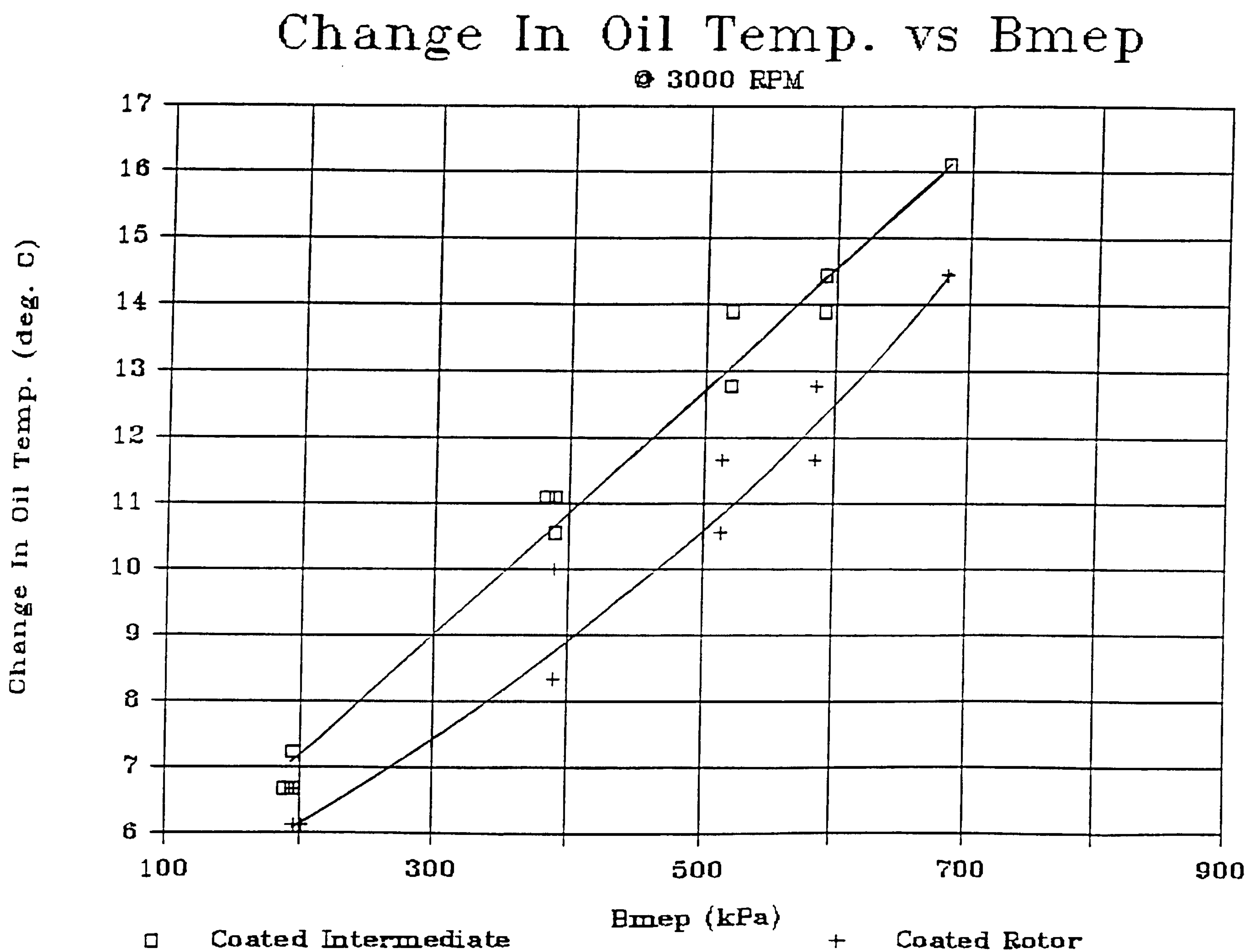


Figure 5.6.1-3. Change in Oil Temperature vs. Bmep Chart.

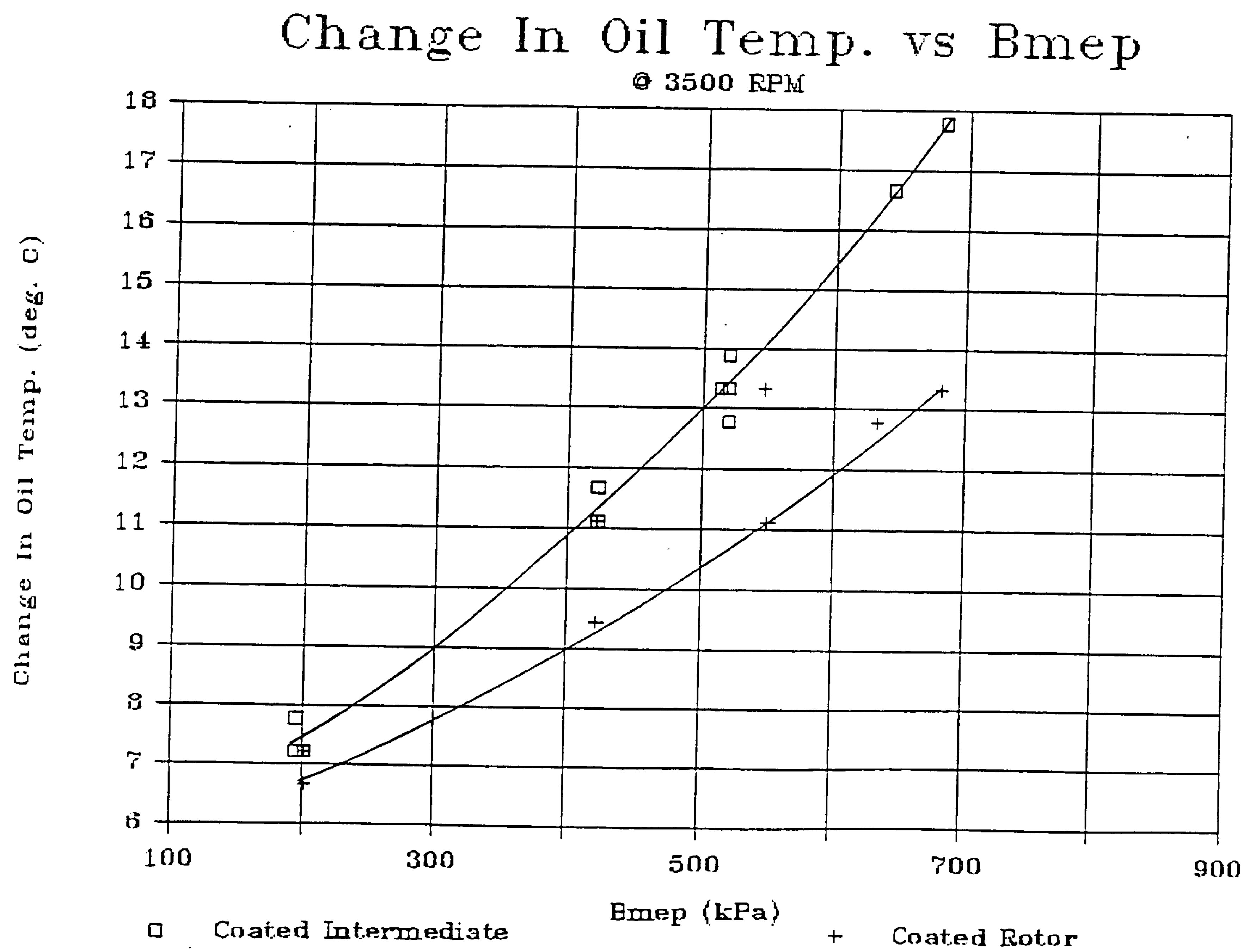


Figure 5.6.1-4. Change in Oil Temperature vs. Bmep Chart.

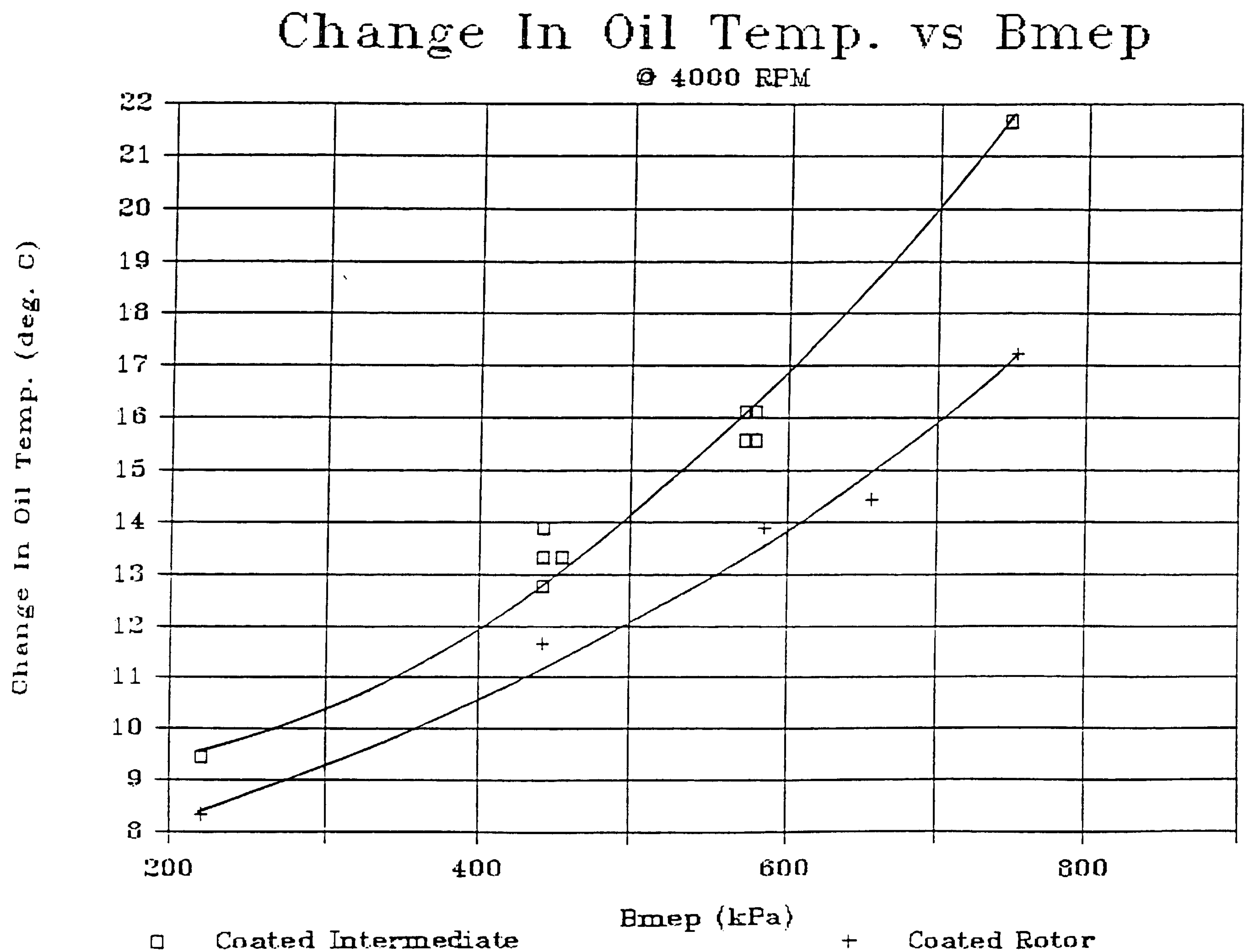


Figure 5.6.1-5. Change in Oil Temperature vs. Bmep Chart.

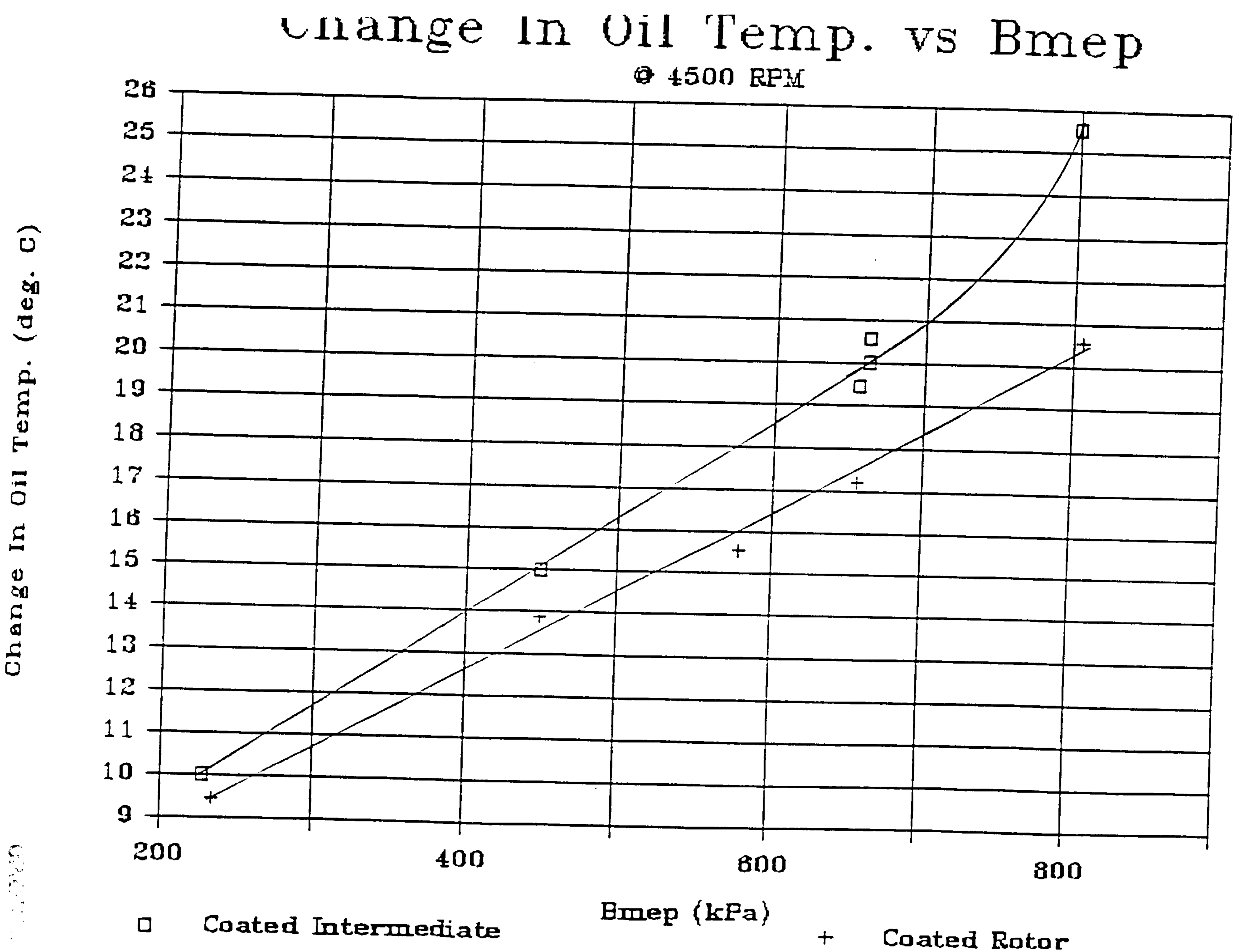


Figure 5.6.1-6. Change in Oil Temperature vs. Bmep Chart.

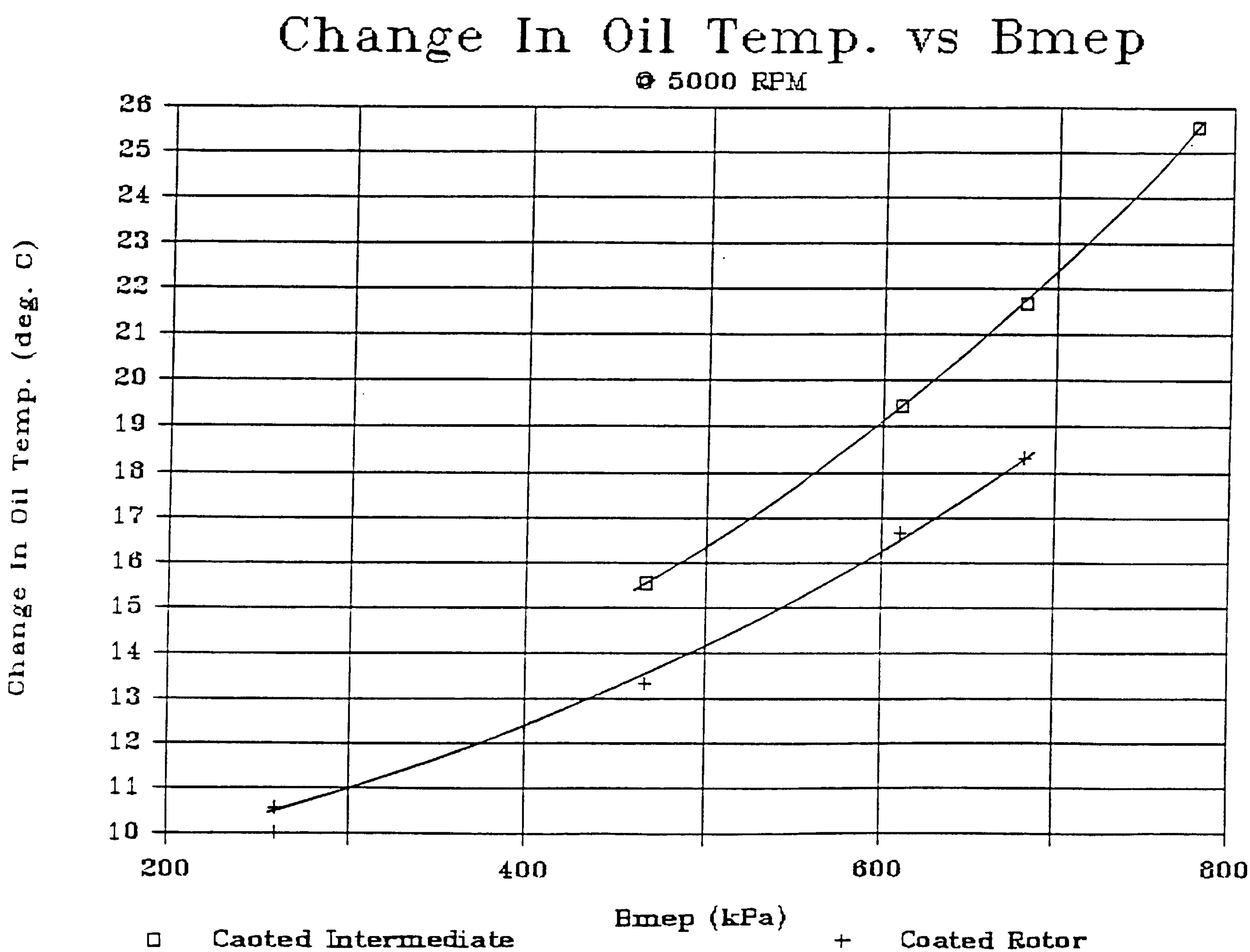


Figure 5.6.1-7. Change in Oil Temperature vs. Bmep Chart.

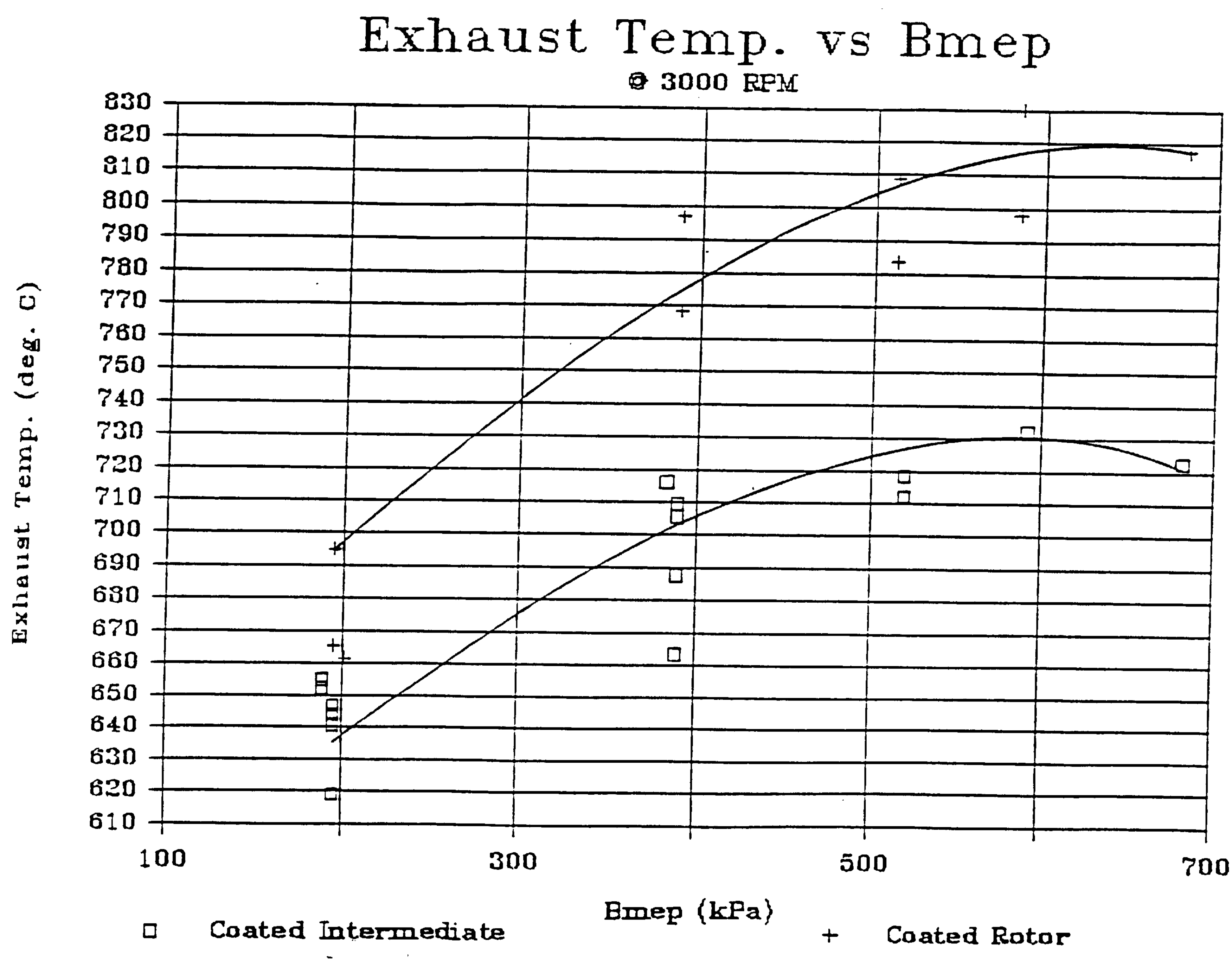


Figure 5.6.1-8. Change in Exhaust Temperature vs. Bmep Chart.

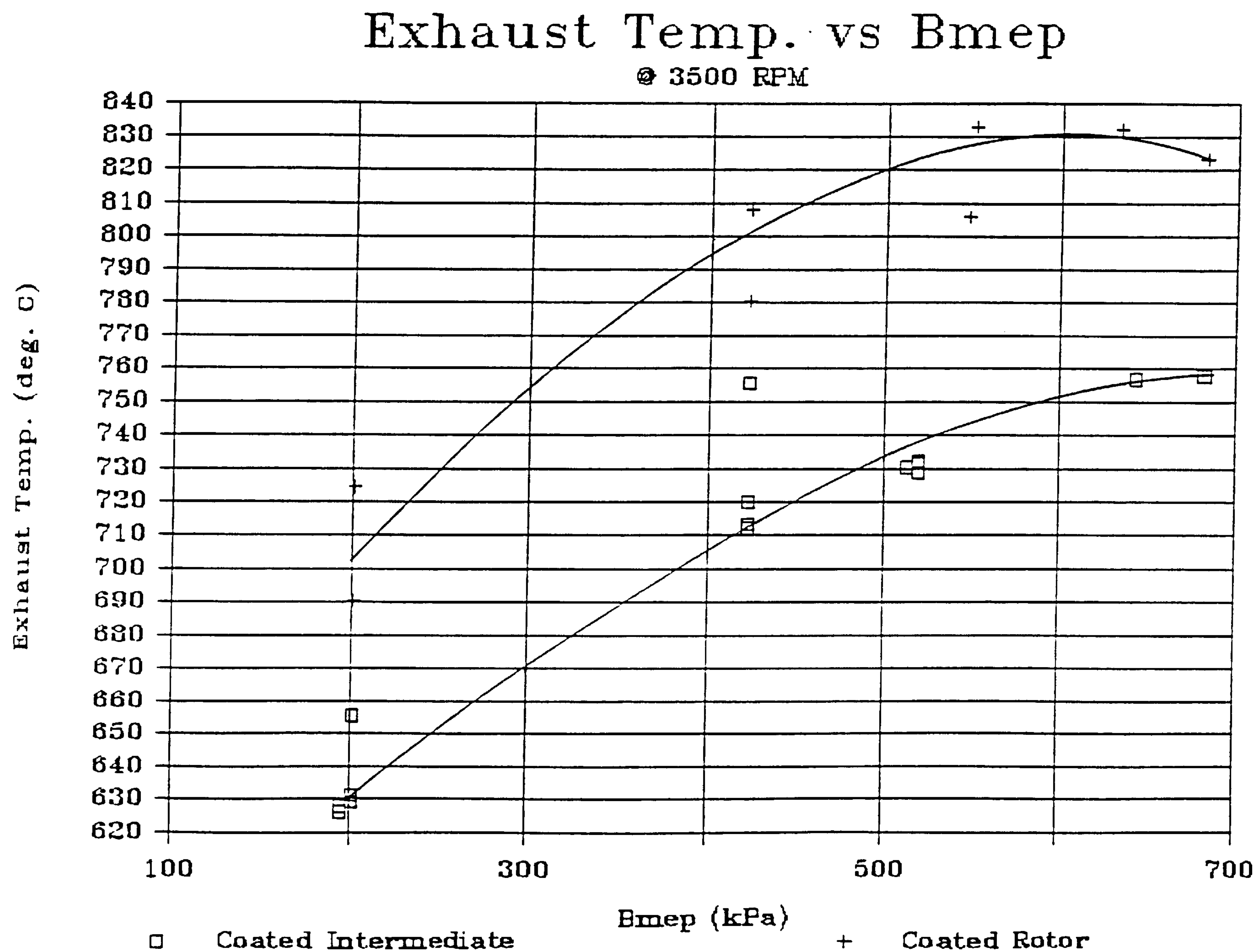


Figure 5.6.1-9. Change in Exhaust Temperature vs. Bmep Chart.

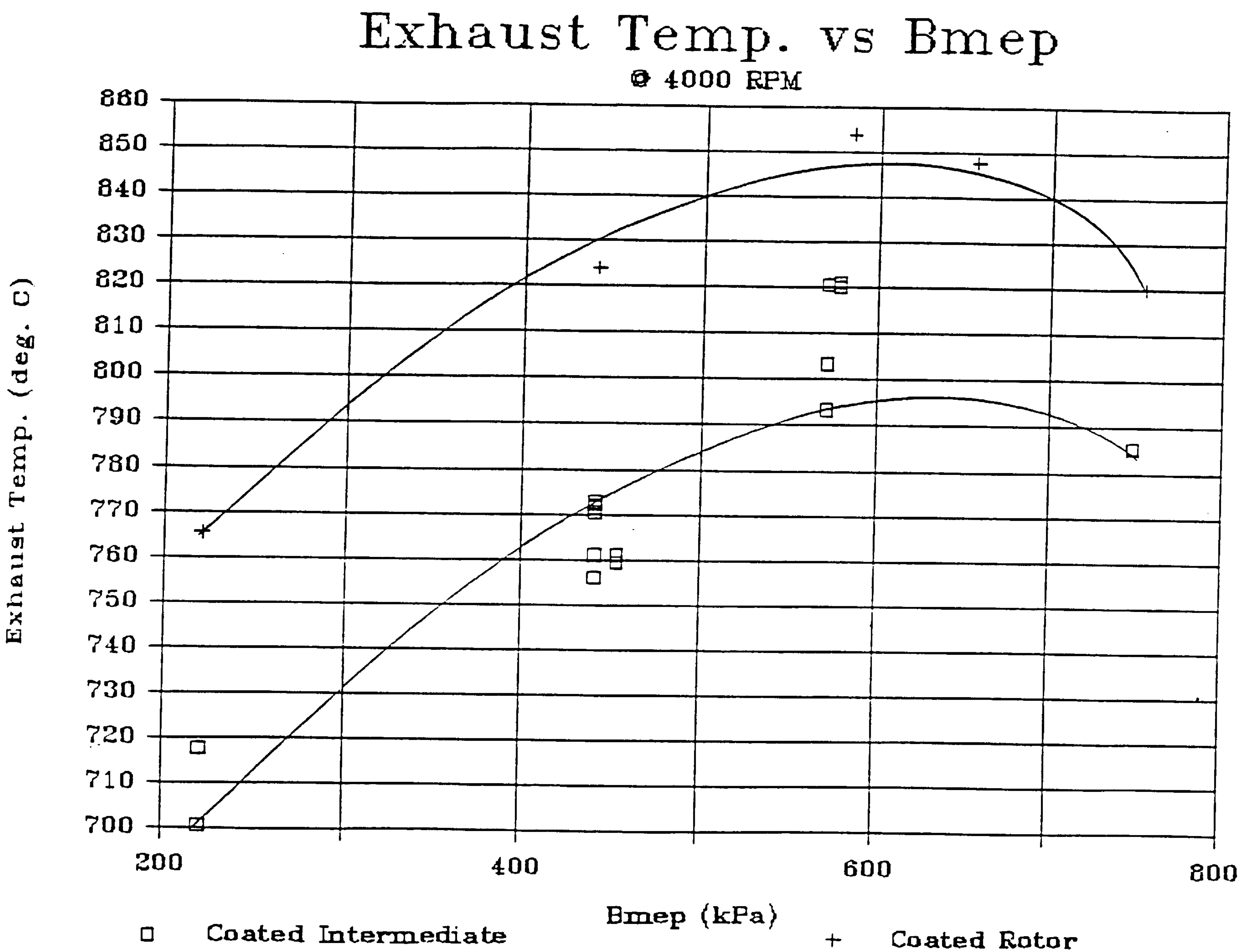


Figure 5.6.1-10. Change in Exhaust Temperature vs. Bmep Chart.

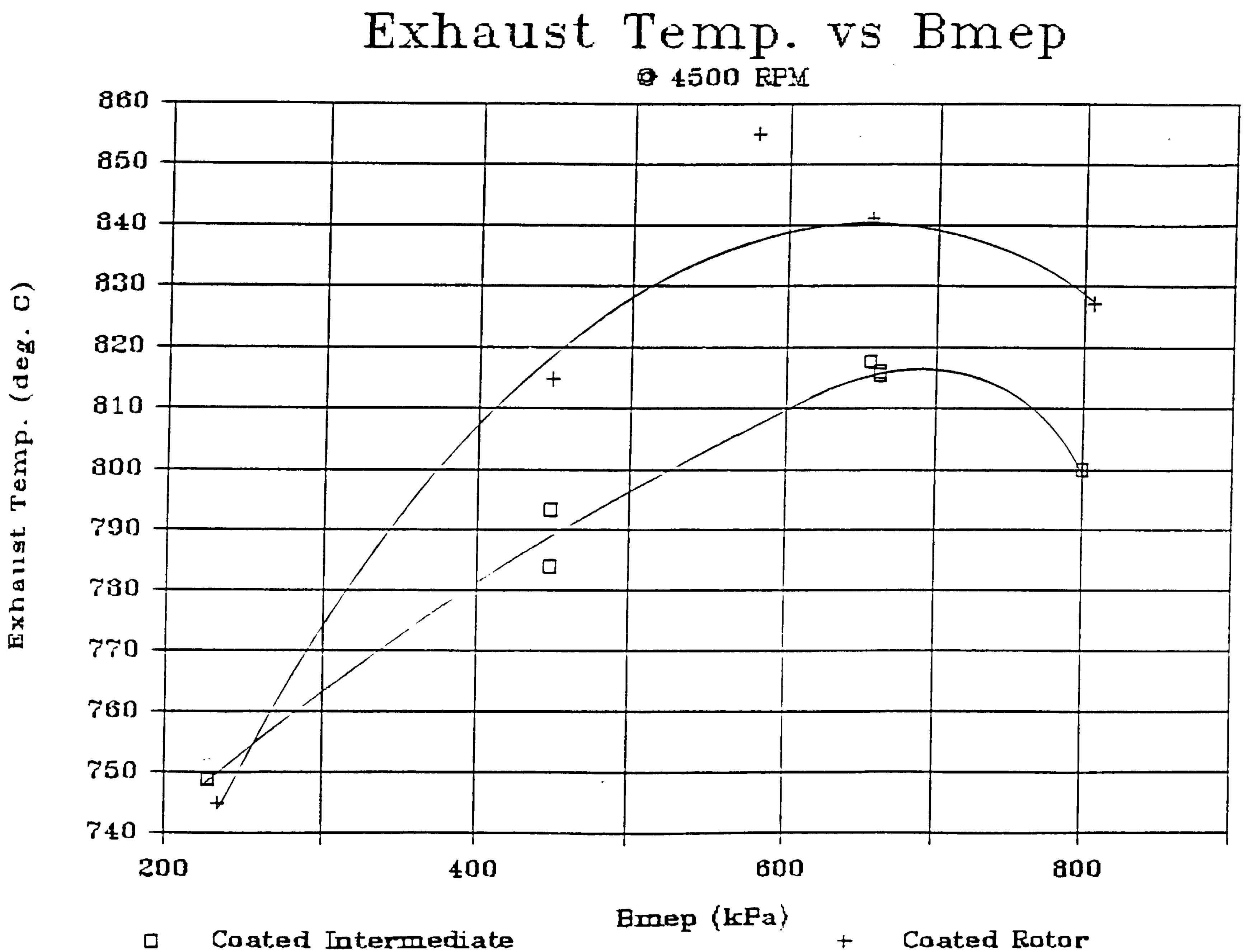


Figure 5.6.1-11. Change in Exhaust Temperature vs. Bmep Chart.

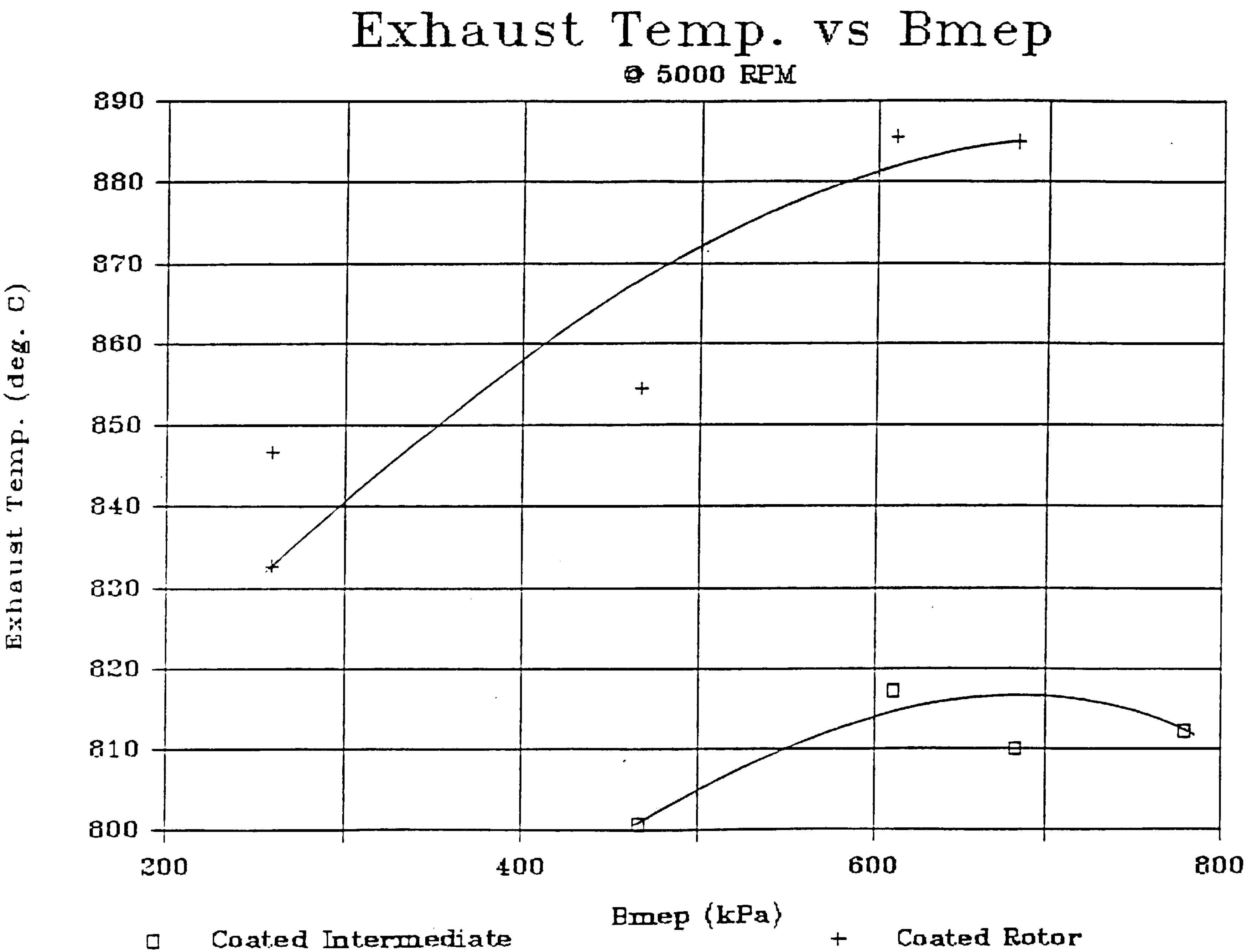
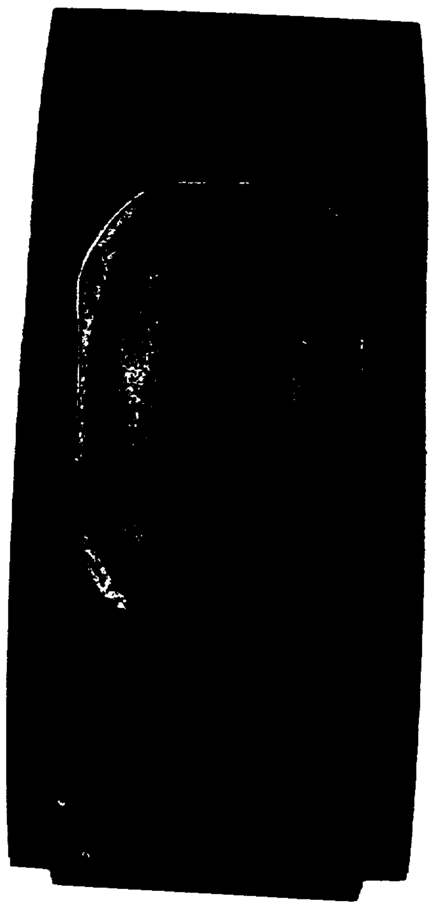


Figure 5.6.1-12. Change in Exhaust Temperature vs. Bmep Chart.



AI-C/137-22A

Figure 5.6.1-13. Densified Zirconia Coated Mazda Rotor After 100 Hours of Testing.

AI-C/137-19A

AI-C/137-15A

Figure 5.6.1-14. Stock Mazda Rotor (a) Compared with Densified Coated Mazda Rotor After 100 Hours Testing Together in One Build.

engine testing visual inspection through the exhaust ports revealed coating failure. Data gathered from the housing test is found in Appendix H. Photos of the failed rotor housing are shown in figure 5.6.2-1.
When the coated stock aluminum rotor housings failed the apex seals which were made form M2 tool steel were also destroyed.

A request was then made by Adiabatics to NASA for an additional one month extension for testing coated cast iron rotor housings. This request was granted at a meeting at NASA LeRC with the Project Manager on June 17, 1988. This one month extension was later increased one additional month.

The screening test of the cast iron rotor housings consisted of an engine configuration with 2 thermal-barrier-coated cast iron rotor housing (detailed in Task V). The front rotor housing had a stock rotor and stock apex seals plus 3 candidate side seals coated with Chem 2 (details in Task IV) which were placed against a stock intermediate housing. The rear rotor housing had a stock rotor and apex seals made of M2 tool steel plus 3 candidate side seals coated by Adiabatics (detailed in Task IV) which were placed against the stock intermediate housing. The engine was assembled and tested in the same manner as in all the previous tests.

As soon as the engine was started, blow-by was noticed. The engine was given a lengthy slow break-in but blow-by never returned to zero. Visual inspections through the exhaust ports showed the coating on the rotor housings to be in excellent condition After the break-in cycle the first 2 data points at 3000 rpm were run. At this point blow-by reached 3 inches of water and the engine was shut down.

The engine was removed from the test cell, disassembled, and inspected. The coating on both front and rear rotor housing was in excellent condition (see figure 5.6.2-2). Likewise, the side seals coated by Adiabatics and the apex seals made from M2 tool steel were in excellent condition. However, the Chem 2 coating on all 3 side seals located in the front rotor housing had worn off. Also, after 16.75 hours into tests the stock apex seals in the front rotor housing had become stuck. These were the only 2 major problems found. The rest of the engine passed inspection.

Since the coating on the rotor housings was still in good condition, further testing was performed. The engine was reassembled using the 2 coated cast iron rotor housings with a complete set of new apex seals made from M2 tool steel. The apex seals had not stuck previously. The same side seals were placed back in the engine. At this point a lubricant change was made to 10W40 AMS-oil instead of SDL-1. The engine was assembled and tested in the same manner as before.

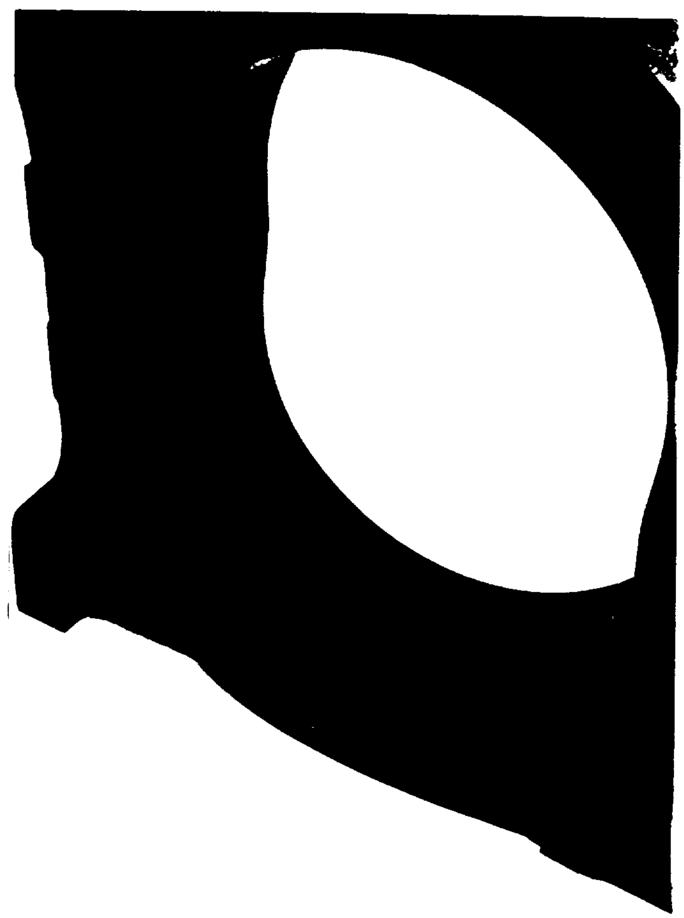
This build ran over 9 hours before the engine had to be disassembled again. During this run blow-by remained zero and the engine ran quite well. Then, when trying to run a point at 3500 rpm a problem developed. A safety device malfunctioned shutting the engine ignition off. This problem was quickly corrected but the engine would not restart. A compression test on each rotor housing showed the compression to be essentially zero. Upon post-disassembly the reason for low compression was found. The seals which were made from M2 tool steel had warped (figure 5.6.2-3). The warpage occurred along the edge of the apex seal which contacts the trochoid contour of the rotor housing.

AI-C/137-14

AI-C/145-15

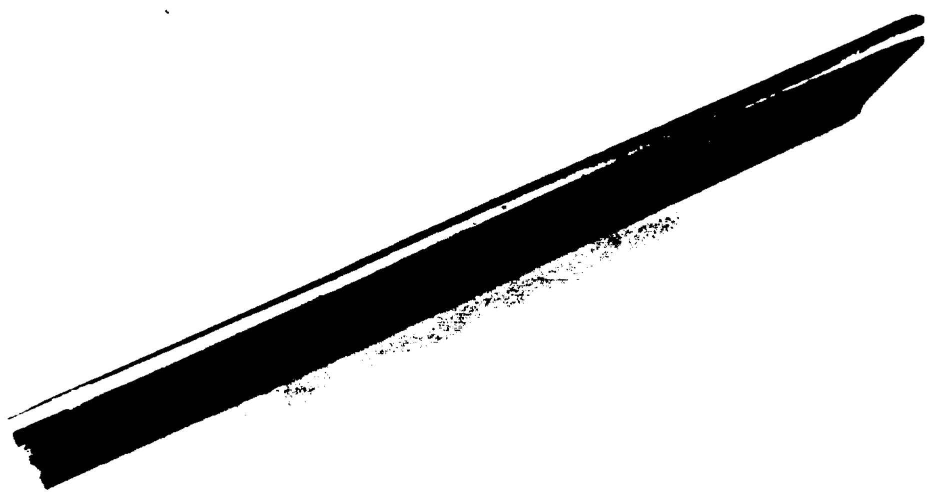
Figure 5.6.2-1. Failed Thermal Barrier Coating on Mazda Rotor Housing After 14 Hours of Testing.

ORIGINAL PAGE IS
OF POOR QUALITY



AI-C/150-22A

Figure 5.6.2-2. Coated Cast Iron Rotor Housing After Testing 16.75 Hours.



AI-C/150-25A

Figure 5.6.2-3. Warped M2 Tool Steel Apex Seals Tested with Coated Cast Iron Rotor Housing.

At this point the coating on the rotor housings was still in good condition so the engine was reassembled for further testing. This build consisted of all the previous components with the exception of the warped M2 apex seals which were replaced with stock apex seals. It was hoped that the change in lubricant to AMS-oil would be sufficient to keep the apex seals from sticking. Other components like the side seals which were coated by Adiabatics, Inc. and the coated cast iron rotor housings were in good condition and therefore placed back in the engine in their original locations.

The engine was reassembled and tested in the same manner as in the previous tests. Again, while the engine was running a point at 3500 rpm the compression was lost. The engine was disassembled and warped apex seals were again found (5.6.2-4). Unfortunately, the coating on the rotor housings was also found to be in bad condition. Small areas of coating had chipped at various areas around the trochoid contour. In 1 area of the compression zones of the front rotor housing the coating had separated from the parent material at the bond coat. Between the problem with the apex seals and the coating failure on the rotor housings, the testing was stopped at this point. The total testing time for the cast iron rotor housings was 32.5 hours and the final condition of the rotor housings can be seen in figure 5.6.2-5. A comparison between a stock side seal and one of the slurry coated side seals (after testing) is shown in figure 5.6.2-6. The data gathered from the testing of the cast iron rotor housings is found in appendix I.

During the testing with coated cast iron rotor housings, housing temperatures were observed as being twice as high as was observed during other testing.

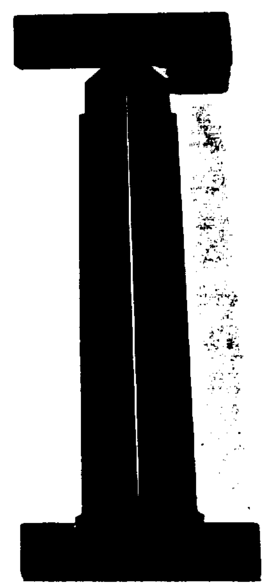
Table 3 summarizes the results of the testing performed with the components procured for the Mazda engine.

5.7 <u>Task VII Prototype Engine - Procurement/Assembly - NASA 1007R</u>

The engine which will ultimately pursue the goals of the better efficiencies discovered in Phase I is the NASA-owned 1007R engine built by John Deere. Completion of this contract entails modifying four different components of a 1007R engine with thermal-barrier coatings. Actual 1007R engine assembly and testing will be performed by John Deere and is not included in this project. The following is a description of the modifications of the 1007R components.

5.7.0 Rotor

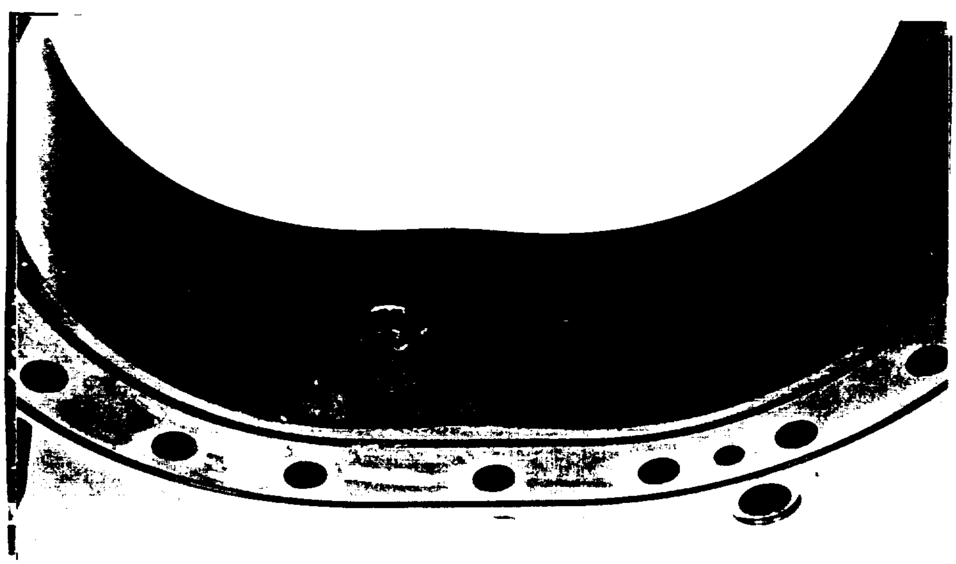
One 1007R rotor was machined to remove 0.762 mm (0.030 inch) of material on the rotor combustion faces with the exception of a 9.5 mm (0.375 inch) land at each apex (such that the apex seals are fully supported by the parent rotor material) and a 0.762 mm (0.030 inch) land along the side lands. A thin band of parent material was left untouched during machining around the lip of the combustion chamber (figure 5.7.0-1). A 0.762 mm (0.030 inch) layer of plasma-sprayed zirconia [including a 0.127 mm (0.005 inch) layer of NiCrAlY bond coat] was then sprayed onto the resultant pocket in the faces of the rotor and the high spots removed. The surface was then densified. The coating densification process was the non-toxic, low-temperature process developed by Adiabatics, Inc.



AI-C/152-2A

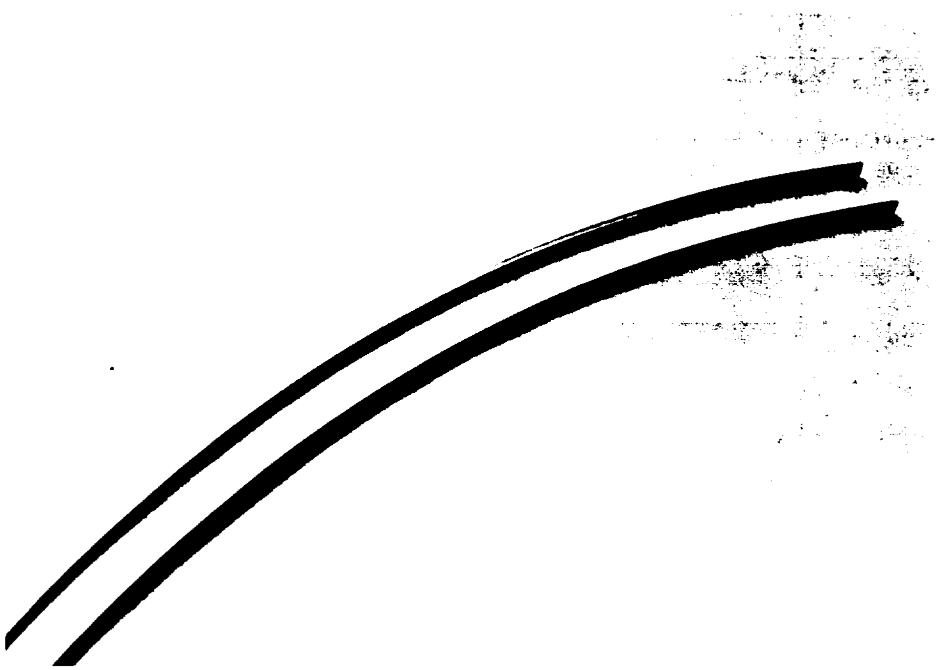
Figure 5.6.2-4. Warped Standard Cast Iron Apex Seals Tested with Coated Cast Iron Rotor Housing.

AI-C/152-5A



AI-C/152-6A

Figure 5.6.2-5. Coated Cast Iron Rotor Housing After 32.3 Hours of Testing.



AI-C/152-3A

Figure 5.6.2-6. Adiabatics' Slurry Coating on a Mazda Side Seal (below) Compared to a Stock Side Seal (top) After 32.5 Hours of Engine Testing.

TABLE 3. TESTING RESULTS - PROCURED MAZDA 13B COMPONENTS

COMPONENTS	QUANTITY	MATERIAL	TYPE COATING APPLIED	TOTAL HOURS TESTED	CONDITION AFTER TESTING
A) SIDE SEALS	3	STOCK CAST IRON	SLURRY	31	EXCELLENT
B) SIDE SEALS	6	STOCK CAST IRON	CHEM 2	10	SCRAP
C) APEX SEALS	12	M2 TOOL STEEL	NONE	14 MAX	SCRAP
D) ROTORS	2	STOCK CAST IRON	PLASMA-SPRAYED ZIRCONIA	100	EXCELLENT
E) ROTOR	1	STOCK CAST IRON	PLASMA-SPRAYED ZIRCONIA DENSIFIED	100	EXCELLENT
F) INTERMEDIATE	1	STOCK CAST IRON	PLASMA-SPRAYED ZIRCONIA DENSIFIED	51	GOOD-(SLIGHT WEAR)
G) ROTOR HOUSING	1	STOCK ALUMINUM	PLASMA-SPRAYED ZIRCONIA TRIBALOY	14	SCRAP
H) CAST ROTOR HOUSINGS	2	CAST DUCTILE IRON	PLASMA-SPRAYED ZIRCONIA DENSIFIED	31	SCRAP

AI-C/144-6

Figure 5.7.0-1. 1007R Rotor After Machining Process Showing the Lip of Untouched Material Around the Combustion Chamber.

Photographs in figures 5.7.0-1 and 5.7.0-2 show the rotor in the different phases of coating application. Figure 5.7.0-3 is a drawing which details the coating on the rotor.

5.7.1 Side Housings

Both a front and a rear aluminum 1007R side housings were coated with thermal-barrier coatings. Since these pieces are made of aluminum they could not be densified with chrome oxide at 537.8 C (1000 F). Obviously, the aluminum will not withstand such an extreme densification temperature. Therefore an alternate wear coating was required.

The alternative was to spray the insulative coating first and then coat the insulation with a wear coating. More specifically, spray on the zirconia and then spray a wear surface directly on top the zirconia. The wear coating selected was Tribaloy 800 (the same type of coating combination used in modifying the aluminum Mazda rotor housing).

Two attempts were made to apply the zirconia/Tribaloy 800 combination onto the side housings. The first attempt was as follows:

1. 0.889 mm (0.035 inch) of parent material was machined from the face of each side housing in the area where the housing is exposed to the rotor.

2. The housing was sent to APS Material, Inc. where a 0.127 mm (0.005 inch) layer of plasma-sprayed NiCrAlY bond coat plus a 0.508 mm (0.020 inch) layer of plasma-sprayed zirconia was applied.

3. After the zirconia coating application the pieces were sent to a machine shop where zirconia was ground to ensure dimensional correctness.

4. After grinding, the housings were sent to Stellite, Inc. to have the wear coating applied. A jet coat process was used to apply more than a 0.254 mm (0.010 inch) layer of Tribaloy 800.

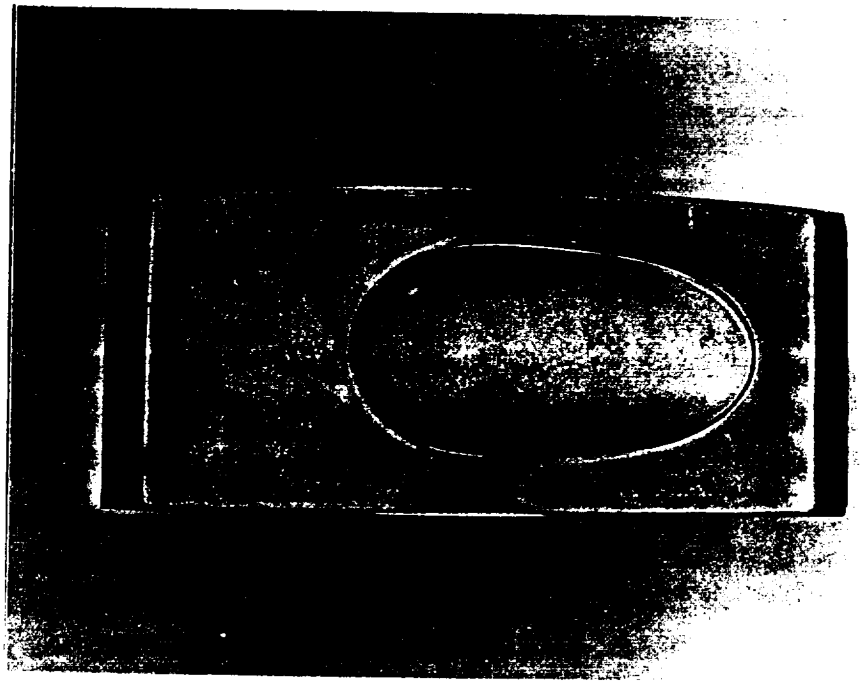
At this point the coating process was stopped because Stellite, Inc. could not get the T. Pictures of the Mazda engine mounted in the test cell can be seen in figure 5.1.3-1.

The fifth operation was the test itself. Engine testing started with a compression test. The compression tester takes six (6) measurements (one for each rotor face). Next, the engine was started and run through the break-in cycle which consisted of running at varying speeds with light to no-load. During this run all systems were checked to make sure they were functioning properly.

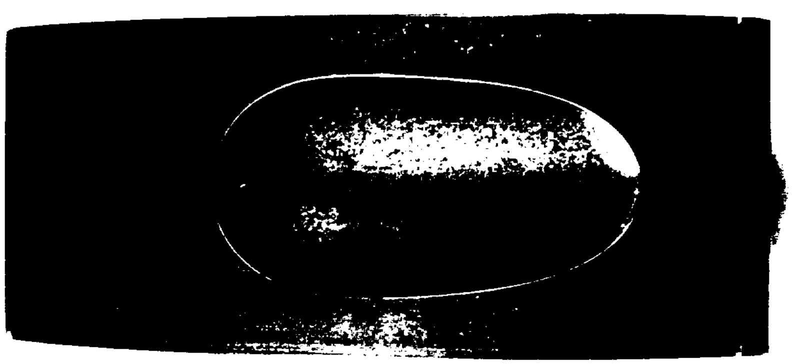
A test was to be run to develop inch) layer of plasma-sprayed zirconia and a layer exceeding 0.254 mm (0.010 inch) thick of plasma-sprayed Tribaloy 800 were applied. The drawing in figure 5.7.1-1 details the coating applied to the side housings.

2. After coating the side housings were ground and lapped.

One of the 2 side housing completed the grinding and lapping operation successfully. Unfortunately, the other side housing was under sprayed and



(a) AI-C/145-14A



(b) AI-C/145-19A

Figure 5.7.0-2. 1007R Rotor Shown (a) After Zirconia Application and (b) After Zirconia Densification.

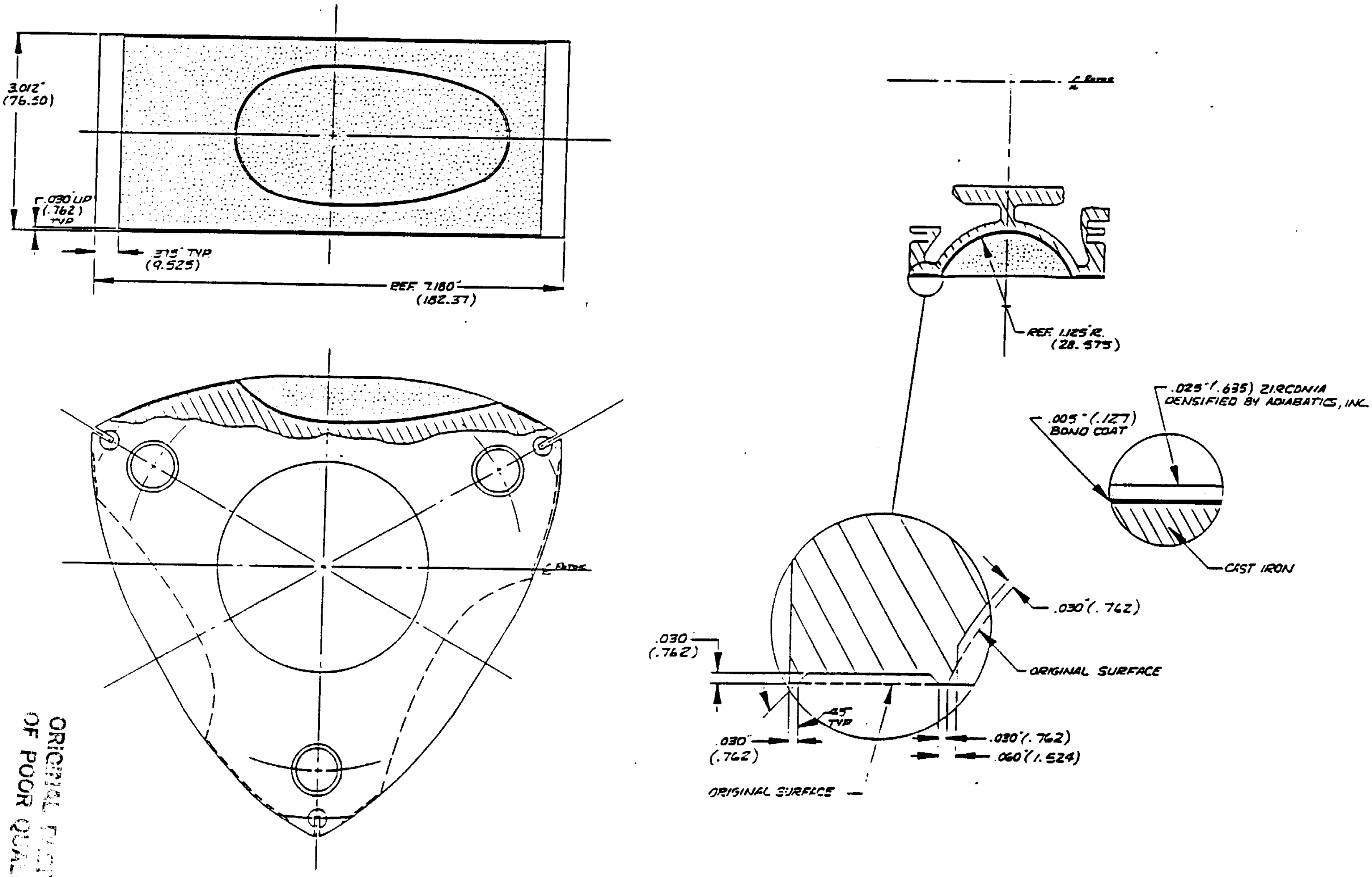


Figure 5.7.0-3. Details of the Thermal Barrier Coating on the 1007R Rotor.

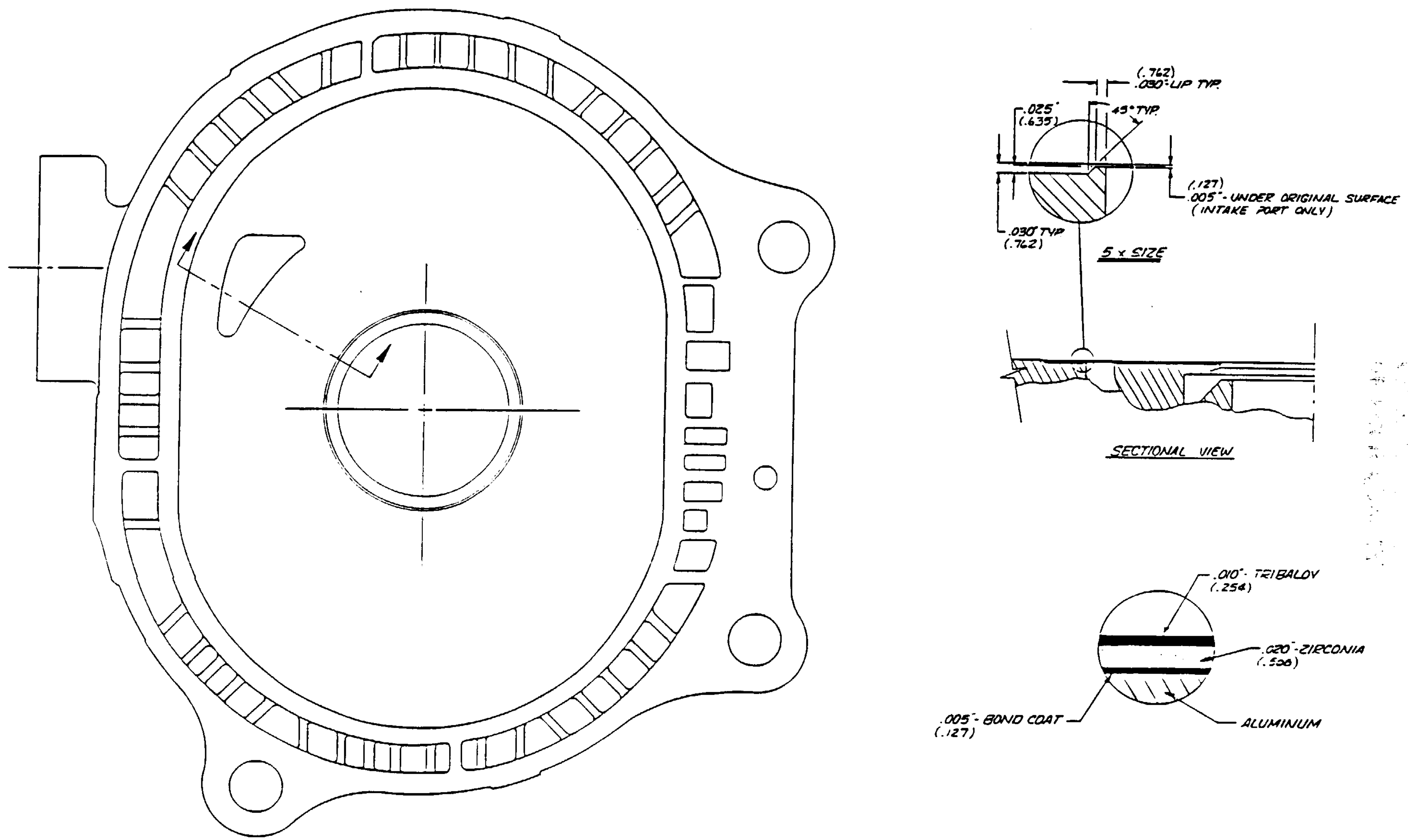


Figure 5.7.1-1. Details of Thermal Barrier Coating on the 1007R Aluminum Side Housing.

therefore was shipped back to APS Material Inc. to have additional Tribaloy 800 applied. This housing was then reground and lapped. Pictures in figure 5.7.1-2 show the 1007R side housing after machining and after grinding and lapping. After lapping was completed Adiabatics Inc. noticed some cracking around the crankshaft hole in the area which had been built up (figure 5.7.1-3).

5.7.2 Rotor Housing

The aluminum 1007R rotor housing was coated with the same zirconia/Tribaloy 800 combination used on the aluminum side housing.

1. The rotor housing was sent to Eonic, Inc. where 0.889 mm (0.035 inch) of parent material was removed.

2. The housing was sent to APS Materials, Inc. where a 0.127 mm (0.005 inch) bond coat plus 0.508 mm (0.020 inch) of zirconia was applied to the trochoid contour and 0.635 mm (0.025 inch) of zirconia to the exhaust port.

3. With the zirconia applied the housing was then sent back to Eonic where the coating on the trochoid contour was ground. The trochoid was ground to 0.254 mm (0.010 inch) over size (per side) to ensure dimensional correctness and ensure room for the wear coating application.

4. After grinding, the rotor housing was sent back to APS Material, Inc. for the application of a wear coating. Tribaloy 800 was plasma-sprayed on top of the zirconia more than 0.254 mm (0.010 inch) thick.

5. After applying the Tribaloy, the housing was sent back to Eonic for final grinding and lapping of the Tribaloy coating back to original dimensions.

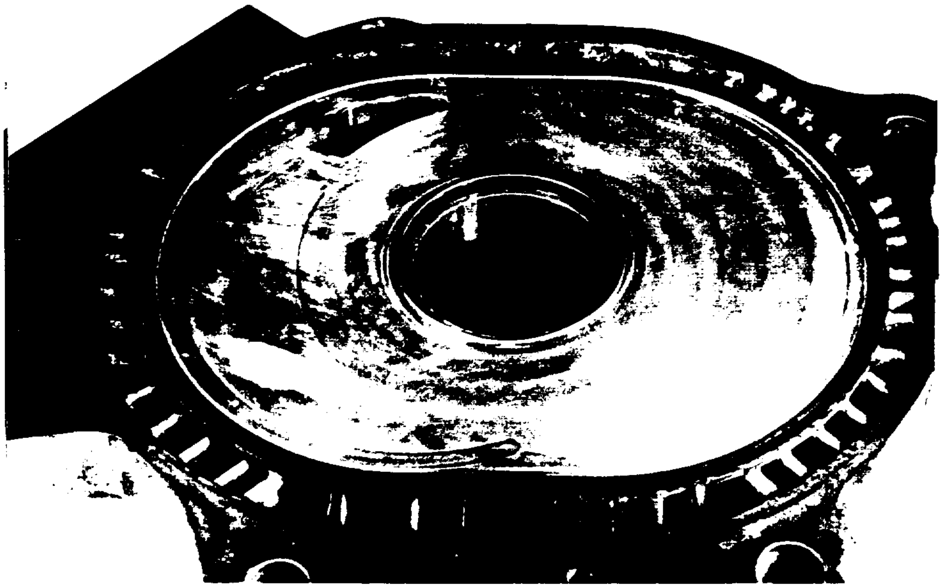
A drawing detailing this coating is shown in figure 5.7.2-1. Pictures in figure 5.7.2-2 show the rotor housing in different phases of coating application.

Table 4 summarizes the components procured for the assembly of the insulated 1007R engine.

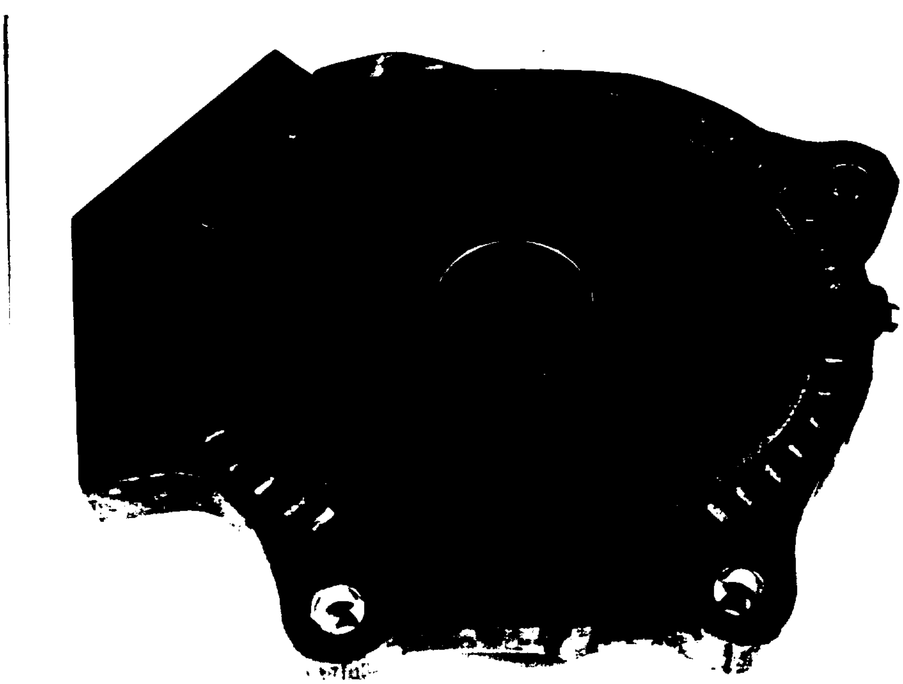
5.8 <u>Task VIII Exhaust Energy Utilization</u>

As an internal combustion engine is made more adiabatic a greater amount of exhaust enthalpy will flow from the engine. That is, some of the energy which would have been lost to engine coolant, lubrication, radiation and convection will appear in the exhaust gas in the form of a higher exhaust temperature. This higher exhaust temperature represents a large energy flow which can be recovered.

An analytical assessment was made of compounding a turbocharged 1007R John Deere rotary engine. The engine specifications and data for 2 test conditions are tabulated in Tables 5, 6, and 7. These data were employed in a rotary engine simulation which works on an energy balance of the engine, and was used to determine additional energy which would become available as the engine was insulated and the coolant was removed. An energy balance of the baseline noninsulated, cooled engine appears in Table 8. Changes (percentages) in heat rejection to the oil, coolant, and radiation due to insulation and coolant



(a) AI-C/141-19



(b) AI-C/155-12A

Figure 5.7.1-2. 1007R Side Housing After Maching (a) and Final Lapping (b).

AI-C/155-17A

Figure 5.7.1-3. Cracking Around the Crankshaft Hole of 1007R Side Housing After Final Lapping.

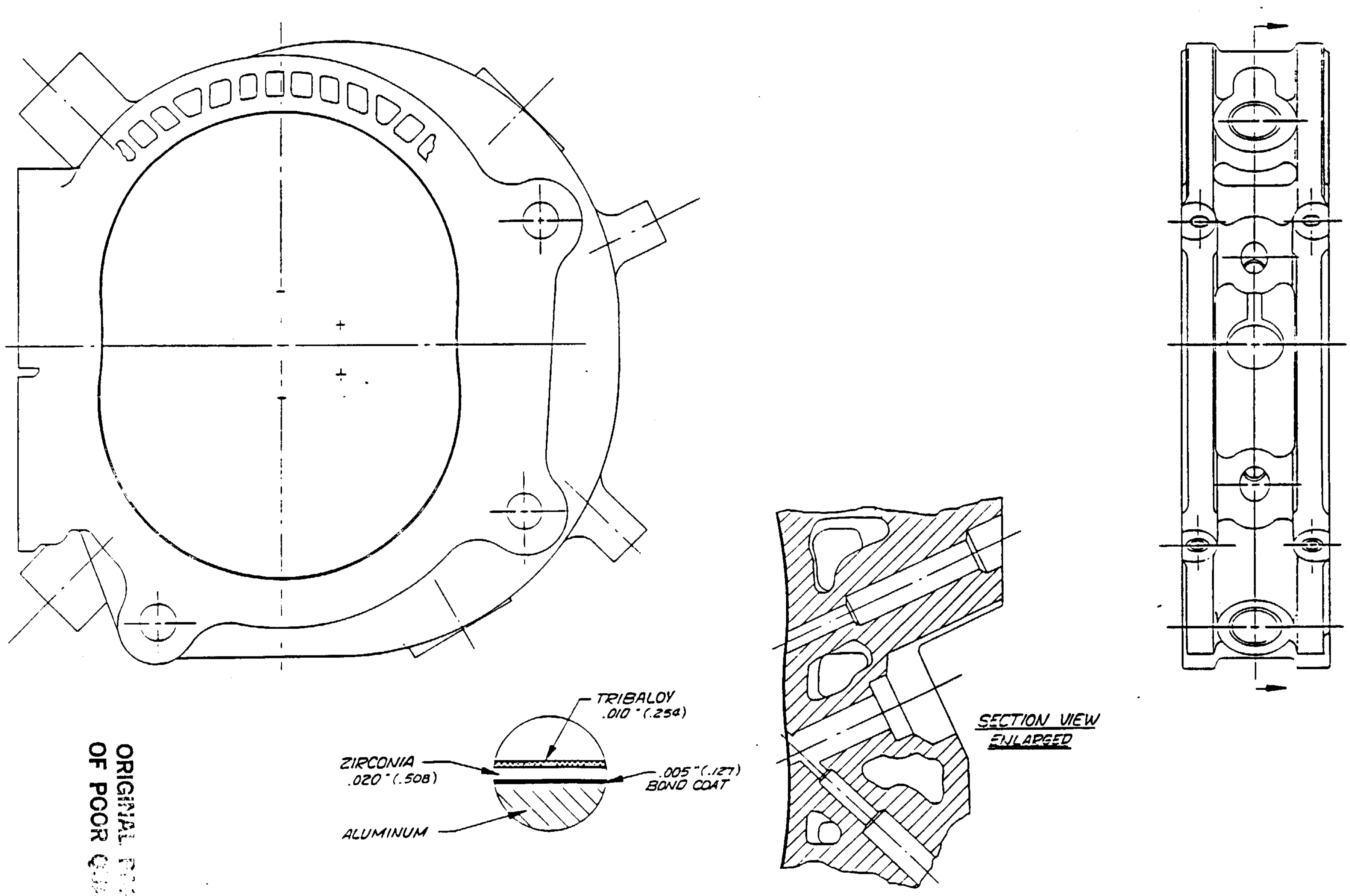
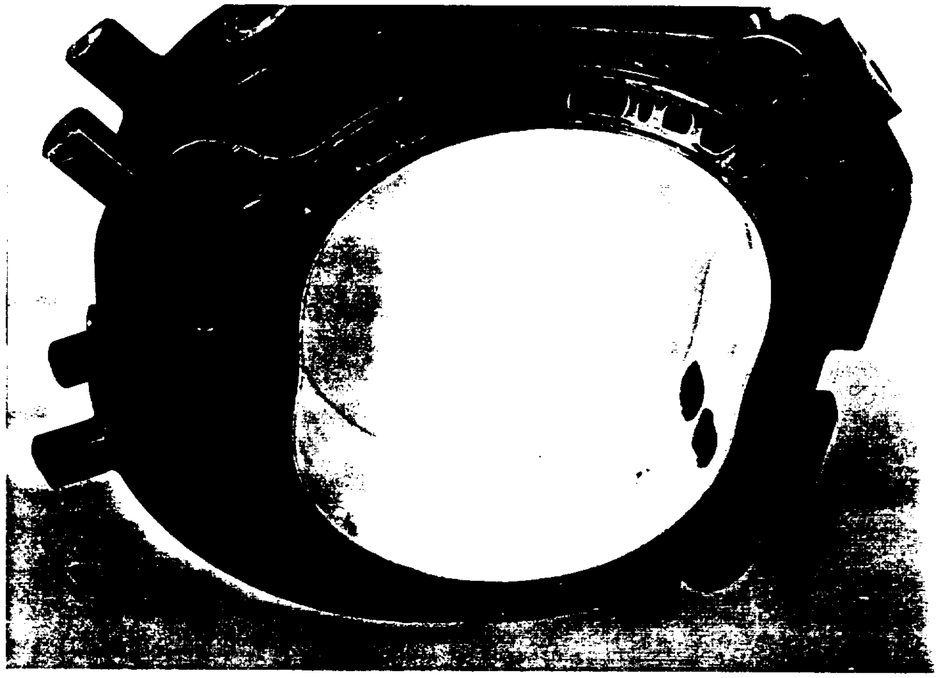
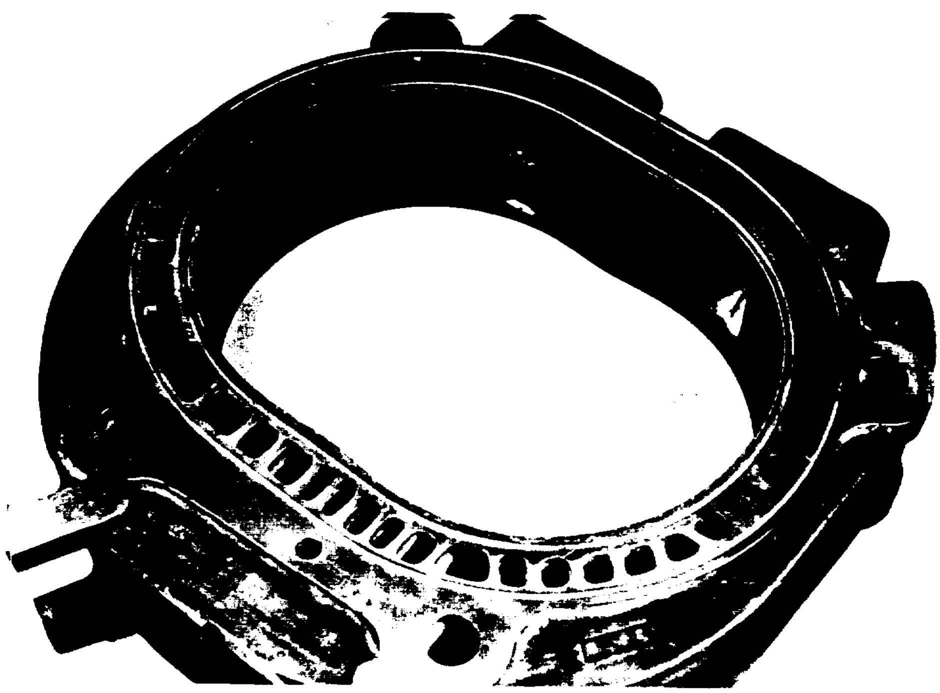


Figure 5.7.2-1. Details of Thermal Barrier Coating on the 1007R Aluminum Rotor Housing.

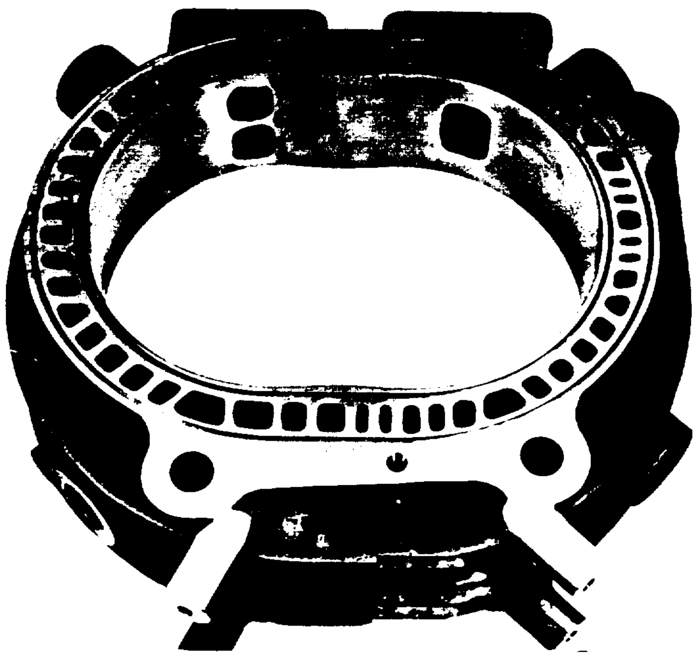


(a) AI-C/146-20



(b) AI-C/152-17A

Figure 5.7.2-2. 1007R Rotor Housing Shown After Zirconia (a) and Tribaloy 800 (b) Application.



AI-C/155-15A

Figure 5.7.2-2 Cont. 1007R Rotor Housing After Final Lapping.

TABLE 4. PROTOTYPE PROCUREMENT - NASA 1007R

	COMPONENT	QUANTITY	MATERIAL	TYPE OF COATING APPLIED	VENDOR	CONDITION AFTER COATING
1)	ROTOR	1	STAINLESS STEEL	0.762mm (0.030 INCH) THICK LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN DENSIFIED	APS MATERIALS APS MATERIALS	EXCELLENT EXCELLENT
2)	SIDE HOUSING	2	STOCK ALUNIMUN	0.889mm (0.035 INCH) THICK LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN COVERED WITH TRIBALOY 800	APS MATERIALS APS MATERIALS	EXCELLENT 1 CRACKED
3)	ROTOR HOUSING	1	STOCK ALUNIMUN	0.762mm (0.030 INCH) INLAYED LAYER OF PLASMA-SPRAYED ZIRCONIA -ZIRCONIA THEN COVERED WITH TRIBALOY 800	APS MATERIALS APS MATERIALS	EXCELLENT EXCELLENT

Table 5. 1007R Baseline Engine Basic Engine Configuration

ENGINE TYPE	Rotary Turbocharged DISC
ECCENTRICITY (in)	0.607
TROCHOID GENERATING RADIUS (in)	4.221
CHAMBER DEPTH (in)	3.036
DISPLACEMENT (in^3)	40.42
COMPRESSION RATIO	7.500
PORT TIMING (deg. ATC):	
INTAKE PORT OPENS	-626.3
INTAKE PORT CLOSES	-229.5
EXHAUST PORT OPENS	208.7
EXHAUST PORT CLOSE	610.5

ORIGINAL PAGE IS OF POOR QUALITY

Table 6. Engine Operating Conditions and Performance

	BASELINE ENGINE JDTI	MIT-DISC SIMULATION		
	TEST DATA (POINT 57)	BASELINE ENGINE	INSULATED WATER COOLED	INSULATED UNCOOLED
ENGINE SPEED (RPM)	8003	8000	8000	8000
INTAKE PRESSURE (atm)	1.98	1.98	1.98	1.98
INTAKE TEMPERATURE (F)	119	119	119	119
EXHAUST PRESSURE (atm)	1.50	1.50	1.50	1.50
EXHAUST TEMPERATURE (F)	1457	Time Average: 1463 Energy Basis: 2350	Time Average: 1494 Energy Basis: 2390	Time Average: 1494 Energy Basis: 2435
PEAK PRESSURE (atm)	61.65	61.61	61.95	62.12
FUEL TYPE	JetA	Light Diesel	Light Diesel	Light Diesel
FUEL FLOW (lb/hr)	81.50	88.25	87.97	87.52
AIR FLOW (lb/hr)	1950	1946	1939	1929
FUEL-AIR RATIO	0.0418	0.0453	0.0454	0.0454
INDICATED POWER (HP)	195	211.8	213.0	213.5
BRAKE POWER (HP)	160.9	—	—	—
NET INDICATED MEP (psi)	238.8	259.4	260.8	261.5
BRAKE MEP (psi)	197.0	—	—	—
HEAT LOSS (Btu/cycle) ROTOR SIDE HOUSING TROCHOID HOUSING TOTAL	0.305 (est.)	0.1075 0.0522 0.1391 0.2988	0.1052 0.0445 0.0869 0.2366	0.1055 0.0420 0.0271 0.1746

TABLE 7 JOHN DEERE TEST DATA

ENGINE 0701-3
COMPRESSION RATIO: 7.5
TURBOCHARGER: AIRESEARCH T04, 1.3 A/R

POINT NO.	-	54	57
ENGINE SPEED	RPM	7990	8003
LOAD	lb	102.6	120.6
BRAKE POWER	HP	136.6	160.9
BMEP	psi	167.6	197.0
BSFC	lb/HP-hr	0.5098	0.5066
FUEL-AIR RATIO	-	0.0378	0.0417
AIR FLOW	lb/hr	1840	1950
FUEL	-	JET A	JET A
T TEST CELL AMB	F	97	88
T AIR PLENUM	F	83	76
T AIR FILTER	F	82	74
T AIR BOTTLE	F	80	72
T COMP IN	F	81	73
T COMP OUT	F	263	272
T ENG IN	F	119	119
P BAROMETRIC	in Hg	29.84	29.88
P COMP IN	in H20	-18.5	-21.5
P COMP OUT	in Hg	31.3	34.2
P ENG IN	in Hg	24.3	29.4
RPM TURBO	RPM	99500	104060
FUEL FLOW, TOTAL	lb/hr	69.66	81.50
TUEL FLOW, PILTO	lb/hr	6.11	5.49
T FUEL, MAIN	C	38	39
T FUEL, PILTO	C	37	36
MAIN INJ PRES	psi	10000	15000
PILOT INJ PRES	psi	7000	7000
T TURBINE IN	F	1423	1457
T TURBINE OUT	F	1361	1425
P TURBINE IN	in Hg	12.7	15.0
P TURBINE OUT	in H20	-5.3	-4.8
OIL FLOW	gal/min	4.61	4.87
P OIL	psi	63	61
T ENG OIL IN	F	173.4	174
T ENG OIL OUT	F	213.2	217
T T/C OIL OUT	F	192	195
COOLANT FLOW	lb/hr	1613	1599
T COOLANT IN	F	177.8	175.1
T COOLANT OUT	F	184.5	182.7
DELTA T COOLANG	F	7.0	7.6
P COOLANT IN	psi	19.4	20.0
P COOLANT, ROT hsg	psi	12.0	12.8
P COOLANT, DE hsg	psi	10.5	10.8
P COOLANT OUT	psi	8.0	8.4
T INTERCOOLER IN	F	79.4	77
T INTERCOOLER OUT	F	92.2	91

TABLE 7 JOHN DEERE TEST DATA (Cont.)

ENGINE 0701-3

POINT NO.	-	54	57
IGNITION START	deg BTC	53	56
IGNITION END	deg BTC	7	5 ATC
PILOT START	deg BTC	52	55
PILOT END	deg BTC	3	10 ATC
MAIN START	deg BTC	51	52
MAIN END	deg BTC	8 ATC	10
T ENG OIL OUT DE	F	238	243
T ENG OIL OUT ADE	F	217	221
T ROTOR hSG DE	F	360	377
T ROTOR hsg ADE	F	379	392
T ROTOR hsg #1	F	207	204
T ROTOR hsg #2A	F	223	221
T ROTRR hsg #2B	F	220	219
T ROTOR hsg #3A	F	238	236
T ROTOR hsg #3B	F	230	228
T ROTOR hsg #4A	F	231	235
T ROTOR hsg #4B	F	244	253
T ROTOR hsg #5	F	196	191
T ROTOR hsg #5A	F	215	215
T ROTOR hsg #5B	F	OUT	212
T ROTOR hsg #6A	F	199	198
T ROTOR hsg #6	F	190	188
T ROTOR hsg #6B	F	206	208
T ROTOR hsg #7A	F	191	192
T ROTOR hsg #7B	F	195	195
T DE hsg #32	F	192	194
T DE hsg #33	F	OUT	OUT
T DE hsg #34	F	223	228
T DE hsg #35	F	214	217
T DE hsg #36	F	214	219
T DE hsg #37	F	196	197
T DE hsg #38	F	198	200
T ADE hsg #39	F	199	201
T ADE hsg #40	F	209	211
T ADE hsg #41	F	199	201

TABLE 8. : ENERGY BALANCE (simulation)

Energy In = Energy Out

Heat Input + Air Input = Coolant Rej. - Oil Rej. - Inter-Cooler Rej. - Radiation Rej. - Exhaust Rej. - Work Out

Heat Input = $\dot{m}_{air}$ * (F/A) * ΔH_c = + 1,502,323.2 BTU/Hr

Air Input = $\dot{m}_{air}$ * C_p * T_{in} = + 248,676.5 BTU/Hr

Coolant Rej. = $\dot{m}_{cool}$ * $C_{p\ cool}$ * ΔT = - 107,548.7 BTU/Hr

Oil Rej. = p * Q * C_p * ΔT = - 43,557.9 BTU/Hr

Inter-Cooler Rej. = $\dot{m}$ * C_p * ΔT = - 67,651.2 BTU/Hr

Radiation Rej. = Oil Rej. = - 43,5557.9 BTU/Hr

Work Out = Bhp * 2545 BTU/Bhp·Hr = - 409,490.5 BTU/Hr

Exhaust Rej. = $\dot{m}$ * C_p * T = - 1,022,749.7 BTU/Hr

Balance = + 56,443.8 BTU/Hr

= 3% error

Assumptions

Fuel Enthalpy Neglected
Radiation Rej. = Oil Rej.

removal were obtained from a study performed by ADAPCO. It was decided that the percentage changes in heat rejection would be more approximate rather than the absolute changes reported by ADAPCO for addition of insulation and removal of engine coolant. These percentages were obtained from the heat transfer rates in Table 6.

The simulation was calibrated to the John Deere data (point 57) for a baseline. The output from the simulation appears as the baseline data in Table 9.

The specific heat rejections to coolant and oil were then successively changed by the percentages developed from Table 6. The input and output for an insulated, cooled engine appears in Table 10. Input and output for the insulated, uncooled engine appears in Table 11.

The additional power in the exhaust is plotted in figure 5.8-1. A nearly linear relationship exists between % adiabacity and % power gain. Approximately 7.5 % additional power becomes available for 20.8% adiabacity (insulated, cooled), and 14.9 % additional power becomes available for 41.6% adiabacity (insulated, uncooled). A portion of this additional power can be recovered in the bottoming cycle. The amount of recovery then is dependent on the efficiency of the bottoming cycle used. As mentioned above a value of 50% was assumed. Then the recoverable power is shown in figure 5.8-1 to be 3.75% of the rotary engine brake power for 20.8% adiabacity and 7.45% for 41.6% adiabacity.

This analysis indicated that a significant amount of additional power becomes available in the exhaust gas by adding thermal insulation to the engine and removing the engine coolant.

5.9 Task IX Reporting

Quarterly Technical and Progress Reports were submitted throughout the program. Each task was reported in each progress report. One copy of the Final Report draft shall be submitted for review in lieu of the 4 copies specified.

6.0 CONCLUSIONS

1. Application of adiabatic (low heat rejection) engine technology to the rotary (Wankel type) engine is highly dependent upon the materials used for the basic engine components.

2. Fundamental work on increasing the permissible operating temperature of the apex seal/rotor housing tribological system is required before the adiabatic technology can be successfully applied to a complete engine.

3. Successful low heat rejection major engine components have been designed, analyzed, fabricated and tested in a Mazda gasoline rotary engine and low heat rejection components fabricated for the NASA 1007R stratified charge engine. The 1007R components are available for testing by John Deere's Rotary Engine Division.

TABLE 9 BASELINE

INPUT

INLET TEMPERATURE - DEGREES F	73.00
INLET PRESSURE - IN HG ASB	29.88
INTAKE PRESSURE DROP - IN H20	21.50
COMPRESSOR EFFICIENCY	75.00
INTERCOOLER COOLANT IN TEMP - F	77.0
INTERCOOLER EFFECTIVITY	80.00
BASELINE EXHAUST ENTHALPY - BTU/MIN	18095.30

OUTPUT

BMEP - PSI	197.0000
FMEP - PSI	37.0000
BSFC - LBS/BHP/HR	0.5076
ISFC - LBS/IHP/HR	0.4272
FUEL AIR RATIO	0.0420
FRICTION HORSEPOWER	30.3000
COMPRESSOR MASS FLOW - LBS/HR	19443.0000
COMPRESSOR PRESSURE RATIO	2.26
TURBINE PRESSURE RATIO	1.46
COMPRESSOR HORSEPOWER	34.30
ADDITIONAL POWER FOR TURBOCOMPOUNDING	0.00
COOLANT HEAT REJECTION - BTU/MIN	1792.000
LUBE OIL HEAT REJECTION - BTU/MIN	673.000
INTERCOOLER HEAT FLOW - BTU/MIN	1132.000
RADIATION HEAT REJECTION - BTU/MIN	673.000
ENGINE THERMAL EFFICIENCY	0.272
AMBIENT PRESSURE - IN HG	29.88
COMPRESSOR INLET	28.30
COMPRESSOR OUTLET	63.95
ENGINE INLET	59.81
TURBINE INLET	43.77
TURBINE OUTLET	29.88
AMBIENT TEMPERATURE - F	73.
COMPRESSOR INLET	73.
COMPRESSOR OUTLET	258.
ENGINE INLET	113.
TURBINE INLET	1573.
TURBINE OUTLET	1410.

TABLE 10 INSULATED COOLED ENGINE

INPUT

INLLET TEMPERATURE - DEGREES F	73.000
INLET PRESSURE - IN HG ABS	29.880
INTAKE PRESSURE DROP - IN H20	21.500
COMPRESSION RATIO	7.500
DESIRED FUEL AIR RATIO	0.042
APPARENT VOLUMETRIC EFFICIENCY	125.000
FRICTION REDUCTION PERCENTAGE	15.000
ISFC REDUCTION PERCENTAGE	-22.500
COMPRESSOR EFFICIENCY	75.000
INTERCOOLER COOLANT IN TEMP - F	77.000
INTERCOOLER EFFECIVITY	80.000
COOLANT - SPECIFIC HEAT REJECTION	8.821
LUBE - SPECIFIC HEAT REJECTION	3.573
BASELINE EXHAUST ENTHALPY - BTU/MIN	18095.300

OUTPUT

BMEP - PSI	197.0000
FMEP - PSI	37.0000
BSFC - LBS/BHP/HR	0.5076
ISFC - LBS/IHP/HR	0.4272
FUEL FLOW - CU MM PER STROKE	93.5805
ACTUAL FUEL AIR RATIO	0.0420
FRICTION HORSEPOWER	30.3000
COMPRESSOR MASS FLOW - LBS/HR	1944.0000
COMPRESSOR PRESSURE RATIO	2.2600
TURBINE PRESSURE RATIO	1.4600
COMPRESSOR HORSEPOWER	34.3000
ADDITIONAL POWER FOR TURBOCOMPOUNDING	24.0000
COOLANT HEAT REJECTION - BTU/MIN	1120.000
LUBE OIL HEAT REJECTION - BTU/MIN	564.000
INTERCOOLER HEAT FLOW - BTU/MIN	1132.000
RADIATION HEAT REJECTION - BTU/MIN	564.000
ENGINE THERMAL EFFICIENCY	0.272
AMBIENT PRESSURE - IN HG	29.88
COMPRESSOR INLET	28.30
COMPRESSOR OUTLET	63.95
ENGINE INLET	59.81
TURBINE INLET	43.77
TURBINE OUTLET	29.88
AMBIENT TEMPERATURE - F	73.
COMPRESSOR INLET	73.
COMPRESSOR OUTLET	258.
ENGINE INLET	113.
TURBINE INLET	1573.
TURBINE OUTLET	1410.

TABLE 11 INSULATED UNCOOLED ENGINE

INPUT

INLLET TEMPERATURE - DEGREES F	73.000
INLET PRESSURE - IN HG ABS	29.880
INTAKE PRESSURE DROP - IN H20	21.500
COMPRESSION RATIO	7.500
DESIRED FUEL AIR RATIO	0.042
APPARENT VOLUMETRIC EFFICIENCY	125.000
FRICTION REDUCTION PERCENTAGE	15.000
ISFC REDUCTION PERCENTAGE	-22.500
COMPRESSOR EFFICIENCY	75.000
INTERCOOLER COOLANT IN TEMP - F	77.000
INTERCOOLER EFFECIVITY	80.000
COOLANT - SPECIFIC HEAT REJECTION	6.510
LUBE - SPECIFIC HEAT REJECTION	2.636
BASELINE EXHAUST ENTHALPY - BTU/MIN	18095.300

OUTPUT

BMEP - PSI	197.0000
FMEP - PSI	37.0000
BSFC - LBS/BHP/HR	0.5076
ISFC - LBS/IHP/HR	0.4272
FUEL FLOW - CU MM PER STROKE	93.5805
ACTUAL FUEL AIR RATIO	0.0420
FRICTION HORSEPOWER	30.3000
COMPRESSOR MASS FLOW - LBS/HR	1944.0000
COMPRESSOR PRESSURE RATIO	2.2600
TURBINE PRESSURE RATIO	1.4600
COMPRESSOR HORSEPOWER	34.3000
ADDITIONAL POWER FOR TURBOCOMPOUNDING	24.0000
COOLANT HEAT REJECTION - BTU/MIN	349.000
LUBE OIL HEAT REJECTION - BTU/MIN	534.000
INTERCOOLER HEAT FLOW - BTU/MIN	1132.000
RADIATION HEAT REJECTION - BTU/MIN	534.000
ENGINE THERMAL EFFICIENCY	0.272
AMBIENT PRESSURE - IN HG	29.88
COMPRESSOR INLET	28.30
COMPRESSOR OUTLET	63.95
ENGINE INLET	59.81
TURBINE INLET	43.77
TURBINE OUTLET	29.88
AMBIENT TEMPERATURE - F	73.
COMPRESSOR INLET	73.
COMPRESSOR OUTLET	258.
ENGINE INLET	113.
TURBINE INLET	1573.
TURBINE OUTLET	1410.

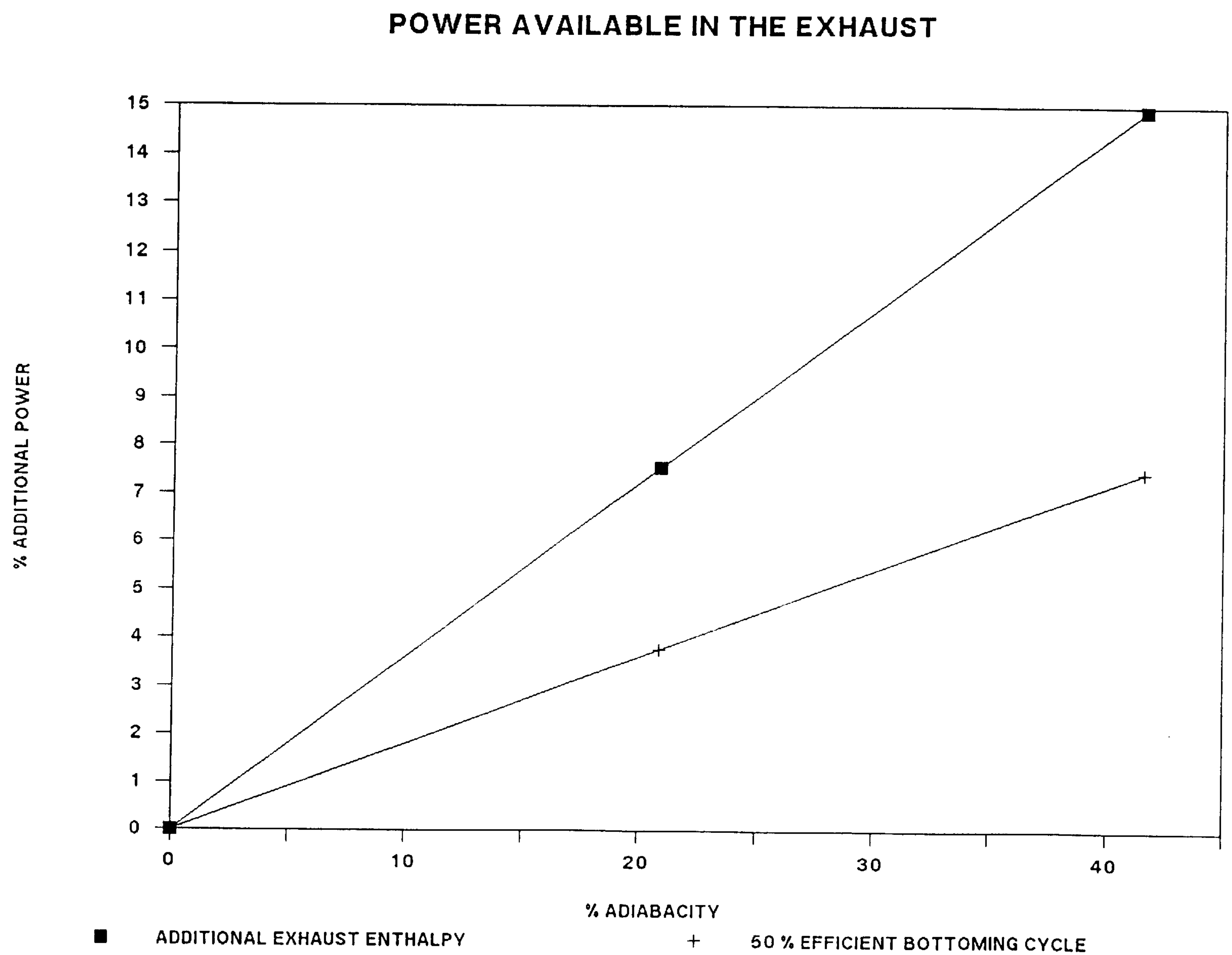


Figure 5.8-1 Power Available in the Exhaust Chart

4. Application of insulating coatings to the engine's rotor, by plasma spraying partially stabilized zirconia (PSZ) followed by surface densification, has proven to be successful. A similar coating with high temperature chrome oxide densification to provide a good wear surface was successful on the Mazda cast iron side housings. However, application of the same material to the aluminum side housings and aluminum rotor housing of the 1007R engine is not possible because the processing temperatures required to obtain good wear surfaces are above the maximum permissible temperature to which the aluminum can be exposed.

5. A layered coating consisting of PSZ and Tribaloy 800 has been applied to the aluminum 1007R components to provide a thermal barrier insulating layer with a good tribological surface. Testing by John Deere is required to demonstrate the integrity of this coating.

6. Conclusive data on reduction of heat rejection is not available from the Mazda testing but will be generated when the components are tested in the stratified charge combustion engine by John Deere. Examination of the data from the Mazda engine testing with the insulated components result in the conclusion that dramatic reductions in heat rejection are achievable with todays coating technology. For instance, looking at Figure 5.6.1-8, adding only 0.75 mm of coating to the rotors raised the peak exhaust temperature 90 C. from 730 to 820 C. and Figure 5.6.1-3 shows that the temperature rise in the lube oil in the engine dropped more than 20 percent. Application of 0.5 mm of insulating coating to both sides of the Mazda intermediate housing (the two end housing sides were not coated) reduced the temperature rise in the lube oil by 50 percent (Figure 5.6.0-3). If similar results are observed on the stratified charge combustion engine, reductions of heat transfer to the lube oil of 75 percent or greater are expected.

7. Testing of the coated aluminum and coated cast iron rotor housings was not sufficient to demonstrate the thermal performance of the coating systems as the coatings failed before adequate data could be obtained. A conclusion which can be drawn from the rotor housing testing is that successfully coating the aluminum rotor housing with an insulating material with good tribological properties may not be possible. The aluminum rotor housings tested on the Mazda engine failed in the zirconia layer probably from the combination of high compressive loads under the apex seals and high tensile loads caused by the high thermal expansion of the aluminum housing. The coating failure may have been aggravated by either a poor quality PSZ plasma spray or damage to the PSZ caused by the trochoid grinding process. Based on these results, the processing of the rotor housing for the 1007R engine has been closely watched at every step to improve the quality of the resulting coating which will hopefully provide sufficient life to enable heat rejection data to be obtained.

8. Testing of the special coated cast iron Mazda rotor housings with minimal cooling (no cooling passages in the high heat flux area) were more successful, in that the coatings did not fail immediately (they were used for three engine builds). The engine ran very well with the cast iron housings and sounded different (less high frequency noise)

at low power levels and experienced failures of the apex seal system which terminated each test as the power was increased. The apex seal system failures included severe bowing of the seals (indicating that the wear surface was running significantly higher temperature than the inner surface of the seal), accelerated apex seal wear and sticking of the seals in the rotors. These failures are due to breakdown of the lubrication system at the very high surface temperatures which were experienced on the inner surface of the insulated cast iron rotor housing. Based upon extrapolation of the rotor housing heat flux thermocouple data, the temperature of the cast iron and coating interface was in excess of 244 C. as compared to 103 C. for the baseline engine at the same load. The baseline engine had a wall temperature of 127 C. at full load. While the absolute values of these data are highly questionably (actual temperatures are known to be higher) the data does show that the minimally cooled, insulated cast iron housing runs significantly hotter than the standard cooled aluminum housing. This high temperature operation breaks down the lubricating oil causing an increase in friction and also forms hard deposits (which cause the apex seals to stick).

9. As discussed separately in the ADAPCO report the conclusion of the cycle analysis, thermal analysis and stress analysis are that the design approach to insulating the rotor is sound and has acceptable stress levels. However, it is predicted that the insulated aluminum rotor housing with water cooling and the uncooled, insulated, cast iron rotor housing both have excessively high stress levels and will fail. ADAPCO does point out that their analysis could be greatly improved with additional fundamental property data for the coating systems and by using a more sophisticated cycle analysis and transient thermal analysis.

10. Analysis of the cycle simulation data, with various degrees of heat rejection reduction, shows that for a 40 percent reduction of heat rejection to the coolant and lube that an additional 15 percent of the rated engine power is available in the exhaust for compounding recovery.

7.0 RECOMMENDATIONS

This program has concluded that it is possible to reduce the heat rejection of high performance rotary engines by using state-of-the-art thermal barrier coatings provided that the basic engine components are made of compatible materials. In order to improve the engine for aircraft applications (or other applications which are weight sensitive) it is necessary to find an alternative to aluminum and cast iron for the engine housings and rotors. A material with low density and good high temperature strength is required. A study to identify an optimal material to replace aluminum or ductile iron for high temperature piston engines [3] has identified a titanium alloy (Ti6242) as having the desired properties and which also has low thermal conductivity.

It is recommended that a technology demonstrator engine be designed using the Ti6242 alloy with thermal barrier coatings on the side housings, rotors and (to a limited extent) the rotor housing. The design should prove that titanium is a superior material for a high performance aircraft engine and that the resulting engine will be inherently more reliable (as compared to an engine with aluminum housing castings). A techno-economic analysis should then be performed to determine the cost and marketing implications.

It is recommended that efforts be continued (by NASA and others) to develop high temperature lubrication systems which are applicable to the apex seal. This effort should include high temperature liquid lubrication, dry lubrication systems and work on material compatibility.

RECOMMENDATION FOR TESTING AT JOHN DEERE

It is recommended that the components be tested together in one engine build to determine the performance implications in the stratified charge combustion engine. Testing should be done with an eye to obtaining as much data as possible before coating failure occurs. The coated rotor (which should survive any coating failure of the rotor housing or side housings) should then be tested by itself for durability and performance. If the rotor coating is damaged, Adiabatics, Inc. will recoat it for free.

APPENDIX A

ADIABATIC, INC.

STATEMENT OF WORK

APPENDIX A

ADIABATIC, INC.

STATEMENT OF WORK

TABLE OF CONTENTS

ADIABATIC WANKEL TYPE ROTARY ENGINE
CONTRACT NAS3-24880

STATEMENT OF WORK

INTRODUCTION

The objective of this project is to design, fabricate, procure, assemble and test a prototype low heat rejection rotary engine based on studies performed in the SBIR Phase I contract entitled "Adiabatic Wankel TYPE Rotary Engines" completed in 1985. A program consisting of eight (8) tasks was formulated to accomplish this project as follows:

I Engine Selection and Baseline Test
II Thermal Analysis
III Adiabatic Component Design
IV High Temperature Apex/Side Seal Tribology
V Prototype Engine - Procurement/Assembly - MAZDA 13B
VI Engine Testing
VII Prototype Engine - Procurement - NASA 1007R
VIII Exhaust Energy Utilization

The following is a narrative description of the work plan for each task.

TASK I Engine Selection and Baseline Test

This first task starts with selection and purchase of a test engine followed by instrumentation of the engine and baseline testing. Per the conclusions of the first quarterly report and review at a meeting with Mr. William Hady at NASA LeRC November 12, 1986 a Mazda 13B engine of the latest configuration was procured. Based on engine availability and suitability for test cell operation the engine was purchased (following approval from Mr. William Hady) from Racing Beat, Inc. of Anaheim California. The configuration of the engine is listed in the following table:

Model	Mazda 13B
Displacement	1.308 L (80 Cu In)
Rated Power	132 KW (177 Horsepower)
Intake Ports	6 Side Ports (2 Valved)
Exhaust Ports	2 Peripheral
Exhaust Manifold	Racing Type Header
Carburetion	Dellorto 48 DHLA (Dual sidedraft)
Ignition Distributor	Mazda Breakerless (Integral Electronics)
Ignition Coils	Mazda Transistor Ignition Type
Flywheel	Lightweight Steel Type

The plan is to use this engine for component screening (mechanical screening as opposed to performance development). The logic behind this approach is that the addition of low heat rejection components to a homogeneous charge engine will raise the temperature of the gases during the compression stroke and increase the tendency of the engine to detonate (early combustion). To counteract this phenomena special fuels with very high octane numbers will have to be used along with power reductions. A test plan for the engine is to be prepared which includes engine and test cell instrumentation, assembly instructions, test cell installation details and the actual listing of tests to be run. An eddy current type dyno matched to the Mazda engine is being used for this project.

Because the selected engine is a mature product the initial testing is limited to refinement of the test facility and baseline performance measurements of the engine with no endurance or durability testing. A partial listing of the parameters which are be measured and the measuring method are as follows:

Engine Speed	Speed pickup on dyno.
Torque	Load Cell on dyno.
Fuel Flow	Mass Type Flowmeter
Air Flow	Mass Type Flowmeter
Intake Temperature	Thermocouple
Exhaust Temperature	Thermocouple
Coolant In Temperature	Thermocouple
Coolant Out Temperature	Thermocouple
Oil In Temperature	Thermocouple
Oil Out Temperature	Thermocouple
Rotor Housing Temperature	Thermocouple
Side Housing Temperature	Thermocouple
Coolant Pressure	Bourdon tube gage
Oil Pressure	Bourdon tube gage
Barometric Pressure	Mercury Barometer
Wet and Dry Bulb Amb Temps.	Sling Psychrometer

Following receipt of the inputs from NASA the detailed test plan will be finalized and submitted to NASA for approval.

Following approval of the test plan the Contractor will conduct the test program and prepare and issue an informal test report.

Task II Thermal Analysis

A thermal analysis shall be conducted for NASA's 1007R engine to obtain a thermal history including the temperature distribution in the rotor and rotor housings during rated and peak torque operating conditions.

The analysis shall provide the basis for calculating the distortion, allowable clearances and thermal stresses in these components. The thermal stresses obtained in this analysis shall be combined with the rotating stresses and pressure loading stresses to provide input for the component design to be performed in Task III - Adiabatic Component Design.

After completion of the thermal analysis, the Contractor shall prepare an informal report and present it to the NASA Project

Manager for his approval. Upon approval, the Contractor shall proceed with the design of all the adiabatic components as determined in Task III - Adiabatic Component Design.

The following method will be used to accomplish this task:.

a. NASA to furnish 1007R drawings and test data to ADAPCO.
b. NASA to furnish MIT Stratified Charge Combustion Model.
c. ADAPCO will incorporate 1007R geometry and run the MIT model to generate boundary conditions.
d. ADAPCO to use John Deere data to verify model.
e. ADAPCO to generate FE model of 1007R rotor and rotor hsg.
f. ADAPCO to use boundary conditions from c. and run FE analysis.
g. ADAPCO to prepare informal report.

III. Adiabatic Component Design

Following completion of TASK 2, the Contractor will upon approval from NASA's Project Manager have ADAPCO proceed to modify the models for combustion and the FE models for the rotor and rotor housing to include selected low heat rejection components and to run the models and analysis at the low heat rejection conditions. These results will be used in an iterative manner to design the actual modifications to the 1007R parts. Detailed drawings of the modifications will be completed by Contractor personnel and submitted to the Project Engineer for approval. Upon approval, the Contractor may initiate procurement of the adiabatic components outlined in task IV - High Temperature Apex/Side Seal Tribology and task VI - Prototype Engine Procurement - NASA 1007R.

IV High Temperature Apex/Side Seal Tribology

The Contractor shall evaluate and procure candidate apex seals, side seals and high temperature lubricants as follows:

Based on experience from reciprocating adiabatic engine testing four candidate sets each of apex seals and side seals for high temperature operation along with high temperature oil for two oil changes will be procured for the 1007R engine. The same candidate apex seal and side seal designs will be procured for the Mazda engine along with the same high temperature oil. The apex seals and high temperature oil will be run in the Mazda engine build with the low heat rejection rotor housing and the side seals and high temperature lube will be run in the engine build with the low heat rejection side housings.

V Prototype Engine - Procurement/Assembly - Mazda 13B

The Contractor shall procure, fabricate, modify, and assemble a complete prototype adiabatic rotary engine utilizing those parts and or components obtained in performance of Tasks I, III and IV. This engine is to be used for screening components for later inclusion in the 1007R engine. A series of screening tests are to be planned wherein a concept can be tested individually for mechanical and tribological integrity.

VI Engine Testing

The Contractor shall install the Mazda 13B rotary engine and auxiliary components from Task IV (High Temperature Apex/Side Seal Tribology) to his test facility and make all necessary preparations for testing. Prior to commencing the engine testing a test plan will be prepared and approved by the NASA Project Manager. The engine testing shall consist of separate engine builds and tests for the rotor, rotor housing, and side housings along with a final test of the complete engine. A minimum of four separate engine build and test cycles are required.

VII Prototype Engine - Procurement - NASA 1007R

The Contractor is to provide thermal barrier coatings for the following parts of the NASA 1007R engine:

Note: The parts to be coated are NASA owned parts which are presently at John Deere.

ROTOR - The 1007R rotor will be machined and coated the same as the Mazda rotor.

SIDE HOUSINGS - The present 1007R side housings are aluminum and present the same problem as the aluminum rotor housings. Depending upon the results from the Mazda testing and the thermal analysis program, either zirconia coated aluminum housings with the three cycle coating or plasma sprayed chrome-oxide or the K-Ramic coated cast iron housings will be supplied.

ROTOR HOUSING - The selection of rotor housing material and coating will be dependant upon the results of the Mazda testing and the thermal analysis.

The testing of the 1007R components will be accomplished by John Deere and is not included in this project.

VIII Exhaust Energy Utilization

The Contractor shall conduct a study on methods of recovering waste energy from the exhaust of the adiabatic rotary engine using exhaust gas data from the 1007R engine and the results of the thermodynamic modeling of that engine with low heat rejection components. The results of this study will be presented to the NASA Project Manager for his approval.

Reporting Requirements

Reporting shall be in accordance with the Reports of Work attachment except as modified below:

1. A Quarterly Technical and Progress Report shall be substituted in lieu of the Monthly Report.

2. Each task shall be reported in the Quarterly Progress Report.

3. The Quarterly Progress Report shall include the number of labor hours expended for each category of labor for the quarter as well as cumulative totals.

4. One (1) copy of the Final Report draft shall be submitted for review in lieu of the four (4) copies specified.

APPENDIX B

ENGINE TEST PLAN

ENGINE TEST PLAN

The engine test plan encompasses five engine configuration tests: the standard engine, the standard engine with coated rotors, the standard engine with coated intermediate housing, the standard engine with coated rotor housings, and the standard engine with a combination of all above mentioned coated components. The purpose of the engine tests is to screen components for later inclusion on the 1007R engine. The data from the testing will be analyzed to determine the change in heat rejection.

The first test configuration, the standard engine, is being run to develop baseline information. Because the selected engine is a mature product the initial testing is limited to refinement of the test facility and performance measurements of the engine with no endurance or durability testing.

The test consists of engine preparation, instrumentation, and machining of the engine rotor housings and intermediate housing to enable installation of thermocouples. The assembled engine will be placed on the test stand and connected to an Eaton eddy current type dynamometer Model AD-8081.

The following parameters will be measured and recorded:

Engine Speed	Speed pickup on dyno.
Torque	Load cell on dyno.
Fuel Flow	Mass type flow meter.
Intake Temperature	Thermocouple
Exhaust Temperature	"
Coolant In Temperature	"
Coolant Out Temperature	"
Oil In Temperature	"
Oil Out Temperature	"
Rotor Housing Temperature	"
Side Housing Temperature	"

(Continued on next page.)

Intake Pressure	Mercury Manometer
Exhaust Pressure	Mercury Manometer
Blow by	Mercury Manometer
Coolant Pressure	Bourdon Tube Gauge
Oil Pressure	Bourdon Tube Gauge
Barometric Pressure	Mercury Barometer
Wet & Dry Bulb Amb. Temps.	Sling Psychrometer

(For locations of rotor housing and intermediate housing thermocouples see Figures 1 & 2.)

Periodic visual inspection through the exhaust ports and pre and post test measurements of the wear surfaces will be performed.

The second engine configuration to be tested is the baseline engine with the addition of two insulated rotors. The two rotors will be coated with plasma sprayed zirconia and then densified with a chrome oxide coating. This test will include an endurance test at various loads to ensure proper component screening. The same parameters will be measured as outlined in the first test configuration.

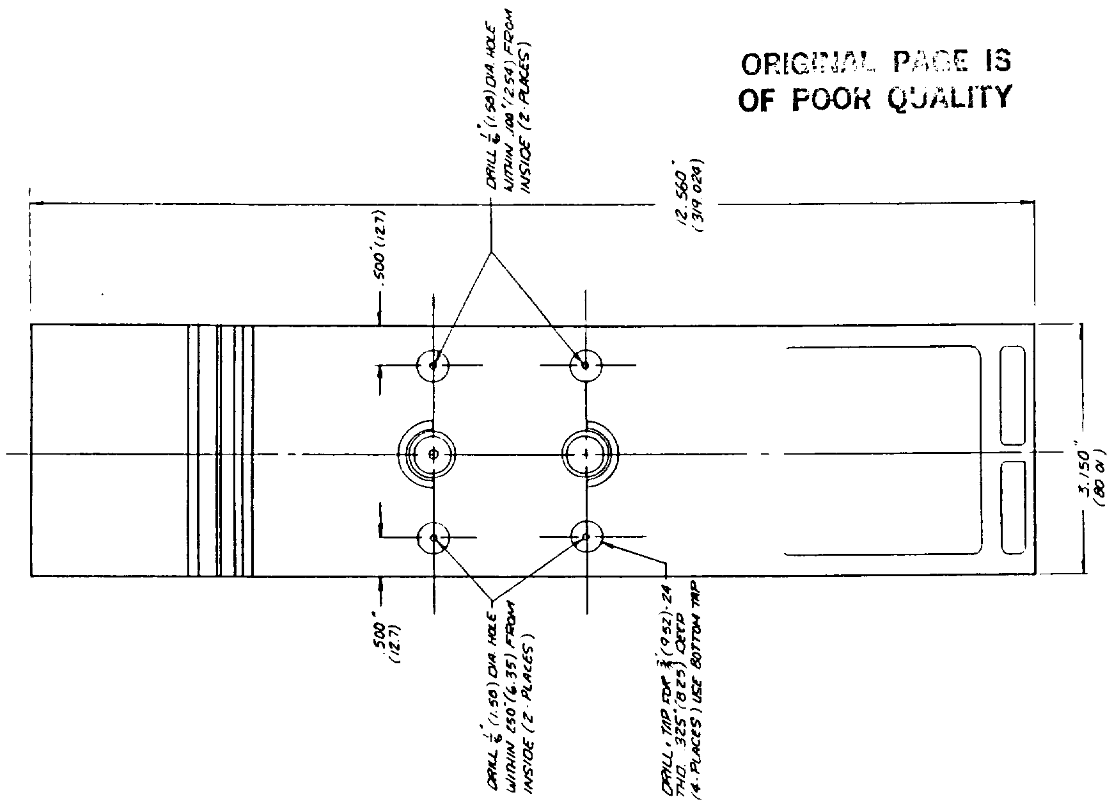
The third engine configuration tested is the baseline engine with a coated intermediate housing and coated side seal. This test will also be performed under endurance conditions and the test will measure the same parameters as above.

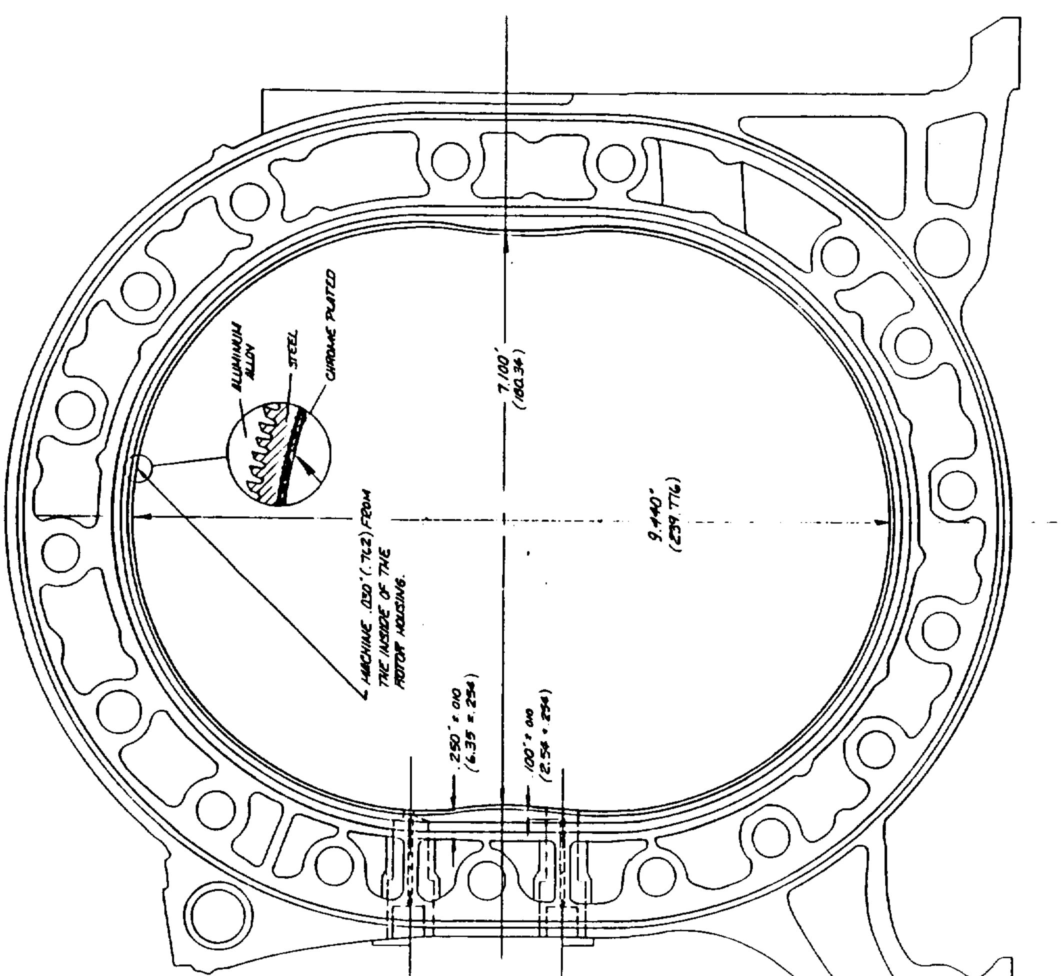
The fourth engine configuration tested is the baseline engine with coated rotor housings and coated apex seals. Testing will be done in the same manner as above.

The last engine configuration tested is with a combination of all coated components. This test will be performed if all components endure the previous tests. The same parameters will be measured.

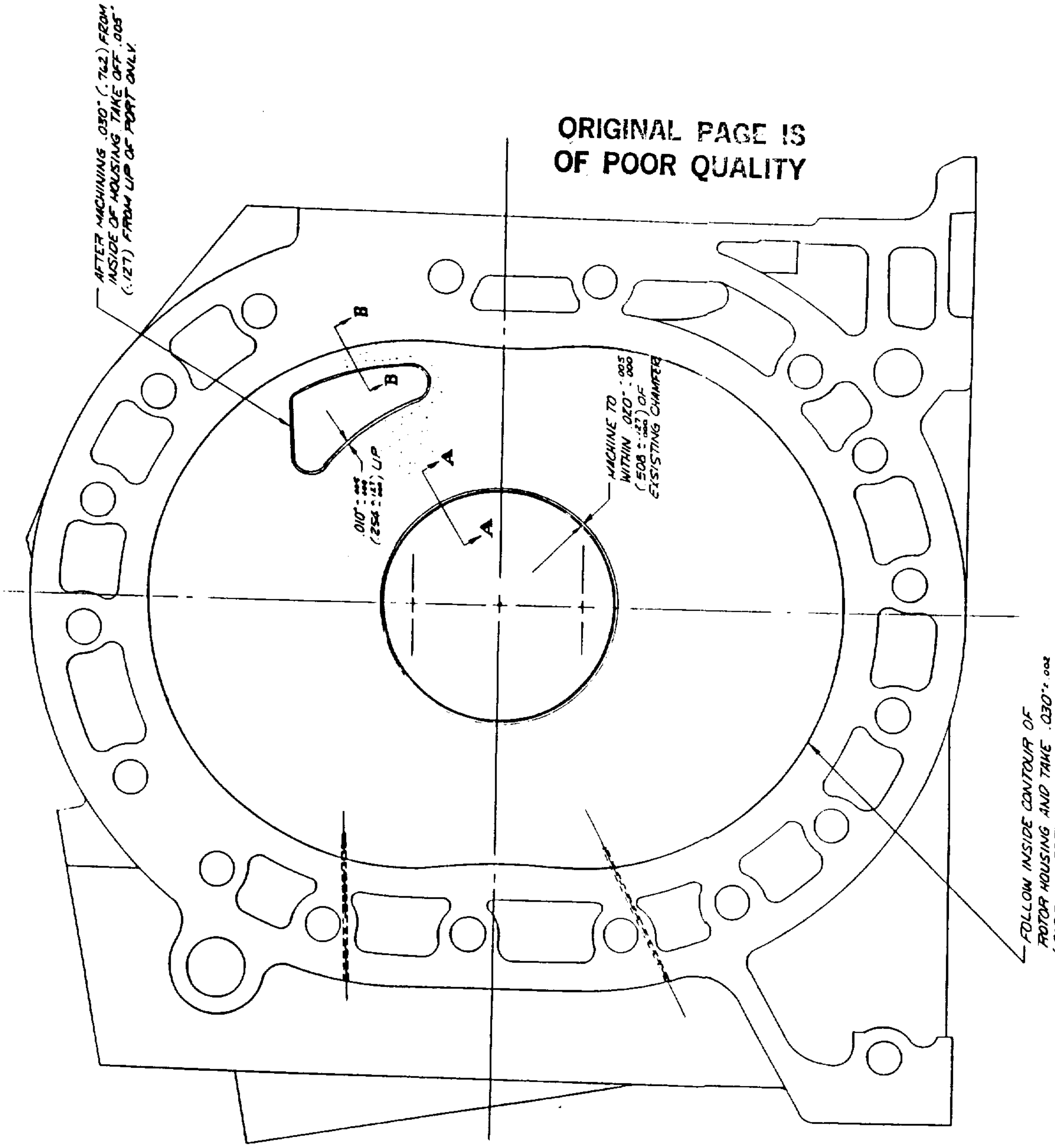
Once the test program is performed, Adiabatics, Inc. will prepare and issue an informal test report.

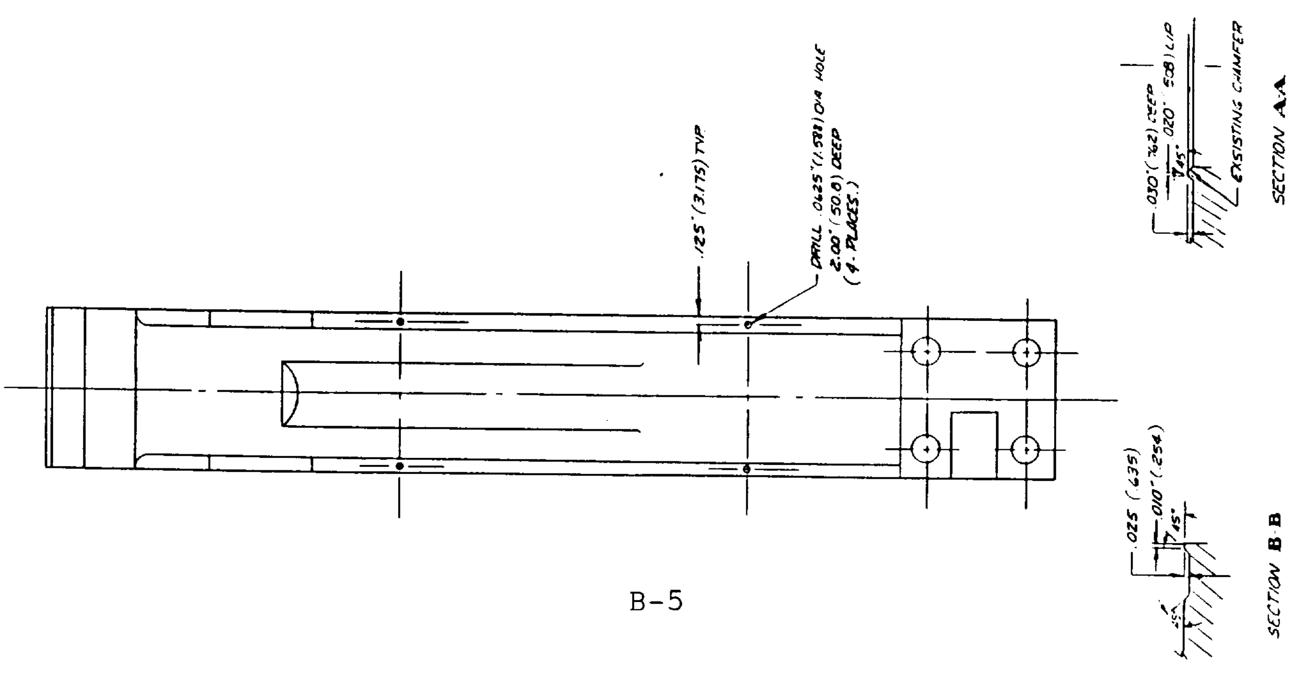
ORIGINAL PAGE IS
OF POOR QUALITY





ORIGINAL PAGE IS OF POOR QUALITY





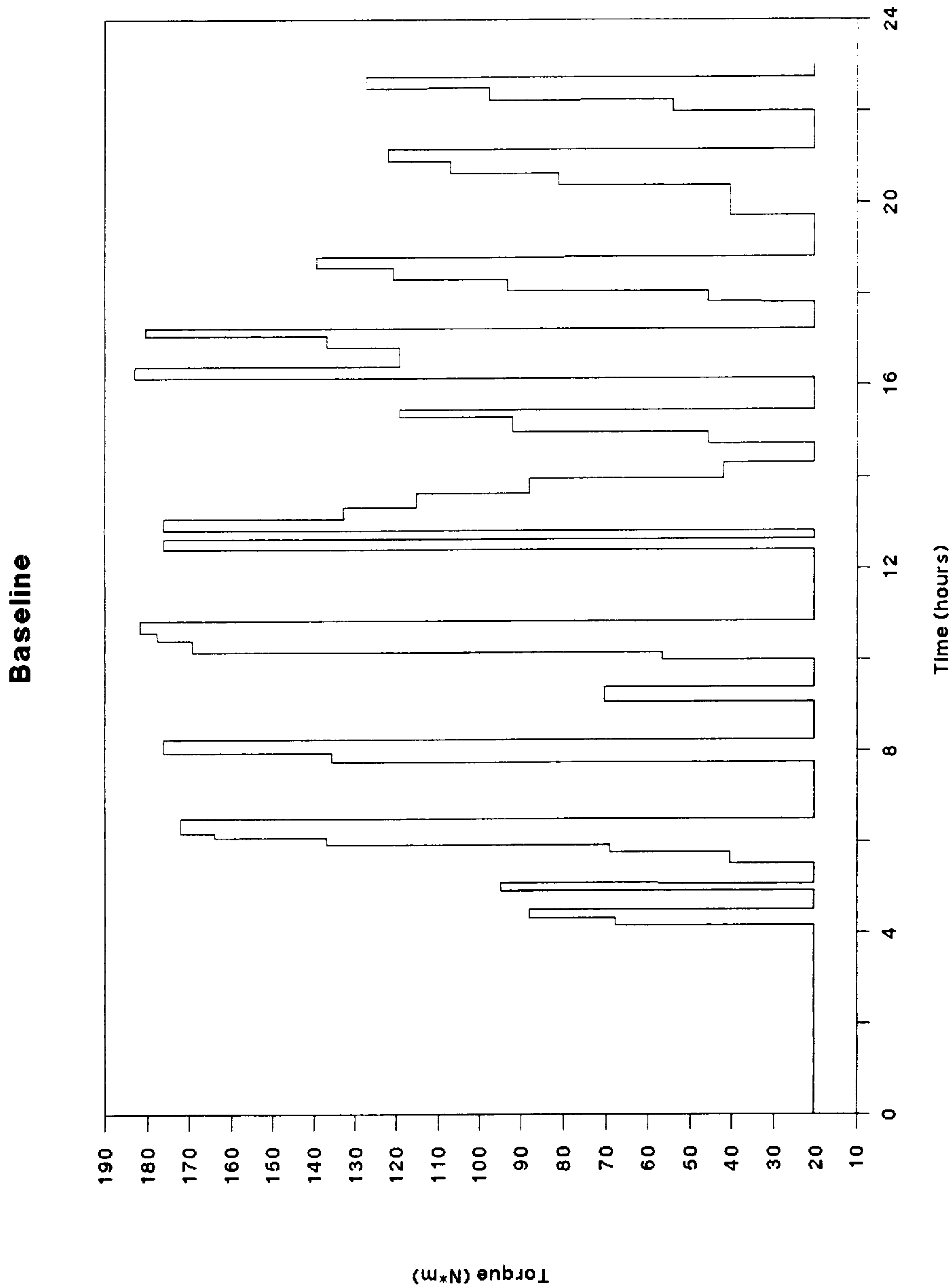
APPENDIX C

BASELINE DATA

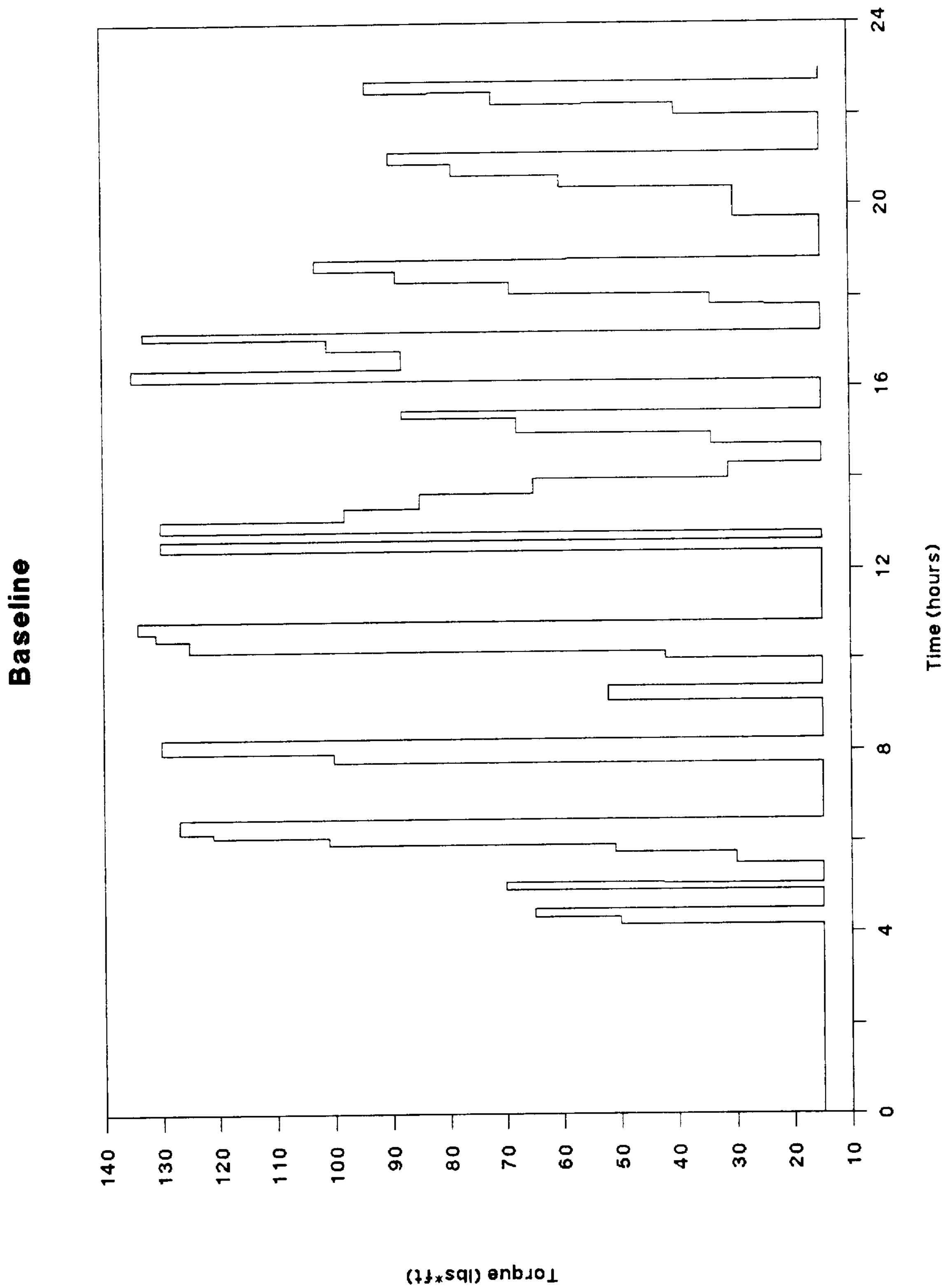
BASELINE DATA

TABLE OF CONTENTS

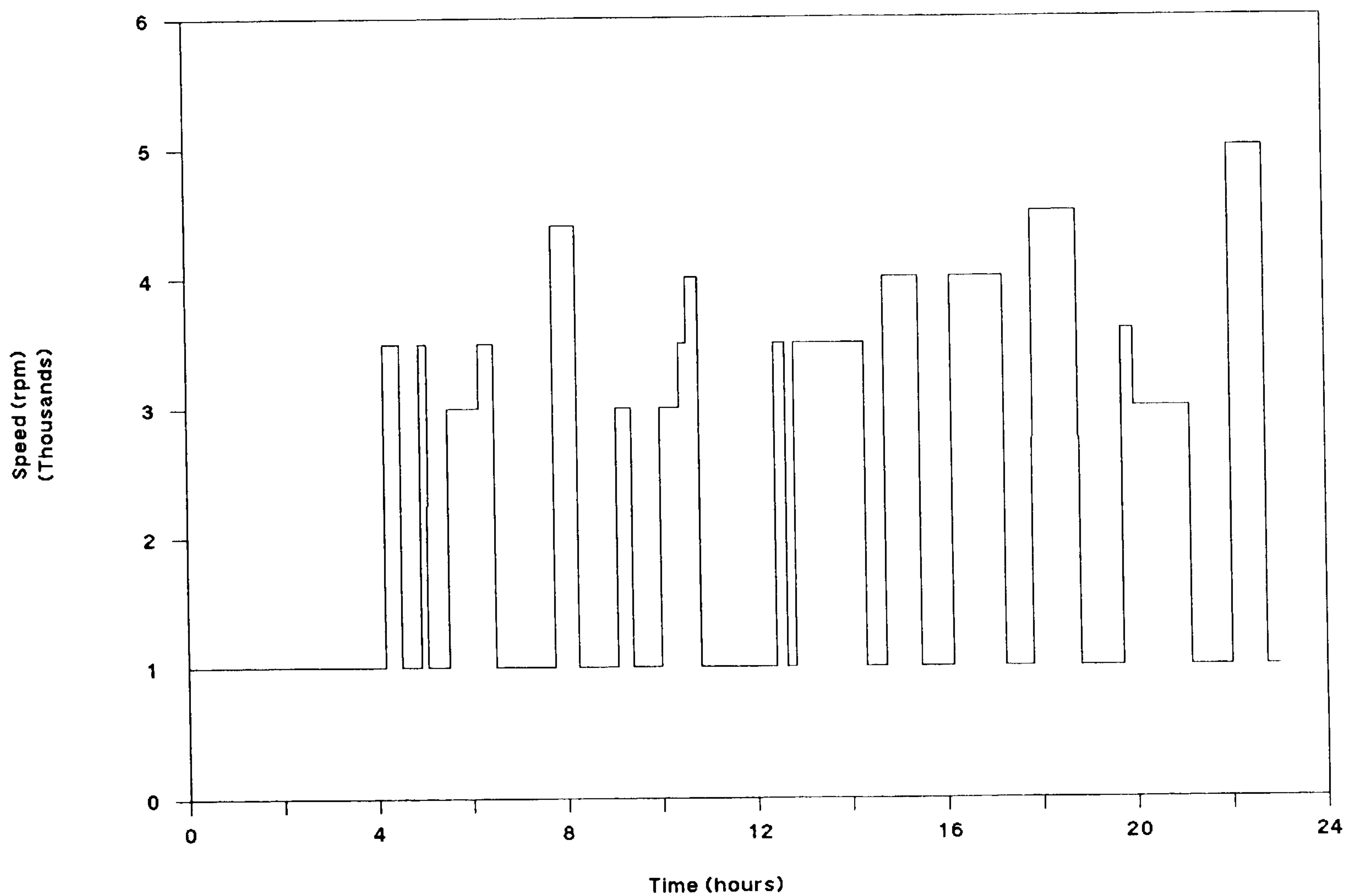
Title	Page



Baseline
Torque (N*m)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Time (hours)
0
4
8
12
16
20
24


Baseline
Torque (lbs*ft)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
4
8
12
16
20
24
Time (hours)

Baseline



** BASELINE **

Point	Date	RPM	Torque (N*m)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gm/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/ bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in/hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
16	08/16	3000	40.7	30.0	12.8	17.1	195	28.3	8	9181	20.2	718	1.181	47.3	14.0	0.323	1.3	0	0	103	15	469	68	100.1	29.64	74	7	45	680	1256	82	179
17	08/16	3000	81.4	60.0	25.6	34.3	390	56.5	10	11476	25.3	449	0.738	26.7	7.9	1.095	4.4	0	0	83	12	469	68	100.1	29.64	70	14	58	811	1491	82	179
18	08/16	3000	107.1	79.0	33.7	45.1	513	74.5	12	13771	30.4	409	0.673	17.9	5.3	1.767	7.1	0	0	83	12	462	67	100.1	29.65	68	18	65	833	1532	82	179
19	08/16	3000	122.0	90.0	38.3	51.4	585	84.8	13	14919	32.9	389	0.640	14.5	4.3	2.090	8.4	0	0	83	12	455	66	100.1	29.65	68	21	70	814	1498	82	179
1	08/10	3000	170.9	126.0	53.7	72.0	819	118.8	NA	NA	NA	NA	NA	2.0	0.6	3.683	14.8	0	0	83	12	469	68	100.3	29.71	62	15	59	807	1485	83	181
6	08/12	3500	42.0	31.0	15.4	20.7	201	29.2	9	10328	22.8	670	1.102	49.0	14.5	0.921	3.7	0	0	103	15	483	70	100.2	29.66	68	5	41	716	1321	81	178
5	08/12	3500	88.1	65.0	32.3	43.3	422	61.3	12	13771	30.4	426	0.701	29.7	8.8	1.792	7.2	0	0	103	15	469	68	100.2	29.66	68	11	52	793	1459	82	179
4	08/12	3500	114.6	84.5	42.0	56.3	549	79.6	14	16066	35.4	383	0.629	19.9	5.9	2.513	10.1	0	0	97	14	469	68	100.2	29.66	68	19	66	818	1504	82	180
3	08/12	3500	132.2	97.5	48.5	65.0	634	91.9	16	18361	40.5	379	0.623	14.9	4.4	2.986	12.0	0	0	90	13	462	67	100.2	29.66	68	23	73	831	1528	82	180
2	08/12	3500	176.3	130.0	64.6	86.6	845	122.5	19	21804	48.1	338	0.555	1.7	0.5	5.723	23.0	0	0	90	13	462	67	100.2	29.66	68	14	57	871	1600	83	182
7	08/12	4000	46.1	34.0	19.3	25.9	221	32.0	10	11476	25.3	594	0.977	48.3	14.3	1.194	4.8	0	0	124	18	483	70	100.2	29.66	62	5	41	749	1380	83	181
8	08/12	4000	92.2	68.0	38.6	51.8	442	64.1	14	16066	35.4	416	0.684	30.4	9.0	2.563	10.3	0	0	124	18	476	69	100.2	29.66	62	17	63	803	1477	83	181
9	08/13	4000	119.3	88.0	50.0	67.0	572	82.9	16	18361	40.5	367	0.604	18.9	5.6	4.131	16.6	0	0	138	20	469	68	100.2	29.68	73	21	69	857	1575	82	180
10	08/13	4000	137.0	101.0	57.4	76.9	656	95.2	18	20657	45.5	360	0.592	15.2	4.5	5.051	20.3	0	0	138	20	469	68	100.2	29.68	68	28	82	847	1556	83	181
11	08/13	4000	180.3	133.0	75.5	101.3	864	125.4	23	26395	58.2	349	0.574	1.7	0.5	8.411	33.8	0	0	138	20	455	66	100.2	29.68	68	16	60	866	1590	83	181
12	08/13	4500	46.1	34.0	21.7	29.1	221	32.0	11	12623	27.8	581	0.955	49.0	14.5	1.070	4.3	0	0	152	22	469	68	100.3	29.70	69	8	46	761	1402	83	181
13	08/13	4500	93.6	69.0	44.1	59.1	448	65.0	15	17214	38.0	390	0.642	30.4	9.0	2.588	10.4	0	0	165	24	469	68	100.3	29.70	69	17	63	817	1502	83	182
14	08/13	4500	120.7	89.0	56.9	76.3	578	83.9	18	20657	45.5	363	0.597	18.6	5.5	4.404	17.7	0	0	172	25	462	67	100.3	29.70	66	28	83	859	1578	83	182
15	08/13	4500	139.7	103.0	65.8	88.3	669	97.1	20	22952	50.6	349	0.573	14.9	4.4	5.748	23.1	0	0	165	24	455	66	100.3	29.70	66	31	88	847	1556	84	183
20	08/16	5000	54.2	40.0	28.4	38.1	260	37.7	13	14919	32.9	525	0.864	45.2	13.4	1.020	4.1	0	0	179	26	469	68	100.2	29.67	66	10	50	773	1424	84	183
21	08/16	5000	97.6	72.0	51.1	68.5	468	67.9	18	20657	45.5	404	0.664	27.7	8.2	2.737	11.0	0	0	186	27	462	67	100.2	29.67	66	19	66	828	1523	84	183
22	08/16	5000	127.5	94.0	66.7	89.5	611	88.6	20	22952	50.6	344	0.565	13.8	4.1	4.927	19.8	0	0	193	28	455	66	100.2	29.67	56	27	81	866	1591	84	183

ORIGINAL PAGE IS
OF POOR QUALITY

** BASELINE **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
16	83	182	66	150	82	179	16	29	89	193	103	217	90	194	103	217	89	192	113	236	90	194	119	247	89	192	103	217	87	188	101	214	34	93
17	84	183	70	158	88	190	18	32	92	198	109	228	93	200	108	227	91	195	121	250	92	198	133	272	92	197	112	233	89	192	109	228	35	95
18	84	184	71	160	91	195	19	35	95	203	115	239	96	205	115	239	93	199	132	269	94	201	141	286	93	200	116	240	90	194	112	234	36	96
19	84	184	72	161	92	197	20	36	97	206	118	245	98	208	118	245	93	200	135	275	94	202	144	292	94	202	118	245	91	196	115	239	34	94
1	86	186	68	154	92	198	24	44	102	215	126	259	103	218	127	261	97	206	143	290	99	211	154	309	100	212	128	262	96	205	123	254	32	89
6	83	182	59	139	77	171	18	32	90	194	104	220	91	195	104	219	89	192	116	241	90	194	123	254	89	193	104	219	87	189	102	216	34	94
5	84	183	63	146	84	183	21	37	94	201	113	235	95	203	112	234	92	198	128	263	93	199	136	277	93	200	113	235	90	194	111	231	36	96
4	84	184	67	152	89	192	22	40	97	207	118	245	98	209	118	244	93	200	133	272	94	202	142	288	95	203	117	243	92	197	115	239	38	100
3	85	185	68	154	91	195	23	41	99	211	122	252	101	213	122	252	96	204	137	279	97	206	147	297	97	207	122	251	93	200	118	245	37	99
2	86	187	71	159	97	206	26	47	104	219	131	267	105	221	130	266	99	210	147	296	101	213	155	311	102	215	132	269	97	206	127	260	36	96
7	84	184	66	150	83	182	18	32	92	197	107	224	92	198	106	222	91	195	119	246	92	197	127	260	91	196	107	224	88	191	105	221	37	99
8	84	184	70	158	90	194	20	36	97	206	118	244	98	209	116	240	94	202	131	268	95	203	141	286	95	203	116	241	92	197	114	237	37	99
9	84	184	73	163	93	200	21	37	100	212	123	253	101	214	122	252	96	205	136	276	96	205	144	291	97	207	120	248	93	199	118	244	38	100
10	85	185	74	166	97	207	23	41	103	217	128	262	104	219	127	261	98	208	142	287	98	208	149	301	99	210	124	256	94	202	121	250	41	106
11	86	186	78	173	103	218	25	45	106	223	136	276	108	226	136	276	100	212	153	307	101	213	159	319	103	217	135	275	98	208	129	264	42	108
12	84	184	71	160	88	191	17	31	93	199	109	228	94	201	108	226	92	198	122	251	93	199	127	260	92	197	107	225	89	192	107	224	38	100
13	85	185	76	169	96	205	20	36	99	210	121	250	101	213	119	247	96	205	133	272	97	206	142	287	97	207	119	247	93	200	117	242	39	102
14	86	186	78	173	100	212	22	39	102	216	127	261	104	219	126	258	98	209	140	284	98	209	149	301	99	211	125	257	95	203	122	251	42	107
15	86	187	82	180	106	222	23	42	106	223	134	274	107	225	133	271	101	213	147	296	101	214	154	310	102	216	132	269	97	207	127	261	42	107
20	86	186	79	174	97	206	18	32	96	205	114	237	98	208	113	236	95	203	126	259	95	203	132	269	96	204	113	235	92	197	111	232	34	94
21	86	186	82	180	102	216	20	36	102	215	126	259	103	217	124	256	98	209	138	281	98	209	146	295	99	211	124	255	94	202	121	250	37	98
22	86	187	87	188	108	227	22	39	106	223	136	276	108	227	134	273	102	215	149	301	102	215	159	318	103	218	133	272	97	207	129	264	37	99

APPENDIX D

ADAPCO

STATEMENT OF WORK

STATEMENT OF WORK

The purpose of this program is to determine the structural implications of an "adiabatic" direct injection stratified charge combustion rotary (Wankel) type engine.

To accomplish this program ADAPCO is to perform the following tasks using the NASA (John Deere) 1007R engine as the candidate engine:

1. Generate the three dimensional ANSYS finite element model for the rotor and rotor housing using the drawings generated by John Deere.

2. Using the MIT DISC model, generate the thermal and pressure boundary conditions for the above engine at rated and torque peak conditions.

3. Compare the results of the above analysis with test data supplied by John Deere and iterate the model as necessary such that the predicted pressures and temperatures agree with the measurements.

4. Using the above boundary conditions along with inertia loads and assembly loads, run the FE models and determine the deflections, stresses and temperatures of the components.

5. Run the MIT DISC model for the adiabatic configuration assuming a .030 inch plasma sprayed zirconia thermal barrier coating densified from chrome oxide on the combustion face of the rotor, the side housings and the rotor housing to determine the pressure and temperature boundary conditions for the insulated engine.

6. Modify the FE models to include the thermal barrier coatings.

7. Run the FE models with and without coolant in the rotor housing. Reiterate back through task 5 as necessary such that the MIT DISC and ANSYS surface temperatures are in agreement.

8. Analyze the results of the above run to determine if the stresses, temperature and deflections are acceptable. If they are not acceptable, modify the models to incorporate design changes to make the values acceptable and recycle until a satisfactory solution is found.

REPORTING

An interim report and a final report which details all of the effort and results shall be prepared and submitted per the schedule. A magnetic tape copy of the completed ANSYS finite element models is required.

SCHEDULE

Program start date - 1 April 1987
Interim report due - 1 July 1987
Program complete - 1 October 1987
Final report due - 1 November 1987

APPENDIX E

PRE & POST MEASUREMENT

PRE & POST MEASUREMENT

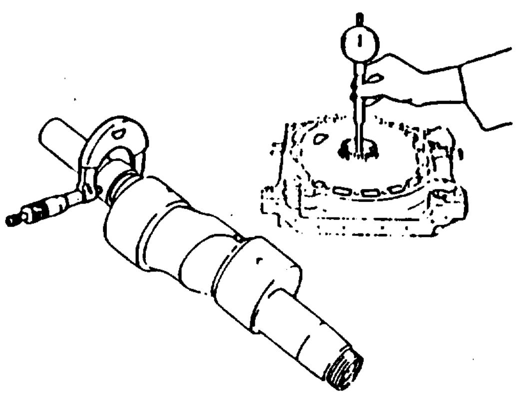
TABLE OF CONTENTS

PRE & POST MEASUREMENT

TABLE OF CONTENTS (Cont.)

The five pages that follow are a description of the pre and post test measurement procedures. The procedures are described in the 1987 Mazda shop manual. All measurements not recorded were checked and were OK.

MAIN BEARING

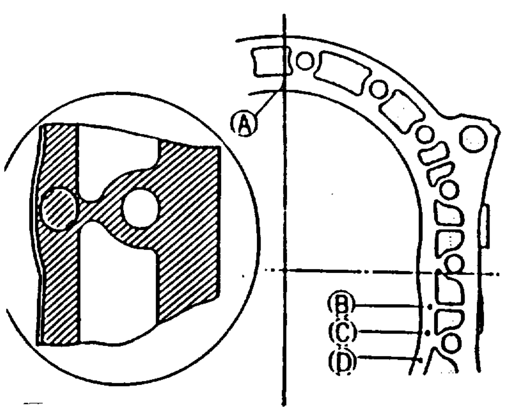


1. Check the main bearing clearance. Measure the inner diameter of the main bearing and the outer diameter of the eccentric shaft main journal.

   Standard Clearance: 0.04 - 0.08mm (.0016 - .0031 in)

   Clearance Limit: 0.10mm (.0039 in.)

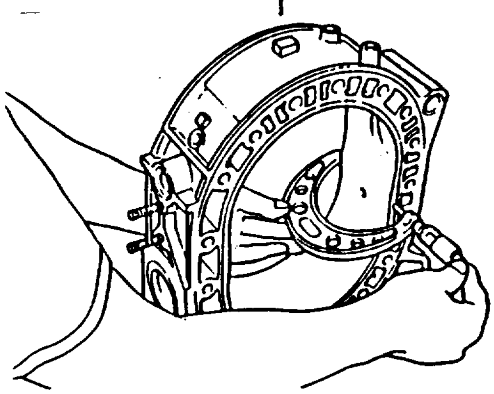
ROTOR HOUSING



1. Check the width difference of the rotor housing. Measure the rotor housing width at the points A,B,C, and D as shown in the figure.

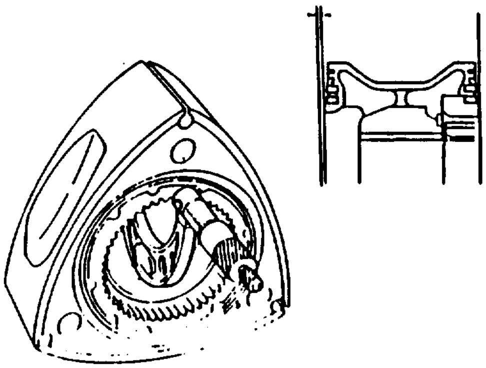
2. Check the difference between the value of point A and the minimum value among the points B, C, and D.

   Difference Limit: 0.06mm (.0024 in.)



ROTOR

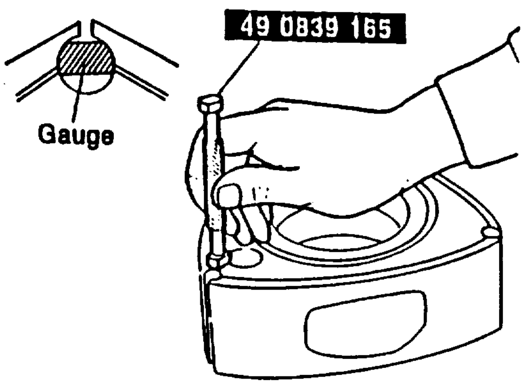
Check the clearance between the side housing and rotor.



1. Measure the rotor housing width and the maximum rotor width at three points.

   Standard Clearance: 0.12 - 0.21mm (.0047 - .0083 in.)

   Clearance Limit: .004 in.

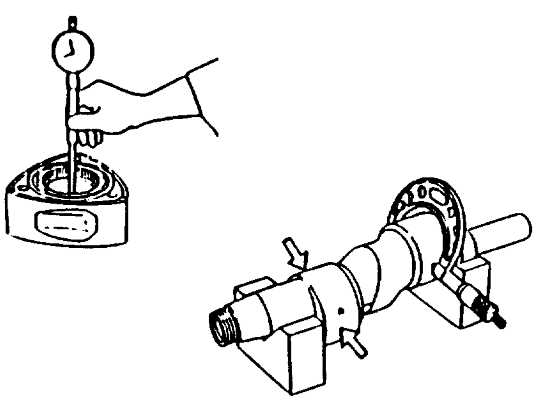


2. Check the corner seal bores for wear

   1) If neither end of the gauge goes into the bore, use the original corner seal.

   2) If only one end of the gauge goes into the bore, replace the corner seal.

   3) If both ends of the gauge go into the bore, replace the rotor.



3. Check the rotor bearing clearance. Measure the inner diameter of the rotor bearing and the outer diameter of the eccentric shaft rotor journal. Standard

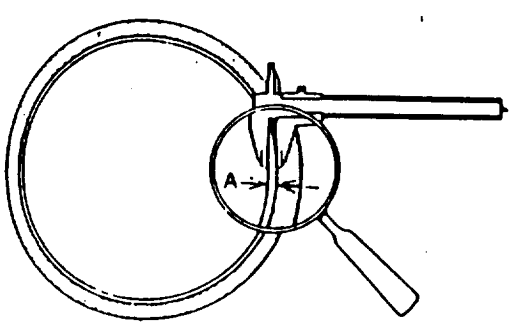
   Clearance: 0.04 - 0.08mm (.0016 - .0031 in.)

Clearance Limit: 0.10mm (.0039 in.)

ROTOR OIL SEAL

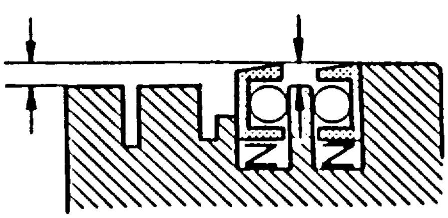
1. Check the oil seal lip width.

   Lipwidth: .0.05mm
   (.020 in max.)



2. Check oil seal protrusion.

   Protrusion: 0.05mm
   (.020 in min.)

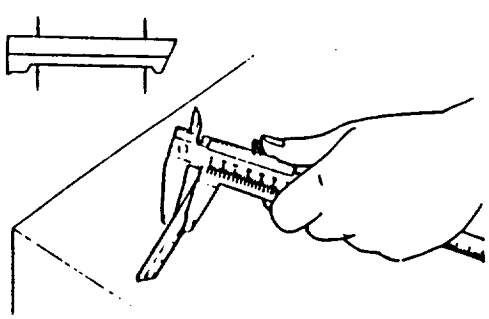


APEX SEAL

1. Measure the height of the apex seal at two points.

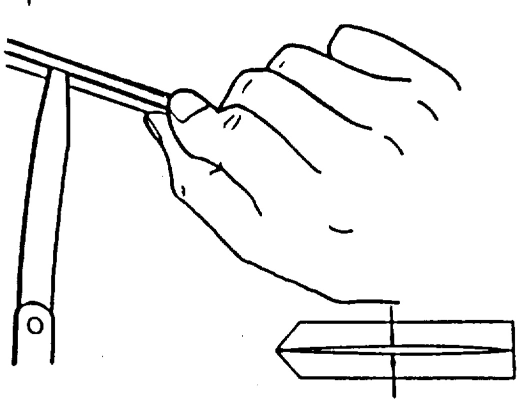
   Standard Height: 8.0mm
   (.315 in.)

   Height Limit: 6.5mm
   (.256 in.)



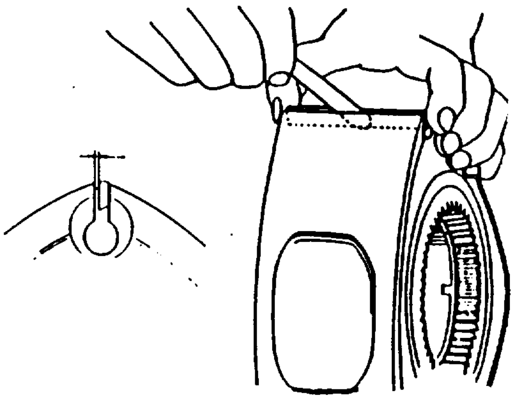
2. Check the apex seals for warpage.

   Warpage Limit: 0.06mm
   (0.0024 in.)



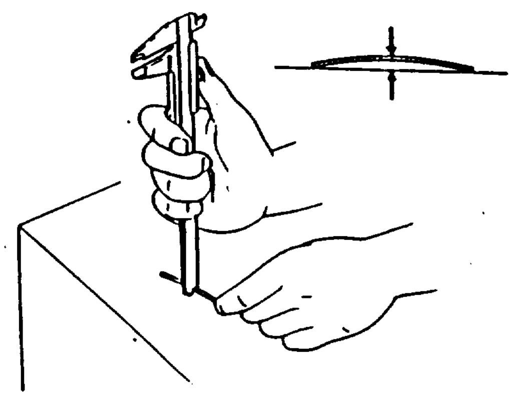
APEX SEAL cont.

3. Check the clearance of the apex seal and the groove.



Standard Clearance:	0.062 - 0.102mm (.0024 - .004 in.)
Clearance Limit:	0.15mm (.0059 in.)

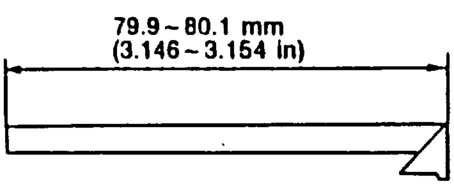
4. Check the apex seal spring for wear and free height.



Free Height Limit:

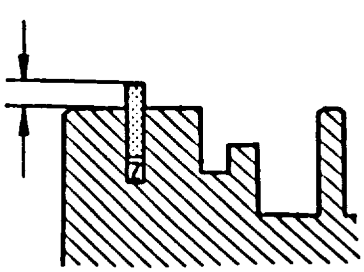
Long Spring	4.6mm (.181 in.)

5. Measure the apex seal length.



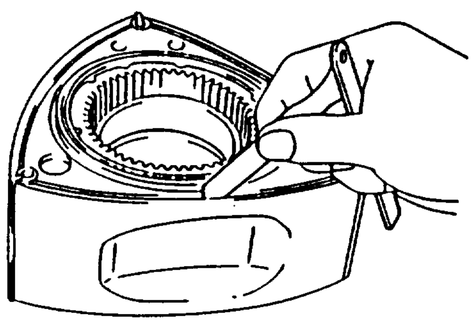
SIDE SEAL

1. Check side seal protrusion.



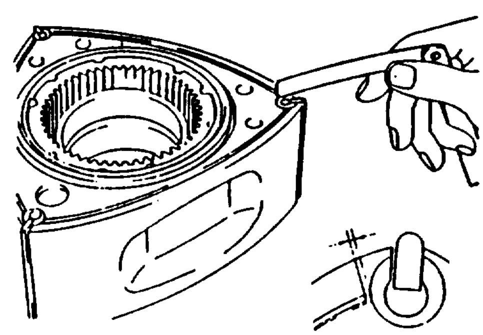
Protrusion: 0.5mm (.020 in.) min.

SIDE SEAL cont.



2. Check the clearance between the side seal and the groove.

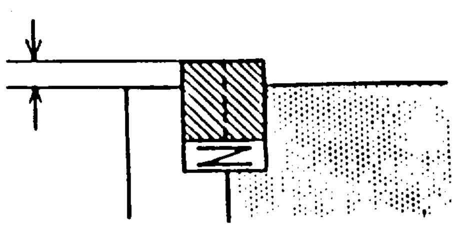
Standard Clearance:	0.028 - 0.078mm (.0011 - .0031 in.)
Clearance Limit:	0.10mm (.0039 in.)



3. Check the clearance between the side seal and the corner seal.

Standard Clearance:	0.05 - 0.15mm (0.0020 - 0.0059 in.)
Clearance Limit:	0.4mm (.016 in.)

CORNER SEAL



Check the corner seal protrusion.

Protrusion:	0.5mm (.020 in) min.

** Pre & Post Compression Tests **

Build	Number		Rotor flank No.	Compression Pre (Kg/Cmsq)	(rpm)	Post (Kg/Cmsq)	(rpm)
Baseline test	A) 1	front rotor	1	7.8	164	7.6	126
			2	7.7		7.7	
			3	7.4		7.5	
		rear rotor	1	7.2	243	5.3	243
			2	6.9		5.3	
			3	7.0		5.3	
Coated intermediate housing test	B) 1	front rotor	1	7.2	164	8.8	230
			2	7.2		9.3	
			3	7.2		9.0	
		rear rotor	1	6.8	243	6.6	222
			2	7.0		6.7	
			3	7.0		6.5	
Undensified coated rotor test	C) 1	front rotor	1	8.1	225	Not Available	NA
			2	7.3			
			3	7.2		"	
		rear rotor	1	8.7	216	NA	NA
			2	7.0		"	
			3	6.5		"	
Undensified coated rotor test	C) 2	front rotor	1	8.0	215	NA	NA
			2	7.8		"	
			3	8.5		"	
		rear rotor	1	7.1	213	NA	NA
			2	7.8		"	
			3	7.6		"	
Undensified coated rotor test	C) 3	front rotor	1	7.4	235	NA	NA
			2	7.2		"	
			3	7.6		"	
		rear rotor	1	8.0	228	NA	NA
			2	7.8		"	
			3	7.7		"	

** Pre & Post Compression Tests **

Build	Number		Rotor flank No.	Compression Pre (Kg/Cmsq)	(rpm)	Post (Kg/Cmsq)	(rpm)
Densified coated rotor test	C) 4	front rotor	1	7.9	203	NA	NA
			2	6.5		"	
			3	6.7		"	
		rear rotor	1	7.7	201	NA	NA
			2	7.3		"	
			3	6.6		"	
Coated aluminum rotor housing test	D) 1	front rotor	1	9.2	216	NA	NA
			2	9.6		"	
			3	9.4		"	
		rear rotor	1	8.5	209	NA	NA
			2	7.2		"	
			3	8.7		"	
Coated cast iron rotor housing test	D) 2	front rotor	1	8.5	215	NA	NA
			2	8.9		"	
			3	8.6		"	
		rear rotor	1	9.7	215	NA	NA
			2	9.0		"	
			3	9.5		"	
Coated cast iron rotor housing test	D) 3	front rotor	1	4.7	217	0.0	220
			2	4.0		0.0	
			3	5.3		0.0	
		rear rotor	1	4.2	323	0.0	219
			2	4.0		0.0	
			3	4.1		0.0	
Coated cast iron rotor housing test	D) 4	front rotor	1	8.1	221	0.0	212
			2	7.9		0.0	
			3	7.9		0.0	
		rear rotor	1	7.1	221	0.0	205
			2	6.7		0.0	
			3	7.1		0.0	

** Front Main Bearing Clearance **

Build Number	Standard Clearance (inch)	Clearance Limit (inch)	Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	0.0016 to 0.0031	0.0039	0.0020	0.0508	0.0020	0.0508
B) 1			0.0020	0.0508	0.0020	0.0508
C) 1			0.0020	0.0508	0.0020	0.0508
C) 2			0.0020	0.0508	0.0020	0.0508
C) 3			0.0020	0.0508	0.0028	0.0711
C) 4			0.0029	0.0737	0.0030	0.0762
D) 1			0.0030	0.0762	0.0030	0.0762
D) 2			0.0030	0.0762	0.0030	0.0762
D) 3			0.0030	0.0762	0.0030	0.0762
D) 4			0.0030	0.0762	0.0030	0.0762

** Rear Main Bearing Clearance **

Build Number	Standard Clearance (inch)	Clearance Limit (inch)	Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	0.0016 to 0.0031	0.0039	0.0020	0.0508	0.0020	0.0508
B) 1			0.0020	0.0508	0.0020	0.0508
C) 1			0.0020	0.0508	0.0020	0.0508
C) 2			0.0020	0.0508	0.0020	0.0508
C) 3			0.0020	0.0508	0.0028	0.0711
C) 4			0.0028	0.0711	0.0028	0.0711
D) 1			0.0029	0.0737	0.0029	0.0737
D) 2			0.0029	0.0737	0.0030	0.0762
D) 3			0.0030	0.0762	0.0030	0.0762
D) 4			0.0030	0.0762	0.0030	0.0762

** Front Rotor Bearing Clearance **

Build Number	Standard Clearance (inch)	Clearance Limit (inch)	Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	0.0016 to 0.0031	0.0039	0.0020	0.0508	0.0020	0.0508
B) 1			0.0020	0.0508	0.0020	0.0508
C) 1			0.0020	0.0508	0.0020	0.0508
C) 2			0.0020	0.0508	0.0020	0.0508
C) 3			0.0020	0.0508	0.0022	0.0559
C) 4			0.0020	0.0508	0.0024	0.0610
D) 1			0.0020	0.0508	0.0020	0.0508
D) 2			0.0020	0.0508	0.0020	0.0508
D) 3			0.0021	0.0533	0.0023	0.0584
D) 4			0.0023	0.0584	0.0025	0.0635

** Rear Rotor Bearing Clearance **

Build Number	Standard Clearance (inch)	Clearance Limit (inch)	Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	0.0016 to 0.0031	0.0039	0.0020	0.0508	0.0020	0.0508
B) 1			0.0020	0.0508	0.0020	0.0508
C) 1			0.0020	0.0508	0.0020	0.0508
C) 2			0.0020	0.0508	0.0020	0.0508
C) 3			0.0020	0.0508	0.0023	0.0584
C) 4			0.0020	0.0508	0.0028	0.0711
D) 1			0.0020	0.0508	0.0021	0.0533
D) 2			0.0024	0.0610	0.0024	0.0610
D) 3			0.0024	0.0610	0.0028	0.0711
D) 4			0.0028	0.0711	0.0030	0.0762

ORIGINAL PAGE IS
OF POOR QUALITY

** Front Rotor Housing Width Difference **

Build Number	Difference Limit (inch)		Pre (inch)	Difference (inch)	Pre (mm)	Difference (mm)
A) 1	0.0024	A)	3.1490	0.0010	79.9846	0.0254
		B)	3.1500		80.0100	
		C)	3.1490		79.9846	
		D)	3.1500		80.0100	
B) 1		A)	3.1489	0.0004	79.9821	0.0102
		B)	3.1490		79.9846	
		C)	3.1490		79.9846	
		D)	3.1493		79.9922	
C) 1		A)	3.1484	0.0009	79.9694	0.0229
		B)	3.1493		79.9922	
		C)	3.1489		79.9821	
		D)	3.1490		79.9846	
C) 2		A)	3.1484	0.0009	79.9694	0.0229
		B)	3.1493		79.9922	
		C)	3.1489		79.9821	
		D)	3.1490		79.9846	
C) 3		A)	NA	NA	NA	NA
		B)	"		"	
		C)	"		"	
		D)	"		"	
C) 4		A)	3.1491	0.0005	79.9871	0.0127
		B)	3.1496		79.9998	
		C)	3.1493		79.9922	
		D)	3.1494		79.9948	
D) 1		A)	NA	NA	NA	NA
		B)	"		"	
		C)	"		"	
		D)	"		"	
D) 2		A)	3.1505	0.0001	80.0227	0.0025
		B)	3.1506		80.0252	
		C)	3.1506		80.0252	
		D)	3.1506		80.0252	
D) 3		A)	3.1506	0.0003	80.0252	0.0076
		B)	3.1505		80.0227	
		C)	3.1506		80.0252	
		D)	3.1503		80.0176	
D) 4		A)	3.1513	0.0011	80.0430	0.0279
		B)	3.1503		80.0176	
		C)	3.1502		80.0151	
		D)	3.1511		80.0379	

** Front Rotor Housing Width Difference **

Build Number	Difference Limit (inch)		Post (inch)	Difference (inch)	Post (mm)	Difference (mm)
A) 1	0.0024	A)	3.1489	0.0004	79.9821	0.0102
		B)	3.1490		79.9846	
		C)	3.1490		79.9846	
		D)	3.1493		79.9922	
B) 1		A)	3.1484	0.0009	79.9694	0.0229
		B)	3.1493		79.9922	
		C)	3.1489		79.9821	
		D)	3.1490		79.9846	
C) 1		A)	3.1484	0.0009	79.9694	0.0229
		B)	3.1493		79.9922	
		C)	3.1489		79.9821	
		D)	3.1490		79.9846	
C) 2		A)	NA	NA	NA	NA
		B)	"		"	
		C)	"		"	
		D)	"		"	
C) 3		A)	3.1491	0.0005	79.9871	0.0127
		B)	3.1493		79.9922	
		C)	3.1494		79.9948	
		D)	3.1496		79.9998	
C) 4		A)	3.1484	0.0006	79.9694	0.0152
		B)	3.1490		79.9846	
		C)	3.1490		79.9846	
		D)	3.1490		79.9846	
D) 1		A)	3.1473	0.0010	79.9414	0.0254
		B)	3.1463		79.9160	
		C)	3.1463		79.9160	
		D)	3.1468		79.9287	
D) 2		A)	3.1506	0.0003	80.0252	0.0076
		B)	3.1505		80.0227	
		C)	3.1506		80.0252	
		D)	3.1503		80.0176	
D) 3		A)	3.1506	0.0003	80.0252	0.0076
		B)	3.1505		80.0227	
		C)	3.1506		80.0252	
		D)	3.1503		80.0176	
D) 4		A)	3.1505	0.0003	80.0227	0.0076
		B)	3.1508		80.0303	
		C)	3.1507		80.0278	
		D)	3.1507		80.0278	

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Housing Width Difference **

Build Number	Difference Limit (inch)		Pre (inch)	Difference (inch)	Pre (mm)	Difference (mm)
A) 1	0.0024	A)	3.1490	0.0010	79.9846	0.0254
		B)	3.1500		80.0100	
		C)	3.1500		80.0100	
		D)	3.1500		80.0100	
B) 1		A)	3.1491	0.0003	79.9871	0.0076
		B)	3.1491		79.9871	
		C)	3.1494		79.9948	
		D)	3.1491		79.9871	
C) 1		A)	3.1484	0.0005	79.9694	0.0127
		B)	3.1485		79.9719	
		C)	3.1488		79.9795	
		D)	3.1489		79.9821	
C) 2		A)	3.1484	0.0005	79.9694	0.0127
		B)	3.1485		79.9719	
		C)	3.1488		79.9795	
		D)	3.1489		79.9821	
C) 3		A)	NA	NA	NA	NA
		B)	"		"	
		C)	"		"	
		D)	"		"	
C) 4		A)	3.1490	0.0013	79.9846	0.0330
		B)	3.1502		80.0151	
		C)	3.1493		79.9922	
		D)	3.1492		79.9897	
D) 1		A)	NA	NA	NA	NA
		B)	"		"	
		C)	"		"	
		D)	"		"	
D) 2		A)	3.1505	0.0003	80.0227	0.0076
		B)	3.1505		80.0227	
		C)	3.1504		80.0202	
		D)	3.1507		80.0278	
D) 3		A)	3.1505	0.0003	80.0227	0.0076
		B)	3.1505		80.0227	
		C)	3.1504		80.0202	
		D)	3.1507		80.0278	
D) 4		A)	3.1504	0.0003	80.0202	0.0076
		B)	3.1504		80.0202	
		C)	3.1507		80.0278	
		D)	3.1506		80.0252	

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Housing Width Difference **

Build Number	Difference Limit (inch)		Post (inch)	Difference (inch)	Post (mm)	Difference (mm)
A) 1	0.0024	A)	3.1491	0.0007	79.9871	0.0178
		B)	3.1491		79.9871	
		C)	3.1494		79.9948	
		D)	3.1494		79.9948	
B) 1		A)	3.1484	0.0005	79.9694	0.0127
		B)	3.1485		79.9719	
		C)	3.1488		79.9795	
		D)	3.1489		79.9821	
C) 1		A)	3.1484	0.0005	79.9694	0.0127
		B)	3.1485		79.9719	
		C)	3.1488		79.9795	
		D)	3.1489		79.9821	
C) 2		A)	NA	NA	NA	NA
		B)	"		"	
		C)	"		"	
		D)	"		"	
C) 3		A)	3.1490	0.0006	79.9846	0.0152
		B)	3.1496		79.9998	
		C)	3.1495		79.9973	
		D)	3.1495		79.9973	
C) 4		A)	3.1490	0.0008	79.9846	0.0203
		B)	3.1498		80.0049	
		C)	3.1497		80.0024	
		D)	3.1496		79.9998	
D) 1		A)	3.1487	0.0022	79.9770	0.0559
		B)	3.1509		80.0329	
		C)	3.1495		79.9973	
		D)	3.1502		80.0151	
D) 2		A)	3.1505	0.0003	80.0227	0.0076
		B)	3.1505		80.0227	
		C)	3.1504		80.0202	
		D)	3.1507		80.0278	
D) 3		A)	3.1505	0.0002	80.0227	0.0051
		B)	3.1506		80.0252	
		C)	3.1504		80.0202	
		D)	3.1505		80.0227	
D) 4		A)	3.1505	0.0002	80.0227	0.0051
		B)	3.1504		80.0202	
		C)	3.1505		80.0227	
		D)	3.1506		80.0252	

** Front Rotor CLearance **

Build Number	Standard Clearance (inch)	Clearance Limit (inch)	Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	0.0047 to 0.0083	0.0040	NA	NA	0.0061	0.1549
B) 1			0.0061	0.1549	0.0069	0.1753
C) 1			0.0060	0.1524	0.0060	0.1524
C) 2			0.0060	0.1524	0.0060	0.1524
C) 3			0.0072	0.1829	0.0073	0.1854
C) 4			0.0070	0.1778	0.0071	0.1803
D) 1			0.0080	0.2032	0.0081	0.2057
D) 2			0.0081	0.2057	0.0081	0.2057
D) 3			0.0081	0.2057	0.0082	0.2083
D) 4			0.0082	0.2083	0.0082	0.2083

** Rear Rotor CLearance **

Build Number	Standard Clearance (inch)	Clearance Limit (inch)	Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	0.0047 to 0.0083	0.0040	NA	NA	0.0071	0.1803
B) 1			0.0067	0.1702	0.0069	0.1753
C) 1			0.0070	0.1778	0.0070	0.1778
C) 2			0.0070	0.1778	0.0070	0.1778
C) 3			0.0071	0.1803	0.0071	0.1803
C) 4			0.0065	0.1651	0.0065	0.1651
D) 1			0.0065	0.1651	0.0066	0.1676
D) 2			0.0080	0.2032	0.0082	0.2083
D) 3			0.0082	0.2083	0.0083	0.2108
D) 4			0.0083	0.2108	0.0083	0.2108

** Front Rotor Oil Seal Lip Width **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	max 0.0200	gear side	inner	NA	NA	NA	NA
			outer	NA	NA	NA	NA
		plain side	inner	NA	NA	NA	NA
			outer	NA	NA	NA	NA
B) 1		gear side	inner	0.0110	0.2794	0.0200	0.5080
			outer	0.0100	0.2540	0.0140	0.3556
		plain side	inner	0.0160	0.4064	0.0400	1.0160
			outer	0.0100	0.2540	0.0400	1.0160
C) 1		gear side	inner	0.0080	0.2032	0.0080	0.2032
			outer	0.0080	0.2032	0.0080	0.2032
		plain side	inner	0.0080	0.2032	0.0080	0.2032
			outer	0.0080	0.2032	0.0080	0.2032
C) 2		gear side	inner	0.0080	0.2032	0.0080	0.2032
			outer	0.0080	0.2032	0.0080	0.2032
		plain side	inner	0.0080	0.2032	0.0080	0.2032
			outer	0.0080	0.2032	0.0080	0.2032
C) 3		gear side	inner	0.0080	0.2032	0.0130	0.3302
			outer	0.0080	0.2032	0.0120	0.3048
		plain side	inner	0.0080	0.2032	0.0100	0.2540
			outer	0.0080	0.2032	0.0100	0.2540
C) 4		gear side	inner	0.0110	0.2794	0.0130	0.3302
			outer	0.0100	0.2540	0.0130	0.3302
		plain side	inner	0.0100	0.2540	0.0120	0.3048
			outer	0.0110	0.2794	0.0130	0.3302
D) 1		gear side	inner	0.0150	0.3810	0.0180	0.4572
			outer	0.0160	0.4064	0.0150	0.3810
		plain side	inner	0.0130	0.3302	0.0140	0.3556
			outer	0.0120	0.3048	0.0120	0.3048
D) 2		gear side	inner	0.0120	0.3048	0.0130	0.3302
			outer	0.0120	0.3048	0.0150	0.3810
		plain side	inner	0.0120	0.3048	0.0130	0.3302
			outer	0.0200	0.5080	0.0140	0.3556

** Front Rotor Oil Seal Lip Width **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
D) 3	max 0.0200	gear side	inner	0.0130	0.3302	0.0190	0.4826
			outer	0.0150	0.3810	0.0180	0.4572
		plain side	inner	0.0130	0.3302	0.0160	0.4064
			outer	0.0140	0.3556	0.0180	0.4572
D) 4		gear side	inner	0.0200	0.5080	0.0200	0.5080
			outer	0.0170	0.4318	0.0170	0.4318
		plain side	inner	0.0150	0.3810	0.0150	0.3810
			outer	0.0180	0.4572	0.0180	0.4572

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Oil Seal Lip Width **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
A) 1	max	gear	inner	NA	NA	NA	NA
	0.0200	side	outer	NA	NA	NA	NA
		plain	inner	NA	NA	NA	NA
		side	outer	NA	NA	NA	NA
B) 1		gear	inner	0.0110	0.2794	0.0210	0.5334
		side	outer	0.0100	0.2540	0.0130	0.3302
		plain	inner	0.0160	0.4064	0.0480	1.2192
		side	outer	0.0120	0.3048	0.0390	0.9906
C) 1		gear	inner	0.0080	0.2032	0.0080	0.2032
		side	outer	0.0080	0.2032	0.0080	0.2032
		plain	inner	0.0080	0.2032	0.0080	0.2032
		side	outer	0.0080	0.2032	0.0080	0.2032
C) 2		gear	inner	0.0080	0.2032	0.0080	0.2032
		side	outer	0.0080	0.2032	0.0080	0.2032
		plain	inner	0.0080	0.2032	0.0080	0.2032
		side	outer	0.0080	0.2032	0.0080	0.2032
C) 3		gear	inner	0.0080	0.2032	0.0130	0.3302
		side	outer	0.0080	0.2032	0.0130	0.3302
		plain	inner	0.0080	0.2032	0.0120	0.3048
		side	outer	0.0080	0.2032	0.0140	0.3556
C) 4		gear	inner	0.0110	0.2794	0.0160	0.4064
		side	outer	0.0110	0.2794	0.0160	0.4064
		plain	inner	0.0100	0.2540	0.0130	0.3302
		side	outer	0.0100	0.2540	0.0130	0.3302
D) 1		gear	inner	0.0130	0.3302	0.0160	0.4064
		side	outer	0.0120	0.3048	0.0160	0.4064
		plain	inner	0.0150	0.3810	0.0130	0.3302
		side	outer	0.0100	0.2540	0.0130	0.3302
D) 2		gear	inner	0.0160	0.4064	0.0160	0.4064
		side	outer	0.0100	0.2540	0.0110	0.2794
		plain	inner	0.0150	0.3810	0.0100	0.2540
		side	outer	0.0160	0.4064	0.0160	0.4064

** Rear Rotor Oil Seal Lip Width **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)	Post (inch)	Post (mm)
D) 3	max	gear	inner	0.0090	0.2286	0.0090	0.2286
	0.0200	side	outer	0.0110	0.2794	0.0120	0.3048
		plain	inner	0.0100	0.2540	0.0130	0.3302
		side	outer	0.0160	0.4064	0.0180	0.4572
D) 4		gear	inner	0.0090	0.2286	0.0100	0.2540
		side	outer	0.0120	0.3048	0.0120	0.3048
		plain	inner	0.0120	0.3048	0.0120	0.3048
		side	outer	0.0180	0.4572	0.0180	0.4572

** Front Rotor Apex Seal Clearance **

Build Number	Standard Clearance (inch)		Pre (inch)	Pre (mm)		Post (inch)	Post (mm)
A) 1	0.0024	A)	0.0030	0.0762	A)	0.0030	0.0762
	to	B)	0.0030	0.0762	B)	0.0030	0.0762
	0.0040	C)	0.0030	0.0762	C)	0.0030	0.0762
B) 1		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 1		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 2		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 3		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 4		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 1		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 2		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 3		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 4		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762

** Front Rotor Apex Seal Height **

Build Number	Standard Height (inch)		Pre (inch)	Pre (mm)		Post (inch)	Post (mm)
A) 1	min 0.315	A)	0.3330	8.4582	A)	0.3310	8.4074
		B)	0.3320	8.4328	B)	0.3320	8.4328
		C)	0.3330	8.4582	C)	0.3320	8.4328
B) 1		A)	0.3310	8.4074	A)	0.3300	8.382
		B)	0.3320	8.4328	B)	0.3310	8.4074
		C)	0.3320	8.4328	C)	0.3310	8.4074
C) 1		A)	0.3310	8.4074	A)	0.3310	8.4074
		B)	0.3320	8.4328	B)	0.3320	8.4328
		C)	0.3320	8.4328	C)	0.3320	8.4328
C) 2		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
C) 3		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
C) 4		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 1		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 2		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 3		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 4		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315

** Front Rotor Apex Spring Free Height **

Build Number	Standard (inch)		Pre (inch)	Pre (mm)		Post (inch)	Post (mm)
A) 1	min	A)	0.2150	5.4610	A)	0.2190	5.5626
	0.1810	B)	0.2150	5.4610	B)	0.2160	5.4864
		C)	0.2180	5.5372	C)	0.2180	5.5372
B) 1		A)	0.2190	5.5626	A)	0.2150	5.4610
		B)	0.2160	5.4864	B)	0.2130	5.4102
		C)	0.2180	5.5372	C)	0.2100	5.3340
C) 1		A)	0.2150	5.4610	A)	0.2150	5.4610
		B)	0.2130	5.4102	B)	0.2130	5.4102
		C)	0.2100	5.3340	C)	0.2100	5.3340
C) 2		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
C) 3		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.131	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.191	> 0.181
C) 4		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 1		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 2		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 3		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 4		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181

** Front Rotor Apex Seal Weight **

Build Number		Pre (g)	Post (g)	Difference (g)
A) 1	A)	13.20	13.18	0.02
	B)	13.24	13.22	0.02
	C)	13.29	13.27	0.02
B) [illegible]	A)	13.18	13.16	0.02
	B)	13.27	13.24	0.03
	C)	13.22	13.18	0.04
C) 1	A)	13.16	13.16	0.00
	B)	13.24	13.24	0.00
	C)	13.18	13.18	0.00
C) 2	A)	13.16	13.10	0.06
	B)	13.24	13.19	0.05
	C)	13.18	12.99	0.19
C) 3	A)	NA	13.30	NA
	B)	"	13.25	"
	C)	"	13.27	"
C) 4	A)	13.30	13.20	0.09
	B)	13.25	13.18	0.07
	C)	13.27	13.13	0.13
D) 1	A)	14.29	13.78	0.51
	B)	14.21	13.63	0.58
	C)	14.20	13.66	0.53
D) 2	A)	13.92	13.16	0.76
	B)	13.95	13.24	0.71
	C)	13.95	13.18	0.77
D) 3	A)	14.92	15.02	-0.09
	B)	15.01	15.03	-0.02
	C)	15.06	15.05	0.00
D) 4	A)	15.12	12.86	2.26
	B)	15.16	12.79	2.36
	C)	15.22	13.10	2.12

ORIGINAL [illegible]
OF POOR [illegible]

** Rear Rotor Apex Seal Clearance **

Build Number	Standard Clearance (inch)		Pre (inch)	Pre (mm)		Post (inch)	Post (mm)
A) 1	0.0024	A)	0.0030	0.0762	A)	0.0030	0.0762
	to	B)	0.0030	0.0762	B)	0.0030	0.0762
	0.0040	C)	0.0030	0.0762	C)	0.0030	0.0762
B) 1		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 1		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 2		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 3		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
C) 4		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 1		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 2		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 3		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762
D) 4		A)	0.0030	0.0762	A)	0.0030	0.0762
		B)	0.0030	0.0762	B)	0.0030	0.0762
		C)	0.0030	0.0762	C)	0.0030	0.0762

** Rear Rotor Apex Seal Height **

Build Number	Standard Height (inch)		Pre (inch)	Pre (mm)		Post (inch)	Post (mm)
A) 1	min	A)	0.3340	8.4836	A)	0.3320	8.4328
	0.315	B)	0.3340	8.4836	B)	0.3320	8.4328
		C)	0.3330	8.4582	C)	0.3330	8.4582
B) 1		A)	0.3320	8.4328	A)	0.3300	8.3820
		B)	0.3320	8.4328	B)	0.3310	8.4074
		C)	0.3330	8.4582	C)	0.3300	8.3820
C) 1		A)	0.3300	8.3820	A)	0.3300	8.3820
		B)	0.3310	8.4074	B)	0.3310	8.4074
		C)	0.3300	8.3820	C)	0.3300	8.3820
C) 2		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
C) 3		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
C) 4		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 1		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 2		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 3		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315
D) 4		A)	> 0.315	> 0.315	A)	> 0.315	> 0.315
		B)	> 0.315	> 0.315	B)	> 0.315	> 0.315
		C)	> 0.315	> 0.315	C)	> 0.315	> 0.315

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Apex Spring Free Height **

Build Number	Standard (inch)		Pre (inch)	Pre (mm)		Post (inch)	Post (mm)
A) 1	min 0.1810	A)	0.2160	5.4864	A)	0.2180	5.5372
		B)	0.2150	5.4610	B)	0.2190	5.5626
		C)	0.2140	5.4356	C)	0.2150	5.4610
B) 1		A)	0.2180	5.5372	A)	0.0210	0.5334
		B)	0.2190	5.5626	B)	0.2140	5.4356
		C)	0.2150	5.4610	C)	0.2120	5.3848
C) 1		A)	0.0210	0.5334	A)	0.0210	0.5334
		B)	0.2140	5.4356	B)	0.2140	5.4356
		C)	0.2120	5.3848	C)	0.2120	5.3848
C) 2		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
C) 3		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
C) 4		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 1		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 2		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 3		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181
D) 4		A)	> 0.181	> 0.181	A)	> 0.181	> 0.181
		B)	> 0.181	> 0.181	B)	> 0.181	> 0.181
		C)	> 0.181	> 0.181	C)	> 0.181	> 0.181

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Apex Seal Weight **

Build Number		Pre (g)	Post (g)	Difference (g)
A) 1	A)	13.22	13.19	0.03
	B)	13.23	13.21	0.02
	C)	13.12	13.10	0.02
B) 1	A)	13.10	13.04	0.06
	B)	13.21	13.16	0.05
	C)	13.19	13.13	0.06
C) 1	A)	13.04	13.04	0.00
	B)	13.16	13.16	0.00
	C)	13.13	13.13	0.00
C) 2	A)	13.04	12.38	0.66
	B)	13.16	13.13	0.03
	C)	13.13	13.11	0.02
C) 3	A)	NA	13.26	NA
	B)	"	13.19	"
	C)	"	13.24	"
C) 4	A)	13.26	13.24	0.02
	B)	13.24	13.22	0.02
	C)	13.19	13.19	-0.01
D) 1	A)	NA	13.20	NA
	B)	"	13.18	"
	C)	"	13.13	"
D) 2	A)	15.17	15.12	0.05
	B)	15.22	15.10	0.13
	C)	15.11	15.02	0.09
D) 3	A)	14.99	14.93	0.07
	B)	15.01	15.01	0.01
	C)	15.01	15.01	0.00
D) 4	A)	15.09	12.81	2.29
	B)	15.17	13.14	2.04
	C)	15.22	13.15	2.07

ORIGINAL PAGE IS
OF POOR QUALITY

** Front Rotor Side Seal Protrusion **

Build Number	Height Limit (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
A) 1	min 0.0200		A)	0.0500	1.2700		A)	0.0450	1.1430
			B)	0.0580	1.4732		B)	0.0420	1.0668
			C)	0.0490	1.2446		C)	0.0490	1.2446
		gear side	A)	0.0590	1.4986	gear side	A)	0.0500	1.2700
			B)	0.0550	1.3970		B)	0.0530	1.3462
			C)	0.0450	1.1430		C)	0.0490	1.2446
B) 1			A)	0.0450	1.1430		A)	0.0500	1.2700
			B)	0.0450	1.1430		B)	0.0420	1.0668
			C)	0.0490	1.2446		C)	0.0450	1.1430
		gear side	A)	0.0500	1.2700	gear side	A)	0.0450	1.1430
			B)	0.0530	1.3462		B)	0.0500	1.2700
			C)	0.0490	1.2446		C)	0.0450	1.1430
C) 1			A)	0.0500	1.2700		A)	0.0500	1.2700
			B)	0.0420	1.0668		B)	0.0420	1.0668
			C)	0.0450	1.1430		C)	0.0450	1.1430
		gear side	A)	0.0450	1.1430	gear side	A)	0.0450	1.1430
			B)	0.0500	1.2700		B)	0.0500	1.2700
			C)	0.0450	1.1430		C)	0.0450	1.1430
C) 2			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 1			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

** Front Rotor Side Seal Protrusion **

Build Number	Height Limit (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
D) 2	min 0.0200		A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

** Front Rotor Side Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
A) 1		A)	3.91	3.97	-0.06
		B)	3.95	3.94	0.01
		C)	3.99	3.98	0.01
	gear	A)	3.99	3.98	0.01
	side	B)	4.00	3.97	0.03
		C)	3.99	3.98	0.01
B) 1		A)	3.97	3.91	0.06
		B)	3.95	3.97	-0.02
		C)	3.99	3.88	0.11
	gear	A)	3.98	4.00	-0.02
	side	B)	3.97	4.00	-0.03
		C)	3.98	4.00	-0.02
C) 1		A)	3.91	3.91	0.00
		B)	3.97	3.97	0.00
		C)	3.88	3.88	0.00
	gear	A)	4.00	4.00	0.00
	side	B)	4.00	4.00	0.00
		C)	4.00	4.00	0.00
C) 2		A)	3.91	3.91	0.00
		B)	3.97	3.97	0.00
		C)	3.88	3.88	0.00
	gear	A)	4.00	4.00	0.00
	side	B)	4.00	4.00	0.00
		C)	4.00	4.00	0.00
C) 3		A)	3.91	3.94	-0.03
		B)	3.97	3.97	0.00
		C)	3.88	3.98	-0.10
	gear	A)	4.00	3.99	0.01
	side	B)	4.00	3.99	0.01
		C)	4.00	4.00	0.00
C) 4		A)	3.94	4.01	-0.06
		B)	3.97	4.02	-0.05
		C)	3.98	3.98	0.00
	gear	A)	3.99	3.97	0.01
	side	B)	3.99	3.97	0.01
		C)	4.00	4.01	-0.01
D) 1		A)	NA	3.97	NA
		B)	"	3.95	"
		C)	"	3.96	"
	gear	A)	"	3.97	"
	side	B)	"	3.97	"
		C)	"	4.01	"

** Front Rotor Side Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
D) 2		A)	3.97	3.97	0.00
		B)	3.95	3.95	0.00
		C)	3.96	3.96	0.00
	gear	A)	3.90	3.90	0.00
	side	B)	3.92	3.92	0.00
		C)	3.91	3.91	0.00
D) 3		A)	3.90	3.90	0.00
		B)	3.92	3.92	0.00
		C)	3.91	3.91	0.00
	gear	A)	3.97	3.97	0.00
	side	B)	3.95	3.95	0.00
		C)	3.96	3.95	0.00
D) 4		A)	3.90	3.90	0.00
		B)	3.92	3.92	0.00
		C)	3.91	3.91	0.00
	gear	A)	3.97	3.97	0.00
	side	B)	3.95	3.95	0.00
		C)	3.95	3.95	0.00

** Rear Rotor Side Seal Protrusion **

Build Number	Height Limit (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
A) 1	min 0.0200		A)	0.0500	1.2700		A)	0.0450	1.1430
			B)	0.0460	1.1684		B)	0.0450	1.1430
			C)	0.0530	1.3462		C)	0.0500	1.2700
		gear side	A)	0.0550	1.3970	gear side	A)	0.0430	1.0922
			B)	0.0510	1.2954		B)	0.0460	1.1684
			C)	0.0460	1.1684		C)	0.0450	1.1430
B) 1			A)	0.0450	1.1430		A)	0.0380	0.9652
			B)	0.0450	1.1430		B)	0.0320	0.8128
			C)	0.0500	1.2700		C)	0.0280	0.7112
		gear side	A)	0.0430	1.0922	gear side	A)	0.0470	1.1938
			B)	0.0460	1.1684		B)	0.0340	0.8636
			C)	0.0450	1.1430		C)	0.0280	0.7112
C) 1			A)	0.0380	0.9652		A)	0.0380	0.9652
			B)	0.0320	0.8128		B)	0.0320	0.8128
			C)	0.0280	0.7112		C)	0.0280	0.7112
		gear side	A)	0.0470	1.1938	gear side	A)	0.0470	1.1938
			B)	0.0340	0.8636		B)	0.0340	0.8636
			C)	0.0280	0.7112		C)	0.0280	0.7112
C) 2			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 1			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Side Seal Protrusion **

Build Number	Height Limit (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
D) 2	min 0.0200		A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

ORIGINAL PAGE IS
OF POOR QUALITY

** Rear Rotor Side Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
A) 1		A)	3.98	3.99	-0.01
		B)	3.99	3.99	0.00
		C)	3.99	3.98	0.01
	gear	A)	4.03	4.02	0.01
	side	B)	4.02	4.02	0.00
		C)	4.02	4.01	0.01
B) 1		A)	3.99	3.91	0.08
		B)	3.99	3.94	0.05
		C)	3.98	3.94	0.04
	gear	A)	4.02	4.00	0.02
	side	B)	4.02	3.97	0.05
		C)	4.01	4.00	0.01
C) 1		A)	3.91	3.91	0.00
		B)	3.94	3.94	0.00
		C)	3.94	3.94	0.00
	gear	A)	4.00	4.00	0.00
	side	B)	3.97	3.97	0.00
		C)	4.00	4.00	0.00
C) 2		A)	3.91	3.91	0.00
		B)	3.94	3.94	0.00
		C)	3.94	3.94	0.00
	gear	A)	4.00	4.00	0.00
	side	B)	3.97	3.97	0.00
		C)	4.00	4.00	0.00
C) 3		A)	3.98	3.98	0.00
		B)	3.99	3.98	0.01
		C)	3.99	3.98	0.01
	gear	A)	4.03	4.03	0.00
	side	B)	4.02	3.98	0.04
		C)	4.02	4.01	0.01
C) 4		A)	3.98	3.98	0.00
		B)	3.98	3.97	0.01
		C)	3.98	3.99	-0.01
	gear	A)	4.03	4.02	0.01
	side	B)	3.98	3.98	0.00
		C)	4.01	3.99	0.02
D) 1		A)	NA	3.97	NA
		B)	"	3.97	"
		C)	"	4.01	"
	gear	A)	"	4.01	"
	side	B)	"	4.02	"
		C)	"	3.97	"

** Rear Rotor Side Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
D) 2		A)	3.97	3.97	0.00
		B)	3.97	3.97	0.00
		C)	4.01	4.01	0.00
	gear	A)	3.68	3.68	0.00
	side	B)	3.90	3.90	0.00
		C)	3.80	3.80	0.00
D) 3		A)	3.97	3.97	0.00
		B)	4.01	4.01	0.00
		C)	3.68	3.68	0.00
	gear	A)	3.97	3.97	0.00
	side	B)	3.89	3.89	0.00
		C)	3.80	3.79	0.00
D) 4		A)	3.97	3.97	0.00
		B)	4.01	4.01	0.00
		C)	3.68	3.68	0.00
	gear	A)	3.97	3.97	0.00
	side	B)	3.89	3.89	0.00
		C)	3.79	3.79	0.00

** Front Rotor Corner Seal Protrusion **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
A) 1	min 0.0200		A)	0.0370	0.9398		A)	0.0340	0.8636
			B)	0.0340	0.8636		B)	0.0290	0.7366
			C)	0.0340	0.8636		C)	0.0330	0.8382
		gear side	A)	0.0350	0.8890	gear side	A)	0.0400	1.0160
			B)	0.0260	0.6604		B)	0.0320	0.8128
			C)	0.0370	0.9398		C)	0.0300	0.7620
B) 1			A)	0.0450	1.1430		A)	0.0300	0.7620
			B)	0.0490	1.2446		B)	0.0270	0.6858
			C)	0.0440	1.1176		C)	0.0300	0.7620
		gear side	A)	0.0400	1.0160	gear side	A)	0.0370	0.9398
			B)	0.0320	0.8128		B)	0.0450	1.1430
			C)	0.0300	0.7620		C)	0.0350	0.8890
C) 1			A)	0.0300	0.7620		A)	0.0300	0.7620
			B)	0.0270	0.6858		B)	0.0270	0.6858
			C)	0.0300	0.7620		C)	0.0300	0.7620
		gear side	A)	0.0370	0.9398	gear side	A)	0.0370	0.9398
			B)	0.0450	1.1430		B)	0.0450	1.1430
			C)	0.0350	0.8890		C)	0.0350	0.8890
C) 2			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 1			A)	> 0.020	> 0.020		A)	0.0060	0.1524
			B)	> 0.020	> 0.020		B)	0.0080	0.2032
			C)	> 0.020	> 0.020		C)	0.0070	0.1778
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

** Front Rotor Corner Seal Protrusion **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
D) 2	min		A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
	0.0200		B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

** Front Rotor Corner Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
A) 1		A)	NA	NA	NA
		B)	"	"	"
		C)	"	"	"
	gear	A)	"	"	"
	side	B)	"	"	"
		C)	"	"	"
B) 1		A)	2.68	2.67	0.01
		B)	2.68	2.64	0.04
		C)	2.67	2.67	0.00
	gear	A)	2.68	2.67	0.01
	side	B)	2.67	2.67	0.00
		C)	2.70	2.69	0.01
C) 1		A)	2.67	2.67	0.00
		B)	2.64	2.64	0.00
		C)	2.67	2.67	0.00
	gear	A)	2.67	2.67	0.00
	side	B)	2.67	2.67	0.00
		C)	2.69	2.69	0.00
C) 2		A)	2.67	2.67	0.00
		B)	2.64	2.64	0.00
		C)	2.67	2.67	0.00
	gear	A)	2.67	2.67	0.00
	side	B)	2.67	2.67	0.00
		C)	2.69	2.69	0.00
C) 3		A)	2.67	2.67	0.00
		B)	2.64	2.68	-0.04
		C)	2.67	2.68	-0.01
	gear	A)	2.67	2.69	-0.02
	side	B)	2.67	2.68	-0.01
		C)	2.69	2.67	0.02
C) 4		A)	2.67	2.64	0.03
		B)	2.68	2.66	0.02
		C)	2.68	2.68	0.00
	gear	A)	2.69	2.67	0.02
	side	B)	2.68	2.67	0.01
		C)	2.67	2.67	0.00
D) 1		A)	NA	2.64	NA
		B)	"	2.67	"
		C)	"	2.69	"
	gear	A)	"	2.69	"
	side	B)	"	2.66	"
		C)	"	2.67	"

** Front Rotor Corner Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
D) 2		A)	2.64	2.65	0.00
		B)	2.67	2.67	0.00
		C)	2.69	2.70	0.00
	gear	A)	2.69	2.68	0.00
	side	B)	2.66	2.66	0.00
		C)	2.67	2.67	0.00
D) 3		A)	2.68	2.68	0.00
		B)	2.66	2.66	0.00
		C)	2.67	2.67	0.00
	gear	A)	2.65	2.65	0.00
	side	B)	2.67	2.67	0.00
		C)	2.70	2.69	0.00
D) 4		A)	2.68	2.68	0.00
		B)	2.66	2.66	0.00
		C)	2.67	2.67	0.00
	gear	A)	2.65	2.65	0.00
	side	B)	2.67	2.67	0.00
		C)	2.69	2.69	0.00

** Rear Rotor Corner Seal Protrusion **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
A) 1	min		A)	0.0400	1.0160		A)	0.0400	1.0160
	0.0200		B)	0.0370	0.9398		B)	0.0320	0.8128
			C)	0.0400	1.0160		C)	0.0410	1.0414
		gear	A)	0.0350	0.8890	gear	A)	0.0460	1.1684
		side	B)	0.0400	1.0160	side	B)	0.0380	0.9652
			C)	0.0300	0.7620		C)	0.0450	1.1430
B) 1			A)	0.0570	1.4478		A)	0.0500	1.2700
			B)	0.0520	1.3208		B)	0.0510	1.2954
			C)	0.0550	1.3970		C)	0.0520	1.3208
		gear	A)	0.0460	1.1684	gear	A)	0.0550	1.3970
		side	B)	0.0380	0.9652	side	B)	0.0510	1.2954
			C)	0.0450	1.1430		C)	0.0500	1.2700
C) 1			A)	0.0500	1.2700		A)	0.0500	1.2700
			B)	0.0510	1.2954		B)	0.0510	1.2954
			C)	0.0520	1.3208		C)	0.0520	1.3208
		gear	A)	0.0550	1.3970	gear	A)	0.0550	1.3970
		side	B)	0.0510	1.2954	side	B)	0.0510	1.2954
			C)	0.0500	1.2700		C)	0.0500	1.2700
C) 2			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
C) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 1			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear	A)	> 0.020	> 0.020	gear	A)	> 0.020	> 0.020
		side	B)	> 0.020	> 0.020	side	B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

** Rear Rotor Corner Seal Protrusion **

Build Number	Standard (inch)			Pre (inch)	Pre (mm)			Post (inch)	Post (mm)
D) 2	min 0.0200		A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 3			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
D) 4			A)	> 0.020	> 0.020		A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020
		gear side	A)	> 0.020	> 0.020	gear side	A)	> 0.020	> 0.020
			B)	> 0.020	> 0.020		B)	> 0.020	> 0.020
			C)	> 0.020	> 0.020		C)	> 0.020	> 0.020

** Rear Rotor Corner Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
A) 1		A)	NA	NA	NA
		B)	"	"	"
		C)	"	"	"
	gear	A)	"	"	"
	side	B)	"	"	"
		C)	"	"	"
B) 1		A)	2.67	2.67	0.00
		B)	2.68	2.67	0.01
		C)	2.68	2.67	0.01
	gear	A)	2.67	2.69	-0.02
	side	B)	2.70	2.69	0.01
		C)	2.68	2.67	0.01
C) 1		A)	2.67	2.67	0.00
		B)	2.67	2.67	0.00
		C)	2.67	2.67	0.00
	gear	A)	2.69	2.69	0.00
	side	B)	2.69	2.69	0.00
		C)	2.67	2.67	0.00
C) 2		A)	2.67	2.67	0.00
		B)	2.67	2.67	0.00
		C)	2.67	2.67	0.00
	gear	A)	2.69	2.69	0.00
	side	B)	2.69	2.69	0.00
		C)	2.67	2.67	0.00
C) 3		A)	2.67	2.67	0.00
		B)	2.67	2.66	0.01
		C)	2.67	2.67	0.00
	gear	A)	2.69	2.69	0.00
	side	B)	2.69	2.69	0.00
		C)	2.67	2.67	0.00
C) 4		A)	2.67	2.67	0.00
		B)	2.66	2.66	0.00
		C)	2.67	2.68	0.00
	gear	A)	2.69	2.67	0.02
	side	B)	2.69	2.68	0.00
		C)	2.67	2.68	0.00
D) 1		A)	NA	2.64	NA
		B)	"	2.66	"
		C)	"	2.68	"
	gear	A)	"	2.60	"
	side	B)	"	2.67	"
		C)	"	2.67	"

** Rear Rotor Corner Seal Weight **

Build Number			Pre (g)	Post (g)	Difference Pre - Post (g)
D) 2		A)	2.64	2.64	0.00
		B)	2.66	2.66	0.00
		C)	2.68	2.68	0.00
	gear side	A)	2.60	2.67	-0.07
		B)	2.67	2.67	0.00
		C)	2.67	2.67	0.00
D) 3		A)	2.64	2.64	0.00
		B)	2.66	2.66	0.00
		C)	2.68	2.68	0.00
	gear side	A)	2.67	2.67	0.00
		B)	2.67	2.67	0.00
		C)	2.67	2.66	0.00
D) 4		A)	2.64	2.64	0.00
		B)	2.66	2.66	0.00
		C)	2.68	2.68	0.00
	gear side	A)	2.67	2.67	0.00
		B)	2.67	2.67	0.00
		C)	2.66	2.66	0.00

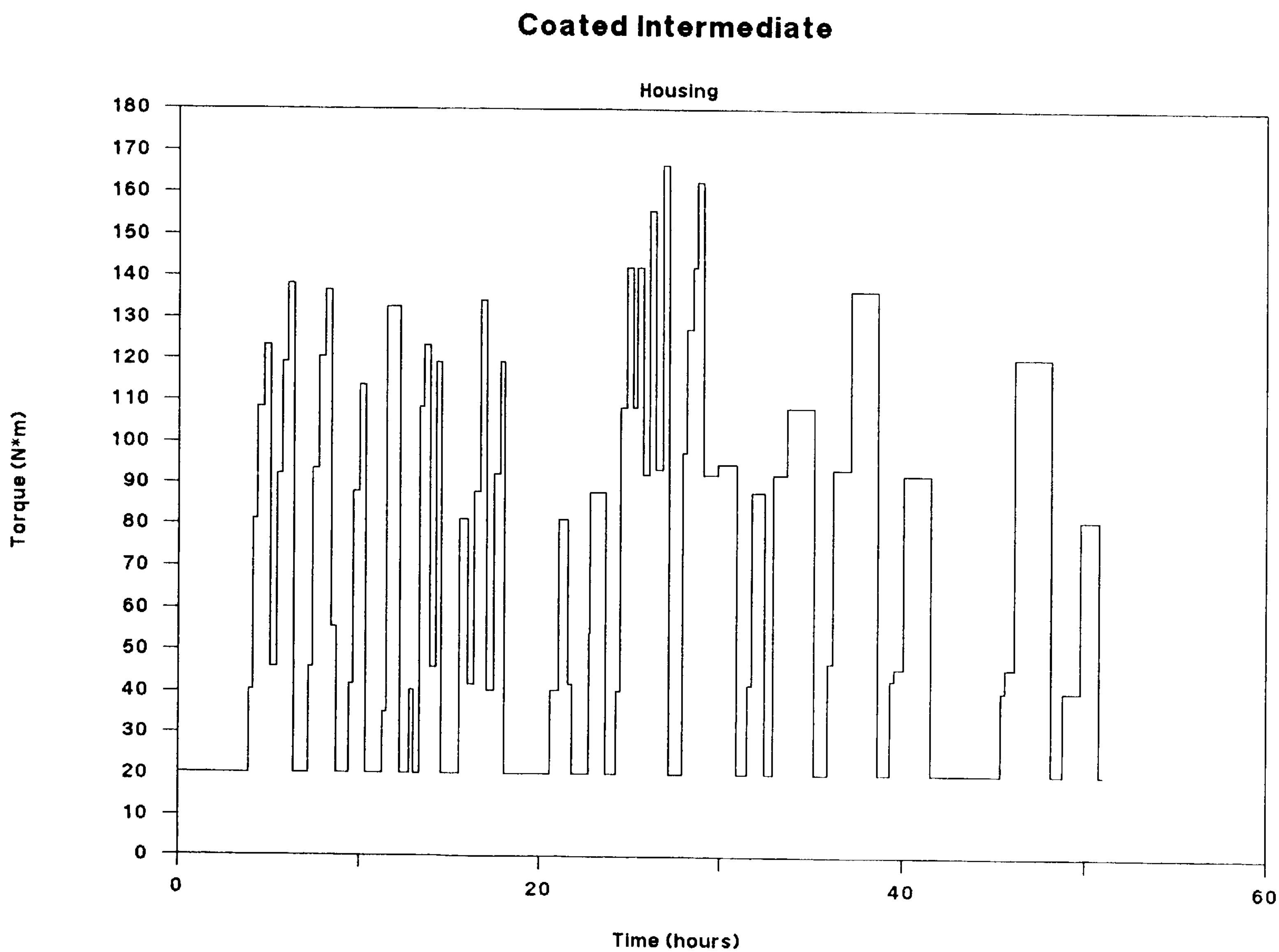
APPENDIX F

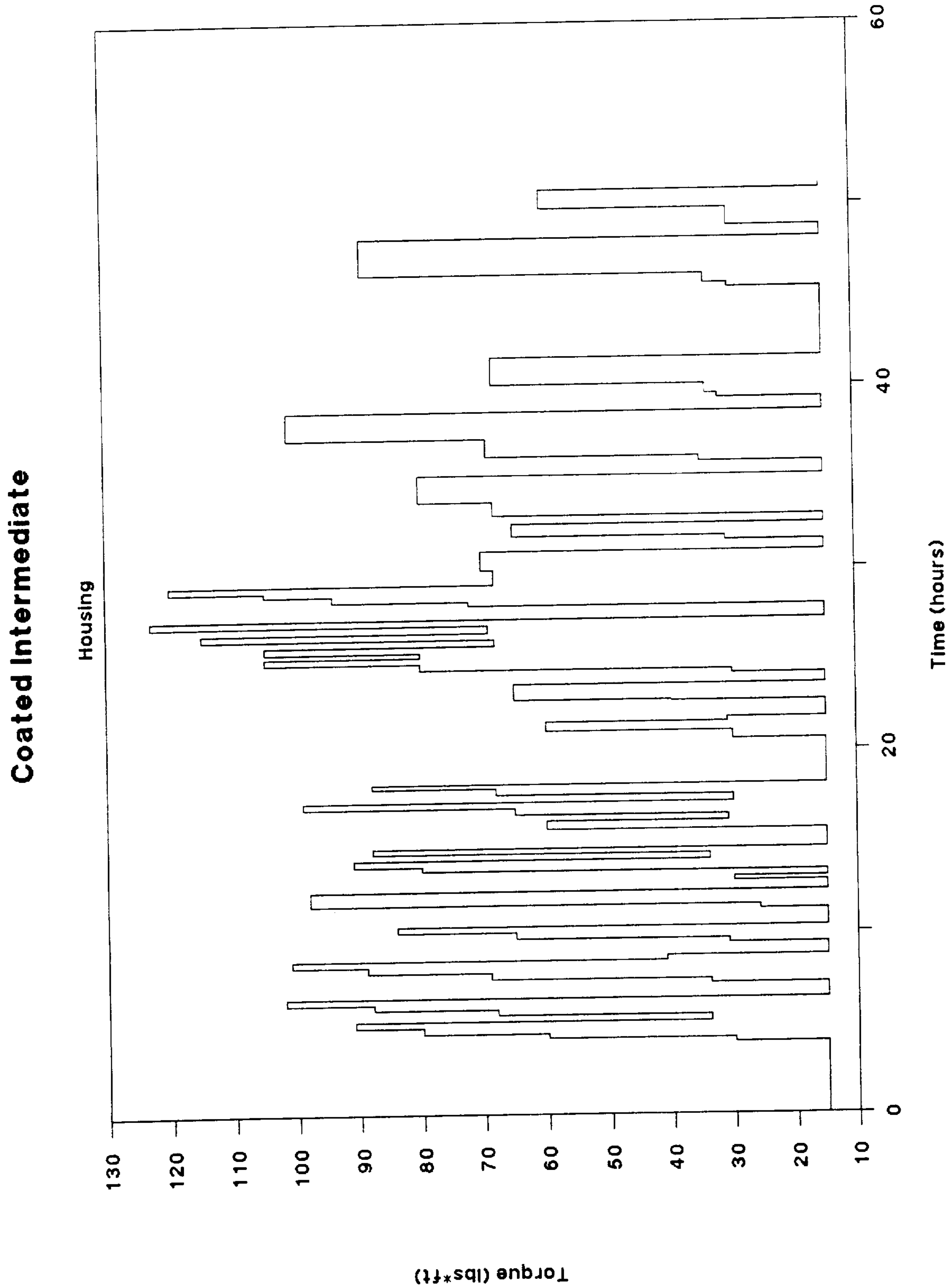
COATED INTERMEDIATE

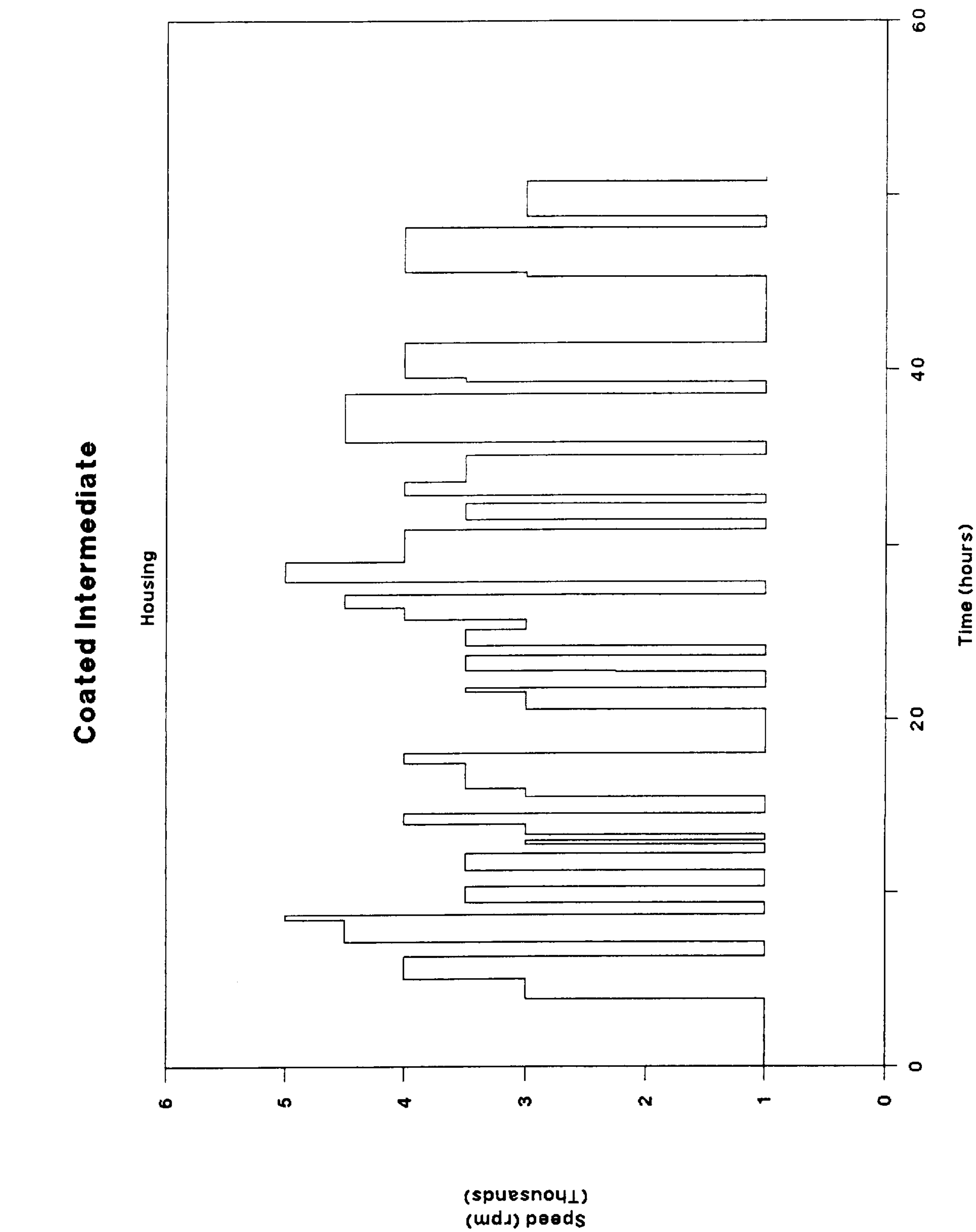
HOUSING DATA

COATED INTERMEDIATE HOUSING DATA

TABLE OF CONTENTS


Coated Intermediate
Housing
Torque (N*m)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
Time (hours)


Coated Intermediate
Housing
Torque (lbs*ft)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
20
40
60
Time (hours)


Coated Intermediate
Housing
Speed (rpm)
(Thousands)
Time (hours)
0
1
2
3
4
5
6
0
20
40
60

** COATED INTERMEDIATE HOUSING **

Point	Date	RPM	Torque (Nm)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gm/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in/hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
25	09/25	3000	40.7	30.0	12.8	17.1	195	28.3	7	8033	17.7	629	1.033	44.7	13.2	0.124	0.5	0	0	97	14	441	64	100.5	29.77	46	5	41	689	1273	82	179
26	09/25	3000	81.4	60.0	25.6	34.3	390	56.5	10	11476	25.3	449	0.738	24.4	7.2	0.747	3.0	0	0	90	13	441	64	100.5	29.77	46	12	53	794	1461	81	178
27	09/25	3000	108.5	80.0	34.1	45.7	520	75.4	12	13771	30.4	404	0.664	15.2	4.5	1.617	6.5	0	0	90	13	441	64	100.5	29.77	46	17	62	788	1451	82	179
28	09/25	3000	123.4	91.0	38.8	52.0	591	85.8	13	14919	32.9	385	0.633	13.2	3.9	1.941	7.8	0	0	97	14	441	64	100.5	29.77	46	18	65	776	1429	82	180
41	10/01	3000	108.5	80.0	34.1	45.7	520	75.4	11	12623	27.8	370	0.609	21.7	6.4	0.970	3.9	0	0	83	12	427	62	100.1	29.65	48	12	53	718	1325	82	179
42	10/01	3000	123.4	91.0	38.8	52.0	591	85.8	13	14919	32.9	385	0.633	16.3	4.8	1.493	6.0	0	0	90	13	414	60	100.1	29.65	48	16	61	732	1350	82	180
45	10/02	3000	81.4	60.0	25.6	34.3	390	56.5	10	11476	25.3	449	0.738	33.9	10.0	0.398	1.6	0	0	83	12	427	62	99.4	29.45	44	7	45	663	1226	82	179
58	10/07	3000	108.5	80.0	34.1	45.7	520	75.4	11	12623	27.8	370	0.609	22.4	6.6	0.323	1.3	0	0	83	12	421	61	99.8	29.54	42	11	51	712	1314	83	182
59	10/07	3000	142.4	105.0	44.7	60.0	682	99.0	14	16066	35.4	359	0.591	12.5	3.7	0.871	3.5	0	0	86	13	414	60	99.8	29.54	42	19	66	723	1333	84	183
88	10/20	3000	40.7	30.0	12.8	17.1	195	28.3	5	5738	12.7	449	0.738	53.9	15.9	0.100	0.4	0	0	103	15	427	62	100.4	29.73	44	3	38	647	1196	81	178
89	10/20	3000	39.3	29.0	12.4	16.6	188	27.3	5	5738	12.7	465	0.764	54.2	16.0	0.025	0.1	0	0	103	15	427	62	100.4	29.73	44	4	39	652	1206	81	178
90	10/20	3000	39.3	29.0	12.4	16.6	188	27.3	5	5738	12.7	465	0.764	54.2	16.0	0.025	0.1	0	0	103	15	427	62	100.4	29.73	44	6	42	655	1211	81	178
91	10/20	3000	81.4	60.0	25.6	34.3	390	56.5	8	9181	20.2	359	0.591	34.6	10.2	0.149	0.6	0	0	97	14	427	62	100.4	29.73	44	8	47	706	1302	81	178
92	10/20	3000	81.4	60.0	25.6	34.3	390	56.5	8	9181	20.2	359	0.591	34.6	10.2	0.274	1.1	0	0	97	14	421	61	100.5	29.76	44	9	49	709	1309	82	179
93	10/21	3000	40.7	30.0	12.8	17.1	195	28.3	5	5738	12.7	449	0.738	55.2	16.3	0.025	0.1	0	0	97	14	427	62	101.1	29.93	29	1	33	641	1185	81	178
99	10/22	3000	40.7	30.0	12.8	17.1	195	28.3	6	6886	15.2	539	0.886	55.2	16.3	0.025	0.1	0	0	90	13	427	62	100.8	29.84	30	1	34	619	1146	83	181
100	10/22	3000	40.7	30.0	12.8	17.1	195	28.3	5	5738	12.7	449	0.738	55.2	16.3	0.000	0.0	0	0	90	13	427	62	100.8	29.84	30	3	38	644	1191	83	181
101	10/22	3000	81.4	60.0	25.6	34.3	390	56.5	9	10328	22.8	404	0.664	36.9	10.9	0.149	0.6	0	0	90	13	414	60	100.8	29.84	30	4	40	688	1270	83	182
102	10/22	3000	80.0	59.0	25.1	33.7	383	55.6	8	9181	20.2	365	0.601	36.9	10.9	0.149	0.6	0	0	90	13	414	60	100.8	29.84	30	6	42	716	1321	83	181
37	09/28	3500	42.0	31.0	15.4	20.7	201	29.2	8	9181	20.2	596	0.980	47.8	14.1	0.796	3.2	0	0	103	15	441	64	100.7	29.83	53	7	44	713	1315	82	179
38	09/28	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	26.4	7.8	1.617	6.5	0	0	90	13	441	64	100.7	29.83	53	16	60	778	1432	82	179
39	09/28	3500	113.9	84.0	41.7	56.0	546	79.2	14	16066	35.4	385	0.633	16.6	4.9	2.538	10.2	0	0	97	14	427	62	100.7	29.83	53	24	75	807	1485	82	180
40	09/30	3500	132.9	98.0	48.7	65.3	637	92.4	16	18361	40.5	377	0.620	13.6	4.0	2.961	11.9	0	0	103	15	434	63	100.4	29.72	46	20	68	774	1425	83	181
46	10/02	3500	42.0	31.0	15.4	20.7	201	29.2	8	9181	20.2	596	0.980	52.2	15.4	0.523	2.1	0	0	103	15	441	64	99.4	29.45	44	2	35	629	1164	82	180
47	10/02	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	31.2	9.2	1.344	5.4	0	0	103	15	441	64	99.4	29.45	44	11	51	712	1314	82	180
48	10/02	3500	134.2	99.0	49.2	66.0	643	93.3	15	17214	38.0	350	0.575	14.6	4.3	2.687	10.8	0	0	103	15	434	63	99.4	29.45	44	19	66	757	1394	82	180
49	10/02	3500	40.7	30.0	14.9	20.0	195	28.3	8	9181	20.2	616	1.012	51.2	15.1	0.523	2.1	0	0	110	16	441	64	99.4	29.45	44	2	35	626	1159	82	180
52	10/05	3500	42.0	31.0	15.4	20.7	201	29.2	8	9181	20.2	596	0.980	52.9	15.6	0.299	1.2	0	0	97	14	441	64	99.5	29.48	28	1	34	631	1168	83	181
53	10/06	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	31.5	9.3	0.697	2.8	0	0	103	15	441	64	99.3	29.42	49	7	45	720	1328	83	181
54	10/06	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	31.5	9.3	0.697	2.8	0	0	103	15	441	64	99.3	29.42	49	8	46	713	1316	83	181
55	10/07	3500	40.7	30.0	14.9	20.0	195	28.3	8	9181	20.2	616	1.012	53.9	15.9	0.025	0.1	0	0	103	15	441	64	99.8	29.54	42	-2	29	628	1162	83	181
56	10/07	3500	108.5	80.0	39.8	53.3	520	75.4	12	13771	30.4	346	0.569	23.4	6.9	0.995	4.0	0	0	103	15	441	64	99.8	29.54	42	10	50	732	1350	83	182
57	10/07	3500	142.4	105.0	52.2	70.0	682	99.0	16	18361	40.5	352	0.579	12.2	3.6	2.090	8.4	0	0	103	15	427	62	99.8	29.54	42	19	66	758	1396	85	185
75	10/15	3500	107.1	79.0	39.3	52.6	513	74.5	11	12623	27.8	322	0.529	23.4	6.9	0.921	3.7	0	0	76	11	414	60	100.9	29.88	28	11	51	731	1347	83	182
76	10/15	3500	108.5	80.0	39.8	53.3	520	75.4	11	12623	27.8	318	0.522	23.4	6.9	0.970	3.9	0	0	76	11	414	60	100.9	29.88	28	10	50	732	1349	83	182
77	10/15	3500	108.5	80.0	39.8	53.3	520	75.4	11	12623	27.8	318	0.522	23.4	6.9	0.921	3.7	0	0	7	1	414	60	100.9	29.88	28	9	49	729	1344	83	182
29	09/25	4000	46.1	34.0	19.3	25.9	221	32.0	10	11476	25.3	594	0.977	46.4	13.7	1.170	4.7	0	0	124	18	455	66	100.5	29.77	46	5	41	766	1410	83	181
30	09/25	4000	92.2	68.0	38.6	51.8	442	64.1	13	14919	32.9	386	0.635	26.4	7.8	2.538	10.2	0	0	131	19	455	66	100.5	29.77	46	14	58	805	1481	82	180
31	09/25	4000	119.3	88.0	50.0	67.0	572	82.9	15	17214	38.0	344	0.566	16.3	4.8	3.757	15.1	0	0	138	20	448	65	100.5	29.77	46	23	74	827	1520	83	181
32	09/25	4000	138.3	102.0	57.9	77.7	663	96.1	18	20657	45.5	357	0.586	12.5	3.7	4.653	18.7	0	0	138	20	441	64	100.6	29.78	46	23	74	818	1505	83	181
43	10/01	4000	46.1	34.0	19.3	25.9	221	32.0	9	10328	22.9	535	0.879	50.1	14.8	0.995	4.0	0	0	117	17	441	64	100.1	29.65	34	3	38	701	1293	82	180
44	10/01	4000	119.3	88.0	50.0	67.0	572	82.9	15	17214	38.0	344	0.566	18.6	5.5	3.285	13.2	0	0	124	18	427	62	100.1	29.65	30	16	61	793	1460	84	183
50	10/02	4000	92.2	68.0	38.6	51.8	442	64.1	13	14919	32.9	386	0.635	31.2	9.2	1.642	6.6	0	0	124	18	441	64	99.4	29.45	44	10	50	756	1393	82	180
51	10/02	4000	119.3	88.0	50.0	67.0	572	82.9	15	17214	38.0	344	0.566	18.6	5.5	3.061	12.3	0	0	124	18	441	64	99.4	29.45	40	16	61	803	1478	83	181
60	10/07	4000	92.2	68.0	38.6	51.8	442	64.1	12	13771	30.4	357	0.586	29.1	8.6	0.821	3.3	0	0	117	17	441	64	99.3	29.54	42	12	53	761	1402	84	183

ORIGINAL PAGE IS
OF POOR QUALITY

** COATED INTERMEDAITED HOUSING **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
25	84	183	102	215	109	228	7	13	89	193	103	217	91	195	103	218	91	196	112	234	90	194	122	251	88	191	100	212	86	187	101	213	27	81
26	84	183	101	213	111	232	11	19	92	197	108	226	93	199	108	227	92	198	118	245	93	199	137	278	92	198	109	228	89	193	111	231	28	82
27	84	184	102	216	115	239	13	23	95	203	115	239	97	206	116	241	95	203	128	262	95	203	143	289	95	203	114	238	92	197	116	240	30	86
28	85	185	101	214	116	240	14	26	97	206	118	244	98	209	119	246	96	204	131	268	96	204	146	294	96	205	117	242	93	199	118	244	28	83
41	84	183	102	216	115	239	13	23	95	203	116	241	96	205	116	241	94	202	131	268	95	203	145	293	94	202	116	240	91	196	117	243	31	87
42	84	184	103	218	117	243	14	25	97	207	122	251	99	210	97	206	97	206	137	279	96	205	150	302	96	205	118	245	93	199	120	248	32	90
45	84	183	102	216	113	235	11	19	93	199	112	233	94	201	91	196	93	200	127	261	93	200	137	278	92	198	110	230	89	193	112	233	27	80
58	86	186	102	216	116	241	14	25	97	207	121	249	98	209	121	249	98	208	136	277	97	207	151	304	96	205	118	245	93	200	121	249	27	80
59	86	187	102	216	118	245	16	29	102	215	129	265	103	218	130	266	101	214	145	293	100	212	164	328	100	212	126	259	96	204	127	260	28	83
88	83	182	102	215	109	228	7	13	89	192	103	218	89	193	104	220	89	193	116	241	89	193	125	257	89	192	102	216	87	188	103	218	28	83
89	83	182	102	216	109	228	7	12	89	193	104	219	90	194	104	220	89	193	117	242	89	193	126	258	89	192	102	215	87	188	103	218	29	85
90	83	182	102	216	109	228	7	12	89	193	104	220	90	194	105	221	90	194	117	242	89	193	125	257	89	192	102	215	87	188	103	217	31	88
91	83	182	101	214	112	233	11	19	93	200	114	237	94	202	114	238	93	199	129	264	92	198	142	288	92	198	111	231	89	193	112	233	33	91
92	84	183	102	216	113	235	11	19	94	201	114	237	94	202	114	238	93	199	129	264	93	199	143	289	93	199	111	232	90	194	112	234	34	93
93	83	182	101	214	108	227	7	13	89	193	104	220	90	194	104	220	89	193	116	241	89	193	125	257	89	193	103	217	87	189	103	218	22	71
99	84	184	102	216	109	228	7	12	91	196	106	223	92	197	107	224	91	196	119	247	91	196	128	262	91	195	104	219	88	191	104	220	22	72
100	84	184	103	218	110	230	7	12	91	196	106	223	92	197	107	224	91	196	119	247	91	196	128	263	90	194	103	218	88	191	104	220	23	74
101	86	186	102	215	113	235	11	20	96	204	117	242	97	206	118	244	95	203	132	270	94	202	146	294	94	202	114	237	92	197	114	238	24	76
102	85	185	102	215	113	235	11	20	95	203	116	241	96	204	116	241	94	202	131	268	94	202	144	291	94	202	114	237	92	197	114	238	26	79
37	84	183	101	213	109	229	9	16	91	195	106	223	92	197	105	221	91	196	117	243	91	196	126	259	90	194	103	217	88	190	104	220	34	93
38	84	184	102	216	114	237	12	21	94	201	115	239	96	204	114	238	94	202	131	268	94	201	141	285	94	201	112	233	91	195	115	239	37	98
39	84	184	102	216	117	242	14	26	98	208	122	252	99	211	122	251	97	206	139	282	96	204	149	301	96	205	118	244	93	199	121	249	36	96
40	85	185	103	218	119	246	16	28	101	213	128	262	103	217	127	261	99	210	146	294	98	208	159	319	99	210	123	254	95	203	125	257	31	88
46	84	183	102	215	109	228	7	13	91	195	106	222	92	197	106	222	92	197	118	245	91	196	123	254	89	193	103	217	88	190	104	219	28	82
47	84	183	103	217	114	238	12	21	95	203	117	242	96	205	117	243	96	204	134	273	94	202	143	290	95	203	115	239	91	196	116	241	28	83
48	84	184	101	214	118	244	17	30	101	213	129	264	102	216	129	264	99	211	146	295	98	209	162	324	98	209	124	255	94	202	125	257	28	83
49	84	183	102	215	109	229	8	14	91	196	106	223	92	197	106	222	92	197	118	244	91	196	123	254	90	194	103	217	88	190	104	219	27	80
52	84	184	103	218	111	231	7	13	92	197	107	224	92	198	106	223	93	199	119	246	92	198	126	259	91	195	104	219	89	192	105	221	28	82
53	84	184	103	218	114	238	11	20	96	204	118	245	97	207	118	245	97	206	133	272	96	204	146	294	95	203	115	239	92	198	117	243	25	77
54	85	183	104	219	115	239	11	20	96	205	119	246	98	208	119	246	97	207	134	273	96	205	146	294	96	204	116	240	93	199	117	243	27	80
55	84	184	102	215	109	228	7	13	91	196	107	224	92	198	106	223	93	199	117	243	92	198	125	257	91	195	104	219	88	191	105	221	25	77
56	86	186	103	217	117	242	14	25	99	210	125	257	100	212	124	256	99	210	139	283	98	208	155	311	98	208	121	249	94	202	123	253	24	76
57	87	189	103	217	121	249	18	32	105	221	137	278	107	224	137	278	104	220	154	310	103	217	173	344	103	218	132	269	99	210	132	270	26	79
75	85	185	102	216	116	240	13	24	97	207	121	249	98	208	121	249	96	205	136	276	96	205	151	303	97	206	118	245	93	200	121	249	31	87
76	86	186	103	217	116	241	13	24	98	208	122	251	98	209	122	252	97	206	138	280	97	206	151	304	97	206	119	246	93	200	121	249	28	83
77	86	186	103	217	116	240	13	23	98	208	122	251	98	209	122	251	97	206	138	280	97	206	151	303	97	206	119	247	93	200	121	250	28	82
29	84	184	102	215	111	231	9	16	92	198	107	225	93	200	107	224	93	200	116	241	93	199	128	263	42	107	106	223	89	193	108	227	28	83
30	84	184	101	213	114	237	13	24	96	205	118	245	98	208	117	243	96	205	129	265	95	203	139	283	95	203	114	238	92	197	117	243	32	89
31	85	185	101	214	117	242	16	28	100	212	126	258	102	216	125	257	98	209	135	275	96	205	147	297	97	207	119	246	93	200	122	252	33	92
32	85	185	102	215	119	247	18	32	103	217	132	269	105	221	132	269	101	213	142	288	98	209	155	311	101	213	126	258	96	205	127	261	33	92
43	84	183	102	216	112	233	9	17	92	198	108	227	93	199	108	226	93	199	121	250	92	198	130	266	91	196	106	222	88	191	107	225	29	84
44	86	187	104	219	119	247	16	28	101	214	129	264	102	216	128	262	100	212	144	292	99	210	159	318	99	211	123	254	96	204	126	259	28	82
50	84	184	103	217	116	241	13	24	97	207	122	251	99	210	121	250	97	207	138	280	96	205	149	300	96	205	117	243	93	199	120	248	27	80
51	85	185	102	215	118	244	16	29	100	212	128	263	102	215	127	261	99	211	145	293	98	209	159	319	98	209	123	253	94	202	125	257	26	78
60	86	187	101	214	115	239	14	25	99	210	124	255	100	212	123	253	99	211	137	278	98	208	154	309	98	209	121	249	94	202	123	253	29	84

** COATED INTERMEDIATE HOUSING **

Point	Date	RPM	Torque (Nm)	Torque (lbf ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gm/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in/hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
61	10/07	4000	155.9	115.0	65.3	87.6	747	108.4	20	22952	50.6	351	0.578	8.1	2.4	4.355	17.5	0	0	103	15	427	62	99.8	29.54	42	20	68	786	1446	89	192
68	10/07	4000	92.2	68.0	38.6	51.8	442	64.1	12	13771	30.4	357	0.586	28.8	8.5	1.841	7.4	0	0	110	16	441	64	100.0	29.62	34	10	50	773	1423	82	180
69	10/07	4000	92.2	68.0	38.6	51.8	442	64.1	12	13771	30.4	357	0.586	29.1	8.6	1.817	7.3	0	0	110	16	441	64	100.2	29.68	30	10	50	772	1421	82	180
70	10/07	4000	94.9	70.0	39.8	53.3	455	66.0	13	14919	32.9	375	0.617	30.2	8.9	1.767	7.1	0	0	110	16	441	64	100.2	29.68	30	10	50	761	1402	83	181
71	10/07	4000	94.9	70.0	39.8	53.3	455	66.0	13	14919	32.9	375	0.617	30.2	8.9	1.841	7.4	0	0	110	16	441	64	100.3	29.69	32	10	50	759	1399	83	181
74	10/15	4000	92.2	68.0	38.6	51.8	442	64.1	12	13771	30.4	357	0.586	31.5	9.3	1.767	7.1	0	0	110	16	441	64	101.0	29.90	30	11	51	772	1422	84	184
84	10/19	4000	46.1	34.0	19.3	25.9	221	32.0	9	10328	22.8	535	0.879	52.2	15.4	0.597	2.4	0	0	124	18	441	64	100.3	29.70	36	1	33	718	1324	82	180
85	10/19	4000	92.2	68.0	38.6	51.8	442	64.1	12	13771	30.4	357	0.586	31.5	9.3	1.617	6.5	0	0	124	18	441	64	100.3	29.70	36	7	45	771	1419	83	181
95	10/21	4000	120.7	89.0	50.5	67.8	578	83.9	14	16066	35.4	318	0.523	20.0	5.9	2.787	11.2	0	0	124	18	427	62	101.1	29.93	29	16	61	820	1508	84	183
96	10/21	4000	120.7	89.0	50.5	67.8	578	83.9	14	16066	35.4	318	0.523	19.7	5.8	2.613	10.5	0	0	124	18	427	62	101.1	29.93	29	17	63	821	1510	83	182
97	10/21	4000	119.3	88.0	50.0	67.0	572	82.9	14	16066	35.4	321	0.528	19.3	5.7	2.563	10.3	0	0	124	18	427	62	101.1	29.93	29	18	64	821	1509	83	181
98	10/21	4000	120.7	89.0	50.5	67.8	578	83.9	14	16066	35.4	318	0.523	19.3	5.7	2.488	10.0	0	0	124	18	427	62	101.1	29.93	29	17	62	820	1508	82	180
33	09/25	4500	46.1	34.0	21.7	29.1	221	32.0	10	11476	25.3	528	0.868	47.1	13.9	0.921	3.7	0	0	145	21	455	66	100.6	29.78	40	8	46	760	1400	83	182
34	09/25	4500	93.6	69.0	44.1	59.1	448	65.0	15	17214	38.0	390	0.642	27.1	8.0	2.464	9.9	0	0	152	22	427	62	100.6	29.78	40	16	61	811	1492	84	183
35	09/25	4500	120.7	89.0	56.9	76.3	578	83.9	18	20657	45.5	363	0.597	15.9	4.7	4.280	17.2	0	0	152	22	427	62	100.6	29.78	40	25	77	838	1540	84	183
36	09/25	4500	137.0	101.0	64.5	86.5	656	95.2	21	24099	53.1	373	0.614	10.5	3.1	5.101	20.5	0	0	159	23	414	60	100.6	29.78	32	24	76	816	1501	83	182
62	10/07	4500	93.6	69.0	44.1	59.1	448	65.0	14	16066	35.4	364	0.599	27.4	8.1	1.170	4.7	0	0	103	15	441	64	100.0	29.62	31	12	54	784	1443	84	183
63	10/07	4500	166.8	123.0	78.6	105.4	799	115.9	26	29837	65.8	380	0.624	4.4	1.3	7.117	28.6	0	0	103	15	427	62	100.0	29.62	31	16	61	800	1472	87	189
78	10/16	4500	47.5	35.0	22.4	30.0	227	33.0	10	11476	25.3	513	0.844	50.5	14.9	0.622	2.5	0	0	145	21	441	64	100.7	29.81	29	5	41	749	1380	83	182
79	10/16	4500	93.6	69.0	44.1	59.1	448	65.0	14	16066	35.4	364	0.599	28.8	8.5	1.841	7.4	0	0	145	21	441	64	100.7	29.81	29	11	52	793	1460	84	183
81	10/16	4500	137.0	101.0	64.5	86.5	656	95.2	20	22952	50.6	356	0.585	13.2	3.9	4.529	18.2	0	0	138	20	427	62	100.7	29.81	29	23	73	818	1504	84	183
82	10/16	4500	138.3	102.0	65.2	87.4	663	96.1	20	22952	50.6	352	0.579	13.2	3.9	4.529	18.2	0	0	138	20	427	62	100.7	29.81	29	23	73	816	1500	84	184
83	10/16	4500	138.3	102.0	65.2	87.4	663	96.1	20	22952	50.6	352	0.579	13.2	3.9	4.529	18.2	0	0	138	20	427	62	100.7	29.81	29	23	73	816	1501	85	185
64	10/07	5000	97.6	72.0	51.1	68.5	468	67.9	17	19509	43.0	382	0.627	27.1	8.0	2.190	8.8	0	0	159	23	441	64	100.0	29.62	34	12	54	801	1473	84	183
65	10/07	5000	127.5	94.0	66.7	89.5	611	88.6	21	24099	53.1	361	0.594	13.9	4.1	4.305	17.3	0	0	159	23	441	64	100.0	29.62	34	19	66	817	1503	84	184
66	10/07	5000	142.4	105.0	74.5	100.0	682	99.0	24	27542	60.7	369	0.607	10.2	3.0	5.649	22.7	0	0	152	22	441	64	100.0	29.62	34	18	64	810	1490	84	184
67	10/07	5000	162.7	120.0	85.2	114.2	780	113.1	28	32132	70.8	377	0.620	4.4	1.3	7.988	32.1	0	0	145	21	434	63	100.0	29.62	34	14	57	812	1494	84	184

** COATED INTERMEDAITED HOUSING **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
61	91	195	103	218	125	257	22	39	113	236	150	302	115	239	150	302	112	233	171	339	109	228	183	361	111	232	143	290	106	222	144	291	30	86
68	84	184	103	217	116	241	13	24	97	207	122	251	98	209	121	250	97	206	134	274	96	205	151	303	97	207	118	245	93	200	121	249	27	80
69	84	184	103	217	116	240	13	23	97	207	122	251	98	209	121	250	97	206	134	274	96	205	150	302	97	206	118	245	93	199	121	249	28	82
70	64	184	102	215	115	239	13	24	98	208	122	251	98	209	122	251	97	206	135	275	96	205	151	303	97	207	119	247	94	201	121	250	28	82
71	84	184	103	217	116	241	13	24	98	209	123	254	99	210	123	253	97	207	135	275	96	205	151	303	98	208	119	247	93	200	121	250	27	80
74	86	187	104	219	117	243	13	24	100	212	124	256	101	213	124	255	98	209	138	280	98	208	159	318	99	210	122	251	95	203	123	254	31	87
84	84	183	102	215	111	232	9	17	92	198	111	231	93	199	111	231	92	197	122	252	91	196	134	274	92	197	107	225	89	192	109	228	23	74
85	85	185	102	215	115	239	13	24	98	209	123	254	99	211	124	255	96	205	137	278	96	204	156	312	98	208	121	249	94	201	122	251	26	78
95	86	186	103	218	119	246	16	28	102	216	132	270	103	218	132	270	99	211	147	296	99	210	166	330	102	215	128	263	97	207	129	265	29	84
96	86	186	102	216	118	245	16	29	102	216	132	269	103	218	132	270	99	211	147	297	98	209	163	325	101	214	127	261	96	205	129	264	30	86
97	84	184	102	215	118	244	16	29	101	214	130	266	102	216	131	268	98	209	144	292	97	207	161	322	101	213	127	260	95	203	128	263	31	88
98	84	184	101	214	117	243	16	29	101	214	131	268	102	216	131	268	98	208	144	292	97	206	161	321	100	212	127	260	95	203	128	263	29	84
33	85	185	102	215	112	233	10	18	93	200	109	228	94	202	109	228	94	202	119	246	94	201	129	264	93	200	108	226	91	195	111	231	33	92
34	86	186	102	215	116	241	14	26	100	212	124	256	102	215	123	254	99	210	134	274	97	207	146	294	99	210	120	248	94	202	122	252	33	92
35	86	186	102	215	119	246	17	31	102	216	131	268	106	222	131	267	101	214	144	291	98	209	158	316	101	214	126	258	97	206	128	263	36	96
36	87	188	102	216	121	249	18	33	106	222	136	277	107	225	137	278	103	217	149	300	101	213	163	326	104	219	131	268	99	210	134	274	35	95
62	86	186	101	214	116	241	15	27	102	215	129	264	103	217	128	263	101	214	144	292	99	211	159	319	100	212	123	254	96	204	124	256	31	88
63	89	192	103	217	128	263	26	46	118	245	161	322	120	248	163	325	118	244	184	363	111	231	186	367	115	239	153	307	108	226	153	307	32	89
78	84	184	102	216	112	234	10	18	95	203	116	240	96	204	114	238	94	202	126	258	94	201	141	286	94	202	111	232	91	196	112	234	28	83
79	86	186	103	217	118	244	15	77	102	215	129	264	103	217	129	264	99	211	143	289	98	209	164	327	101	214	125	257	97	206	127	260	30	86
81	86	186	103	217	122	252	19	35	108	227	142	288	109	228	143	289	104	219	157	315	102	216	176	348	106	223	137	279	100	212	138	280	30	86
82	86	187	102	216	123	253	21	37	108	227	142	288	109	229	144	291	104	219	158	316	102	216	173	344	107	224	138	280	101	213	138	281	29	85
83	87	188	103	217	123	253	20	36	109	228	143	290	110	230	144	292	104	220	158	317	103	217	172	342	107	225	138	281	101	214	139	282	29	85
64	86	186	103	217	118	245	16	28	103	218	133	271	105	221	132	270	101	214	144	292	99	211	165	329	102	215	127	260	97	206	128	263	28	83
65	86	187	103	218	123	253	19	35	109	228	143	289	111	231	144	291	107	224	157	314	102	216	179	354	106	223	136	277	100	212	137	279	29	85
66	86	187	104	219	126	258	22	39	112	234	149	301	114	237	151	303	109	229	163	326	105	221	184	363	109	228	142	288	103	217	143	290	29	84
67	86	187	104	219	129	265	26	46	116	241	157	314	118	244	160	320	116	241	180	356	108	227	189	372	113	236	151	304	106	222	152	305	30	86

ORIGINAL PAGE IS
OF POOR QUALITY

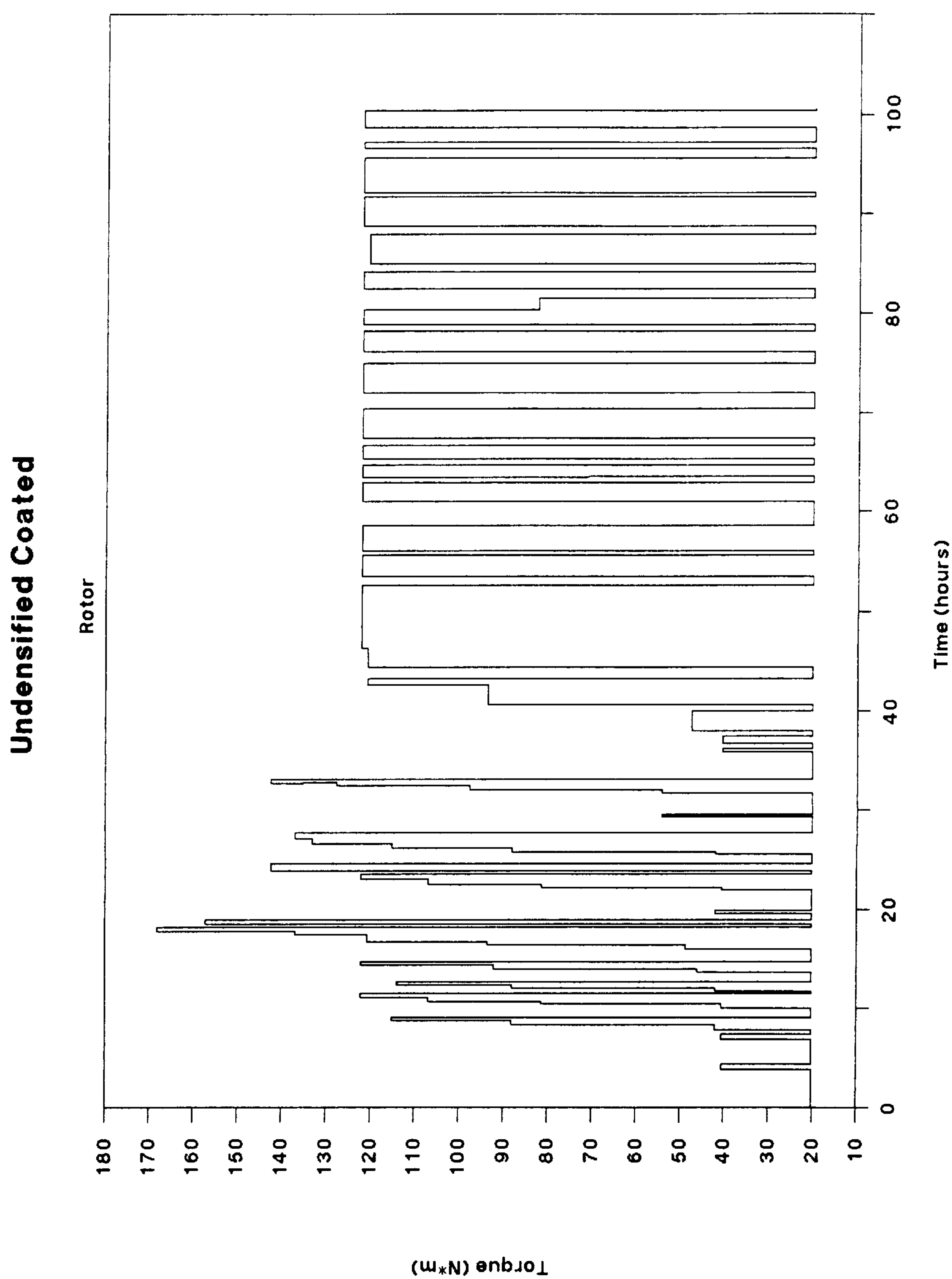
APPENDIX G - I

UNDENSIFIED COATED

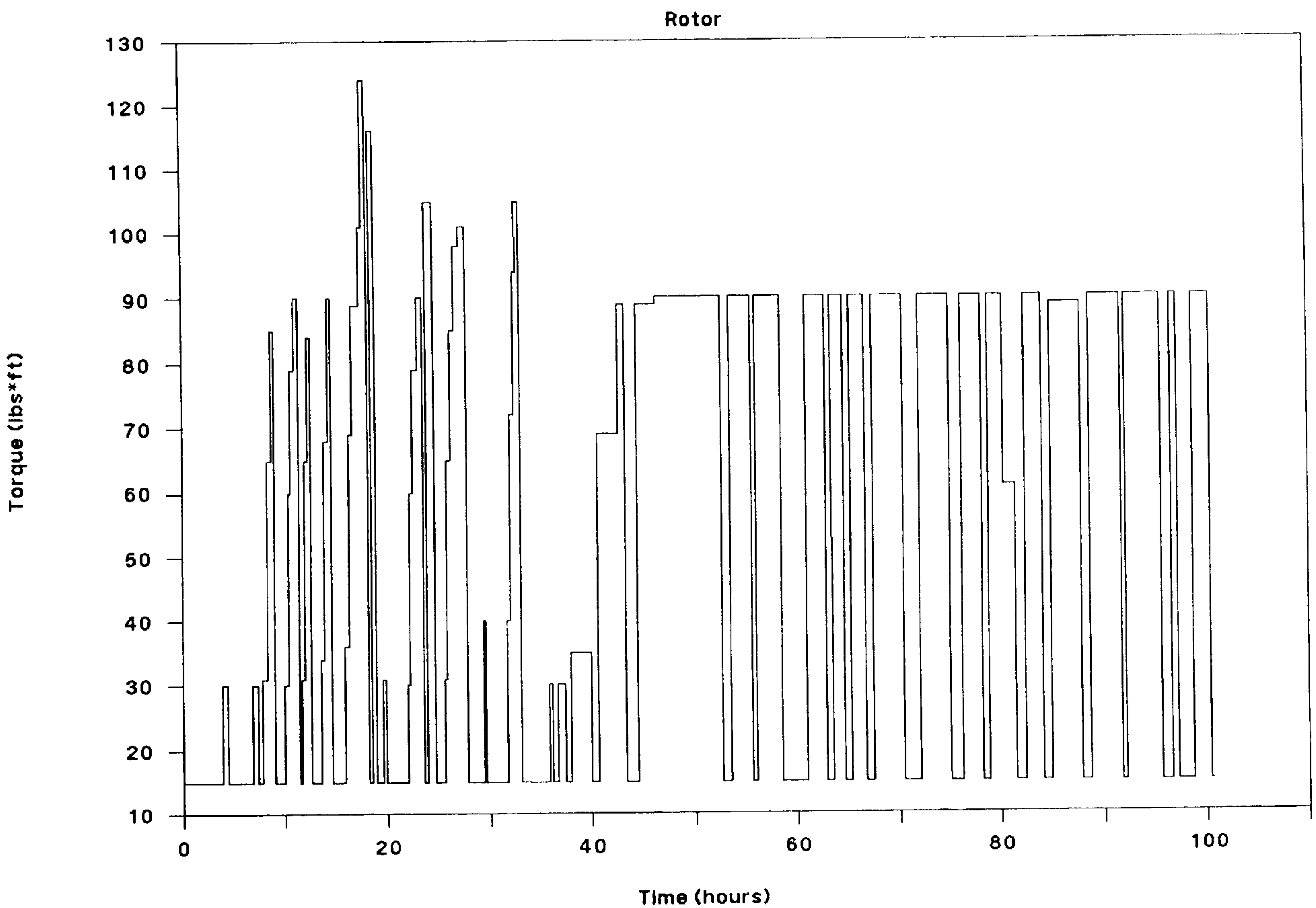
ROTOR DATA

UNDENSIFIED COATED ROTOR DATA

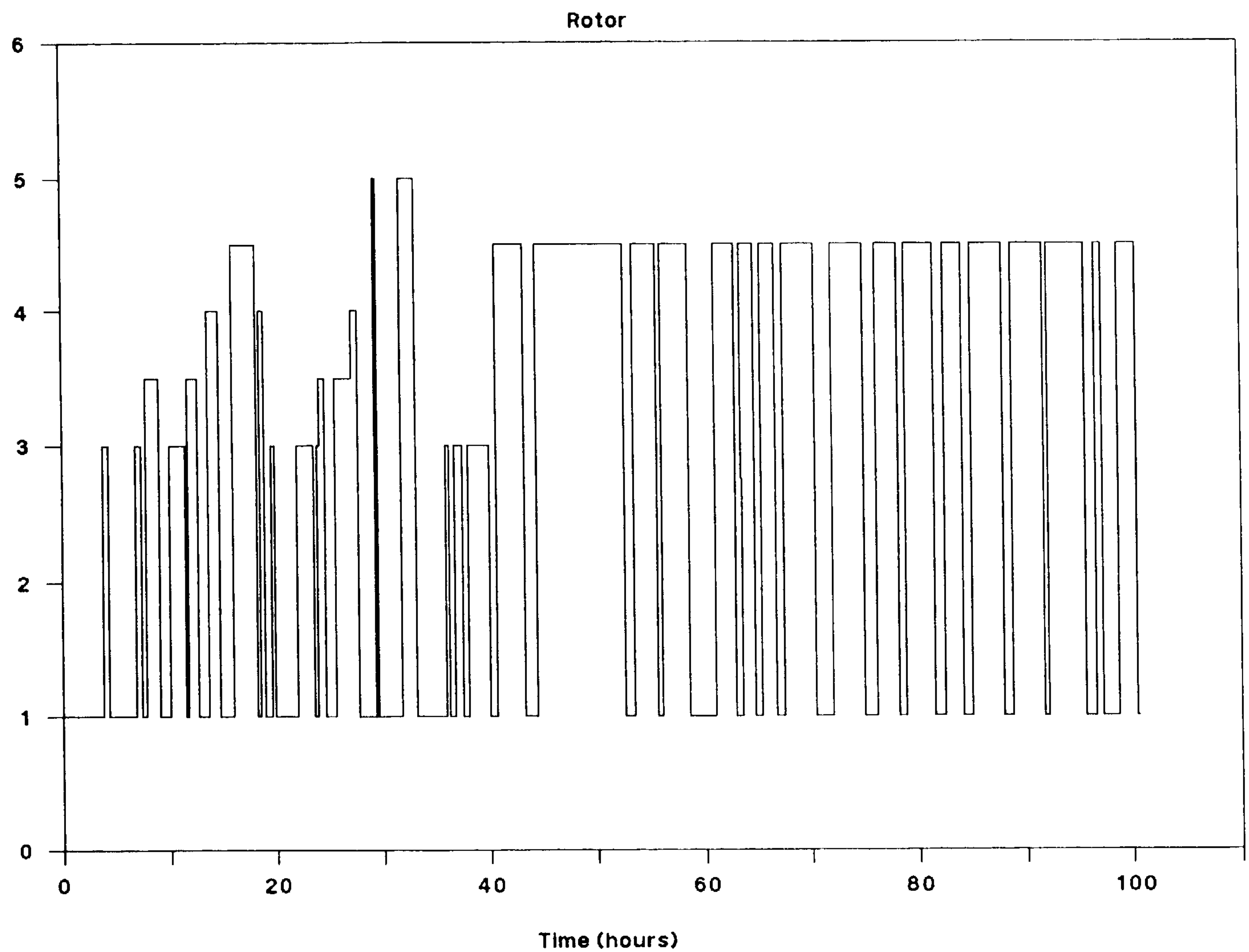
TABLE OF CONTENTS


Undensified Coated
Rotor
Torque (N*m)
Time (hours)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100

Undensified Coated



Undensified Coated



** UNDENSIFIED COATED ROTOR **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
103	84	183	101	214	108	226	7	12	91	196	105	221	92	198	106	223	93	200	118	244	94	202	121	249	91	195	105	221	91	195	104	220	30	86
121	84	184	103	217	111	232	8	15	93	200	112	234	96	204	112	234	94	202	124	255	98	208	134	274	94	201	113	236	92	197	114	238	22	72
104	84	184	102	215	112	233	10	18	94	201	113	236	96	204	114	238	96	204	127	260	99	210	134	273	95	203	115	239	93	199	114	238	36	96
122	85	185	104	219	114	238	11	19	97	206	120	248	99	211	121	249	98	208	134	274	101	213	143	289	97	206	121	250	94	201	112	234	22	72
105	85	185	102	216	114	237	12	21	97	207	120	248	99	210	122	251	98	208	134	274	102	215	143	289	98	208	121	249	95	203	120	248	38	101
106	85	185	102	216	115	239	13	23	99	211	124	255	102	215	126	258	99	211	139	283	103	218	146	295	99	210	124	256	96	205	123	254	35	95
124	86	186	103	217	117	243	14	26	102	215	129	265	105	221	130	266	102	215	147	296	105	221	151	304	101	214	129	265	97	207	127	260	23	73
126	85	185	102	216	109	228	7	12	92	198	108	227	94	201	108	226	94	202	121	249	95	203	123	254	92	197	107	224	89	193	107	224	21	70
127	85	185	103	217	112	234	9	17	96	205	118	244	98	209	118	244	98	208	132	270	100	212	141	285	97	206	119	246	93	200	119	246	22	72
108	86	186	101	214	112	234	11	20	97	207	119	247	99	211	119	247	98	208	133	271	101	213	139	282	97	207	119	246	94	202	119	246	34	93
128	86	186	104	219	115	239	11	20	99	211	124	256	102	216	125	257	101	214	141	285	103	217	149	301	99	211	124	256	110	230	124	255	24	76
129	86	187	104	219	117	242	13	23	103	217	131	267	106	222	131	268	102	216	146	295	105	221	153	307	102	215	129	264	98	208	127	261	25	77
125	86	187	104	219	117	243	13	24	104	219	133	272	107	225	133	272	103	217	149	300	106	222	153	308	103	217	132	269	99	210	130	266	24	76
110	85	185	102	215	110	230	8	15	93	200	111	231	95	203	111	231	97	206	121	249	98	208	126	259	94	201	110	230	92	197	111	232	27	81
111	86	186	103	217	114	238	12	21	99	210	122	251	101	214	122	252	101	213	133	271	103	217	145	293	99	210	122	251	95	203	122	252	22	71
112	86	187	103	217	117	242	14	25	102	216	130	266	105	221	130	266	103	217	143	290	106	223	154	309	102	216	129	264	98	209	129	264	27	81
130	86	187	103	218	118	244	14	26	104	220	135	275	108	226	135	275	103	218	151	304	107	224	158	316	104	219	133	272	99	210	132	269	28	83
	86	187	103	218	118	244	14	26	104	220	135	275	108	226	135	275	103	218	151	304	107	224	158	316	104	219	133	272	99	210	132	269	28	83
118	86	187	103	217	120	248	17	31	109	228	143	289	113	235	144	291	106	222	161	321	111	231	163	325	108	226	141	286	103	217	139	283	38	100
113	86	186	102	216	112	233	9	17	96	204	114	237	97	207	114	238	98	209	126	258	100	212	130	266	96	204	112	234	93	199	113	236	38	101
114	86	187	102	215	116	240	14	25	102	215	128	262	104	220	128	263	103	217	141	285	104	220	151	303	101	214	125	257	97	207	126	258	39	102
115	87	188	103	217	118	245	16	28	106	222	136	276	109	228	136	276	106	222	149	300	109	228	161	321	105	221	133	272	101	213	133	271	39	103
116	87	188	102	216	119	247	17	31	108	226	142	287	112	234	143	290	107	225	159	319	111	231	165	329	108	226	139	282	102	216	138	280	39	102
117	87	188	103	217	123	254	21	37	114	238	154	309	119	247	156	312	111	231	171	339	116	241	170	338	113	235	151	303	107	224	148	298	38	101
132	86	187	103	217	113	236	11	19	97	207	118	244	99	210	118	244	101	213	131	267	101	214	138	280	97	206	116	241	93	200	118	245	36	96
133	86	186	103	217	116	241	13	24	104	220	133	271	107	224	133	271	105	221	145	293	106	222	155	311	102	216	128	262	98	208	128	263	38	101
134	84	184	101	213	117	243	17	30	107	225	141	286	110	230	141	286	107	224	156	312	107	225	163	326	105	221	136	276	99	211	135	275	42	107
135	86	187	102	216	121	249	18	33	112	234	150	302	116	240	150	302	110	230	166	330	112	233	168	334	109	228	142	288	102	216	141	286	44	112
136	83	182	101	214	108	227	7	13	91	195	106	223	92	197	106	223	93	199	119	247	93	199	121	250	91	195	105	221	88	191	106	223	24	75
137	84	183	102	215	108	227	7	12	91	196	107	224	92	198	107	225	93	200	121	249	93	200	122	251	91	195	105	221	89	192	107	224	25	77
138	84	183	102	216	109	228	7	12	91	196	107	224	92	198	107	224	93	200	121	249	93	200	122	251	91	196	106	223	89	192	107	224	24	75
139	84	183	102	216	109	228	7	12	91	196	107	224	92	198	107	224	93	200	121	250	93	200	122	251	91	195	106	222	89	192	107	224	NA	NA
140	85	185	102	216	114	237	12	21	99	210	122	252	101	213	123	253	99	210	136	276	99	211	144	291	99	210	121	249	95	203	122	251	27	80
141	85	185	102	215	114	237	12	22	98	208	121	250	100	212	121	250	99	210	137	278	99	211	143	289	98	209	119	247	95	203	122	251	27	81
142	84	184	101	214	113	236	12	22	99	210	123	253	101	213	123	253	99	210	137	278	99	210	144	291	98	209	119	247	94	202	121	250	28	82
143	85	185	101	214	113	236	12	22	98	209	122	252	100	212	122	251	99	210	136	277	99	210	144	291	99	210	120	248	95	203	122	251	27	80
144	85	185	101	214	115	239	14	25	102	216	131	267	104	220	131	268	101	214	146	295	101	213	151	304	101	213	124	256	97	206	126	259	29	84
145	84	184	101	214	115	239	14	25	102	216	131	268	104	220	131	268	101	214	146	295	101	213	151	303	101	213	125	257	97	206	127	260	28	83
146	85	185	103	217	116	241	13	24	102	216	131	267	104	220	131	268	101	214	147	297	101	213	152	306	101	213	125	257	97	206	127	260	29	84
147	85	185	102	216	116	241	14	25	102	215	131	267	104	219	129	265	101	214	145	293	101	214	151	304	101	213	124	256	97	206	127	260	28	83

** UNDENSIFIED COATED ROTOR **

Point	Date	RPM	Torque (Nm)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
103	12/01	3000	40.7	30.0	12.8	17.1	195	28.3	6	6886	15.2	539	0.886	48.5	14.3	0.025	0.1	0	0	103	15	434	63	100.6	29.80	47	3	37	666	1230	82	180
121	12/08	3000	81.4	60.0	25.6	34.3	390	56.5	9	10328	22.8	404	0.664	27.8	8.2	0.896	3.6	0	0	90	13	434	63	100.5	29.75	53	7	44	797	1467	82	180
104	12/01	3000	81.4	60.0	25.6	34.3	390	56.5	9	10328	22.8	404	0.664	28.5	8.4	0.075	0.3	0	0	103	15	427	62	100.6	29.80	47	9	49	768	1415	82	180
122	12/08	3000	107.1	79.0	33.7	45.1	513	74.5	11	12623	27.8	375	0.617	17.6	5.2	1.717	6.9	0	0	86	13	427	62	100.5	29.75	53	9	49	809	1488	83	181
105	12/01	3000	107.1	79.0	33.7	45.1	513	74.5	11	12623	27.8	375	0.617	19.3	5.7	0.473	1.9	0	0	97	14	427	62	100.7	29.81	36	13	55	784	1443	82	180
106	12/01	3000	122.0	90.0	38.3	51.4	585	84.8	13	14919	32.9	389	0.640	14.2	4.2	2.090	8.4	0	0	97	14	427	62	100.7	29.81	36	16	61	798	1469	83	181
124	12/08	3000	142.4	105.0	44.7	60.0	682	99.0	NA	NA	NA	NA	NA	11.2	3.3	2.563	10.3	0	0	79	11	427	62	100.5	29.75	53	18	65	818	1504	83	182
126	12/08	3500	42.0	31.0	15.4	20.7	201	29.2	8	9181	20.2	596	0.980	48.1	14.2	0.473	1.9	0	0	107	16	441	64	99.7	29.52	64	-1	30	724	1336	83	181
127	12/08	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	28.5	8.4	1.593	6.4	0	0	103	15	441	64	99.7	29.52	64	3	38	808	1487	83	182
108	12/01	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	29.5	8.7	1.593	6.4	0	0	117	17	441	64	100.7	29.81	36	9	48	781	1437	83	182
128	12/09	3500	114.6	84.5	42.0	56.3	549	79.6	13	14919	32.9	355	0.584	19.0	5.6	2.563	10.3	0	0	103	15	441	64	99.7	29.52	64	11	52	833	1531	84	183
129	12/09	3500	132.2	97.5	48.5	65.0	634	91.9	15	16640	36.7	343	0.565	13.9	4.1	3.310	13.3	0	0	103	15	441	64	99.7	29.52	64	14	58	832	1530	84	184
125	12/08	3500	142.4	105.0	52.2	70.0	682	99.0	12	13771	30.4	264	0.434	23.7	7.0	3.733	15.0	0	0	97	14	434	63	100.5	29.75	53	16	60	823	1514	84	183
110	12/02	4000	46.1	34.0	19.3	25.9	221	32.0	10	11476	25.3	594	0.977	48.8	14.4	0.771	3.1	0	0	124	18	441	64	100.3	29.69	32	0	32	766	1410	83	182
111	12/02	4000	92.2	68.0	38.6	51.8	442	64.1	13	14919	32.9	386	0.635	29.5	8.7	2.240	9.0	0	0	124	18	441	64	100.3	29.69	32	10	50	824	1515	83	182
112	12/02	4000	122.0	90.0	51.1	68.5	585	84.8	15	17214	38.0	337	0.554	18.0	5.3	3.932	15.8	0	0	124	18	434	63	100.3	29.69	32	15	59	854	1569	84	184
130	12/09	4000	137.0	101.0	57.4	76.9	656	95.2	17	19509	43.0	340	0.559	14.9	4.4	4.728	19.0	0	0	117	17	434	63	99.7	29.52	64	17	62	848	1558	84	184
	12/09	4000	137.0	101.0	57.4	76.9	656	95.2	17	19509	43.0	340	0.559	14.9	4.4	4.728	19.0	0	0	117	17	434	63	99.7	29.52	64	17	62	848	1558	84	184
118	12/03	4000	157.3	116.0	65.9	88.3	754	109.3	20	22952	50.6	348	0.573	10.2	3.0	5.848	23.5	0	0	124	18	427	62	98.9	29.28	40	19	66	820	1508	84	184
113	12/03	4500	48.8	36.0	23.0	30.8	234	33.9	11	12623	27.8	549	0.902	47.1	13.9	0.896	3.6	0	0	159	23	441	64	98.7	29.24	36	3	37	745	1373	84	183
114	12/03	4500	93.6	69.0	44.1	59.1	448	65.0	14	16066	35.4	364	0.599	28.5	8.4	2.339	9.4	0	0	152	22	441	64	98.7	29.24	36	8	47	815	1499	84	184
115	12/03	4500	120.7	89.0	56.9	76.3	578	83.9	17	19509	43.0	343	0.564	18.3	5.4	4.205	16.9	0	0	152	22	434	63	98.7	29.24	36	18	65	855	1571	85	185
116	12/03	4500	137.0	101.0	64.5	86.5	656	95.2	20	22952	50.6	356	0.585	13.9	4.1	5.226	21.0	0	0	152	22	427	62	98.7	29.24	36	20	68	841	1546	85	185
117	12/03	4500	168.1	124.0	79.2	106.2	806	116.9	25	29837	65.8	377	0.619	6.8	2.0	8.013	32.2	0	0	145	21	427	62	98.7	29.24	36	17	62	827	1521	85	185
132	12/17	5000	54.2	40.0	28.4	38.1	260	37.7	12	13771	30.4	485	0.797	44.0	13.0	1.344	5.4	0	0	179	26	455	66	101.4	30.04	24	6	42	847	1556	84	184
133	12/17	5000	97.6	72.0	51.1	68.5	468	67.9	16	18361	40.5	359	0.591	28.1	8.3	3.086	12.4	0	0	172	25	448	65	101.4	30.04	24	12	54	854	1570	84	184
134	12/17	5000	127.5	94.0	66.7	89.5	611	88.6	20	22952	50.6	344	0.565	13.9	4.1	5.674	22.8	0	0	165	24	441	64	101.4	30.04	24	20	68	886	1626	83	181
135	12/17	5000	142.4	105.0	74.5	100.0	682	99.0	22	25247	55.7	339	0.557	13.2	3.9	6.843	27.5	0	0	159	23	441	64	101.4	30.04	24	21	69	885	1625	84	183
136	1/21	3500	47.5	35.0	17.4	23.3	227	33.0	9	10328	22.8	594	0.976	44.4	13.1	0.672	2.7	0	0	117	17	441	64	100.2	29.67	39	-1	31	723	1334	81	178
137	1/21	3500	47.5	35.0	17.4	23.3	227	33.0	9	10328	22.8	594	0.976	45.4	13.4	0.572	2.3	0	0	114	17	441	64	100.2	29.67	39	1	34	716	1321	82	179
138	1/21	3500	47.1	34.7	17.2	23.1	225	32.7	9	10328	22.8	599	0.985	45.7	13.5	0.547	2.2	0	0	114	17	441	64	100.2	29.67	39	1	33	732	1349	82	179
139	1/21	3500	47.5	35.0	17.4	23.3	227	33.0	9	10328	22.8	594	0.976	45.4	13.4	0.498	2.0	0	0	114	17	441	64	100.2	29.67	39	1	33	727	1341	82	179
140	1/21	4500	93.6	69.0	44.1	59.1	448	65.0	14	16066	35.4	364	0.599	30.5	9.0	2.090	8.4	0	0	152	22	441	64	100.9	29.89	39	5	41	883	1621	83	182
141	1/21	4500	93.2	68.7	43.9	58.9	446	64.7	14	16066	35.4	366	0.602	30.8	9.1	2.065	8.3	0	0	145	21	441	64	100.9	29.89	39	5	41	830	1526	83	181
142	1/21	4500	94.2	69.5	44.4	59.5	452	65.5	14	16066	35.4	362	0.595	31.2	9.2	2.065	8.3	0	0	148	22	441	64	100.9	29.89	39	6	42	827	1521	83	181
143	1/21	4500	94.1	69.4	44.3	59.5	451	65.4	14	16066	35.4	362	0.596	31.2	9.2	2.065	8.3	0	0	152	22	441	64	100.9	29.89	39	6	42	821	1510	83	182
144	1/21	4500	120.4	88.8	56.7	76.1	577	83.7	17	18935	41.7	334	0.549	21.3	6.3	3.733	15.0	0	0	152	22	434	63	100.9	29.89	39	13	55	853	1567	83	181
145	1/21	4500	120.8	89.1	56.9	76.3	579	84.0	17	18935	41.7	333	0.547	20.3	6.0	3.807	15.3	0	0	155	23	434	63	100.9	29.89	39	12	54	854	1570	83	181
146	1/21	4500	121.5	89.6	57.2	76.8	582	84.4	17	18935	41.7	331	0.544	20.7	6.1	3.708	14.9	0	0	162	24	434	63	100.9	29.89	39	14	57	854	1570	83	181
147	1/22	4500	120.3	88.7	56.7	76.0	576	83.6	17	18935	41.7	334	0.549	21.0	6.2	3.459	13.9	0	0	159	23	434	63	100.5	29.75	38	12	53	859	1579	83	182

** UNDENSIFIED COATED ROTOR **

Point	Date	RPM	Torque (Nm)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
148	1/22	4500	119.3	88.0	56.2	75.4	572	82.9	17	18935	41.7	337	0.554	21.3	6.3	3.484	14.0	0	0	159	23	434	63	100.5	29.75	38	12	54	861	1581	83	182
149	1/22	4500	120.0	88.5	56.5	75.8	575	83.4	17	18935	41.7	335	0.551	21.3	6.3	3.285	13.2	0	0	162	24	434	63	100.5	29.75	38	12	54	861	1582	83	182
150	1/22	4500	121.4	89.5	57.2	76.7	582	84.4	17	18935	41.7	331	0.544	20.3	6.0	3.459	13.9	0	0	162	24	434	63	100.5	29.75	38	13	56	859	1579	83	181
151	1/22	4500	121.4	89.5	57.2	76.7	582	84.4	17	18935	41.7	331	0.544	20.0	5.9	3.459	13.9	0	0	165	24	427	62	100.5	29.75	38	14	57	860	1580	83	181
152	1/22	4500	121.9	89.9	57.4	77.0	584	84.7	17	18935	41.7	330	0.542	21.0	6.2	3.285	13.2	0	0	165	24	427	62	100.5	29.75	38	14	57	856	1572	83	182
153	1/22	4500	121.2	89.4	57.1	76.6	581	84.3	17	18935	41.7	331	0.545	20.7	6.1	3.285	13.2	0	0	165	24	427	62	100.5	29.75	38	15	59	860	1580	83	181
154	1/22	4500	121.5	89.6	57.2	76.8	582	84.4	17	18935	41.7	331	0.544	21.0	6.2	3.285	13.2	0	0	165	24	427	62	100.5	29.75	38	13	56	859	1579	83	181
155	1/22	4500	122.4	90.3	57.7	77.4	587	85.1	17	18935	41.7	328	0.540	21.0	6.2	3.285	13.2	0	0	159	23	427	62	100.5	29.75	38	14	57	858	1577	83	181
156	1/22	4500	122.4	90.3	57.7	77.4	587	85.1	17	18935	41.7	328	0.540	21.0	6.2	3.285	13.2	0	0	162	24	427	62	100.5	29.75	38	13	56	858	1576	83	181
157	1/22	4500	122.2	90.1	57.6	77.2	585	84.9	17	19509	43.0	339	0.557	21.0	6.2	3.285	13.2	0	0	165	24	427	62	100.4	29.73	38	14	57	857	1575	83	181
158	1/22	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.0	6.2	3.111	12.5	0	0	165	24	427	62	100.4	29.73	42	14	58	858	1576	83	181
159	1/22	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.0	6.2	3.086	12.4	0	0	162	24	427	62	100.4	29.73	42	13	56	856	1572	83	181
160	1/22	4500	122.9	90.6	57.9	77.6	589	85.4	17	19509	43.0	337	0.554	21.0	6.2	3.061	12.3	0	0	165	24	427	62	100.4	29.73	42	13	56	856	1573	83	181
161	1/22	4500	122.7	90.5	57.8	77.5	588	85.3	17	19509	43.0	337	0.555	20.7	6.1	2.936	11.8	0	0	162	24	427	62	100.4	29.73	42	13	56	854	1569	83	181
162	1/25	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.0	6.2	2.737	11.0	0	0	165	24	434	63	99.9	29.58	32	12	54	854	1570	83	181
163	1/25	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.0	6.2	2.787	11.2	0	0	159	23	434	63	99.9	29.58	32	12	53	855	1571	83	182
164	1/25	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.0	6.2	2.687	10.8	0	0	159	23	427	62	99.9	29.58	32	12	53	853	1568	83	182
165	1/25	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.0	6.2	2.712	10.9	0	0	159	23	427	62	99.9	29.58	32	12	53	855	1571	83	182
166	1/25	4500	121.9	89.9	57.4	77.0	584	84.7	17	19509	43.0	340	0.558	21.0	6.2	4.305	17.3	0	0	145	21	427	62	100.8	29.85	29	11	51	857	1575	83	182
167	1/25	4500	122.3	90.2	57.6	77.3	586	85.0	17	19509	43.0	339	0.557	21.3	6.3	4.280	17.2	0	0	159	23	427	62	100.8	29.85	29	12	53	858	1576	83	182
168	1/25	4500	122.0	90.0	57.5	77.1	585	84.8	17	18935	41.7	329	0.541	21.0	6.2	4.181	16.8	0	0	162	24	427	62	100.8	29.85	29	12	54	862	1583	83	182
169	1/26	4500	122.6	90.4	57.8	77.5	587	85.2	17	18935	41.7	328	0.539	21.0	6.2	4.255	17.1	0	0	138	20	434	63	100.8	29.85	36	12	54	866	1591	83	182
170	1/26	4500	123.0	90.7	58.0	77.7	589	85.5	17	19509	43.0	337	0.553	21.0	6.2	4.255	17.1	0	0	141	21	434	63	100.8	29.85	36	12	54	865	1589	83	182
171	1/26	4500	122.9	90.6	57.9	77.6	589	85.4	17	19509	43.0	337	0.554	21.0	6.2	4.230	17.0	0	0	145	21	434	63	100.8	29.85	36	13	56	866	1590	83	182
172	1/26	4500	123.1	90.8	58.0	77.8	590	85.6	17	19509	43.0	336	0.553	21.3	6.3	4.205	16.9	0	0	159	23	427	62	100.8	29.85	36	13	55	864	1588	83	182
173	1/26	4500	122.6	90.4	57.8	77.5	587	85.2	17	18935	41.7	328	0.539	22.0	6.5	4.031	16.2	0	0	145	21	434	63	100.8	29.85	36	13	55	862	1584	83	182
174	1/26	4500	122.2	90.1	57.6	77.2	585	84.9	17	18935	41.7	329	0.541	21.7	6.4	3.981	16.0	0	0	159	23	434	63	100.8	29.85	36	13	55	862	1583	83	182
175	1/27	4500	122.9	90.6	57.9	77.6	589	85.4	17	19509	43.0	337	0.554	21.0	6.2	4.504	18.1	0	0	138	20	427	62	101.8	30.15	20	13	56	868	1594	83	182
176	1/27	4500	122.2	90.1	57.6	77.2	585	84.9	17	19509	43.0	339	0.557	21.0	6.2	4.380	17.6	0	0	145	21	427	62	101.8	30.15	20	14	57	865	1589	83	182
177	1/27	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.7	6.4	4.181	16.8	0	0	138	20	427	62	101.8	30.14	22	13	56	871	1600	83	182
178	1/27	4500	123.1	90.8	58.0	77.8	590	85.6	17	19509	43.0	336	0.553	22.4	6.6	4.230	17.0	0	0	145	21	427	62	101.8	30.14	22	12	54	868	1595	84	183
179	1/27	4500	123.4	91.0	58.1	78.0	591	85.8	17	19509	43.0	336	0.552	22.4	6.6	4.205	16.9	0	0	155	23	427	62	101.8	30.14	22	13	55	867	1592	84	183
180	1/27	4500	123.8	91.3	58.3	78.2	593	86.1	17	19509	43.0	334	0.550	23.0	6.8	4.181	16.8	0	0	162	24	427	62	101.8	30.14	22	12	53	864	1588	84	183
181	1/27	4500	123.0	90.7	58.0	77.7	589	85.5	17	19509	43.0	337	0.553	21.7	6.4	4.131	16.6	0	0	200	29	427	62	101.8	30.14	22	13	55	863	1586	83	182
182	1/27	4500	123.4	91.0	58.1	78.0	591	85.8	17	19509	43.0	336	0.552	22.0	6.5	4.056	16.3	0	0	203	30	427	62	101.8	30.14	22	12	53	862	1583	84	183
183	1/27	4500	123.4	91.0	58.1	78.0	591	85.8	17	19509	43.0	336	0.552	22.0	6.5	3.957	15.9	0	0	165	24	427	62	101.8	30.14	22	11	52	861	1582	84	183
184	1/28	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	21.7	6.4	4.454	17.9	0	0	148	22	427	62	101.8	30.16	29	12	54	852	1565	83	182
185	1/28	4500	122.3	90.2	57.6	77.3	586	85.0	17	19509	43.0	339	0.557	21.7	6.4	4.429	17.8	0	0	152	22	427	62	101.8	30.16	29	13	55	852	1566	83	182
186	1/28	4500	122.6	90.4	57.8	77.5	587	85.2	17	19509	43.0	338	0.555	22.0	6.5	4.429	17.8	0	0	162	24	427	62	101.8	30.16	29	13	55	849	1561	83	182
187	1/28	4500	122.6	90.4	57.8	77.5	587	85.2	17	19509	43.0	338	0.555	22.0	6.5	4.404	17.7	0	0	165	24	427	62	101.8	30.16	29	14	57	851	1564	83	181
188	1/28	4500	122.4	90.3	57.7	77.4	587	85.1	17	19509	43.0	338	0.556	23.0	6.8	4.380	17.6	0	0	165	24	427	62	101.8	30.16	29	14	57	851	1564	83	181
189	1/28	4500	122.6	90.4	57.8	77.5	587	85.2	17	19509	43.0	338	0.555	22.0	6.5	4.230	17.2	0	0	165	24	427	62	101.8	30.16	29	14	57	850	1562	82	180
190	1/29	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	22.0	6.5	4.056	16.3	0	0	138	20	427	62	101.3	30.00	30	11	52	856	1572	83	181
191	1/29	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	22.0	6.5	4.131	16.6	0	0	145	21	427	62	101.3	30.00	30	12	53	856	1573	82	180
192	1/29	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	22.0	6.5	4.155	16.7	0	0	148	22	427	62	101.3	30.00	30	12	54	854	1570	83	181
193	1/29	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.559	22.0	6.5	4.106	16.5	0	0	159	23	427	62	101.3	30.00	30	12	54	853	1568	83	182
194	1/29	4500	121.5	89.6	57.2	76.8	592	84.4	17	19509	43.0	341	0.560	22.0	6.5	3.732	15.2	0	0	152	22	427	62	101.0	29.92	30	12	54	848	1555	83	181

** UNDENSIFIED COATED ROTOR **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
148	85	185	102	215	116	240	14	25	102	216	131	267	104	219	131	268	101	214	146	294	101	213	151	304	101	213	125	257	97	206	127	261	28	82
149	86	186	102	216	116	241	14	25	102	216	131	267	104	219	131	267	101	214	146	294	101	213	152	305	101	214	125	257	97	206	127	261	29	84
150	85	185	102	215	116	240	14	25	102	215	130	266	104	219	131	267	101	213	146	294	100	212	152	305	101	213	126	258	96	205	128	262	29	84
151	84	184	102	215	116	240	14	25	102	215	130	266	103	218	131	267	101	213	147	296	101	213	152	306	101	213	126	258	96	205	127	261	29	85
152	86	186	102	216	117	242	14	26	102	216	131	267	104	220	132	269	101	214	147	296	101	213	153	308	101	214	126	259	97	207	128	263	32	89
153	84	184	102	215	116	240	14	25	102	215	130	266	103	218	131	267	101	213	146	295	100	212	153	307	101	213	126	258	96	205	127	261	32	89
154	85	185	102	215	116	241	14	26	102	215	130	266	104	219	131	267	101	213	147	296	100	212	153	308	101	213	126	259	97	206	128	262	31	87
155	85	185	101	214	116	240	14	26	102	215	130	266	104	219	131	267	101	213	147	296	101	213	153	307	101	213	126	258	96	205	128	262	31	88
156	84	184	101	214	116	240	14	26	102	215	130	266	104	219	131	267	101	213	146	295	101	213	153	308	101	214	126	259	97	206	128	262	32	90
157	85	185	102	215	116	241	14	26	102	215	130	266	104	219	131	268	101	213	147	296	101	213	153	308	101	213	127	260	97	206	128	262	30	86
158	85	185	102	215	116	241	14	26	102	215	131	267	104	219	132	269	101	213	147	296	100	212	153	308	101	214	126	259	96	205	128	263	31	87
159	85	185	102	215	116	241	14	26	102	215	130	266	104	219	131	268	101	213	147	296	101	213	154	309	101	214	127	260	97	206	129	264	30	86
160	85	185	102	215	116	241	14	26	102	215	130	266	104	219	131	268	101	213	147	297	100	212	152	306	101	214	127	260	97	206	128	263	30	86
161	85	185	102	215	116	241	14	26	102	215	130	266	104	219	131	268	101	213	147	297	100	212	152	306	101	214	127	260	97	206	128	263	29	85
162	84	184	102	216	116	240	13	24	102	215	130	266	103	218	131	268	101	213	148	299	100	212	153	307	101	214	126	259	96	205	129	264	30	86
163	86	186	103	217	116	241	13	24	102	216	130	266	104	220	132	269	101	214	149	300	101	213	153	307	101	214	127	261	97	207	129	264	29	85
164	86	186	103	217	116	241	13	24	102	216	131	268	104	220	132	270	101	214	149	300	101	213	152	306	102	215	127	261	97	207	129	264	30	86
165	86	186	103	217	116	241	13	24	102	216	131	268	104	220	132	270	101	214	149	301	101	213	153	308	101	214	127	260	97	207	129	265	29	84
166	85	185	102	216	116	241	14	25	102	216	131	267	104	219	131	268	101	213	148	299	101	213	153	308	101	214	127	261	97	207	129	265	28	83
167	85	185	102	216	116	241	14	25	102	216	131	267	104	220	131	268	101	214	149	300	101	213	153	307	101	214	127	261	97	207	129	264	30	86
168	86	186	103	217	116	241	13	24	102	216	131	267	104	220	132	270	101	214	149	301	101	214	154	309	101	214	127	260	97	207	129	264	29	84
169	86	186	102	216	116	240	13	24	102	216	131	267	104	220	133	271	102	215	151	304	101	214	154	309	102	215	127	261	98	208	129	265	29	85
170	86	186	102	216	116	241	14	25	103	217	131	268	104	220	133	272	102	215	151	303	101	214	154	309	102	215	127	261	97	207	129	265	30	86
171	85	185	103	218	117	242	13	24	102	216	131	267	104	220	132	270	101	214	151	303	101	214	154	309	101	214	127	261	97	207	129	265	32	89
172	86	186	104	219	117	243	13	24	102	215	130	266	104	220	132	269	101	214	151	303	101	214	154	309	101	214	127	260	97	207	129	265	29	84
173	86	186	102	215	115	239	13	24	102	216	131	268	104	220	134	273	102	215	151	303	101	214	154	310	101	214	127	261	97	206	129	265	29	84
174	86	186	104	219	117	243	13	24	102	216	131	268	105	221	133	272	102	215	151	303	102	215	155	311	102	215	128	262	97	207	131	267	29	84
175	86	186	104	220	117	243	13	23	102	215	130	266	104	219	132	270	102	215	153	307	102	216	153	308	102	216	129	264	98	208	131	268	31	87
176	86	186	104	219	118	244	14	25	102	216	132	270	105	221	134	274	102	215	153	308	102	216	154	309	102	215	129	264	98	208	131	268	33	92
177	86	186	104	220	118	244	13	24	103	217	132	269	104	220	134	273	101	214	152	305	102	215	153	308	102	215	128	262	97	207	130	266	30	86
178	86	186	104	219	118	244	14	25	103	217	132	270	105	221	134	274	101	214	153	307	102	215	154	309	102	215	128	263	97	207	131	267	30	86
179	86	186	106	222	119	246	13	24	103	217	132	270	105	221	135	275	102	215	153	308	102	216	154	310	102	215	128	263	98	208	131	267	31	88
180	86	186	105	221	118	245	13	24	103	218	133	272	106	222	136	276	102	215	153	308	102	216	156	313	102	216	129	265	98	208	131	268	31	87
181	86	186	104	220	118	245	14	25	103	217	133	271	105	221	135	275	102	215	153	307	102	216	156	312	102	216	130	266	98	209	132	269	32	90
182	86	186	106	222	118	245	13	23	103	218	134	273	106	223	137	278	102	216	154	309	102	216	155	311	102	216	130	266	98	209	132	269	31	88
183	86	187	107	224	119	247	13	23	103	218	134	273	106	223	137	278	102	216	154	310	102	216	156	313	102	216	130	266	98	209	132	270	30	86
184	85	185	105	221	118	244	13	23	103	218	135	275	106	222	138	280	102	216	156	313	102	216	155	311	102	216	131	267	98	208	133	271	NA	NA
185	85	185	107	224	119	246	12	22	103	218	135	275	106	222	138	280	102	216	157	314	102	216	155	311	102	215	131	267	98	208	132	270	NA	NA
186	86	186	104	219	118	244	14	25	103	218	136	276	106	223	139	282	102	216	156	313	102	216	154	310	102	216	131	267	98	208	133	271	NA	NA
187	84	184	108	226	119	247	12	21	103	218	135	275	106	222	138	281	102	215	157	314	102	215	152	306	101	214	129	264	97	207	131	268	NA	NA
188	84	184	108	226	120	248	12	22	103	218	136	276	106	222	138	281	102	215	157	315	102	215	155	311	101	214	130	266	97	207	132	270	NA	NA
189	84	184	106	222	119	246	13	24	103	217	135	275	106	222	138	281	102	215	157	315	102	215	154	310	101	214	130	266	97	207	132	270	NA	NA
190	85	185	105	221	118	244	13	23	103	217	136	277	106	223	140	284	102	216	161	321	102	216	156	312	102	215	131	268	98	208	133	271	NA	NA
191	84	184	105	221	118	245	13	24	103	217	136	277	106	223	140	284	102	216	161	321	102	216	156	312	102	215	132	269	98	208	134	273	NA	NA
192	84	184	106	222	118	245	13	23	103	218	137	278	107	224	141	286	102	216	162	324	103	217	156	312	101	214	132	269	98	209	135	275	NA	NA
193	85	185	108	226	120	248	12	22	104	219	138	280	107	225	142	288	103	217	163	326	103	218	157	315	102	216	133	271	99	210	136	276	NA	NA
194	84	184	107	225	119	247	12	22	104	219	138	281	107	225	143	289	103	217	163	326	103	218	157	315	102	215	134	273	99	210	137	278	NA	NA

** UNDENSIFIED COATED ROTOR **

Point	Date	RPM	Torque (Nm)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
195	1/29	4500	121.4	89.5	57.2	76.7	582	84.4	NA	NA	NA	NA	NA	22.4	6.6	3.757	15.1	0	0	159	23	427	62	101.0	29.92	30	12	54	848	1559	83	181
196	1/29	4500	121.4	89.5	57.2	76.7	582	84.4	NA	NA	NA	NA	NA	22.7	6.7	3.733	15.0	0	0	162	24	427	62	101.0	29.92	30	13	56	848	1558	83	182
197	1/29	4500	82.3	60.7	38.8	52.0	394	57.2	13	14345	31.6	370	0.608	37.6	11.1	1.792	7.2	0	0	155	23	427	62	101.0	29.92	30	5	41	810	1490	84	183
198	1/29	4500	84.1	62.0	39.6	53.1	403	58.4	13	14919	32.9	377	0.619	37.6	11.1	1.717	6.9	0	0	155	23	427	62	101.0	29.92	30	4	40	814	1498	83	182
199	2/1	4500	122.3	90.2	57.6	77.3	586	85.0	NA	NA	NA	NA	NA	20.7	6.1	3.534	14.2	0	0	155	23	427	62	100.4	29.73	52	10	50	839	1542	83	181
200	2/1	4500	121.9	89.9	57.4	77.0	584	84.7	17	19509	43.0	340	0.558	20.7	6.1	4.031	16.2	0	0	145	21	427	62	100.4	29.73	52	12	53	846	1554	83	182
201	2/1	4500	122.9	90.6	57.9	77.6	589	85.4	17	19509	43.0	337	0.554	20.7	6.1	4.006	16.1	0	0	152	22	427	62	100.4	29.73	52	12	53	847	1556	84	183
202	2/1	4500	123.1	90.8	58.0	77.8	590	85.6	17	19509	43.0	336	0.553	21.0	6.2	4.006	16.1	0	0	152	22	427	62	100.4	29.73	52	12	53	846	1555	83	182
203	2/1	4500	121.2	89.4	57.1	76.6	581	84.3	17	19509	43.0	342	0.561	21.7	6.4	3.832	15.4	0	0	145	21	427	62	100.4	29.73	52	11	52	847	1556	83	182
204	2/1	4500	121.2	89.4	57.1	76.6	581	84.3	17	19509	43.0	342	0.561	21.7	6.4	3.733	15.0	0	0	150	22	427	62	100.4	29.73	52	12	53	843	1549	83	181
205	2/1	4500	120.4	88.8	56.7	76.1	577	83.7	17	19509	43.0	344	0.565	21.7	6.4	3.733	15.0	0	0	152	22	427	62	100.4	29.73	52	12	54	844	1551	83	182
206	2/1	4500	120.4	88.8	56.7	76.1	577	83.7	17	18935	41.7	334	0.549	21.7	6.4	3.658	14.7	0	0	159	23	427	62	100.4	29.73	52	12	54	845	1553	84	183
207	2/1	4500	120.0	88.5	56.5	75.8	575	83.4	17	18935	41.7	335	0.551	21.7	6.4	3.658	14.7	0	0	155	23	427	62	100.4	29.73	52	13	56	843	1550	83	181
208	2/2	4500	121.9	89.9	57.4	77.0	584	84.7	17	19509	43.0	340	0.558	21.3	6.3	3.633	14.6	0	0	141	21	427	62	100.9	29.87	38	11	52	851	1564	82	180
209	2/2	4500	122.3	90.2	57.6	77.3	586	85.0	17	19509	43.0	339	0.557	21.7	6.4	3.608	14.5	0	0	145	21	427	62	100.9	29.87	38	11	52	851	1564	83	182
210	2/2	4500	122.3	90.2	57.6	77.3	586	85.0	17	19509	43.0	339	0.557	22.0	6.5	3.683	14.8	0	0	145	21	427	62	100.9	29.87	38	12	54	853	1568	83	182
211	2/2	4500	122.2	90.1	57.6	77.2	585	84.9	17	18935	41.7	329	0.541	22.0	6.5	3.608	14.5	0	0	145	21	427	62	100.9	29.87	38	13	55	851	1563	83	181
212	2/2	4500	122.2	90.1	57.6	77.2	585	84.9	17	19509	43.0	339	0.557	22.4	6.6	3.558	14.3	0	0	145	21	427	62	100.9	29.87	38	12	54	856	1573	83	182
213	2/2	4500	122.3	90.2	57.6	77.3	586	85.0	17	19509	43.0	339	0.557	22.7	6.7	3.608	14.5	0	0	145	21	427	62	100.9	29.87	38	12	53	852	1565	84	183
214	2/2	4500	122.2	90.1	57.6	77.2	585	84.9	17	19509	43.0	339	0.557	22.7	6.7	3.658	14.7	0	0	145	21	427	62	101.0	29.92	36	12	54	852	1565	83	181
215	2/2	4500	122.9	90.6	57.9	77.6	589	85.4	17	19509	43.0	337	0.554	22.7	6.7	3.409	13.7	0	0	145	21	427	62	101.0	29.92	36	12	53	853	1567	83	181
216	2/2	4500	122.3	90.2	57.6	77.3	586	85.0	NA	NA	NA	NA	NA	22.4	6.6	3.334	13.4	0	0	148	22	427	62	101.0	29.92	36	12	54	852	1566	83	181
217	2/3	4500	121.2	89.4	57.1	76.6	581	84.3	NA	NA	NA	NA	NA	22.7	6.7	4.131	16.6	0	0	141	21	427	62	101.0	29.91	32	11	51	853	1568	83	181
218	2/3	4500	121.4	89.5	57.2	76.7	582	84.4	17	19509	43.0	341	0.561	22.7	6.7	3.907	15.7	0	0	145	21	427	62	100.9	29.89	32	10	50	852	1565	82	180
219	2/3	4500	121.4	89.5	57.2	76.7	582	84.4	17	18935	41.7	331	0.544	22.7	6.7	3.782	15.2	0	0	145	21	427	62	100.9	29.89	32	11	52	853	1567	82	180
220	2/3	4500	120.4	88.8	56.7	76.1	577	83.7	16	18361	40.5	324	0.532	22.7	6.7	NA	NA	0	0	145	21	427	62	100.9	29.89	32	12	54	848	1559	82	180

** UNDENSIFIED COATED ROTOR **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
195	84	184	106	222	118	245	13	23	104	219	138	281	108	226	143	290	103	217	163	326	103	218	156	313	102	216	134	273	99	210	137	279	NA	NA
196	85	185	107	224	121	249	14	25	104	220	139	283	108	227	144	291	103	218	164	328	103	218	157	314	102	216	134	273	99	211	138	280	NA	NA
197	86	186	107	224	117	242	10	18	100	212	127	260	103	217	130	266	99	211	152	305	101	213	145	293	98	209	125	257	96	205	128	262	NA	NA
198	85	185	108	226	117	243	9	17	99	211	127	260	102	216	130	266	99	211	153	307	101	213	146	294	98	208	124	256	96	204	128	262	NA	NA
199	84	184	105	221	117	243	12	22	104	220	139	282	108	226	143	290	103	218	164	328	104	219	158	317	102	216	134	274	99	211	137	279	NA	NA
200	85	185	104	220	119	246	14	26	104	220	141	285	109	228	145	293	104	219	166	330	104	220	159	318	103	217	136	276	100	212	139	282	NA	NA
201	86	186	104	220	118	244	13	24	105	221	141	286	109	229	145	293	104	219	166	330	104	220	158	317	103	217	136	276	100	212	138	281	NA	NA
202	85	185	106	222	119	246	13	24	105	221	141	285	109	228	146	294	104	219	167	332	105	221	158	317	103	217	136	276	100	212	138	281	NA	NA
203	85	185	106	223	118	245	12	22	105	221	140	284	109	228	144	292	104	220	167	333	104	220	159	319	103	217	135	275	99	211	138	280	NA	NA
204	85	185	108	227	120	248	12	21	105	221	140	284	109	228	144	292	104	219	167	333	104	220	159	319	103	217	134	274	99	211	137	279	NA	NA
205	86	186	102	215	116	240	14	25	106	222	140	284	109	228	144	292	104	219	167	332	105	221	160	320	103	218	136	277	100	212	138	281	NA	NA
206	86	186	102	216	116	241	14	25	106	222	140	284	109	228	144	292	104	219	167	333	104	220	159	318	104	219	136	277	100	212	138	281	NA	NA
207	84	184	103	217	116	241	13	24	104	220	139	282	108	226	144	291	103	218	167	333	104	219	159	318	103	217	135	275	99	211	137	279	NA	NA
208	84	184	101	214	116	240	14	26	105	221	141	285	108	226	145	293	103	218	167	333	104	219	159	318	103	218	136	277	99	211	138	281	NA	NA
209	86	186	102	216	117	242	14	26	106	222	141	286	109	228	146	295	104	219	168	335	105	221	161	321	104	219	137	279	101	213	139	283	NA	NA
210	85	185	102	215	116	241	14	26	105	221	141	285	108	227	145	293	103	218	168	334	104	220	161	321	104	219	137	279	109	212	139	283	NA	NA
211	84	184	102	216	116	241	14	25	105	221	140	284	108	226	145	293	103	217	168	334	104	219	160	320	103	218	137	278	99	211	139	282	NA	NA
212	85	185	102	215	116	240	14	25	105	221	140	284	108	227	145	293	103	218	168	335	104	220	159	319	104	219	137	278	100	212	138	281	NA	NA
213	86	186	103	217	117	242	14	25	106	222	140	284	108	227	145	293	103	218	168	334	104	220	160	320	104	219	138	280	101	213	140	284	NA	NA
214	84	184	102	216	116	241	14	25	105	221	139	283	108	226	145	293.	103	217	168	334	104	219	160	320	104	219	137	279	100	212	139	282	NA	NA
215	85	185	103	217	117	242	14	25	105	221	139	283	108	227	145	293	103	217	168	334	104	219	160	320	104	219	137	278	100	212	139	282	NA	NA
216	84	184	103	217	117	243	14	26	105	221	139	283	108	226	145	293	103	217	168	334	104	220	161	321	104	219	137	279	100	212	139	282	NA	NA
217	84	184	102	216	116	241	14	25	104	220	140	284	108	226	144	292	103	217	167	333	104	219	160	320	103	218	137	278	99	211	138	281	NA	NA
218	84	184	102	215	116	240	14	25	104	219	139	282	107	224	143	290	102	216	167	332	103	218	159	319	103	218	137	278	99	211	138	281	NA	NA
219	84	184	102	215	116	241	14	26	104	219	139	282	107	225	144	291	102	216	167	332	103	218	159	319	103	217	136	277	99	210	138	281	NA	NA
220	84	184	102	216	116	241	14	25	104	220	139	282	107	225	144	291	102	216	166	331	103	218	159	318	103	217	136	277	99	210	138	281	NA	NA

APPENDIX G - II

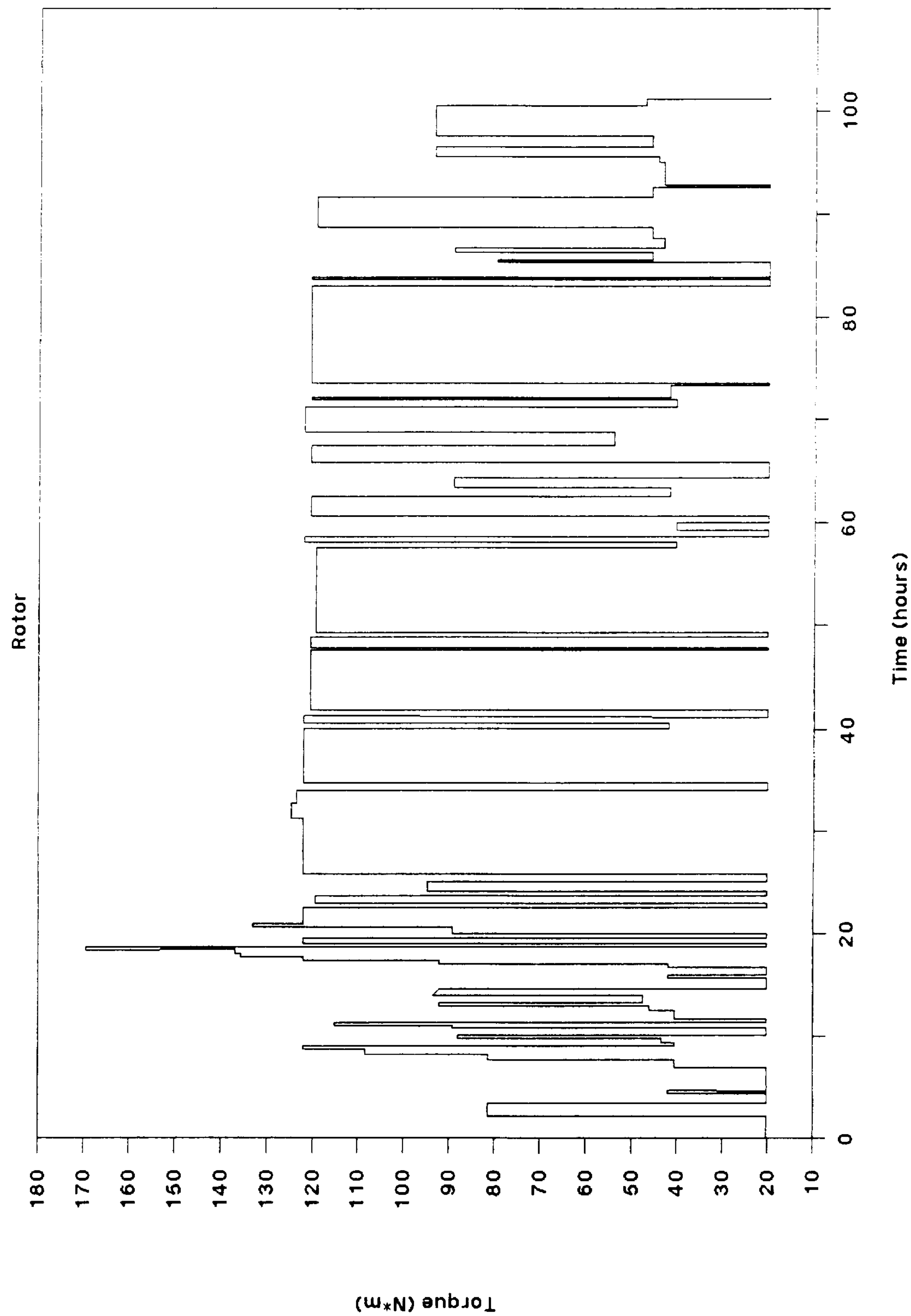
DENSIFIED COATED

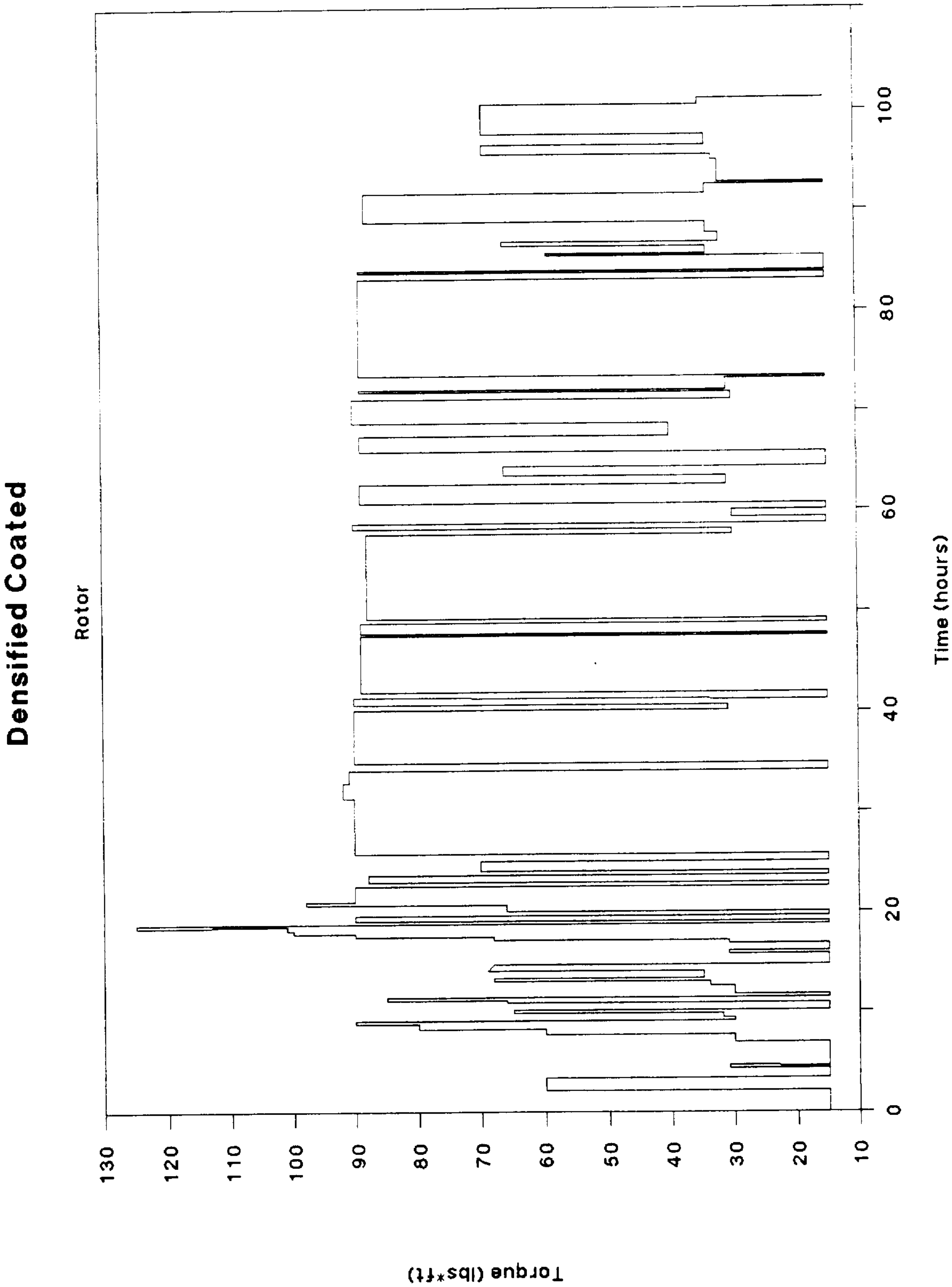
ROTOR DATA

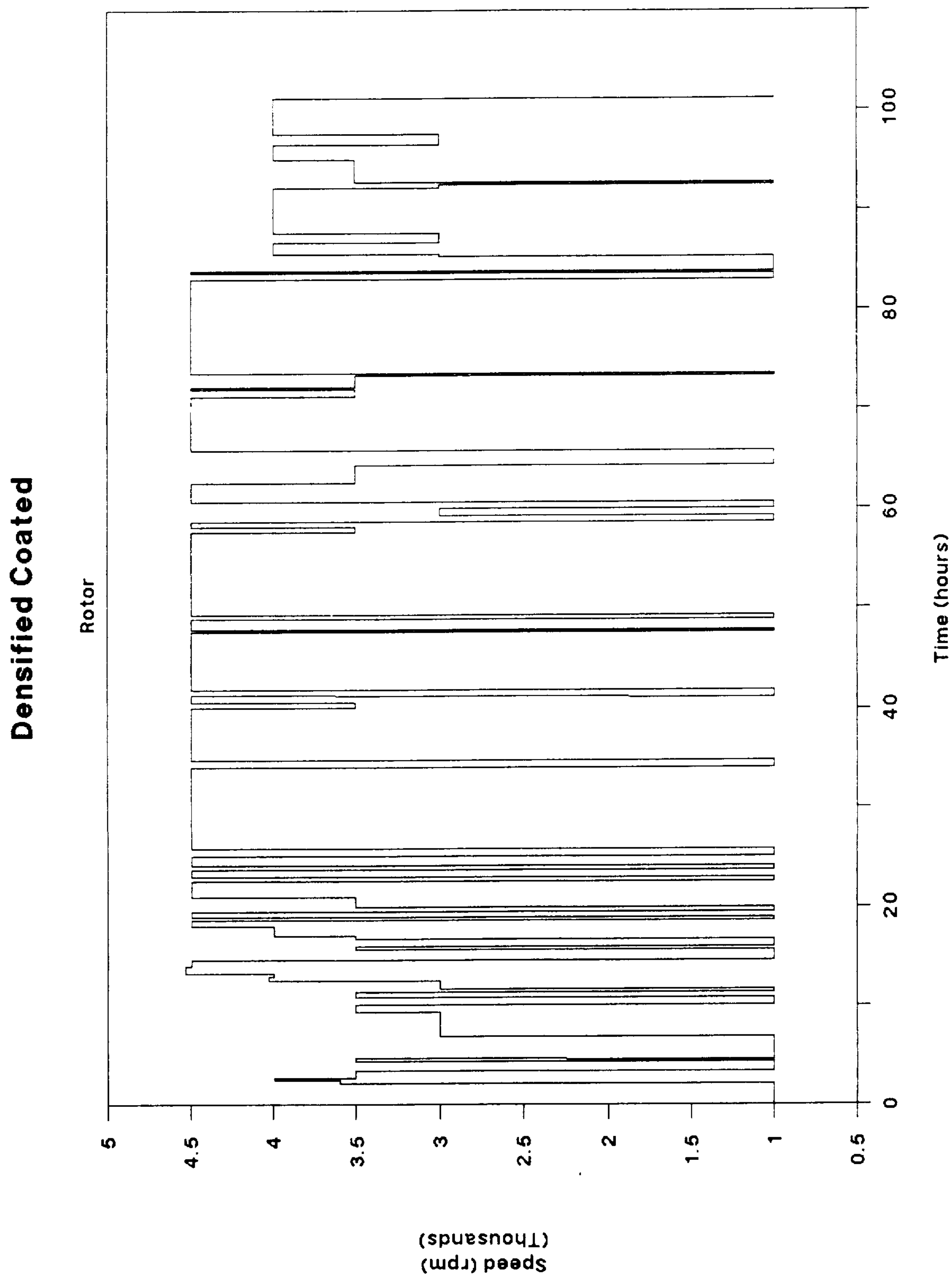
DENSIFIED COATED ROTOR DATA

TABLE OF CONTENTS

Densified Coated




Densified Coated
Rotor
Torque (lbs*ft)
Time (hours)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100


Densified Coated
Rotor
Speed (rpm)
(Thousands)
Time (hours)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
20
40
60
80
100

** DENSIFIED COATED ROTOR **

Point	Date	RPM	Torque (N*m)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
1-Coated Rotor																																
5	2/29	3000	40.7	30.0	12.8	17.1	195	28.3	6	6886	15.2	537	0.886	48.8	14.4	0.249	1.0	0.0	0.0	97	14	441	64	100.7	29.83	33	-1	31	688	1270	81	178
8	2/29	3000	122.0	90.0	38.3	51.4	585	84.8	12	13197	29.1	344	0.566	17.6	5.2	1.493	6.0	0.0	0.0	97	14	427	62	100.7	29.83	33	14	57	793	1460	82	180
6	2/29	3000	81.4	60.0	25.6	34.3	390	56.5	9	10328	22.8	404	0.664	29.8	8.8	0.547	2.6	0.0	0.0	97	14	434	63	100.7	29.83	33	6	43	774	1426	82	179
7	2/29	3000	108.5	80.0	34.1	45.7	520	75.4	10	11476	25.3	337	0.554	22.0	6.5	1.095	4.4	0.0	0.0	97	14	427	62	100.7	29.83	33	9	49	779	1435	82	179
9	2/29	3000	40.7	30.0	12.8	17.1	195	28.3	6	6886	15.2	539	0.886	50.1	14.8	0.199	0.8	0.0	0.0	90	13	434	63	100.7	29.83	33	1	34	657	1215	81	178
15	3/1	3005	41.2	30.4	13.0	17.4	198	28.7	6	6886	15.2	531	0.873	50.5	14.9	0.100	0.4	0.0	0.0	107	16	434	63	100.9	29.87	30	-1	30	653	1207	82	180
14	3/1	3010	41.4	30.5	13.0	17.5	198	28.7	6	6886	15.2	523	0.866	50.1	14.8	0.199	0.8	0.0	0.0	107	16	434	63	101.0	29.92	28	-2	29	652	1206	82	179
10	2/29	3500	42.7	31.5	15.7	21.0	205	29.7	8	9181	20.2	536	0.964	51.2	15.1	0.747	3.0	0.0	0.0	114	17	441	64	100.7	29.83	33	1	33	662	1259	82	190
3	2/24	3500	81.4	60.0	29.9	40.0	390	56.5	10	11476	25.3	335	0.633	31.5	9.3	1.418	5.7	0.0	0.0	90	13	441	64	100.7	29.83	33	1	34	848	1559	82	179
29	3/8	3500	133.2	98.2	48.8	65.4	638	92.6	14	15955	35.4	329	0.541	15.9	5.2	2.553	10.7	0.0	0.0	124	18	427	62	100.5	29.77	38	14	53	831	1527	83	181
19	3/7	3500	41.8	30.8	15.3	20.5	200	29.0	NA	NA	NA	NA	NA	50.8	15.0	0.747	3.0	0.0	0.0	117	17	441	64	100.9	29.87	34	0	32	732	1349	82	180
28	3/8	3500	89.4	65.9	32.7	43.9	428	62.1	11	12623	27.8	335	0.634	31.2	9.2	1.493	6.0	0.0	0.0	124	18	434	63	100.5	29.77	38	3	37	786	1446	82	180
12	3/1	3500	89.2	65.8	32.7	43.8	428	62.0	11	12050	26.6	369	0.606	31.9	9.4	1.394	5.6	0.0	0.1	124	18	434	63	101.0	29.92	28	1	34	786	1447	82	180
13	3/1	3500	115.3	85.0	42.2	56.6	552	80.1	13	14345	31.6	340	0.559	23.0	6.8	2.016	8.1	0.0	0.0	124	18	434	63	101.0	29.92	28	9	49	811	1492	83	182
11	2/29	3500	88.1	65.0	32.3	43.3	422	61.3	11	12623	27.8	391	0.642	32.9	9.7	1.493	6.0	0.0	0.0	117	17	441	64	100.7	29.83	23	4	40	771	1420	83	181
20	3/7	3500	42.6	31.4	15.6	20.9	204	29.6	8	9181	20.2	538	0.967	51.5	15.2	0.597	2.3	0.0	0.0	117	17	441	64	100.9	29.87	34	-3	27	678	1288	82	179
4	2/26	3500	41.9	30.9	15.4	20.6	201	29.1	8	9181	20.2	593	0.980	49.1	14.5	0.747	3.0	0.0	0.1	110	16	441	64	100.9	29.88	33	-1	31	769	1417	83	181
1	2/24	3500	81.4	60.0	30.7	41.1	390	56.5	11	12623	27.8	412	0.677	31.2	9.2	1.817	5.0	0.0	0.0	133	15	441	64	100.9	29.88	33	2	35	849	1559	82	180
21	3/7	4000	92.2	68.0	38.6	51.8	442	64.1	12	13771	30.4	357	0.586	33.7	[illegible]	1.497	6.0	0.0	0.0	145	21	434	63	100.9	29.87	34	6	42	831	1477	83	181
22	3/7	4000	122.4	90.3	51.3	68.8	587	85.1	14	15055	35.4	313	0.515	22.7	6.7	[illegible]	[illegible]	0.0	0.0	145	21	434	63	100.9	29.87	34	12	53	834	1533	83	181
2	2/24	4000	81.4	60.0	34.1	45.7	390	56.6	12	13197	29.1	387	0.637	33.5	9.9	1.841	7.3	0.0	0.2	110	16	441	64	100.7	29.88	33	7	45	854	1571	82	180
23	3/7	4000	135.5	100.0	56.8	76.2	650	94.3	16	18361	40.5	323	0.532	17.3	5.1	3.857	15.5	0.0	0.0	139	20	434	63	100.9	29.87	34	14	58	850	1562	83	181
16	3/1	4026	46.1	34.0	19.4	26.1	221	32.0	10	11476	25.3	590	0.971	50.8	15.0	0.747	3.0	0.0	0.0	145	21	441	64	100.9	29.87	30	-1	30	721	1329	83	182
30	3/8	4500	121.6	89.7	57.3	76.9	583	84.5	17	19509	43.0	340	0.560	23.7	7.0	3.459	13.9	0.0	0.0	159	23	427	62	100.5	29.77	38	12	53	851	1564	83	181
33	3/8	4500	120.1	88.6	56.6	75.9	576	83.5	17	18935	41.7	334	0.550	24.1	7.1	3.260	13.1	0.0	0.0	165	24	427	62	100.5	29.75	42	12	53	856	1573	83	182
25	3/7	4500	168.8	124.5	79.5	106.7	809	117.3	24	27542	60.7	346	0.569	11.2	3.3	6.868	27.6	0.0	0.1	159	23	427	62	100.9	29.67	34	16	61	849	1560	84	183
34	3/8	4500	119.7	88.3	56.4	75.7	574	83.2	17	18935	41.7	336	0.552	23.7	7.0	3.259	13.1	0.0	0.0	162	24	427	62	100.5	29.75	42	13	56	855	1571	83	182
27	3/7	4500	105.9	78.1	49.9	66.9	508	73.6	17	19509	43.0	391	0.643	23.4	6.9	3.235	13.0	0.0	0.0	145	21	427	62	100.9	29.87	34	13	56	852	1566	83	182
35	3/8	4500	94.6	69.9	44.7	59.9	454	65.9	14	16066	35.4	360	0.591	33.2	9.8	1.891	7.6	0.0	0.1	172	25	427	62	100.5	29.75	42	6	43	814	1497	84	183
40	3/9	4500	121.4	89.5	57.2	76.7	582	84.4	17	19509	43.0	341	0.561	22.7	6.7	3.135	12.3	0.0	0.0	162	24	427	62	99.7	29.53	45	14	57	843	1549	84	184
39	3/9	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	22.4	6.6	3.135	12.6	0.0	0.0	162	24	427	62	99.7	29.53	45	13	55	841	1546	84	183
36	3/8	4500	94.2	69.5	44.4	59.5	452	65.5	15	16640	36.7	375	0.616	33.2	9.8	1.366	7.5	0.0	0.0	169	25	434	63	100.5	29.75	42	7	45	809	1489	84	184
32	3/8	4500	122.7	90.5	57.8	77.5	588	85.3	17	19509	43.0	337	0.555	23.4	6.9	3.334	13.6	0.0	0.0	159	23	427	62	100.5	29.77	38	13	55	854	1570	83	182
37	3/9	4500	121.4	89.5	57.2	76.7	582	84.4	17	19509	43.0	341	0.561	22.7	6.7	3.135	12.3	0.0	0.0	172	25	427	62	99.7	29.53	45	11	51	837	1538	83	182
24	3/7	4500	137.4	101.3	64.7	86.8	658	95.5	19	21804	48.1	337	0.554	17.3	5.1	4.504	18.5	0.0	0.1	169	25	427	62	100.9	29.87	34	15	59	869	1596	84	183
26	3/7	4500	105.9	78.1	49.9	66.9	508	73.6	17	19509	43.0	391	0.643	23.4	6.9	3.235	13.0	0.0	0.0	145	21	427	62	100.9	29.87	34	13	56	853	1568	83	182
31	3/8	4500	122.7	90.5	57.8	77.5	588	85.3	17	19509	43.0	337	0.555	23.4	6.9	3.334	13.6	0.0	0.0	159	23	427	62	100.5	29.77	38	11	52	853	1567	83	182
38	3/9	4500	121.1	89.3	57.1	76.5	530	84.2	17	19509	43.0	342	0.562	22.7	6.7	3.210	12.9	0.0	0.0	159	23	427	62	99.7	29.53	45	12	54	842	1547	83	181
18	3/1	4502	82.2	60.7	38.8	52.0	394	57.2	14	16066	35.4	414	0.681	34.6	10.2	2.016	8.1	0.0	0.0	162	24	434	63	100.9	29.57	30	4	39	808	1486	84	183
17	3/1	4502	48.0	35.4	22.6	30.5	230	33.4	10	11476	25.3	504	0.823	50.1	14.3	0.672	2.7	0.0	0.0	162	24	441	64	100.9	29.37	30	-2	29	778	1432	83	182

ORIGINAL PAGE IS
OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

** DENSIFIED COATED ROTOR **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
1-Coated Rotor																																		
5	83	182	98	208	105	221	7	13	89	193	105	221	91	196	108	226	92	198	123	253	92	198	123	254	90	194	106	223	88	191	108	226	27	81
8	84	184	103	218	116	240	12	22	98	208	124	255	100	212	128	263	98	208	153	307	99	210	154	309	97	207	126	259	94	202	127	261	30	86
6	84	183	102	216	112	233	9	17	92	198	113	236	94	202	117	242	94	202	137	278	95	203	138	281	93	200	116	241	91	196	118	244	29	84
7	84	183	103	217	114	238	12	21	96	204	121	249	98	209	125	257	97	206	148	299	98	208	149	300	96	205	123	253	94	201	125	257	30	86
9	83	182	101	214	108	226	7	12	89	193	105	221	91	196	108	226	92	198	123	254	92	198	123	254	89	193	106	223	88	190	107	225	28	83
15	84	183	102	216	108	227	6	11	90	194	106	222	92	197	108	227	93	199	124	256	93	199	125	257	90	194	107	224	107	224	108	226	21	70
14	84	183	102	216	108	227	6	11	90	194	106	222	92	197	108	227	93	199	124	256	93	199	124	256	90	194	106	223	106	223	108	226	21	69
10	84	183	103	217	109	228	6	11	92	197	109	229	93	200	112	233	94	201	129	265	94	201	127	261	91	196	109	228	89	193	111	231	28	83
3	84	183	98	209	110	230	12	21	94	201	116	241	96	205	119	247	96	204	143	290	97	206	140	284	94	201	117	243	92	197	121	249	29	84
29	85	185	103	219	117	243	14	25	102	215	133	272	105	221	133	281	101	213	161	322	101	214	157	314	101	214	133	272	98	208	136	276	28	83
19	83	182	102	216	109	229	7	13	91	195	108	227	93	199	111	231	94	201	129	265	94	202	131	267	91	196	110	230	89	193	112	233	25	77
28	84	184	102	216	114	237	12	21	96	204	121	249	98	209	124	255	97	207	149	300	98	209	144	292	96	205	122	252	94	201	124	256	28	82
12	84	184	103	218	113	236	10	18	96	204	121	249	98	209	124	255	97	207	148	299	97	207	147	296	96	204	121	249	93	200	124	255	23	73
13	86	186	103	218	116	240	12	22	100	212	128	263	103	217	132	270	99	211	156	313	99	210	156	313	98	208	127	260	96	204	131	267	22	71
11	85	185	103	218	114	237	11	19	97	206	121	250	99	210	125	257	98	208	148	298	98	209	147	296	96	205	122	251	94	201	124	256	31	87
20	84	183	102	215	109	228	7	13	91	196	109	228	93	199	111	232	94	201	129	265	94	201	128	263	91	196	109	228	89	193	111	231	23	73
4	83	181	NA	NA	NA	NA	NA	NA	91	195	108	226	92	198	111	231	93	200	129	265	93	200	127	[illegible]	91	195	109	228	89	192	111	232	24	75
1	84	183	99	211	[illegible]	[illegible]	12	21	94	202	118	245	97	[illegible]	[illegible]	[illegible]	97	206	143	[illegible]	97	207	143	289	95	203	119	246	93	199	122	252	31	88
21	84	184	103	217	115	239	12	22	98	208	124	255	101	214	129	264	99	210	153	307	99	210	155	312	98	208	126	259	96	204	129	264	24	75
22	85	195	103	218	113	244	14	26	102	216	134	273	105	220	139	282	102	215	162	323	101	213	167	333	101	214	133	271	98	209	137	279	27	80
2	84	184	100	212	113	236	12	24	97	207	123	253	99	211	126	258	98	208	151	304	99	211	151	303	97	207	124	255	95	203	128	262	28	83
23	84	184	103	217	118	245	15	28	104	219	138	280	108	226	143	290	102	215	167	332	102	215	172	341	102	216	136	276	99	210	139	283	27	80
16	85	185	103	217	111	232	8	15	93	200	113	235	96	204	115	239	96	205	134	274	95	203	134	273	93	199	112	234	91	196	116	240	25	77
30	84	184	103	218	119	246	15	28	104	220	139	282	108	227	144	292	102	216	163	326	102	215	161	322	103	217	136	277	99	211	141	285	27	80
33	85	185	103	217	118	245	15	28	104	220	139	282	109	228	144	291	103	217	165	329	102	216	161	322	103	218	136	277	100	212	141	285	26	79
35	86	186	103	217	124	256	22	39	112	235	157	315	119	246	165	329	108	227	181	357	108	226	177	351	112	234	156	313	107	225	158	317	28	82
34	85	185	103	218	119	246	15	28	104	219	138	281	108	227	144	291	102	216	164	328	102	215	161	321	103	217	136	277	99	211	140	284	27	81
27	86	186	103	218	119	246'	16	28	104	220	138	281	108	227	143	290	103	217	162	323	102	216	161	321	103	217	136	276	100	212	140	284	28	83
25	85	185	103	217	117	242	14	25	102	215	131	268	104	220	136	276	101	213	159	318	100	212	155	311	101	213	130	266	98	208	134	273	27	80
40	85	185	NA	NA	NA	NA	NA	NA	105	221	139	282	108	227	144	291	102	216	164	328	103	217	161	322	103	217	136	276	99	211	141	285	27	81
39	85	185	102	216	119	246	17	30	105	221	139	283	108	227	143	290	102	216	164	327	102	216	159	319	102	216	136	277	100	212	141	286	27	80
36	86	187	103	218	117	242	13	24	102	215	132	270	106	222	137	278	101	214	159	319	101	213	156	312	101	214	131	267	98	209	134	274	28	82
32	85	185	103	216	119	247	16	29	105	221	140	284	109	228	145	293	103	217	163	326	102	216	159	318	103	217	136	277	100	212	141	286	26	79
37	85	185	103	217	118	245	16	28	104	220	139	282	108	227	144	292	103	217	167	332	102	216	163	325	103	218	137	278	100	212	141	285	23	73
24	86	186	103	218	121	249	17	31	107	225	144	292	112	234	151	304	105	221	173	343	104	219	176	348	106	222	141	285	102	215	145	293	28	82
26	86	186	103	218	119	246	16	28	104	220	138	281	109	228	143	290	103	217	162	324	102	216	161	322	103	218	136	276	100	212	140	284	28	83
31	85	185	103	218	119	247	16	29	104	220	139	283	109	228	144	292	103	217	163	325	102	215	159	318	103	217	136	276	99	211	141	285	25	77
38	85	185	102	216	113	245	16	29	105	221	139	283	108	227	144	291	103	217	166	331	102	215	160	320	103	218	137	279	99	211	140	284	25	77
18	86	186	104	219	118	244	14	25	102	215	131	268	105	221	136	277	101	214	159	318	101	214	163	325	101	213	130	266	98	208	134	274	26	79
17	84	184	103	218	113	236	10	18	96	204	117	243	98	208	119	247	97	207	139	283	97	206	140	284	94	202	115	239	92	198	119	247	27	80

DENSIFIED COATED ROTOR

Point	Date	RPM	Torque (Nm)	Torque (lbfft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
41	3/9	4500	121.1	89.3	57.1	76.5	580	84.2	17	19509	43.0	342	0.562	22.4	6.6	3.135	12.6	0.0	0.0	162	24	427	62	99.7	29.53	45	14	57	845	1553	83	181
42	3/9	4500	120.7	89.0	56.9	76.3	578	83.9	17	18935	41.7	333	0.547	22.0	6.5	3.086	12.4	0.0	0.0	162	24	427	62	99.6	29.49	43	14	58	843	1550	83	181
43	3/9	4500	121.2	89.4	57.1	76.6	581	84.3	17	19509	43.0	342	0.561	22.7	6.7	3.160	12.7	0.0	0.0	165	24	427	62	99.6	29.49	43	14	57	841	1546	83	181
44	3/9	4500	121.8	89.8	57.4	76.9	584	84.6	17	19509	43.0	340	0.559	21.7	6.4	3.185	12.8	0.0	0.0	162	24	427	62	99.6	29.49	43	15	59	842	1548	83	181
45	3/9	4500	121.6	89.7	57.3	76.9	583	84.5	17	19509	43.0	340	0.560	21.7	6.4	3.135	12.6	0.0	0.0	162	24	427	62	99.6	29.49	43	13	56	844	1552	84	183
46	3/9	4500	125.2	92.3	59.0	79.1	600	87.0	17	19509	43.0	331	0.544	22.4	6.6	3.111	12.5	0.0	0.0	162	24	427	62	99.6	29.49	43	9	49	848	1559	84	183
47	3/9	4500	125.8	92.8	59.3	79.5	603	87.5	17	19509	43.0	329	0.541	21.3	6.3	3.135	12.6	0.0	0.0	162	24	427	62	99.6	29.49	43	10	50	847	1557	84	184
48	3/9	4500	124.8	92.0	58.8	78.8	598	86.7	17	19509	43.0	332	0.546	21.7	6.4	3.086	12.4	0.0	0.0	162	24	427	62	99.6	29.49	32	12	54	846	1554	83	182
49	3/9	4500	123.0	90.7	58.0	77.7	589	85.5	17	19509	43.0	337	0.553	22.7	6.7	3.111	12.5	0.0	0.0	162	24	427	62	99.6	29.49	32	12	54	844	1551	83	182
50	3/9	4500	123.5	91.1	58.2	78.1	592	85.9	17	19509	43.0	335	0.551	21.7	6.4	3.583	14.4	0.0	0.0	162	24	427	62	99.6	29.49	32	13	55	845	1553	84	183
51	3/10	4500	122.4	90.3	57.7	77.4	587	85.1	17	19509	43.0	338	0.556	23.0	6.8	3.185	12.8	0.0	0.0	172	25	427	62	99.7	29.53	30	11	51	848	1558	83	182
52	3/10	4500	122.0	90.0	57.5	77.1	585	84.8	17	18935	41.7	329	0.541	23.0	6.8	3.160	12.7	0.0	0.0	169	25	427	62	99.7	29.53	30	11	51	847	1557	83	181
53	3/10	4500	121.5	89.6	57.2	76.8	582	84.4	17	18935	41.7	331	0.544	23.0	6.8	3.135	12.3	0.0	0.0	172	25	427	62	99.7	29.53	33	11	52	847	1555	83	182
54	3/10	4500	122.0	90.0	57.5	77.1	585	84.8	17	19509	43.0	339	0.558	22.4	6.6	3.160	12.7	0.0	0.0	172	25	427	62	99.7	29.53	33	13	56	844	1552	84	183
55	3/10	4500	122.6	90.4	57.8	77.5	587	85.2	17	18935	41.7	328	0.539	22.0	6.5	3.185	12.3	0.0	0.0	169	25	427	62	99.9	29.59	28	11	52	845	1553	83	182
56	3/10	4500	122.9	90.6	57.9	77.6	589	85.4	17	18935	41.7	327	0.538	22.0	6.5	3.086	12.4	0.0	0.0	169	25	427	62	99.9	29.59	28	11	52	843	1550	84	183
57	3/10	4500	122.7	90.5	57.8	77.5	588	85.3	17	18935	41.7	327	0.538	23.0	6.8	3.036	12.2	0.0	0.0	172	25	427	62	99.9	29.59	28	12	53	841	1546	84	183
58	3/10	4500	122.7	90.5	57.8	77.5	588	85.3	17	18935	41.7	327	0.538	23.0	6.8	3.086	12.4	0.0	0.0	172	25	427	62	99.9	29.59	28	12	54	844	1551	84	183
59	3/10	4500	122.7	90.5	57.8	77.5	588	85.3	17	18935	41.7	327	0.538	23.0	6.8	3.061	12.3	0.0	0.0	172	25	427	62	99.9	29.59	28	12	54	844	1551	84	183
60	3/10	4500	122.2	90.1	57.6	77.2	585	84.9	17	18935	41.7	329	0.541	23.0	6.8	2.986	12.0	0.0	0.0	165	24	427	62	99.9	29.59	37	13	55	843	1549	83	181
61	3/10	4500	121.3	89.5	57.4	76.9	584	84.6	17	18935	41.7	331	0.543	23.0	6.8	2.986	12.0	0.0	0.0	165	24	427	62	99.9	29.59	37	13	55	844	1551	83	182
62	3/10	4500	120.7	89.0	56.9	76.3	578	83.9	17	18935	41.7	333	0.547	23.0	6.8	2.986	12.0	0.0	0.0	165	24	427	62	100.0	29.62	20	13	56	842	1548	84	183
63	3/11	4500	120.5	88.9	56.8	76.2	578	83.8	17	18935	41.7	333	0.548	24.1	7.1	3.359	13.5	0.0	0.0	165	24	427	62	100.3	29.70	34	14	57	844	1551	84	183
64	3/11	4500	121.2	89.4	57.1	76.6	581	84.3	17	18935	41.7	331	0.545	23.0	6.8	3.235	13.0	0.0	0.0	165	24	427	62	100.3	29.70	34	14	57	844	1551	83	182
65	3/11	4500	121.4	89.5	57.2	76.7	582	84.4	17	18935	41.7	331	0.544	23.7	7.0	3.135	12.6	0.0	0.0	165	24	427	62	100.3	29.70	34	16	60	843	1550	83	182
66	3/11	4500	121.2	89.4	57.1	76.6	581	84.3	17	18935	41.7	331	0.545	22.4	6.6	3.061	12.3	0.0	0.0	165	24	427	62	100.2	29.67	28	17	62	844	1552	83	181
67	3/11	4500	120.3	88.7	56.7	76.0	576	83.6	17	18935	41.7	334	0.549	23.0	6.8	3.111	12.5	0.0	0.0	165	24	427	62	100.2	29.67	28	15	59	843	1549	83	181
68	3/11	4500	120.5	88.9	56.8	76.2	578	83.8	17	18935	41.7	333	0.548	22.0	6.5	3.036	12.2	0.0	0.0	165	24	427	62	100.2	29.67	28	16	61	843	1550	83	182
69	3/11	4500	119.3	88.0	56.2	75.4	572	82.9	17	18935	41.7	337	0.554	23.4	6.9	3.061	12.3	0.0	0.0	165	24	427	62	100.2	29.67	28	18	64	843	1550	83	182
70	3/11	4500	119.9	88.4	56.5	75.7	574	83.3	17	18935	41.7	335	0.551	22.4	6.6	3.036	12.2	0.0	0.0	169	25	427	62	100.2	29.67	28	17	63	842	1548	83	182
71	3/11	4500	120.5	88.9	56.8	76.2	578	83.8	17	18935	41.7	333	0.548	23.0	6.8	2.986	12.0	0.0	0.0	169	25	427	62	100.2	29.67	30	17	63	843	1549	83	182
72	3/11	4500	120.3	88.7	56.7	76.0	576	83.6	17	18935	41.7	334	0.549	23.4	6.9	2.986	12.0	0.0	0.0	169	25	427	62	100.2	29.67	30	19	66	841	1546	83	182
73	3/11	4500	120.4	88.8	56.7	76.1	577	83.7	17	18935	41.7	334	0.549	22.0	6.5	2.862	11.5	0.0	0.0	169	25	427	62	100.2	29.67	30	18	65	843	1549	83	182
74	3/11	4500	121.1	89.3	57.1	76.5	580	84.2	17	18935	41.7	332	0.546	23.0	6.8	2.986	12.0	0.0	0.0	138	20	427	62	100.2	29.67	30	18	64	847	1557	83	182
75	3/11	4500	119.7	88.3	56.4	75.7	574	83.2	16	18361	40.5	325	0.535	23.4	6.9	2.961	11.9	0.0	0.0	138	20	427	62	100.2	29.67	30	19	66	843	1550	84	183
76	3/11	4500	120.3	88.7	56.7	76.0	576	83.6	17	18935	41.7	334	0.549	22.0	6.5	2.911	11.7	0.0	0.0	138	20	427	62	100.2	29.67	30	19	66	842	1548	84	183
77	3/14	4500	119.7	88.3	56.4	75.7	574	83.2	17	18935	41.7	336	0.552	22.4	6.6	2.538	10.2	0.0	0.0	172	25	427	62	99.8	29.55	27	12	53	862	1583	83	181
78	3/14	4500	119.9	88.4	56.5	75.7	574	83.3	17	18935	41.7	335	0.551	23.7	7.0	2.613	10.5	0.0	0.0	172	25	427	62	99.8	29.55	27	12	53	838	1541	83	182
79	3/14	4500	119.9	88.4	56.5	75.7	574	83.3	17	18935	41.7	335	0.551	22.0	6.5	2.687	10.8	0.0	0.0	172	25	427	62	99.8	29.55	27	15	59	843	1550	84	183
80	3/14	4500	119.9	88.4	56.5	75.7	574	83.3	17	18935	41.7	335	0.551	23.0	6.8	2.687	10.8	0.0	0.0	165	24	427	62	99.8	29.55	27	15	59	843	1549	84	183
81	3/14	4500	120.0	88.5	56.5	75.8	575	83.4	17	18935	41.7	335	0.551	23.0	6.8	2.613	10.5	0.0	0.0	165	24	427	62	99.8	29.55	27	15	59	843	1550	84	183
82	3/14	4500	119.6	88.2	56.4	75.6	573	83.1	16	18361	40.5	326	0.536	22.4	6.6	2.613	10.5	0.0	0.0	169	25	427	62	99.8	29.56	27	14	57	845	1553	84	183
83	3/14	4500	121.2	89.4	57.1	76.6	591	84.3	16	18361	40.5	321	0.529	22.4	6.6	2.613	10.5	0.0	0.0	172	25	427	62	99.8	29.56	27	15	59	842	1547	83	182

** DENSIFIED COATED ROTOR **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
41	84	184	103	217	118	245	16	28	104	220	138	281	108	227	144	292	103	218	165	329	102	215	159	318	102	216	136	276	99	211	141	285	28	83
42	84	184	103	218	118	245	15	27	105	221	139	283	108	227	143	290	102	216	164	328	102	216	161	321	104	219	136	276	99	211	141	285	28	83
43	84	184	103	218	118	245	15	27	104	220	139	283	109	229	145	293	102	216	165	329	102	215	161	321	103	218	137	278	99	210	141	285	28	82
44	86	186	103	217	118	245	16	28	104	220	139	283	108	227	146	295	103	217	164	328	102	215	161	321	103	218	136	277	99	210	140	284	27	81
45	86	186	103	217	118	245	16	28	104	220	139	282	109	228	146	294	103	217	166	330	102	215	160	320	103	217	137	279	101	213	141	286	28	82
46	86	186	103	218	119	246	16	28	106	222	141	285	109	229	146	295	104	219	167	332	103	218	161	322	104	219	138	280	101	213	142	288	21	69
47	-86	187	103	218	119	246	16	28	106	223	142	287	110	230	147	296	104	219	167	333	103	218	162	324	104	220	139	282	101	214	143	289	21	70
48	85	185	103	217	118	245	16	28	105	221	141	285	109	229	146	294	103	218	166	331	102	216	160	320	103	217	137	278	99	211	141	286	24	75
49	85	185	103	217	118	245	16	28	105	221	141	285	109	229	146	295	104	219	167	333	103	217	161	322	103	218	137	279	100	212	142	287	25	77
50	86	186	103	218	119	246	16	28	106	222	142	287	110	230	147	296	104	220	168	335	103	218	161	321	104	219	138	280	101	213	142	288	25	77
51	86	186	103	217	118	245	16	28	105	221	141	285	109	228	146	294	104	219	169	336	103	218	165	329	104	219	138	280	101	213	142	288	24	75
52	85	185	102	216	118	244	16	28	104	220	140	284	109	228	146	294	103	217	167	333	102	216	164	328	103	218	138	280	100	212	142	287	25	77
53	85	185	103	217	119	246	16	29	105	221	141	285	109	229	146	294	103	218	167	333	103	217	164	327	104	219	138	280	101	213	142	288	25	77
54	86	186	103	218	119	246	16	28	105	221	141	285	109	229	146	295	104	219	168	334	103	219	165	329	104	219	138	281	101	213	142	289	26	78
55	86	186	103	217	118	245	16	28	105	221	141	286	109	229	146	295	103	218	168	334	103	217	164	327	104	219	138	280	101	213	142	288	24	76
56	86	186	103	218	119	246	16	28	106	222	142	287	110	230	147	297	104	219	169	337	103	218	164	328	104	220	139	282	101	214	143	290	24	76
57	86	186	103	218	119	246	16	28	106	223	142	288	110	230	147	297	104	220	169	337	103	218	164	328	104	220	139	282	101	214	143	290	25	77
58	86	186	103	218	119	246	16	28	106	222	141	286	109	229	147	296	104	219	169	336	103	218	165	329	104	220	139	282	101	214	143	290	26	78
59	86	187	103	218	119	247	16	29	106	223	142	288	110	230	147	297	104	219	169	337	104	219	164	327	104	220	139	282	101	214	143	290	26	78
60	84	184	102	216	118	245	16	29	105	221	141	285	109	228	146	295	103	217	168	335	102	216	163	326	103	218	138	280	100	212	142	289	27	80
61	85	125	102	216	118	245	16	29	105	221	141	286	109	229	147	296	103	218	169	336	103	217	163	326	104	219	138	281	101	213	142	288	27	80
62	86	186	103	218	119	246	16	29	106	222	142	287	109	229	146	295	104	219	168	334	103	218	163	325	104	219	139	282	101	214	143	289	27	30
63	86	186	103	217	119	246	15	29	106	222	142	287	110	230	147	297	104	219	170	338	104	219	166	331	104	220	139	283	101	214	143	289	28	83
64	85	185	103	217	119	245	16	29	106	222	142	287	110	230	147	297	104	219	170	338	103	218	167	333	104	220	140	284	101	214	143	290	30	86
65	85	185	103	217	119	246	16	29	106	222	142	288	110	230	147	296	104	219	170	338	103	218	166	330	104	220	140	284	101	214	143	290	32	90
66	84	184	103	217	119	246	16	29	106	222	142	288	110	230	147	297	104	219	169	337	103	217	164	328	103	218	138	281	100	212	142	288	31	88
67	84	184	103	217	119	246	16	29	105	221	141	286	109	229	147	296	103	218	169	337	103	217	165	329	103	218	138	281	100	212	142	288	31	88
68	85	185	103	217	119	246	16	29	106	222	142	288	110	230	147	297	104	219	170	338	103	217	164	327	103	218	138	281	101	213	142	288	33	91
69	85	185	103	218	119	246	16	28	106	222	142	287	110	230	147	297	104	219	170	338	103	217	163	326	103	218	138	281	101	213	142	288	33	91
70	85	185	103	218	119	247	16	29	106	223	142	288	110	230	147	297	104	220	171	339	103	218	163	326	104	219	138	280	101	213	142	288	33	91
71	85	185	103	217	119	246	16	29	106	223	142	287	110	230	147	297	104	219	169	337	103	217	163	326	103	218	138	281	100	212	142	287	32	90
72	85	185	103	218	119	246	16	28	106	223	142	288	110	230	147	297	104	219	169	337	103	218	163	325	103	218	138	281	101	213	142	288	33	92
73	85	185	103	218	119	246	16	28	106	223	142	288	110	230	147	297	104	219	170	338	103	218	163	326	103	218	138	281	101	213	142	288	34	93
74	85	185	103	217	119	246	16	29	106	223	143	289	111	231	148	299	104	220	171	340	104	219	164	328	104	219	139	292	101	213	142	288	34	93
75	85	185	103	217	118	245	16	28	106	223	142	288	111	231	148	299	104	219	171	339	104	219	163	325	103	218	137	279	100	212	142	287	36	96
76	86	186	103	218	119	246	16	28	107	224	143	289	111	231	147	297	104	220	170	338	104	219	164	327	104	219	138	281	101	213	142	288	36	97
77	84	183	103	217	119	245	16	28	106	222	143	289	111	231	148	299	104	219	170	338	103	218	168	334	103	218	138	281	100	212	142	287	31	87
78	85	185	103	217	119	246	16	29	106	223	143	290	111	231	148	299	104	219	169	337	103	219	166	330	103	218	139	282	100	212	142	288	26	78
79	86	186	103	218	119	246	16	28	107	224	144	291	111	232	149	300	104	220	169	336	104	219	166	331	104	220	140	284	101	214	144	291	21	70
80	86	186	103	217	119	246	16	29	107	224	143	290	111	231	149	300	104	219	171	339	103	218	165	329	104	220	140	284	101	213	143	290	31	88
81	85	185	103	217	118	245	16	28	106	223	143	290	111	232	149	300	104	219	170	338	103	218	165	329	104	219	139	283	101	213	143	289	31	88
82	85	185	103	217	118	245	16	28	106	223	143	289	111	231	147	297	103	218	169	336	103	218	166	330	104	219	139	283	101	213	143	290	30	86
83	85	185	103	217	118	245	16	28	106	223	143	289	111	231	148	299	103	218	169	337	103	218	166	330	104	219	139	282	100	212	143	289	31	87

** DENSIFIED COATED ROTOR **

Point	Date	RPM	Torque (Nm)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
120	3/18	3000	43.0	31.7	13.5	18.1	206	29.9	6	6886	15.2	510	0.838	51.5	15.2	0.000	NA	0.0	0.0	103	15	414	60	100.5	29.76	37	-2	29	674	1245	81	178
117	3/18	3000	80.1	59.1	25.2	33.8	384	55.7	8	9181	20.2	365	0.600	33.2	9.8	0.000	NA	0.0	0.0	107	16	427	62	100.9	29.88	35	3	38	763	1405	82	180
88	3/15	3000	38.4	28.3	12.1	16.2	184	26.7	6	6886	15.2	571	0.939	50.8	15.0	0.050	0.2	0.0	0.0	103	15	434	63	100.3	29.70	22	2	35	704	1299	81	178
87	3/15	3000	41.4	30.5	13.0	17.4	198	28.7	NA	NA	NA	NA	NA	50.8	15.0	0.249	1.0	0.0	0.0	100	15	434	63	100.3	29.70	22	1	33	689	1272	81	177
92	3/15	3500	89.8	66.2	32.9	44.1	430	62.4	10	11476	25.3	349	0.573	32.9	9.7	1.120	4.5	0.0	0.0	114	17	434	63	100.4	29.73	18	4	40	773	1424	83	181
102	3/16	3500	42.6	31.4	15.6	20.9	204	29.6	7	8033	17.7	515	0.846	53.5	15.8	0.647	2.6	0.0	0.0	110	16	441	64	101.2	29.96	27	2	36	707	1304	83	182
115	3/18	3500	57.6	42.5	21.1	28.3	276	40.1	NA	NA	NA	NA	NA	45.7	13.5	0.075	0.3	0.0	0.0	124	18	427	62	100.9	29.88	35	-4	24	716	1320	82	180
91	3/15	3500	42.2	31.1	15.5	20.7	202	29.3	6	6886	15.2	446	0.732	52.2	15.4	0.647	2.6	0.0	0.0	121	18	441	64	100.4	29.73	18	1	34	704	1300	82	179
103	3/17	3500	41.5	30.6	15.2	20.4	199	[illegible]	NA	NA	NA	NA	NA	52.5	15.5	0.373	1.5	0.0	0.0	159	23	427	62	101.4	30.03	29	-3	26	693	1280	36	96
93	3/15	3500	89.1	65.7	32.6	43.8	427	61.9	10	11476	25.3	351	0.578	33.2	9.8	1.120	4.5	0.0	0.0	114	17	434	63	100.4	29.73	18	5	41	769	1416	82	180
119	3/18	4000	94.2	69.5	39.5	52.9	452	65.5	12	13771	30.4	349	0.574	34.2	10.1	1.170	4.7	0.0	0.0	131	19	427	62	100.9	29.88	35	6	42	797	1466	83	181
123	3/18	4000	118.0	87.0	49.4	66.3	565	82.0	14	16066	35.4	325	0.535	22.7	6.7	1.617	7.3	0.0	0.0	134	20	427	62	100.5	29.76	32	13	56	822	1512	83	181
122	3/18	4000	118.7	87.5	49.7	66.6	569	82.5	14	16066	35.4	323	0.532	23.0	6.8	1.391	7.6	0.0	0.0	131	19	427	62	100.5	29.76	32	13	55	824	1516	82	180
124	3/18	4000	119.2	87.9	49.9	66.9	571	82.8	14	16066	35.4	322	0.529	23.0	6.8	1.866	7.5	0.0	0.0	138	20	427	62	100.5	29.76	32	12	54	822	1512	83	182
118	3/18	4000	46.1	34.0	19.3	25.9	221	32.0	8	9181	20.2	475	0.782	51.5	15.2	0.423	1.7	0.0	0.0	138	20	434	63	100.9	29.88	35	-3	27	734	1353	83	182
121	3/18	4000	46.0	33.9	19.3	25.8	220	32.0	8	9181	20.2	477	0.784	51.5	15.2	0.299	1.2	0.0	0.0	141	21	434	63	100.5	29.76	37	-2	29	748	1379	82	180
104	3/17	4500	120.1	88.6	56.6	75.9	576	83.5	17	18935	41.7	334	0.550	23.7	7.0	2.737	11.0	0.0	0.0	159	23	427	62	101.4	30.03	29	11	52	849	1560	82	180
113	3/17	4500	120.5	88.9	56.8	[illegible]	578	83.8	17	18935	41.7	333	0.548	21.3	6.3	2.737	11.0	0.0	0.0	172	25	427	62	101.3	29.99	25	21	70	843	1549	84	184
101	3/16	4500	121.8	[illegible]	[illegible]	[illegible]	584	84.6	17	18935	41.7	330	0.543	22.0	6.5	3.061	12.3	0.0	0.0	138	20	427	62	101.2	29.96	27	20	68	838	1541	84	183
114	3/17	4500	120.7	89.0	56.9	76.3	578	83.9	17	18935	41.7	333	0.547	22.7	6.7	2.712	10.9	0.0	0.0	172	25	427	62	101.2	29.96	25	20	68	842	1548	84	184
99	3/16	4500	122.0	90.0	57.5	77.1	585	84.8	17	18935	41.7	329	0.541	23.4	6.9	3.185	12.8	0.0	0.0	134	20	427	62	101.2	29.96	26	21	69	843	1549	84	184
98	3/16	4500	121.2	89.4	57.1	76.6	581	84.3	17	18935	41.7	331	0.545	23.4	6.9	3.160	12.7	0.0	0.0	138	20	427	62	101.2	29.96	26	20	68	844	1551	84	184
105	3/17	4500	119.9	88.4	56.5	75.7	574	83.3	16	18361	40.5	325	0.534	23.7	7.0	2.787	11.2	0.0	0.0	159	23	427	62	101.4	30.03	29	19	66	847	1557	84	183
116	3/18	4500	120.0	88.5	56.5	75.8	575	83.4	17	18935	41.7	335	0.551	23.7	7.0	2.488	10.0	0.0	0.0	165	24	427	62	100.9	29.88	35	11	52	841	1545	83	182
107	3/17	4500	122.2	90.1	57.6	77.2	585	84.9	17	18935	41.7	329	0.541	21.3	6.3	2.862	11.5	0.0	0.0	159	23	427	62	101.4	30.03	29	17	63	854	1569	83	181
97	3/16	4500	54.5	40.2	25.7	34.4	261	37.9	10	11476	25.3	447	0.735	47.8	14.1	0.747	3.0	0.0	0.0	145	21	434	63	101.0	29.90	26	4	40	766	1410	83	182
109	3/17	4500	121.4	89.5	57.2	76.7	582	84.4	17	18935	41.7	331	0.544	21.7	6.4	2.862	11.5	0.0	0.0	162	24	427	62	101.4	30.03	16	19	66	848	1558	83	181
96	3/16	4500	121.1	89.3	57.1	76.5	580	84.2	17	18935	41.7	332	0.546	23.4	6.9	3.135	12.6	0.0	0.0	141	21	427	62	101.0	29.90	26	19	67	842	1548	84	184
111	3/17	4500	121.0	89.2	57.0	76.4	580	84.1	17	18935	41.7	332	0.546	22.7	6.7	2.737	11.0	0.0	0.0	169	25	427	62	101.4	30.03	16	19	67	842	1548	84	183
95	3/16	4500	119.6	88.2	56.4	75.6	573	83.1	17	18935	41.7	336	0.552	23.7	7.0	3.061	12.3	0.0	0.0	145	21	427	62	101.0	29.90	26	18	65	841	1545	84	183
100	3/16	4500	121.9	89.9	57.4	77.0	584	84.7	17	18935	41.7	330	0.542	23.0	6.8	3.061	12.3	0.0	0.0	134	20	427	62	101.2	29.96	26	19	67	841	1546	84	184
94	3/16	4500	120.3	88.7	56.7	76.0	576	83.6	17	18935	41.7	334	0.549	24.4	7.2	3.061	12.3	0.0	0.0	138	20	427	62	101.0	29.90	26	14	57	839	1543	83	182
106	3/17	4500	120.5	88.9	56.8	76.2	578	83.8	17	18935	41.7	333	0.548	22.0	6.5	2.812	11.3	0.0	0.0	159	23	427	62	101.4	30.03	29	22	72	848	1558	84	183
90	3/15	4500	121.0	89.2	57.0	76.4	580	84.1	17	18935	41.7	332	0.546	22.0	6.5	2.936	11.8	0.0	0.0	159	23	427	62	100.4	29.73	26	16	61	833	1532	84	183
110	3/17	4500	121.1	89.3	57.1	76.5	580	84.2	17	18935	41.7	332	0.546	21.3	6.3	2.737	11.0	0.0	0.0	165	24	427	62	101.4	30.03	16	19	67	843	1549	84	183
89	3/15	45[illegible]	[illegible]	89.1	56.9	76.3	579	84.0	17	18935	41.7	333	0.547	24.1	7.1	3.061	12.3	0.0	0.0	152	22	427	62	100.4	29.73	26	14	57	834	1533	83	182
84	3/14	4500	120.0	88.5	55.5	75.3	575	83.4	16	18361	40.5	325	0.534	23.7	7.0	2.613	10.5	0.0	0.0	172	25	427	62	99.8	29.56	27	13	56	842	1547	83	182
112	3/17	4500	120.3	88.7	56.7	76.0	576	83.6	17	18935	41.7	334	0.549	22.0	6.5	2.737	11.0	0.0	0.0	172	25	427	62	135.0	39.99	28	22	71	836	1541	84	183
108	3/17	4500	121.2	89.4	57.1	76.6	581	84.3	17	18935	41.7	331	0.545	21.3	6.3	2.862	11.5	0.0	0.0	159	23	427	62	101.4	30.03	29	19	67	846	1558	83	181
86	3/14	4500	122.0	90.0	57.5	77.1	585	84.8	16	18361	40.5	319	0.525	23.0	6.8	2.538	10.2	0.0	0.0	162	24	427	62	99.9	29.57	20	17	62	839	1543	83	181
85	3/14	4500	120.3	88.7	56.7	76.0	576	83.6	16	18361	40.5	324	0.533	22.0	6.5	2.513	10.1	0.0	0.0	172	25	427	62	99.8	29.56	20	17	62	840	1544	83	182

** DENSIFIED COATED ROTOR **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
120	83	182	98	209	105	221	7	12	90	194	106	223	92	197	108	227	92	198	129	264	93	200	126	259	90	194	108	227	88	191	108	227	26	79
117	84	184	103	217	112	233	9	16	93	200	116	241	96	205	119	246	95	203	143	290	97	207	142	287	94	202	119	246	92	198	119	247	25	77
88	83	182	102	216	108	227	6	11	89	193	106	222	91	196	108	226	92	198	127	260	92	198	119	246	88	190	106	223	88	190	107	225	30	86
87	83	181	102	215	108	226	6	11	89	192	106	222	91	195	107	225	92	198	127	261	93	199	126	258	89	193	107	225	88	190	108	226	27	80
92	84	184	102	216	113	235	11	19	97	207	123	254	100	212	127	261	98	208	154	310	98	209	148	298	97	206	124	255	94	202	125	257	36	96
102	85	185	102	216	109	229	7	13	93	200	112	233	96	204	114	237	96	204	136	276	96	205	130	266	92	198	111	232	89	192	113	235	33	92
115	87	188	100	212	109	228	9	16	93	200	115	239	96	204	117	243	95	203	139	283	97	206	136	276	93	200	115	239	91	196	116	241	24	75
91	83	182	102	215	108	227	7	12	91	196	110	230	93	200	112	233	94	201	133	272	94	202	128	263	91	196	110	230	89	193	111	231	33	92
103	83	182	102	216	108	227	6	11	91	196	108	226	93	199	110	230	93	200	131	268	94	201	126	259	91	195	108	227	89	192	109	228	38	101
93	84	184	103	217	113	235	10	18	97	207	123	253	100	212	127	261	97	207	155	311	98	209	147	296	96	205	122	252	94	201	124	256	33	92
119	85	185	103	217	115	237	12	22	100	212	130	266	104	219	134	274	100	212	159	318	100	212	156	313	99	211	129	264	97	206	131	268	28	83
123	84	184	102	216	116	241	14	25	103	217	137	278	107	224	142	288	102	215	169	337	101	214	164	327	102	215	135	275	98	209	138	280	32	89
122	84	184	102	216	116	241	14	25	102	216	136	277	106	223	141	286	101	214	168	334	101	214	164	327	101	214	134	274	98	208	137	279	33	91
124	86	186	102	216	116	241	14	25	103	218	137	278	107	225	142	288	102	215	169	337	102	215	164	328	102	216	136	276	99	210	138	281	30	86
118	85	185	103	218	111	232	8	14	94	202	116	240	97	206	118	244	97	206	140	284	97	207	136	276	94	201	114	238	92	198	117	242	27	81
121	84	183	102	215	111	231	9	16	94	202	116	240	96	205	118	244	96	204	141	285	97	206	135	275	93	199	113	236	91	196	116	240	28	82
104	84	183	101	214	117	243	16	29	105	221	143	289	110	230	149	301	103	218	173	344	103	218	169	336	103	218	140	284	101	213	143	290	NA	NA
113	86	186	103	218	119	247	16	29	108	226	145	293	113	235	152	305	106	223	175	347	105	221	172	342	106	222	142	288	102	216	146	294	46	115
101	86	187	103	217	119	246	16	29	107	224	144	291	112	234	151	303	104	220	174	346	105	221	166	334	105	221	141	286	102	215	146	294	37	98
114	86	187	103	217	119	246	16	29	108	226	145	293	113	235	152	306	106	223	176	349	105	221	172	342	106	222	142	298	102	216	146	294	44	112
99	86	187	103	217	119	246	16	29	107	225	144	291	112	234	151	304	106	222	177	350	106	222	169	336	104	220	142	287	102	216	146	295	37	99
98	86	187	103	217	119	746	16	29	107	225	144	292	112	234	151	303	105	221	176	349	106	222	169	337	106	223	142	287	102	216	146	295	37	99
105	86	186	103	217	119	246	16	29	107	225	146	294	112	234	152	306	105	221	174	346	104	220	171	339	105	221	142	287	102	215	144	292	39	103
116	85	185	102	216	117	242	14	26	106	223	144	291	111	232	150	302	104	219	173	343	104	219	171	339	104	220	141	286	101	214	144	292	48	119
107	84	184	102	216	118	245	16	29	107	224	144	291	112	233	151	303	104	219	172	342	104	219	171	339	104	220	141	286	101	213	145	293	37	99
97	86	186	102	216	113	235	11	19	98	208	122	252	101	213	126	259	99	210	151	303	99	211	143	290	97	206	121	249	94	202	124	255	39	103
109	84	184	102	216	118	245	16	29	106	223	144	291	111	232	151	303	104	219	172	342	103	218	170	338	104	219	141	286	101	213	144	292	44	111
96	86	187	104	219	119	247	16	28	108	226	145	293	113	235	152	305	105	221	175	347	105	221	168	335	106	222	141	286	102	216	146	294	41	105
111	86	186	103	217	119	246	16	29	107	225	145	293	112	234	152	305	106	222	174	346	104	220	173	343	105	221	142	287	102	215	145	293	43	110
95	86	186	103	218	119	246	16	28	107	224	143	290	112	233	150	302	104	220	174	346	104	220	169	336	105	221	141	285	102	215	145	293	36	97
100	86	187	103	217	119	246	16	29	108	226	144	292	112	234	152	305	105	221	177	351	106	222	169	337	105	221	141	286	102	216	146	295	38	101
94	85	185	103	217	118	245	16	28	106	222	143	289	111	232	150	302	104	219	174	345	104	219	168	334	104	220	140	284	101	214	144	291	31	87
106	86	186	102	216	119	246	17	30	108	226	146	294	112	234	151	304	105	221	172	342	104	220	171	340	105	221	142	287	102	215	146	294	44	111
90	86	186	103	218	119	246	16	28	107	224	143	290	111	232	150	302	104	219	172	342	104	219	168	334	104	220	141	285	102	215	144	292	36	96
110	86	186	103	217	119	246	16	29	107	225	144	291	112	234	151	304	106	222	173	344	104	220	171	340	105	221	142	287	102	215	145	293	42	107
89	86	186	103	217	118	245	16	28	106	222	143	290	111	231	149	301	104	219	172	342	103	218	168	334	104	220	140	284	101	214	144	291	30	86
84	84	194	103	217	118	245	16	28	106	222	142	287	110	230	148	298	103	218	171	339	103	218	166	331	103	218	139	282	101	213	143	289	28	82
112	86	186	103	217	119	246	16	29	108	226	145	293	112	234	152	305	106	222	174	346	104	220	172	341	105	221	142	287	102	215	146	294	47	116
108	84	184	102	216	118	245	16	29	107	224	144	291	111	232	151	304	104	219	172	342	104	219	171	339	104	219	141	285	101	213	144	292	39	103
86	84	184	102	216	118	245	16	29	106	222	143	290	111	231	148	299	103	218	171	340	103	218	167	332	104	219	140	284	101	213	143	290	31	88
85	85	185	103	217	118	245	16	28	106	222	142	288	110	230	148	298	103	218	171	340	103	218	167	332	104	219	139	282	101	213	143	289	30	86

** DENSIFIED COATED ROTOR **

Point	Date	RPM	Torque (N*m)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
131	3/21	3000	93.6	69.0	29.4	39.4	448	65.0	12	13771	30.4	469	0.770	35.2	10.4	0.050	0.2	0.0	0.0	134	20	427	62	100.9	29.89	26	6	43	787	1448	82	180
126	3/18	3000	45.4	33.5	14.3	19.1	218	31.6	6	6886	15.2	483	0.793	50.8	15.0	0.498	2.0	0.0	0.0	110	16	427	62	100.6	29.79	32	-1	30	657	1214	82	180
132	3/21	3000	46.2	34.1	14.5	19.5	222	32.1	7	8033	17.7	553	0.909	51.2	15.1	0.000	NA	0.0	0.0	110	16	427	62	100.9	29.89	26	0	32	671	1239	82	180
129	3/21	3500	42.6	31.4	15.6	20.9	204	29.6	6	6886	15.2	441	0.725	53.2	15.7	0.050	0.2	0.0	0.0	131	19	434	63	100.9	29.89	26	-1	30	709	1309	82	180
128	3/21	3500	42.3	31.2	15.5	20.8	203	29.4	6	6886	15.2	444	0.730	52.9	15.6	0.398	1.6	0.0	0.0	128	19	434	63	100.9	29.89	26	-3	27	714	1317	82	179
127	3/21	3500	42.7	31.5	15.7	21.0	205	29.7	6	6886	15.2	440	0.723	52.5	15.5	0.423	1.7	0.0	0.0	117	17	427	62	100.9	29.89	26	-6	22	713	1315	81	177
125	3/18	4000	46.9	34.6	19.7	26.4	225	32.6	9	10328	22.8	526	0.864	51.2	15.1	0.498	2.0	0.0	0.0	145	21	427	62	100.6	29.79	32	-1	30	731	1348	83	182
134	3/21	4000	93.6	69.0	39.2	52.6	448	65.0	12	13771	30.4	351	0.578	34.6	10.2	0.796	3.2	0.0	0.0	138	20	427	62	101.2	29.96	31	6	42	788	1450	83	182
133	3/21	4000	46.2	34.1	19.4	26.0	222	32.1	7	8033	17.7	415	0.682	51.5	15.2	0.846	3.4	0.0	0.0	110	16	427	62	100.9	29.89	26	-1	31	665	1229	82	180
130	3/21	4000	44.2	32.6	18.5	24.8	212	30.7	8	9181	20.2	496	0.815	53.2	15.7	0.871	3.5	0.0	0.0	145	21	434	63	100.9	29.69	26	0	32	725	1337	82	180
135	3/21	4000	93.6	69.0	39.2	52.6	448	65.0	12	13771	30.4	351	0.578	34.9	10.3	0.060	NA	0.0	0.0	138	20	427	62	101.2	29.76	31	7	44	764	1444	63	182
136	3/21	4000	46.9	34.6	19.7	26.4	225	32.6	8	9181	20.2	467	0.768	52.5	15.5	0.050	0.2	0.0	0.0	145	21	427	62	101.2	29.96	36	1	34	724	1336	83	182

ORIGINAL PAGE IS OF POOR QUALITY

** DENSIFIED COATED ROTOR **

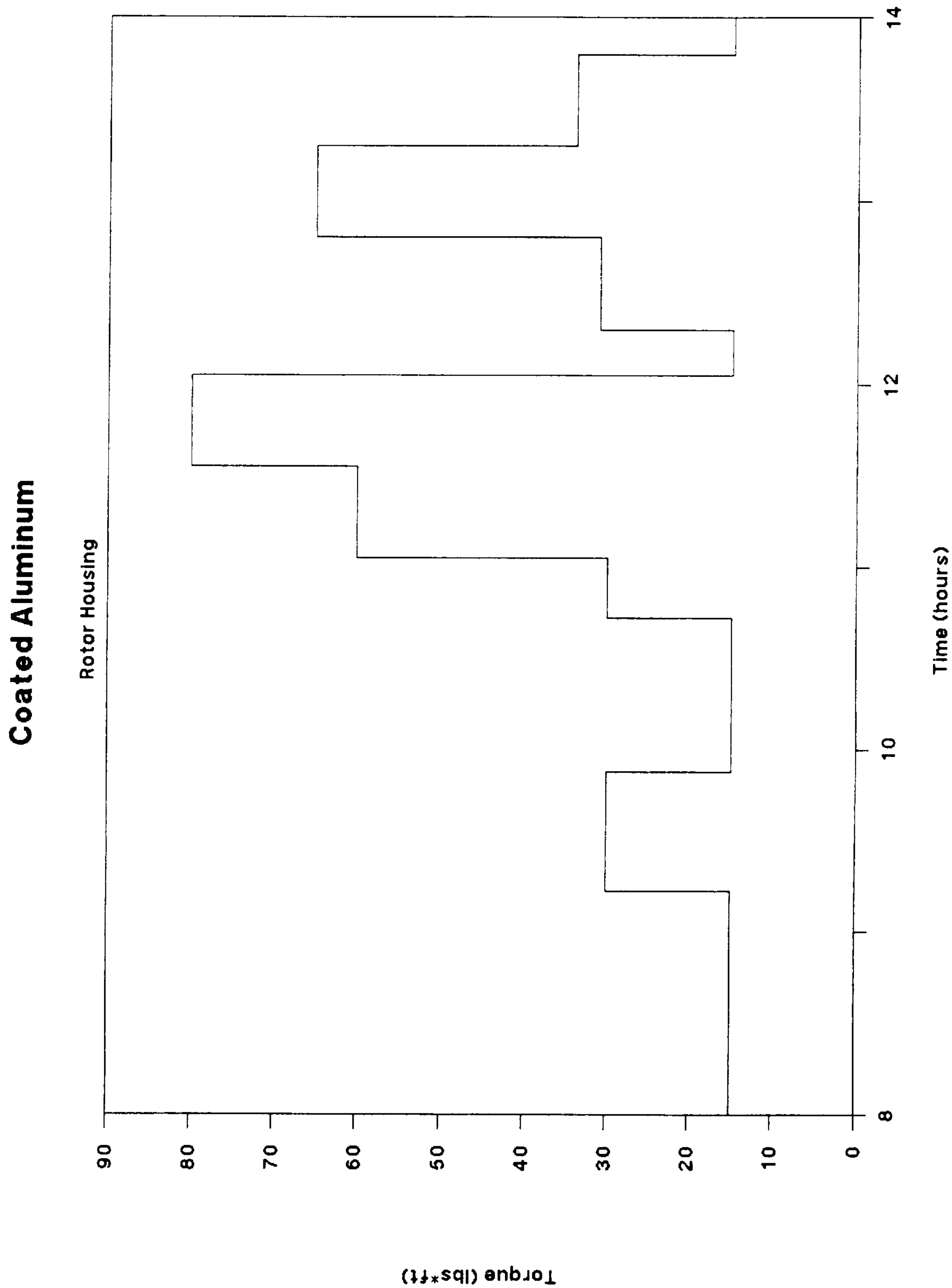
Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing								Intermediate Housing								Front Rotor Housing								Air Temp (C)	Air Temp (F)
									#2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	#6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	#10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)		
131	84	184	104	220	116	241	12	21	101	213	132	269	104	219	136	277	100	212	161	321	100	212	156	313	99	210	129	265	96	205	132	269	32	90
126	84	183	100	212	107	225	7	13	91	196	108	227	93	200	111	232	93	199	132	269	94	201	128	262	91	196	109	229	89	193	109	229	27	81
132	84	183	104	219	110	230	6	11	92	197	109	229	93	200	112	234	93	200	133	271	94	202	130	266	91	196	111	231	89	193	111	231	29	85
129	84	183	102	216	109	228	7	12	92	198	112	233	94	201	114	237	94	202	136	277	95	203	131	268	92	197	111	232	90	194	112	234	25	77
128	83	182	102	215	109	228	7	13	92	197	111	232	93	200	113	236	94	201	136	277	95	203	131	267	91	196	111	231	89	193	112	233	27	80
127	83	181	101	213	108	226	7	13	91	195	110	230	93	199	112	234	93	200	134	274	94	202	129	265	91	195	110	230	89	192	111	231	23	74
125	85	185	102	215	111	231	9	16	94	202	116	241	97	206	118	245	96	205	141	286	97	207	136	276	94	201	115	239	92	198	117	242	29	84
134	85	185	104	219	116	240	12	21	101	214	132	270	104	220	136	276	101	213	162	323	101	213	158	316	100	212	131	267	97	207	133	271	33	91
133	84	184	104	219	110	230	6	11	92	197	109	229	93	200	112	234	94	201	133	272	94	202	130	266	91	196	111	231	90	194	111	231	28	83
130	84	183	103	217	111	232	8	15	94	201	116	241	96	205	118	245	96	205	141	285	97	206	136	276	93	199	114	238	91	196	116	240	31	88
135	86	186	104	219	117	242	13	23	101	214	133	271	105	221	137	279	101	214	164	327	101	214	158	317	100	212	131	268	98	208	133	272	32	89
136	84	184	102	215	111	231	9	16	96	204	118	244	97	207	120	248	97	206	143	289	97	207	137	278	94	201	116	240	92	198	117	243	35	95

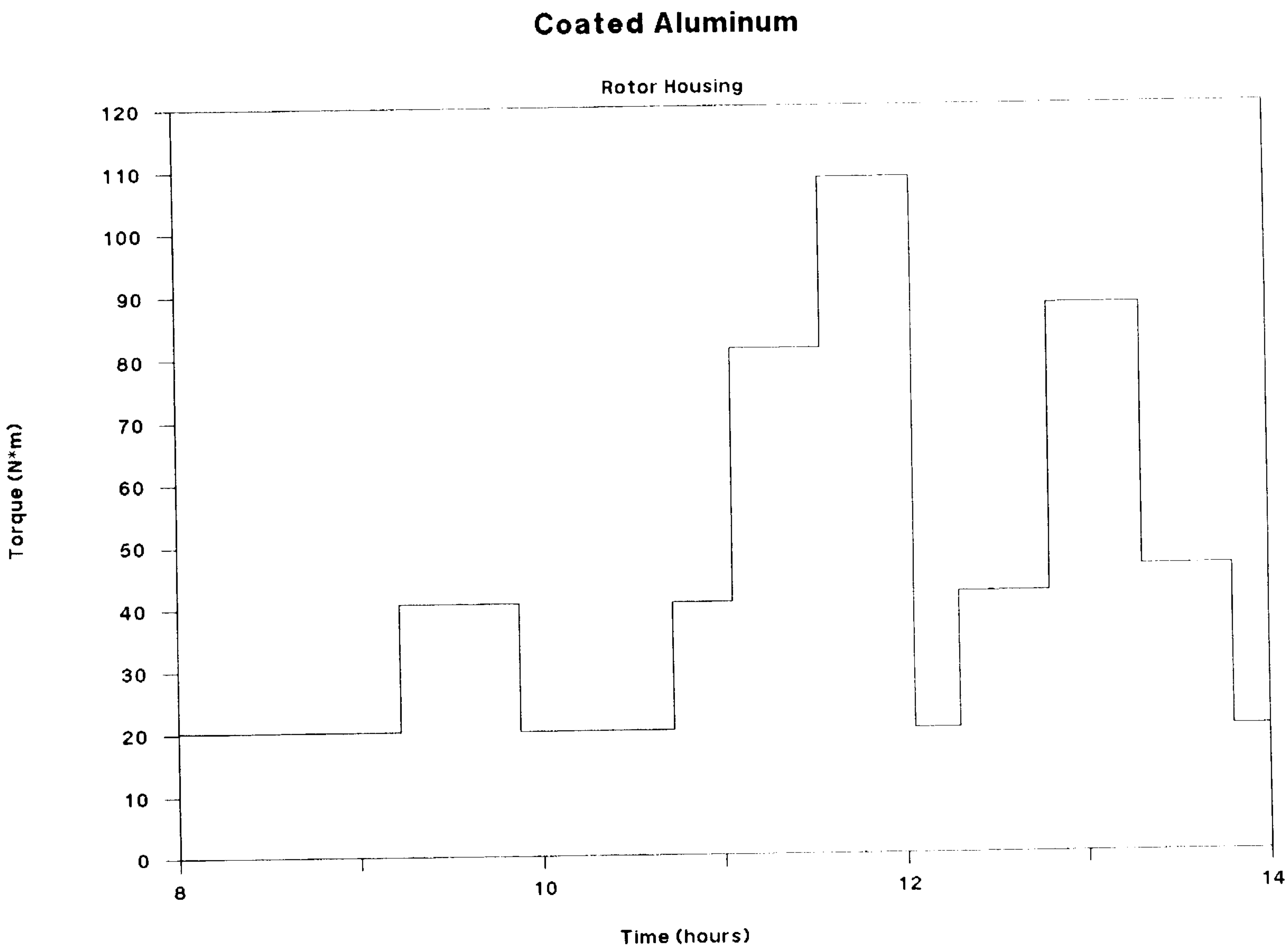
APPENDIX H

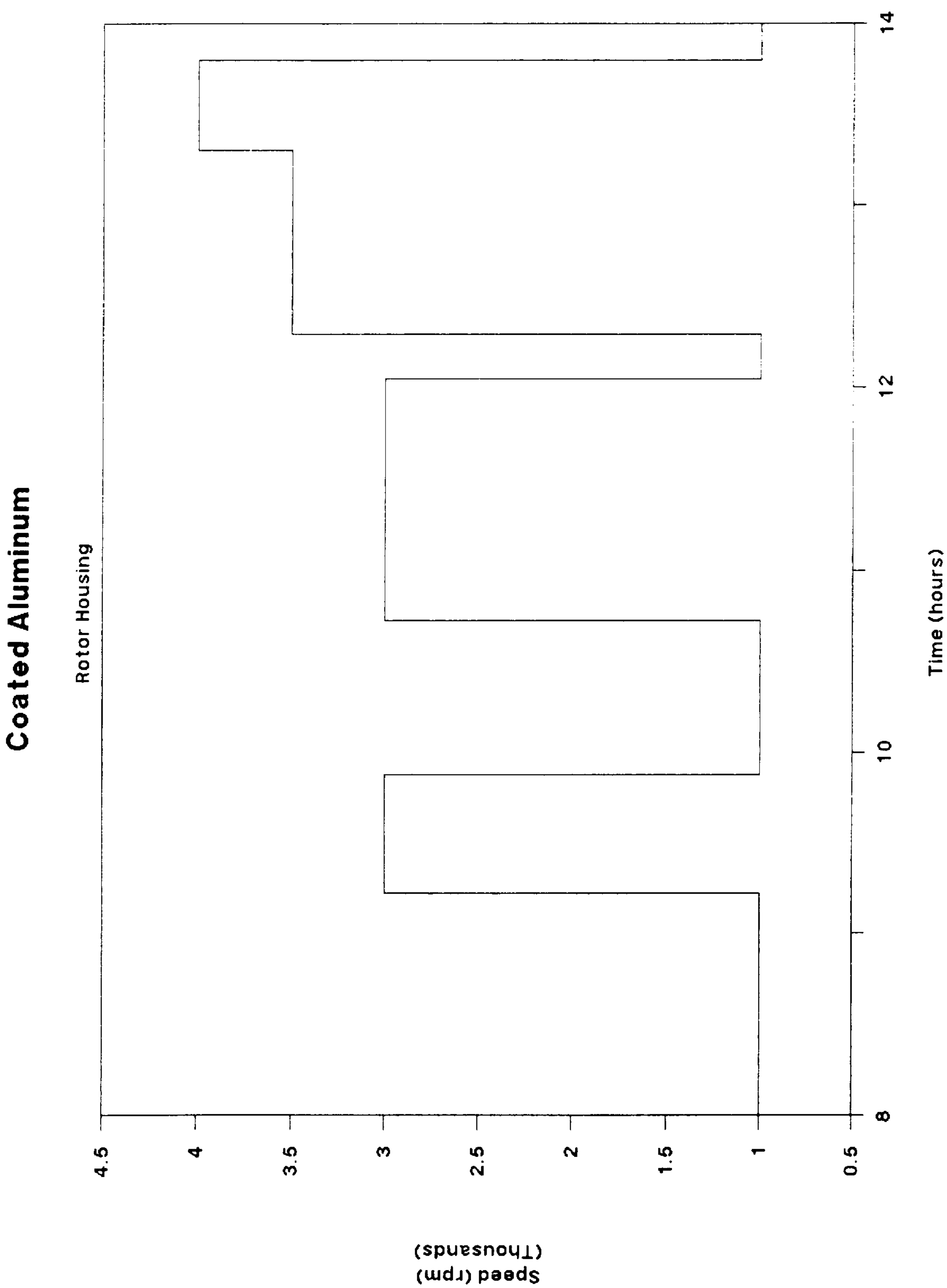
COATED ALUMINUM ROTOR HOUSING DATA

COATED ALUMINUM ROTOR HOUSING DATA

TABLE OF CONTENTS


Coated Aluminum
Rotor Housing
Torque (lbs*ft)
0
10
20
30
40
50
60
70
80
90
Time (hours)
8
10
12
14


Coated Aluminum
Rotor Housing
Torque (N*m)
120
110
100
90
80
70
60
50
40
30
20
10
0
8
10
12
14
Time (hours)


Coated Aluminum
Rotor Housing
Speed (rpm)
(Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
8
10
12
14
Time (hours)

** COATED ALUMINUM ROTOR HOUSING **

Point	Date	RPM	Torque (N*m)	Torque (lbf*ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kwh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
1	6/13	3000	40.7	30.0	12.8	17.1	195	28.3	8	9181	20.2	718.4	1.181	42.7	12.6	0.000	0.0	0	0	79	12	427	62	101.2	29.96	52	7	44	631	1167	82	179
2	6/13	3000	40.7	30.0	12.8	17.1	195	28.3	8	9181	20.2	718.4	1.181	43.4	12.8	0.249	1.0	0	0	79	12	427	62	101.2	29.96	53	8	46	630	1166	82	179
3	6/13	3000	42.8	31.6	13.5	18.1	205	29.8	8	9181	20.2	682.1	1.121	43.7	12.9	0.149	0.6	0	0	79	12	427	62	101.2	29.96	53	7	44	633	1172	82	179
4	6/13	3003	41.0	30.2	12.9	17.3	196	28.5	8	9181	20.2	713.0	1.172	45.4	13.4	0.075	0.3	0	0	69	10	427	62	101.2	29.96	40	6	43	621	1150	82	180
5	6/13	3003	40.4	29.8	12.7	17.0	194	28.1	8	9181	20.2	722.5	1.188	46.1	13.6	0.025	0.1	0	0	69	10	427	62	101.2	29.96	40	7	45	625	1157	82	180
6	6/13	3003	81.6	60.2	25.7	34.4	391	56.7	10	11476	25.3	447.1	0.735	24.4	7.2	0.100	0.4	0	0	62	9	427	62	101.2	29.96	40	12	54	728	1343	81	178
7	6/13	3003	82.2	60.6	25.8	34.7	394	57.1	10	11476	25.3	444.1	0.730	24.4	7.2	0.348	1.4	0	0	62	9	427	62	101.2	29.96	40	13	55	712	1313	81	177
8	6/13	3003	107.8	79.5	33.9	45.5	517	74.9	12	13771	30.4	406.3	0.668	13.6	4.0	0.871	3.5	0	0	62	9	421	61	101.2	29.96	40	26	78	738	1361	82	179
9	6/13	3002	108.8	80.2	34.2	45.8	521	75.6	12	13771	30.4	402.8	0.662	13.6	4.0	0.871	3.5	0	0	62	9	421	61	101.2	29.96	40	25	77	746	1374	81	178
10	6/13	3503	42.4	31.3	15.6	20.9	203	29.5	10	11476	25.3	737.2	1.212	44.7	13.2	0.547	2.2	0	0	103	15	441	64	101.2	29.96	40	8	46	659	1219	81	178
11	6/13	3503	42.6	31.4	15.6	20.9	204	29.6	10	11476	25.3	734.3	1.208	44.7	13.2	0.547	2.2	0	0	97	14	427	62	101.2	29.96	40	7	44	661	1222	82	180
12	6/13	3503	88.1	65.0	32.3	43.4	422	61.3	12	13771	30.4	426.0	0.700	22.7	6.7	1.145	4.6	0	0	90	13	427	62	101.2	29.96	40	20	68	736	1356	82	180
13	6/13	3503	89.2	65.8	32.7	43.9	428	62.0	12	13771	30.4	420.3	0.692	22.4	6.6	1.120	4.5	0	0	90	13	427	62	101.2	29.96	40	18	64	740	1364	91	178
14	6/13	4003	46.1	34.[illegible]	19.3	25.9	221	32.0	10	11476	25.3	[illegible]	0.975	43.4	12.8	0.597	2.4	0	0	110	16	427	62	101.2	29.96	40	10	50	708	1306	82	179
15	6/13	4003	45.2	33.3	18.9	25.4	216	31.4	10	11476	25.3	606.3	0.997	43.4	12.8	0.572	2.3	0	0	110	16	427	62	101.2	29.96	40	10	50	710	1310	82	179

ORIGINAL PAGE IS
OF POOR QUALITY

** COATED ALUMINUM ROTOR HOUSING **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
1	84	183	103	217	110	230	7	13	90	194	107	224	92	198	108	227	93	200	123	254	98	209	131	268	91	196	107	224	92	197	99	211	31	88
2	84	184	103	218	111	232	8	14	91	195	107	225	92	198	109	228	94	201	123	254	99	210	132	269	92	197	107	224	72	197	100	212	34	93
3	84	183	103	217	111	231	8	14	91	195	107	224	92	198	109	228	93	200	123	253	99	210	132	270	42	107	107	224	92	197	100	212	34	93
4	84	183	102	215	109	229	8	14	91	195	106	222	92	198	108	226	93	200	125	257	98	208	131	267	91	196	106	222	91	196	99	210	36	97
5	84	184	102	216	110	230	8	14	90	194	106	222	92	197	107	225	93	199	121	250	97	207	130	266	91	195	105	221	92	197	98	209	37	98
6	83	182	103	217	114	238	12	21	93	200	116	240	96	205	118	245	95	203	136	277	102	215	145	293	94	201	113	236	94	201	104	220	38	101
7	83	182	103	217	114	238	12	21	93	200	116	240	96	204	118	245	95	203	137	278	102	215	145	293	94	201	113	236	94	201	104	220	42	108
8	85	185	103	218	118	244	14	26	98	208	125	257	101	214	123	262	98	209	147	297	104	220	148	299	97	206	118	244	97	206	109	223	41	105
9	84	184	104	219	118	245	14	26	97	207	125	257	101	212	123	262	98	208	147	297	104	219	148	299	96	205	118	245	97	206	109	228	40	104
10	83	182	102	216	110	230	8	14	91	195	108	227	92	198	109	229	93	199	124	255	96	205	129	265	91	195	105	221	91	195	98	209	40	104
11	84	183	103	218	111	232	8	14	91	196	109	228	93	200	111	231	94	201	125	257	97	207	131	268	91	196	106	223	91	196	99	211	39	102
12	84	184	103	218	116	241	13	23	97	207	123	253	100	212	125	257	98	208	143	290	104	220	152	306	97	206	117	243	97	206	108	226	42	107
13	84	183	102	215	115	239	13	24	96	204	121	250	98	209	122	254	97	206	143	289	103	218	151	304	96	204	116	241	96	204	107	225	43	109
14	84	183	102	216	113	235	11	19	93	199	112	234	94	202	113	235	95	203	128	263	100	212	140	284	93	199	110	230	93	199	102	215	44	111
15	84	183	103	217	113	236	11	19	92	198	112	234	94	202	113	230	95	203	123	263	99	211	139	282	92	198	109	229	92	198	102	215	39	102

ORIGINAL PAGE IS
OF POOR QUALITY

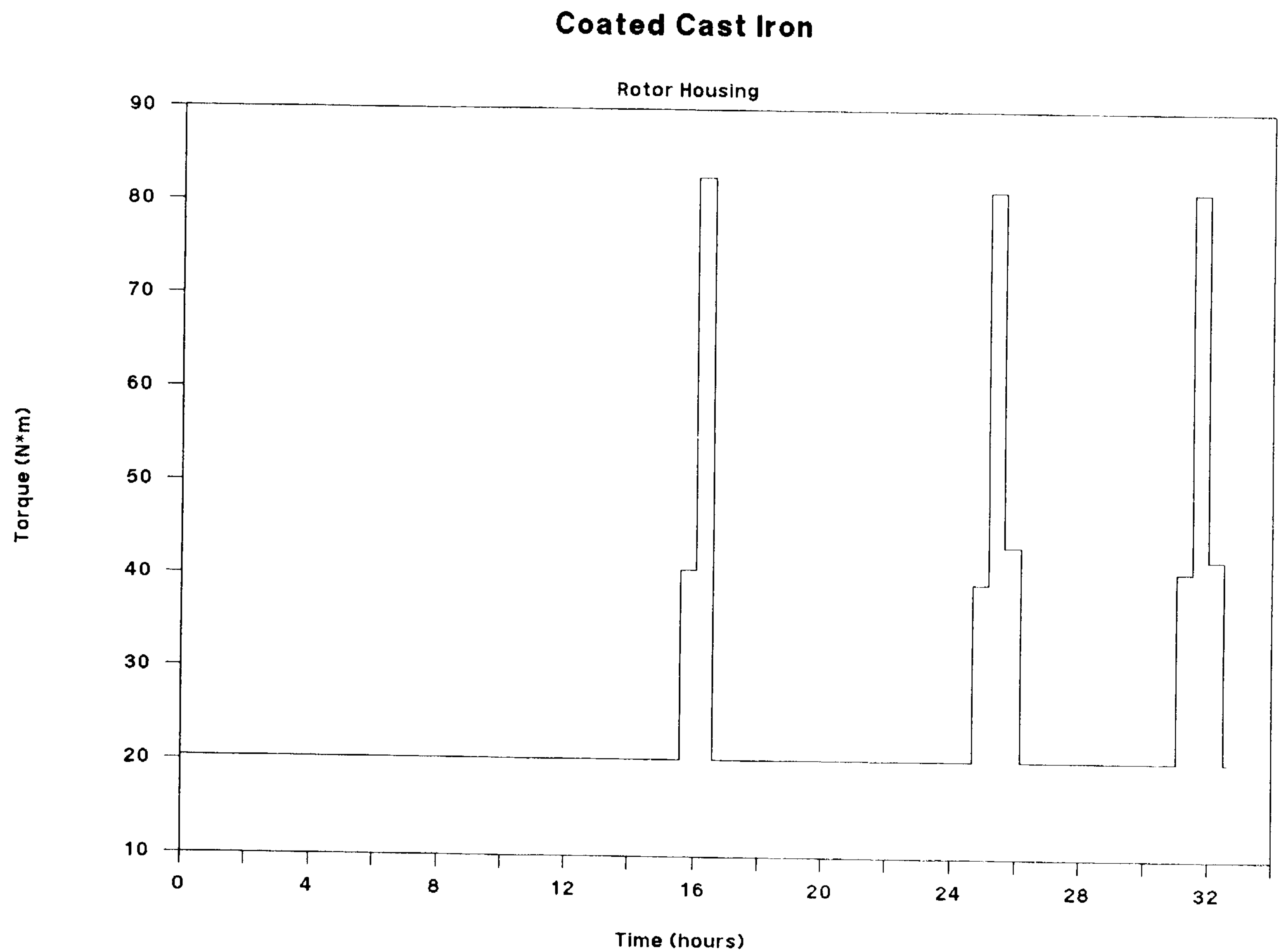
APPENDIX I

COATED CAST IRON

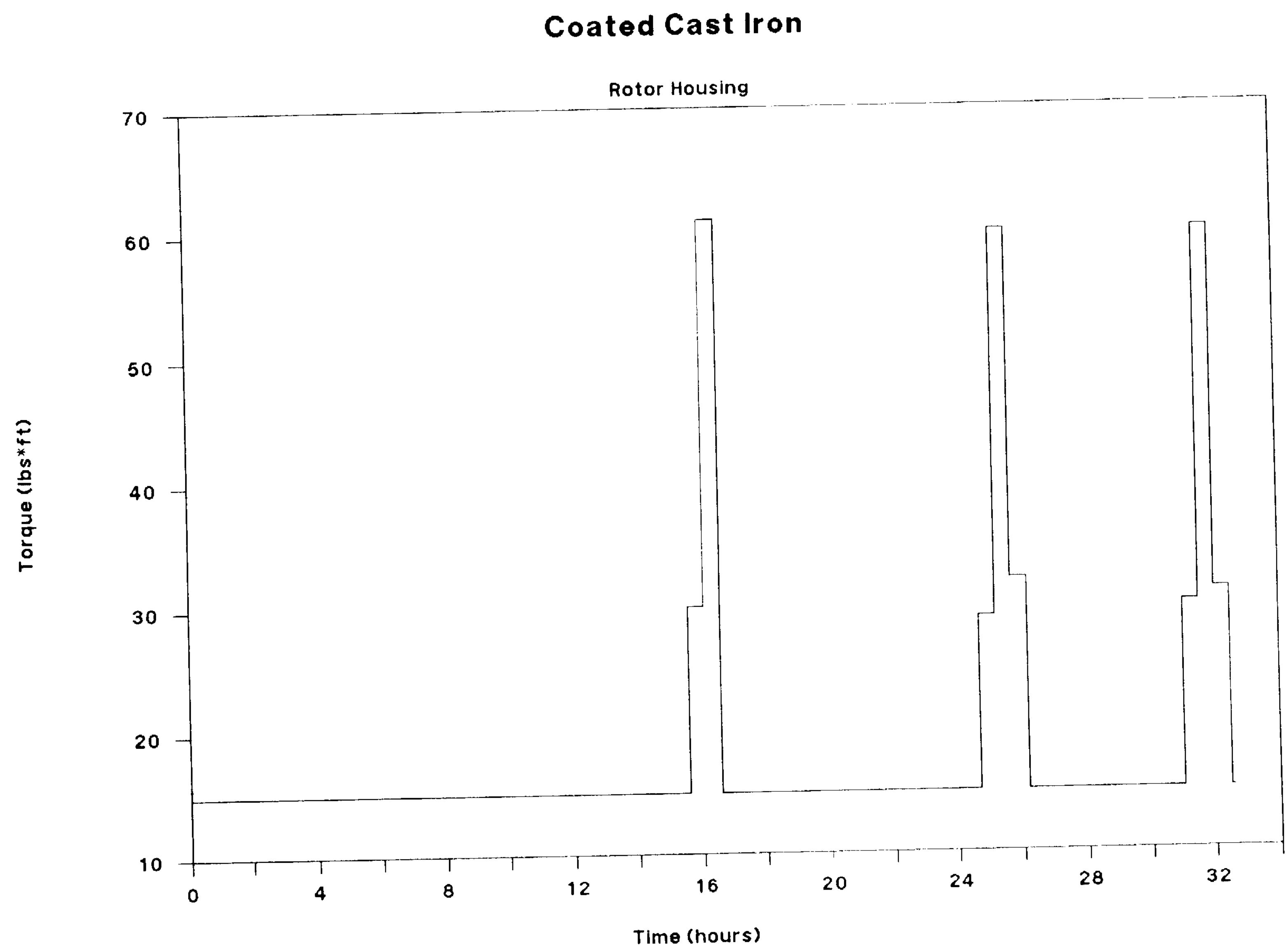
ROTOR HOUSING DATA

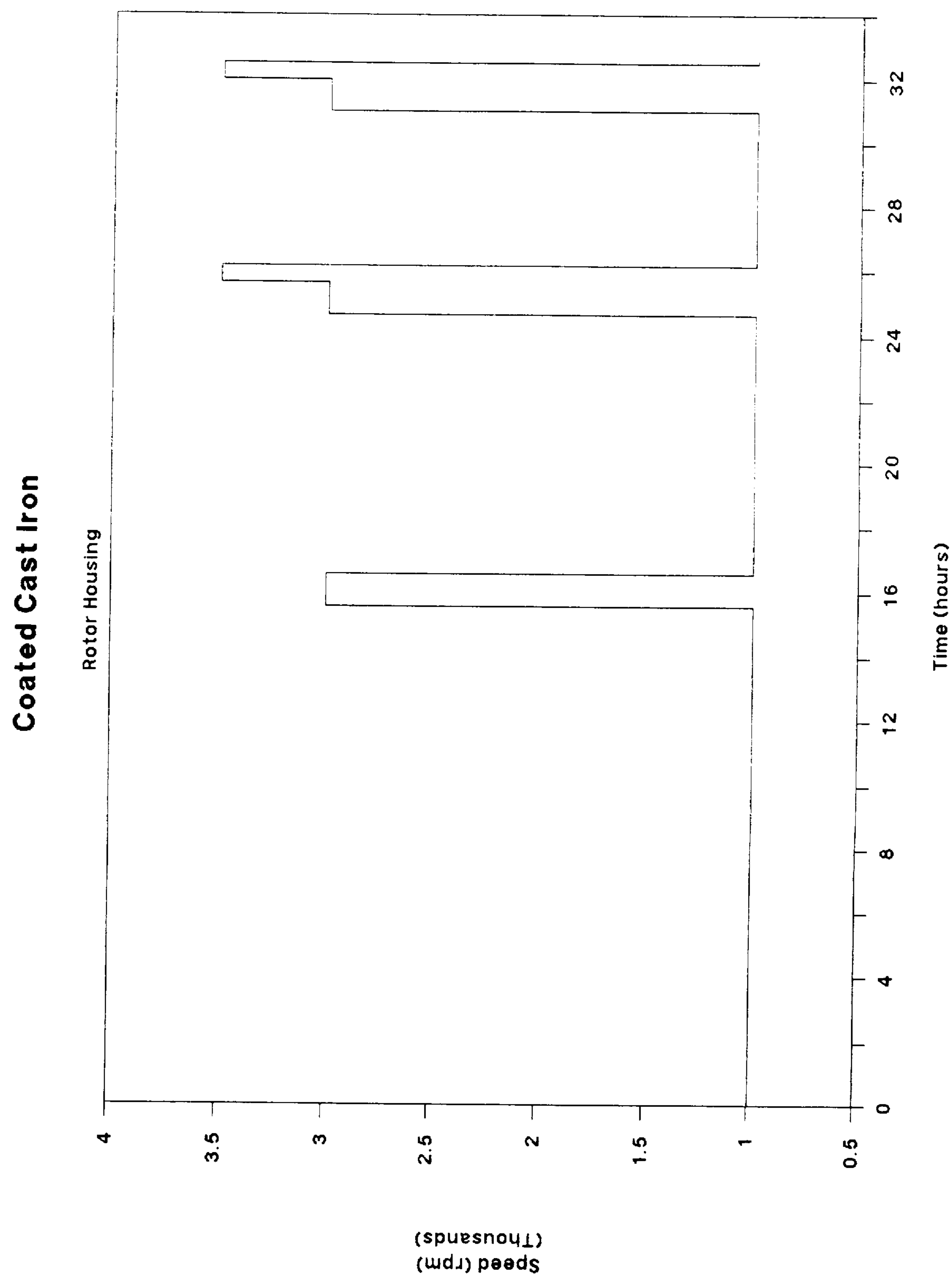
COATED CAST IRON ROTOR HOUSING DATA

TABLE OF CONTENTS



Coated Cast Iron
Rotor Housing
Torque (N*m)
90
80
70
60
50
40
30
20
10
0
4
8
12
16
20
24
28
32
Time (hours)


Coated Cast Iron
Rotor Housing
Torque (lbs*ft)
70
60
50
40
30
20
10
0
4
8
12
16
20
24
28
32
Time (hours)


Coated Cast Iron
Rotor Housing
Speed (rpm)
(Thousands)
Time (hours)
0.5
1
1.5
2
2.5
3
3.5
4
0
4
8
12
16
20
24
28
32

** CAST IRON ROTOR HOUSING **

Point	Date	RPM	Torque (Nm)	Torque (lbf ft)	BHP (kW)	BHP (hp)	BMEP (kPa)	BMEP (psi)	Fuel Flow Rate (%)	Fuel Flow (gr/hr)	Fuel Flow (lbs/hr)	BSFC (g/kWh)	BSFC (lb/bhp-hr)	Intake pres (kPa)	Intake pres (in/hg)	Exhaust pres (kPa)	Exhaust pres (in/H2O)	Blowby pres (kPa)	Blowby pres (in/H2O)	Cool pres (kPa)	Cool pres (psig)	Oil pres (kPa)	Oil pres (psig)	Baro pres (kPa)	Baro pres (in-hg)	Humid (%)	In Temp (C)	In Temp (F)	Exh Temp (C)	Exh Temp (F)	Cool In (C)	Cool In (F)
1	7/22	1130	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	49.5	14.6	0.249	1.0	0.1	0.5	55	8	296	43	NA	NA	NA	15	59	380	716	82	180
2	7/22	1176	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52.2	15.4	0.000	0.0	0.0	0.1	38	6	276	40	NA	NA	NA	25	77	397	746	81	177
3	7/25	1570	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	52.9	15.6	0.000	0.0	0.1	0.3	55	8	303	44	NA	NA	NA	21	69	467	872	81	177
4	7/25	1600	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	54.9	16.2	0.000	0.0	0.2	0.7	41	6	296	43	NA	NA	NA	22	72	463	866	81	178
5	7/26	3000	41.8	30.8	13.1	17.6	200	29.0	7	8033	17.7	612	1.007	49.5	14.6	0.025	0.1	0.5	2.2	69	10	434	63	NA	NA	90	4	39	676	1248	83	181
6	7/26	3000	41.6	30.7	13.1	17.5	199	28.9	7	8033	17.7	614	1.010	49.5	14.6	0.025	0.1	0.5	2.1	69	10	434	63	NA	NA	90	4	39	672	1242	82	180
7	7/26	3000	82.2	60.6	25.8	34.6	394	57.1	9	10328	22.8	400	0.658	28.8	8.5	0.075	0.3	0.7	2.9	69	10	427	62	NA	NA	90	11	51	727	1341	83	181
New Build																																
10	7/29	1145	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34.6	10.2	0.075	0.3	0.0	0	34	5	276	40	NA	NA	NA	31	87	383	722	82	179
11	8/1	3001	39.3	29.0	12.4	16.6	188	27.3	6	6886	15.2	557	0.916	50.1	14.8	0.448	1.8	0.0	0	48	7	441	64	100.7	29.82	72.9	8	46	673	1244	82	180
12	8/1	3002	39.3	29.0	12.4	16.6	188	27.3	6	6886	15.2	557	0.916	50.1	14.8	0.398	1.6	0.0	0	41	6	441	64	100.7	29.82	72.9	8	47	669	1237	81	178
13	8/1	3001	81.0	59.7	25.4	34.1	388	56.3	9	10328	22.8	406	0.667	29.5	8.7	0.747	3.0	0.0	0	55	8	441	64	100.7	29.82	72.9	15	59	761	1402	82	180
14	8/1	3000	81.2	59.9	25.5	34.2	389	56.5	9	10328	22.8	405	0.666	29.5	8.7	0.571	3.5	0.0	0	55	8	441	64	100.7	29.82	72.9	15	59	762	1403	82	160
15	8/1	3500	42.8	31.6	15.7	21.1	205	29.8	9	10328	22.8	658	1.081	50.1	14.8	1.120	4.5	0.0	0	48	7	448	65	100.7	29.82	72.9	8	47	682	1260	82	179
16	8/1	3500	42.8	31.6	15.7	21.1	205	29.8	9	10328	22.8	658	1.081	50.1	14.8	1.095	4.4	0.0	0	48	7	448	65	100.7	29.82	72.9	8	46	691	1276	81	177
New Build																																
21	3/9	3000	41.1	30.3	12.9	17.3	197	28.6	7	8033	17.7	622	1.023	47.8	14.1	0.622	2.5	0.0	0	62	9	441	64	NA	NA	63	6	42	673	1243	82	180
22	3/9	3000	40.5	29.9	12.7	17.1	194	28.2	[illegible]	8033	[illegible]	621	1.027	48.1	14.2	0.622	2.5	0.0	0	55	8	441	64	NA	NA	63	6	42	665	1229	82	180
23	6/9	[illegible]	82.[illegible]	[illegible]	25.8	34.6	[illegible]	57.[illegible]	[illegible]	[illegible]	22.[illegible]	445	[illegible]	25.4	7.5	1.195	4.6	0.[illegible]	0	69	10	434	63	NA	NA	62	[illegible]	54	762	1404	83	181
24	[illegible]	[illegible]	[illegible]	[illegible]	25.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25.4	[illegible]	[illegible]	4.7	[illegible]	[illegible]	69	10	434	63	NA	NA	63	[illegible]	[illegible]	[illegible]	1442	82	[illegible]
25	[illegible]	[illegible]	41.9	[illegible]	15.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43.2	[illegible]	[illegible]	4.2	[illegible]	[illegible]	48	7	448	65	NA	NA	[illegible]	[illegible]	43	[illegible]	1309	82	180
26	3/9	[illegible]	40.[illegible]	[illegible]	15.4	[illegible]	201	29.2	[illegible]	8033	[illegible]	[illegible]	[illegible]	45.3	[illegible]	[illegible]	4.3	[illegible]	0	55	8	448	65	NA	NA	63	[illegible]	43	[illegible]	1306	81	178

** CAST IRON ROTOR HOUSING **

Point	Cool Out (C)	Cool Out (F)	Oil In (C)	Oil In (F)	Oil Out (C)	Oil Out (F)	Delta Oil Temp (C)	Delta Oil Temp (F)	Rear Rotor Housing #2 (C)	#2 (F)	#3 (C)	#3 (F)	#4 (C)	#4 (F)	#5 (C)	#5 (F)	Intermediate Housing #6 (C)	#6 (F)	#7 (C)	#7 (F)	#8 (C)	#8 (F)	#9 (C)	#9 (F)	Front Rotor Housing #10 (C)	#10 (F)	#11 (C)	#11 (F)	#12 (C)	#12 (F)	#13 (C)	#13 (F)	Air Temp (C)	Air Temp (F)
1	83	181	82	179	88	191	7	12	24	75	123	254	109	228	132	269	100	212	121	250	96	205	126	258	117	242	151	303	108	227	145	293	22	72
2	83	181	101	214	104	220	3	6	26	79	131	267	112	233	133	271	101	214	118	244	98	209	122	251	118	244	149	301	112	233	147	296	33	91
3	82	180	100	212	107	225	7	13	27	81	142	288	118	244	143	290	101	213	123	254	98	208	129	264	123	254	163	326	116	241	158	317	33	91
4	83	182	101	214	108	226	7	12	30	86	143	290	116	241	142	287	101	213	121	249	98	208	125	257	121	250	159	318	115	239	154	310	37	98
5	84	183	102	216	114	237	12	21	23	73	225	437	152	306	209	409	106	222	146	294	105	221	147	296	162	323	241	465	154	309	231	448	22	72
6	83	182	102	215	113	236	12	21	23	73	224	436	151	303	209	408	106	223	144	291	107	225	144	291	162	323	239	463	153	308	230	446	22	72
7	84	183	102	216	119	246	17	30	25	77	278	532	172	342	254	490	110	230	157	315	113	235	163	325	187	368	291	555	179	354	276	528	24	76
New Build																																		
10	83	182	101	214	106	222	4	8	108	226	135	275	113	236	134	274	101	214	116	241	101	213	122	251	117	242	150	302	113	236	148	298	38	101
11	82	180	102	216	113	236	11	20	142	287	222	431	148	299	206	402	104	219	148	298	105	221	145	293	156	313	125	257	152	305	229	445	37	98
12	83	182	102	216	114	237	12	21	142	287	222	431	148	299	206	403	102	215	145	293	106	223	146	294	156	313	235	455	152	305	229	444	38	100
13	83	182	103	217	119	246	16	29	166	331	275	527	171	340	252	465	106	223	157	333	112	234	163	326	186	366	288	550	179	355	276	528	39	103
14	83	132	102	216	119	246	17	30	164	328	273	524	169	336	250	482	105	222	167	333	112	233	163	325	183	362	287	549	179	355	273	524	39	103
15	83	181	101	213	113	235	12	22	150	302	242	468	157	314	222	432	103	217	153	308	108	225	149	300	165	329	246	474	161	322	242	467	38	101
16	83	182	101	213	113	235	12	22	150	302	242	468	156	312	222	432	102	215	152	305	107	225	147	296	164	327	244	472	161	321	241	466	38	101
New Build																																		
21	83	181	104	220	116	241	12	21	147	297	237	458	159	319	218	424	109	228	149	300	107	225	152	305	166	330	245	473	28	83	29	85	27	80
22	82	180	104	220	116	240	11	20	145	293	232	449	156	313	213	415	107	225	146	295	107	225	151	303	164	329	241	466	28	82	28	83	28	83
23	83	182	102	216	122	251	19	35	171	339	282	540	179	354	253	486	113	235	159	318	114	237	171	339	200	392	296	565	185	365	288	551	29	84
24	83	181	104	219	121	249	17	30	170	338	283	541	182	359	254	490	113	236	159	318	114	238	171	339	198	388	295	563	185	365	284	544	31	88
25	82	179	102	216	114	238	12	22	153	307	249	481	163	326	226	439	109	228	147	297	109	229	152	306	177	351	253	487	165	329	252	486	32	89
26	82	180	104	219	116	240	12	21	152	306	251	484	162	323	226	439	107	224	148	298	110	230	156	312	176	349	256	492	166	331	254	489	31	87

ORIGINAL PAGE IS
OF POOR QUALITY